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# The Effectiveness Of Implementing Emerging Warehouse Technologies On Warehouse Operations

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***Abstract***. *Emerging technologies are transforming warehouse operations, and this study investigated the effectiveness of implementing the Internet of Things (IoT), Radio-Frequency Identification (RFID), Artificial Intelligence (AI), and Robotics into warehouse operations. A descriptive correlational research design was employed, utilizing surveys to gather data from warehouse personnel and focusing on key performance indicators such as inventory accuracy, order fulfillment efficiency, cost reduction, and timely delivery satisfaction. The findings revealed a high level of familiarity with RFID and IoT among warehouse personnel, and a strong belief in the positive impact of these technologies on warehouse operations. However, challenges such as implementation costs, technical issues, and regulatory compliance were identified. Surprisingly, the analysis did not reveal a significant relationship between the implementation of these technologies and their overall effectiveness on warehouse operations. Future research should consider qualitative methodologies and larger sample sizes to explore other factors influencing warehouse performance.*

***Keywords*** *Warehouse operations, Emerging technologies, Effectiveness, Implementation challenges*

## 1. INTRODUCTION

In the era of rapid technological advancement, businesses across industries are constantly seeking ways to optimize their operations, enhance efficiency, and meet the ever-growing demands of consumers. The implementation of emerging warehouse technologies is synergistic with the ongoing evolution in logistics and supply chain operations. In the early days of warehousing, manual record-keeping and basic inventory management techniques were the norm, leading to inefficiencies and inaccuracies. This changed with the advent of computer technology in the mid-20th century, allowing for automation in inventory control, order processing, and tracking. Ancient civilizations faced the need to store food, leading to early stock control concepts that persisted until modern manual recording tools were introduced. Armenta (2022) highlighted the 19th-century introduction of railroads as a significant development, which led to the establishment of decentralized warehouses near railroad terminals, forming new distribution networks. By the 1990s, the retail industry rapidly adopted computer technology, and major retail chains constructed modern distribution centers with

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communication technologies providing up-to-date information from manufacturing sites. World War II advances in storage and logistics led to the development of Warehouse Management Systems (WMS) software, enhancing processing speed and expanding functionality. Traditional warehouse management models, limited by manual processes, struggled to adapt to evolving business needs, leading to the emergence of new technologies (Mao, 2018). The Internet of Things (IoT), integrating physical and digital worlds through sensors, emerged as a key player in Industry 4.0, using technologies like Wi-Fi, RFID, and cloud computing for efficient supply chain management and real-time data monitoring, thus preventing disruptions like the bullwhip effect. The 1980s and 1990s saw barcoding and RFID technologies transforming warehouse operations, with barcoding enabling quicker data entry and more accurate tracking, and RFID offering real-time visibility and efficient stock control (Mostafa, 2018). Warehouse inventory management systems emerged to address the challenge of locating products within large warehouses. These systems, along with RFID technology, facilitated wireless communication and precise product information cataloging (Tejesh, 2018). However, the implementation of emerging technologies faces challenges, including high costs, data management complexities, security concerns, and worker adaptation issues. Thorough planning, infrastructure investment, and robust cybersecurity measures are essential for successful technology adoption.

Artificial intelligence (AI) significantly impacts warehouse operations by improving accuracy, efficiency, and productivity. McKinsey & Company (2021) reported that AI adoption in supply chain operations leads to significant improvements in logistics costs, inventory levels, and service levels. However, AI implementation presents challenges, such as high costs and complexity, especially for small and medium-sized businesses (Duan et al., 2019). Additionally, AI's potential to automate tasks raises concerns about job displacement within the industry (Smith, 2019). IoT systems offer increased efficiency, enhanced visualization, greater accuracy, improved security, and optimized resource utilization in smart warehousing. However, challenges include compatibility issues between different RFID tag types, limited range and technical capabilities of IoT devices, data acquisition and processing issues, and security and privacy concerns (Ding, 2020). Emerging technologies like AI, machine learning (ML), and IoT empower businesses to optimize inventory levels more effectively by analyzing historical data for demand patterns and forecasting future inventory needs (Hoque et al., 2021). Dhumale et al. (2018) found that integrating IoT across the supply chain offers significant advantages, including improved growth, better challenge management, and enhanced long-term economic prospects. This research aims to identify emerging warehouse technologies,

particularly IoT, RFID, AI, and Robotics, and evaluate their effectiveness in improving inventory accuracy, order fulfillment efficiency, cost reduction, and timely delivery performance. It will also explore the challenges faced by warehouse personnel in implementing these technologies and investigate the relationship between technology implementation and warehouse operations effectiveness. However, it may not comprehensively cover every aspect of warehouse management or all potential technologies utilized in warehouse operations. The focus remains primarily on the specified technologies and their impact on the identified key performance indicators within the scope of warehouse operations. This study will provide insights into the transformation of warehouse operations by emerging technologies, highlight associated benefits and challenges, and contribute to the literature on warehouse and supply chain management. It could guide industry decision-makers and identify areas for further research.

## 2. LITERATURE REVIEW

### Emerging Warehouse Technologies on Warehouse Operations

The integration of emerging technologies, particularly the Internet of Things (IoT), has become crucial in warehouse management, enhancing operational efficiency and overall performance. IoT revolutionizes warehouse operations by enabling real-time data capture and sharing, improving visibility across stages from receiving to shipping, and leading to improved cost efficiency, streamlined operations, and increased inventory accuracy (Sunol, 2023). Kim and Park (2019) emphasized that IoT-enabled Warehouse Management Systems (WMS) secure and efficiently manage material storage and retrieval processes, improving inventory accuracy, reducing error rates, and enhancing customer service standards.

The integration of IoT into WMS enables secure product management, real-time supervision of material flow, and tracking of product movements. Technologies like RFIDs, infrared sensors, GPS, and laser scanners facilitate intelligent identification, tracking, and tracing, resulting in faster order fulfillment and improved job efficiency for warehouse personnel (Jarašūnienė et al., 2023). Mostafa et al. (2018) proposed an advanced WMS framework leveraging IoT for enhanced control and real-time monitoring of operations, providing immediate visibility, improving speed, and safeguarding against inventory shortages and counterfeit products.

AI and machine learning have also emerged as effective solutions for managing warehouse operations, particularly benefiting Small and Medium Enterprises (SMEs) by optimizing tasks such as demand forecasting, inventory management, and order picking routes,

and reducing operational time. Despite initial investment costs, these technologies promise long-term benefits such as reduced labor costs and improved customer satisfaction (Dhande, 2021). Integrating AI algorithms into conventional WMS improves stock planning, product placement, order picking, and transportation processes, leading to more efficient workflows and time-saving operations (Žunić et al., 2018).

The incorporation of automation and AI into warehouse operations demonstrates remarkable improvements in efficiency, inventory accuracy, and overall performance. These technologies offer benefits such as enhanced route optimization, precise inventory planning, and increased accuracy in various warehouse tasks (Ylä-Autio, 2021). To address labor shortages and the growing demands of e-commerce, warehouses are increasingly adopting Industrial IoT-based Smart Robotic WMS, leveraging autonomous Unmanned Ground Vehicles (UGVs) for tasks like picking and restocking, and employing Pick-Put-To-Light devices to guide workers and reduce picking errors (Lee, 2018).

RFID technology has been implemented in many warehouses to minimize errors in logistics processes, offering benefits such as enhanced safety and reliability in supply chains and improved business efficiency. RFID implementation streamlines process flow and increases operational efficiency within warehouse management systems (Nvl, 2024). The incorporation of robots into warehouse operations significantly optimizes picking rates, reduces costs, and improves existing WMS by automating specific tasks, balancing efficiency with human labor, and enhancing overall workflow (Buntak et al., 2019). Research highlights the advantages of robotized and automated warehouse systems, including shuttle-based storage and retrieval systems and robotic mobile fulfillment systems, which offer increased efficiency but also pose new challenges requiring further research into modeling methodologies, human factors, and environmental impacts (Azadeh et al., 2019).

In conclusion, integrating emerging warehouse technologies such as IoT, AI, and robotics has revolutionized warehouse operations, leading to improved efficiency, reduced costs, and enhanced customer satisfaction. As the field evolves, organizations must embrace these technologies to stay competitive and meet the demands of the ever-changing market.

**Challenges faced by Warehouse Personnel**

In today's rapidly evolving logistics industry, warehouses are essential for facilitating the seamless movement of goods from manufacturers to consumers. However, the growing sophistication of cyberattacks presents a significant threat to this function. Chen et al. (2022) noted that malicious actors are constantly developing new methods to exploit vulnerabilities in

software, hardware, and human behavior, such as phishing emails, ransomware attacks, and zero-day exploits. These evolving threats necessitate a proactive approach to cybersecurity, emphasizing continuous vigilance, threat intelligence gathering, and robust security measures. A successful cyberattack can lead to data breaches, operational disruptions, and financial losses.

Human factors remain a significant vulnerability, with social engineering tactics like phishing and a lack of security awareness among employees posing risks (Nguyen et al., 2020). The financial investment in cybersecurity, robotics, and infrastructure can be substantial, particularly for smaller businesses, requiring careful cost-benefit analysis and strategic planning (Matthew, 2024). Resistance from warehouse staff to adopting new cybersecurity measures, driven by fears of job displacement due to automation and unfamiliarity with new technology, presents additional challenges (Garratt, 2023).

Implementing new technologies can be challenging for warehouse staff already under pressure to meet customer demands. Maintaining these systems requires ongoing training and attention (Varghese, 2021). The human aspect of warehouse modernization highlights the need to address employee concerns and skill sets. A growing shortage of skilled personnel, such as experienced forklift operators and those with expertise in new technologies, further complicates these challenges (Garratt, 2023).

The high cost of implementing new warehouse technologies presents a significant obstacle, especially for businesses in developing nations. Automated warehouses offer improved efficiency but have higher initial setup costs compared to traditional warehouses, making it difficult for companies to embrace these advancements (Kamali, 2020). Balancing the desire for innovation with financial limitations is a major concern for businesses.

In conclusion, addressing the challenges faced by warehouse personnel requires a comprehensive approach that includes cybersecurity measures, ongoing training, financial planning, and addressing human factors to ensure successful technology implementation and efficient warehouse operations.

## Theoretical And Conceptual Framework

Figure 1 illustrates the theoretical framework used in this study, clarifying the connections between the independent variable (IV), mediating variable (MV), and dependent variable (DV). The independent variable is "Emerging Warehouse Technologies," which encompass IoT, AI, RFID, and Robotics. The research aimed to assess the effectiveness of implementing these various technologies on warehouse operations, specifically focusing on

aspects like inventory accuracy, order fulfillment efficiency, cost reduction, and timely delivery satisfaction.

The independent variable, Emerging Warehouse Technologies, encompasses four key technologies: IoT, AI, RFID, and Robotics (Silva et al., 2023). The broad versatility of these technologies is enabling significant innovations across various industries. Silva et al. (2023) suggest that integrating these technologies into warehouse operations can lead to positive outcomes by enabling real-time data tracking for all processes and functions. Marak (2023) defines the Internet of Things (IoT) as a technology that allows different devices and systems to share, store, scan, and retrieve data. This real-time connectivity provided by IoT facilitates monitoring and synchronization of various warehouse components, such as drones, beacons, pallets, equipment, inventory, and even workers. Meanwhile, Artificial intelligence (AI) involves machine learning from experience and acting based on that knowledge. Radio Frequency Identification (RFID) technology, as studied by Flora (2023), allows warehouses to maintain a live inventory tracking system using electromagnetic waves. Warehouses can affix RFID tags to their goods or packages, enabling them to track inventory movement throughout various stages of operation with improved accuracy (e.g., faster inventory checks). Robotics, on the other hand, pertains to the planning, building, functioning, and utilization of robots, which are mechanical devices capable of carrying out tasks either fully or partially on their own. Essentially, this study aims to analyze the effectiveness of these technologies on warehouse operations and the specific changes they introduce, providing a detailed understanding of their effectiveness.

The mediating variable, "Challenges Faced by Warehouse Personnel," encompasses the difficulties and barriers encountered by warehouse personnel during the implementation of emerging warehouse technologies. These challenges may include lack of training skills, system integration, cost of implementation, resistance to change, data security, technical issues, regulatory compliance, and supplier support or expertise. According to Marta (2023), ensuring that various technologies seamlessly work together poses a major challenge that needs to be addressed in order to successfully implement warehouse automation. Employees often express concerns about their ability to adapt to new technologies, alongside apprehensions about the security of their positions. This resistance to change can hinder the implementation process and consequently impact overall productivity. Due to the diverse range of electronic and mechanical components comprising warehouse automation systems, regular maintenance and support are imperative to maintain seamless operations. Issues such as technological glitches,

unexpected downtime, or system malfunctions can greatly impede productivity and diminish customer satisfaction.

The dependent variable focuses on the warehouse operations in terms of inventory accuracy, order fulfillment efficiency, cost reduction, and timely delivery satisfaction. According to Rylander (2021) indicate that errors can occur relatively easily in warehouse operations. More than 50% of these errors occur during inventory control and the picking process. As a result, to guarantee both work quality and safety, it underscores the importance of having a substantial presence of technical systems in warehousing activities. In addition, it aims to reduce expenses by enhancing warehouse procedures, and when compared to manual handling systems, it delivers more dependable and efficient outcomes with reduced effort.

In summary, the independent variable (IV) is the implementation of emerging warehouse technologies. The challenges faced by warehouse personnel are depicted as mediating variables, influencing the relationship between the implementation of emerging warehouse technologies (IV) and their effectiveness on warehouse operations performance (DV). The dependent variable (DV) is the performance of warehouse operations, encompassing metrics such as inventory accuracy, order fulfillment efficiency, cost reduction, and timely delivery satisfaction.

**Statement Of The Problem**

This study aims to investigate the effectiveness of implementing emerging warehouse technologies on warehouse operations. Specifically, this research seeks to answer the following questions:

1. What is the demographic profile of warehouse personnel in terms of:
2. Age
3. Position
4. Years of experience in warehouse management

What are the emerging warehouse technologies being implemented by warehouse personnel in terms of:

1. IoT
2. RFID
3. AI
4. Robotics

How effective is the implementation of emerging warehouse technologies in warehouse operations in terms of:

1. Inventory accuracy
2. Order fulfillment efficiency
3. Cost reduction
4. Timely delivery satisfaction

What are the challenges faced by warehouse personnel in implementing emerging warehouse technologies on warehouse operations?

Is there a significant relationship between the implementation of emerging warehouse technologies and their effectiveness on warehouse operations?

**The Hypothesis Of The Study**

- H0: There is no significant relationship between the implementation of emerging warehouse technologies and their effectiveness on warehouse operations.
- H1: There is a significant relationship between the implementation of emerging warehouse technologies and their effectiveness on warehouse operations.

**Significance Of The Study**

The findings of the study will be beneficial to the following:

Warehouse Personnel. The primary beneficiaries of this study are those involved in warehouse management. These results can assist them in understanding and assessing how the implementation of emerging technologies influences warehouse operations. Additionally, the findings can provide practical suggestions and guidance for the selection, integration, operation, and evaluation of these technologies within their warehouse.

Warehousing Companies. The findings provide a valuable insight into the benefits and challenges of implementing emerging technologies in warehouse operations. This information can guide companies in making informed decisions about technology investments and strategies, ultimately leading to improved operational efficiency and competitiveness

Future Researchers. This study serves as a reference, especially for those exploring topics related to warehouse operations and technology innovation. It provides a basis for further research and exploration in the field, offering empirical evidence and insights on how emerging technologies influence warehouse operations and whether these influences vary based on specific factors.

## 3. METHODS

The methodology for this study was guided by a Descriptive Correlational Research Design, as outlined by Miksza et al. (2023). This design was a form of quantitative research that sought to answer the question, 'What is the relationship between variables?' Descriptive correlational research, as described by Dwitanti and Churiyah (2022), is a quantitative research design aimed at establishing relationships between variables without any manipulation, specifically used to answer questions about the relationships between variables. This research method involved the collection of data and the analysis of existing relationships and levels of variables to provide explanations and test hypotheses or theories.

The researchers used Purposive-Convenience Sampling. According to Frost (2022), Purposive sampling is a non-probability method where researchers select participants based on their expertise or characteristics essential for addressing the research question. Meanwhile, Convenience sampling involves selecting individuals based on their accessibility, willingness, or ease of contact, rather than using a more structured or randomized approach (Ncsc, 2022), allowing the researchers to select participants based on specific criteria relevant to the study. This technique involved identifying and selecting individuals who possessed the necessary knowledge or experience sought by the researchers.

### Instrument And Procedures

The research instrument to be utilized in this study will be a self-constructed questionnaire. The questionnaire comprises 4 parts and 19 items. It’s designed to gather data on warehouse operations. It was validated by three experts in the field of customs administration. Based on the feedback from the experts, modifications were made to the questionnaire. The first part collects demographic data of the warehouse participants. The second part employs a familiarity Likert scale response option: (4) Very Familiar, (3) Familiar, (2) Slightly Familiar, and (1) Not at all familiar, to measure the extent of the implementation of emerging technologies in the warehouse. The third to final parts use a Likert scale response option: (4) Strongly Agree, (3) Agree, (2) Disagree, and (1) Strongly Disagree. These sections assess the effectiveness of emerging warehouse technologies in warehouse operations and identify anticipated challenges during implementation. This approach ensures a comprehensive analysis of the research topic, and the collected responses will provide quantitative data for subsequent statistical analysis.

Cronbach's Alpha: a > 0.9 (Excellent), 0.9 > a > 0.8 (Good), 0.8 > a > 0.7 (Acceptable), 0.7 > a > 0.6 (Questionable), 0.6 > a > 0.5 (Poor), 0.5 > a (Unacceptable) (Source: National Research Council Committee on Scientific Principles for Educational Research, 2002)

After pre-testing the research instrument, Cronbach's alpha was utilized to assess reliability. The findings revealed that the reliability levels of all variables were considered acceptable. The instrument's overall Cronbach's alpha resulted in (0.87), interpreted as good, indicating that it passed the reliability test and was accepted for data collection.

The researchers prepared a survey questionnaire for warehouse personnel and distributed it to respondents within the Clark Freeport Zone. Choosing to conduct all of their research in-person, the researchers visited different warehouses. In order to ensure transparency and protect their privacy, researchers asked for permission before collecting survey data, showing sufficient consideration for their freedom of choice. Finally, the researchers collected a total of (38) respondents during their visits to different warehouses within the Clark Freeport Zone. The data gathered from the respondents were tallied, analyzed, and interpreted after being subjected to statistical treatment.

## 4. RESULTS AND DISCUSSION

The gathered data and their interpretations were presented in tabular form, arranged chronologically in line with the statement of the problem. These findings served as the basis for the conclusions and recommendations.

**Table 1.:** Profile of Warehouse Personnel in terms of Age

| Age | Frequency | Percentage | Rank |
|---|---|---|---|
| 26-35 | 15 | 39.5% | 1 |
| 36-45 | 13 | 34.2% | 2 |
| 46-55 | 9 | 23.7% | 3 |
| 56 and above | 1 | 2.6% | 4 |
| **Total** | **38** | **100%** | |

Table 1. shows the age of the respondents and it reveals that there are more (39.5%) respondents with the age range from 26 to 35 years old, as compared to 34.2% of the respondents with the age of 36 to 45 years old while there are 23.7% of the respondents with the age of 46 to 55 years old and only 2.6% of the respondents with the age of 56 and above.

**Table 2.:** Profile of Warehouse Personnel in terms of Position

| Position | Frequency | Percentage | Rank |
|---|---|---|---|
| Manager | 9 | 23.7% | 2 |
| Supervisor | 9 | 23.7% | 2 |
| Worker | 20 | 52.6% | 1 |
| **Total** | **38** | **100%** | |

Table 2. shows the position of the respondents and it reveals that workers (52.6%) make up the largest portion of the warehouse personnel, followed by managers and supervisors, both at 23.7% each.

**Table 3.:** Years of Experience in Warehouse Management

| Year of Experience | Frequency | Percentage | Rank |
|---|---|---|---|
| Less than 1 year | 3 | 7.9% | 4 |
| 1 to 5 | 11 | 28.9% | 2 |
| 6 to 10 | 14 | 36.8% | 1 |
| 11 to 15 | 7 | 18.4% | 3 |
| 16 years above | 3 | 7.9% | 4 |
| **Total** | **38** | **100%** | |

Table 3.illustrates the distribution of warehouse personnel with years of experience in warehouse management. The table shows that the highest percentage of personnel falls within the 6 to 10 year experience range (36.8%). This is followed by those with 1 to 5 years of experience 28.9%. The representation of personnel then decreases for those with 11 to 15 years 18.4%. Finally, the least represented groups are those with less than 1 year of experience and 16 years or more of experience, both at 7.9%.

**Table 4.:** Emerging Warehouse Technologies Implementation

| | Emerging Warehouse Technologies | Mean | SD | Verbal Description | Rank |
|---|---|---|---|---|---|
| 2.1 | Internet of things (IoT) | 3.66 | 0.67 | Very Familiar | 2 |
| 2.2 | Radio-Frequency Identification (RFID) | 3.71 | 0.52 | Very Familiar | 1 |
| 2.3 | Artificial Intelligence (AI) | 3.12 | 0.83 | Familiar | 4 |
| 2.4 | Robotics | 3.26 | 0.86 | Familiar | 3 |
| **Grand Mean** | | **3.44** | | **Familiar** | |

*Legend: 1.00 - 1.49: Not at all familiar, 1.50 - 2.49: Slightly Familiar, 2.5 - 3.49: Familiar, 3.5 - 4.0: Very Familiar*

Table 4. shows the responses of the respondents to the question about the emerging warehouse technologies as implemented by warehouse personnel. It reveals that the

respondents are very familiar with radio-frequency identification, which has the highest mean of (3.71), followed by the Internet of Things with a mean of 3.66, indicating that the respondents are also very familiar with this warehouse technology. The averages for robotics and artificial intelligence, at 3.26 and 3.12 respectively, indicate that the respondents are just familiar with these technologies. The overall mean of these four different warehouse technologies is 3.44, suggesting that the respondents are just familiar with these technologies. According to Nvl (2024), many companies implemented RFID into their warehouses to minimize errors in logistics processes, enhance safety and reliability in their supply chains for customers, and improve overall business efficiency. Additionally, the implementation of RFID has increased operational efficiency and streamlined process flow within the distribution network of warehouse management systems.

**Table 5. :** Effectiveness of Emerging Warehouse Technologies in Warehouse Operations

| | Statements | Mean | SD | Verbal Description | Rank |
|---|---|---|---|---|---|
| 3.1 | The implementation of emerging technologies has significantly enhanced inventory management accuracy within our warehouse. | 3.71 | 0.73 | Strongly Agree | 4 |
| 3.2 | The integration of emerging technologies has measurably improved the efficiency of order fulfillment processes in our warehouse operations. | 3.87 | 0.34 | Strongly Agree | 1 |
| 3.3 | The adoption of emerging technologies has led to a noticeable reduction in operational costs associated with warehouse management. | 3.68 | 0.47 | Strongly Agree | 3 |
| 3.4 | The utilization of emerging technologies has contributed to enhanced customer satisfaction through the timely delivery of goods from our warehouse. | 3.76 | 0.43 | Strongly Agree | 2 |
| **Grand Mean** | | **3.76** | | **Strongly Agree** | |

*Legend: 1.00 - 1.49: Strongly Disagree, 1.50 - 2.49: Disagree, 2.5 - 3.49: Agree, 3.5 - 4.0: Strongly Agree*

Table 5. shows that the implementation of emerging technologies has significantly enhanced inventory management accuracy within warehouses. Respondents strongly agree with this statement, as evidenced by a mean score of 3.71. Sunol (2023) emphasized the role of technologies like IoT in improving inventory accuracy. Additionally, the integration of these technologies has measurably improved the efficiency of order fulfillment processes in warehouse operations, scoring 3.87 and receiving strong agreement. According to Edirisinghe & Liyanage (2022), the integration of emerging technologies to improve the efficiency of order fulfillment processes in warehouse operations is supported. They observed enhancements in warehouse operations, including improved throughput and expedited dispatch times. Furthermore, adopting emerging technologies has led to a noticeable reduction in operational costs associated with warehouse management, with a mean score of 3.68 and strong agreement

from participants. Lastly, the utilization of these technologies has contributed to enhance customer satisfaction through timely delivery of goods from warehouses, scoring 3.76 and also receiving strong agreement. Overall, the grand mean of 3.76 indicates general strong agreement on the positive impacts of emerging technologies in enhancing warehouse operations.

**Table 6.: Challenges in Implementing Emerging Warehouse Technologies**

| | Statements | Mean | Standard Deviation | Verbal Description | Rank |
|---|---|---|---|---|---|
| 1. | I believe our employees are well-trained and skilled. | 3.47 | 0.51 | Agree | 2 |
| 2. | I feel that our systems integrate well with each other. | 3.50 | 0.56 | Strongly Agree | 1 |
| 3. | I think the costs of implementation of technologies are reasonable. | 2.84 | 0.87 | Agree | 5 |
| 4. | I observe that our employees are open to adopting new technologies. | 3.24 | 0.79 | Agree | 3 |
| 5. | I am confident in our data security measures. | 2.79 | 0.62 | Agree | 6 |
| 6. | I have noticed that our technologies are free from technical issues and glitches. | 2.71 | 0.69 | Agree | 7 |
| 7. | I find regulatory compliance manageable and straightforward. | 3.00 | 0,81 | Agree | 4 |
| 8. | I think we receive enough support and expertise from our suppliers. | 3.50 | 0.60 | Strongly Agree | 1 |
| | **Grand Mean** | **3.13** | | **Agree** | |

*Legend: 1.00 - 1.49: Strongly Disagree, 1.50 - 2.49: Disagree, 2.5 - 3.49: Agree, 3.5 - 4.0: Strongly Agree*

The table 4 shows the challenges encountered in implementing emerging warehouse technologies. Respondents generally perceive these challenges positively, indicating a proactive stance towards technological advancement within their organizations. Employee training and skills receive a commendable mean rating of 3.47, suggesting a consensus that the workforce is well-trained and skilled, underscoring a commitment to employee development. System integration gather the highest mean rating of 3.50, respondent believes the different systems within the warehouse effectively work together. As stated by Saadon (2023), WMS seamlessly integrates with a range of technologies, including barcode scanners, Radio-Frequency Identification (RFID) systems, and robotics, to optimize operations. While the mean rating for reasonable implementation costs is slightly lower at 2.84, there remains agreement that the costs are manageable, emphasizing the need to balance innovation with cost-effectiveness. According to Matthew (2024), the investment in robotics, software, and infrastructure upgrades can be substantial, potentially posing financial constraints for smaller businesses. Overcoming this challenge often requires careful cost-benefit analysis, long-term strategic planning, and exploring innovative financing options. Additionally, according to Garratt (2023), resistance from warehouse staff to adopting new systems may result in a delayed implementation process. However, with a mean rating of 3.24, respondents observe an openness among employees to adopt new technologies, highlighting the importance of providing adequate training and support during transitions. Similarly, the presence of technical

issues and glitches is recognized, with a mean rating of 2.71, emphasizing the need for proactive resolution to maintain smooth operations. Regulatory compliance, rated at 3.00, is perceived as manageable and straightforward, emphasizing the importance of staying informed and adhering to industry-specific regulations. Lastly, strong support and expertise from suppliers, with a mean rating of 3.50, are acknowledged as pivotal for successful technology implementation. Overall, the Grand Mean of 3.13 signifies an overarching agreement among respondents regarding the challenges, reflecting a positive perception and proactive approach towards implementing emerging warehouse technologies.

**Table 7.:** Relationship between the implementation of emerging warehouse technologies and their effectiveness on warehouse operations

| Spearman rho Correlation Coefficient | p-value | Interpretation |
|---|---|---|
| 0.109 | 0.516 | No significant relationship |

*Legend: ≥0.70: Very strong relationship, 0.40 - 0.69: Strong relationship, 0.30 - 0.39: Moderate relationship, 0.20 - 0.29: Weak relationship, 0.01 - 0.19: No or negligible relationship*

Based on the results presented in Table 5, where the correlation coefficient is 0.109 and the associated p-value is 0.516 which is greater than 5% level of significance, the researchers failed to reject the null hypothesis ($H_0$). This indicates that there is insufficient evidence to conclude that there is a significant relationship between the implementation of emerging warehouse technologies and their effectiveness on warehouse operations.

The discussion section is arguably the most important part of an article, as it is the last section a reader sees and can significantly impact their perceptions of the article and the research conducted. Different authors take varied approaches when writing this section. The discussion section should:

## 5. CONCLUSION

The researchers concluded that the majority of warehouse personnel were between 26 and 45 years old, with the highest percentage having 6 to 10 years of experience in warehouse management. Workers comprised the largest proportion of respondents, followed by managers and supervisors. The survey results indicated that respondents possessed a high level of familiarity with radio-frequency identification (RFID) and the Internet of Things (IoT), while

also demonstrating familiarity with robotics and artificial intelligence (AI) in warehouse operations. Respondents strongly believed that emerging warehouse technologies have a positive impact on warehouse operations, reporting significant improvements in key performance indicators such as inventory accuracy, order fulfillment efficiency, cost reduction, and customer satisfaction. Despite the perceived benefits, challenges were encountered in implementing emerging warehouse technologies. Respondents acknowledged obstacles related to implementation costs, technical issues, and regulatory compliance but expressed a willingness to address them. Contrary to expectations, the analysis revealed no significant relationship between the implementation of emerging warehouse technologies and their effectiveness on warehouse operations. This unexpected outcome suggests that other factors beyond technology adoption may significantly influence warehouse performance, potentially overshadowing the impact of these technologies. Future research should explore these factors in more detail.

## 6. RECOMMENDATIONS

1. The researchers recommend that warehouse companies should invest in continuous training and development programs to enhance employees' skills and familiarity with emerging warehouse technologies. These programs should focus on areas such as data analysis for AI, operating warehouse robots, and system navigation to ensure employees can effectively leverage these tools to optimize warehouse operations.
2. To maximize the benefits of emerging warehouse technologies, warehouse companies should prioritize seamless integration of RFID systems and IoT devices within their warehouses to create a cohesive and efficient warehouse management ecosystem, enabling improved data flow and real-time visibility across all operations.
3. While acknowledging the challenges associated with implementation costs, warehouse companies should adopt a strategic approach to cost management. This may involve conducting thorough cost-benefit analyses, exploring innovative financing options such as leasing or subscription models for some technologies, and prioritizing investments based on potential returns on investment (ROI) and long-term business objectives.
4. To address challenges related to technical issues and glitches, organizations should implement proactive measures for issue resolution. This may include establishing regular maintenance schedules, timely software updates, and establishing clear protocols for troubleshooting and resolving technical issues to minimize disruptions to warehouse

operations. Additionally, investing in qualified IT staff for maintenance and troubleshooting can significantly improve the effectiveness of these measures.

5. For future researchers, considering the unexpected finding of a lack of significant relationship between the implementation of emerging warehouse technologies and their effectiveness on warehouse operations, future researchers are suggested to utilize the same variables but in a qualitative or case study research design, with a larger sample size. Additionally, they should consider including and exploring additional factors that might influence warehouse operations, such as workforce training, management practices, operational processes, and warehouse layout, to better understand how these interact with technology implementation and affect overall performance.

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