

Market Review and Analysis for the Development of Highly Intuitive Mobile Apps for the Smart Warehouse Management System (SMART WMS) in Supporting Warehousing and Custom Legal Requirement

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ABSTRACT

This project centres on developing highly intuitive mobile applications for the SMART Warehouse Management System (SMART WMS). These apps enable efficient barcode and QR code data collection, integrate seamlessly with existing systems, and leverage big data analytics to optimise inventory movement. They provide real-time alerts for anomalies, ensure material traceability, and streamline warehouse processes through automation. Additionally, the apps support offline operations with synchronisation capabilities. The mobile apps also meet specific legal requirements, offering secure, anytime-anywhere access, online approvals, RFID-based verification, and real-time operational monitoring. The expected outcomes include enhanced operations in asset tracking, inventory management, and real-time inventory updates. Such an enhancement suggests significant cost savings and improved efficiency for distribution and manufacturing companies. Integrating industrial IoT technology within these apps introduces a novel approach, adding substantial value to traditional warehouse management systems

Keywords: Smart Warehouse Management System (SMART WMS), Mobile apps for warehouse management, Barcode/QR code data collection, Real-time inventory updates RFID-based verification, Industrial IoT technology in warehousing

INTRODUCTION

The primary role of a warehouse is to consolidate items in one location and distribute them to corporate clients. Depending on the business, these items may be sourced from manufacturers or produced internally. The distribution process involves several interconnected steps that require careful management. Smart Warehouse Management Systems (WMS) have been developed to streamline these operations. These systems enhance workflow efficiency and provide valuable business insights, enabling distribution and manufacturing companies to achieve significant cost savings.

Effective warehouse management and efficient resource allocation are essential to addressing these challenges. The development of mobile applications for the SMART Warehouse Management System (SMART WMS) meets specific legal requirements. It offers secure, anytime-anywhere access, online approvals via mobile apps, RFID-based verification of physical storage, and real-time operational monitoring. These features enable manufacturers to monitor and automate many complex warehouse processes. While traditional systems have tracked warehouse progress, industrial IoT technology provides managers with more detailed information.

This project aims to develop highly intuitive mobile apps for the SMART WMS. These apps facilitate barcode/QR code data collection, integrate seamlessly with existing systems, and utilise big data analytics to optimise inventory movement. They also offer real-time alerts for anomalies, ensure material traceability, and streamline processes through necessary automation. Additionally, the Smart WMS mobile apps support offline operation and synchronise with the online database once internet connectivity is restored.

Overall, the Smart WMS enhances operations in asset tracking, inventory management, packing list data transfer, receiving transactions, real-time inventory updates, and load carrier identification.

Objectives

- a. To study the demographics of existing mobile application users for the Smart Warehouse Management System (Smart WMS).
- b. To analyse the acceptance and use of the mobile application for the Smart Warehouse Management System (Smart WMS).
- c. To identify the factors that need to be incorporated into the features of the Smart Warehouse mobile application.

LITERATURE REVIEW

The storage of goods along the supply chain is crucial for various activities, such as consolidation and transportation. Mostafa et al. (2018) note that warehouses are designated storage locations. Essential warehouse procedures include receiving, storing, processing orders, and shipping merchandise. These processes often involve value-added services to ensure accurate order fulfilment.

Dr. A. Pasumpon Pandian (2019) examined the logistics and challenges within warehousing systems to identify ways to improve logistics and storage processes. The study introduced a new logistics and warehousing model by developing a warehouse management system to enhance company efficiency, improve departmental coordination, reduce workforce needs, eliminate material confusion, and lower costs. The design and implementation of this system involve continuous trade-offs between price and performance, focusing on prioritising performance outcomes.

The logistics, manufacturing, and supply chain sectors are experiencing rapid, unprecedented changes driven by innovation and technology. However, warehouse management faces challenges, including inconsistent data entry, restricted data access, high costs, security concerns, and human error.

Figure 1: Material Receiving- Methodology (Before / Existing)

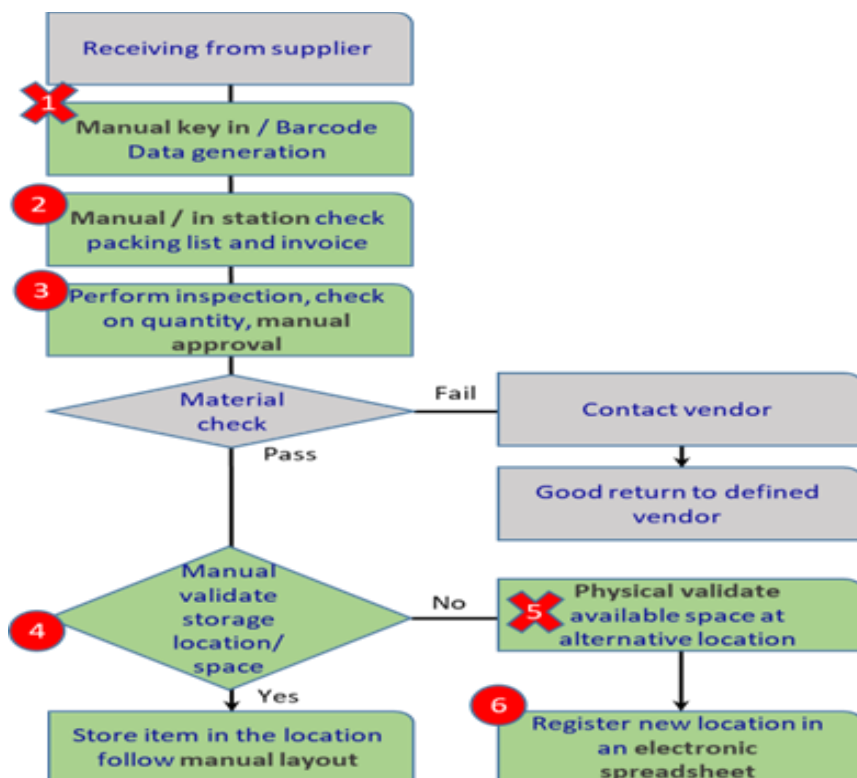
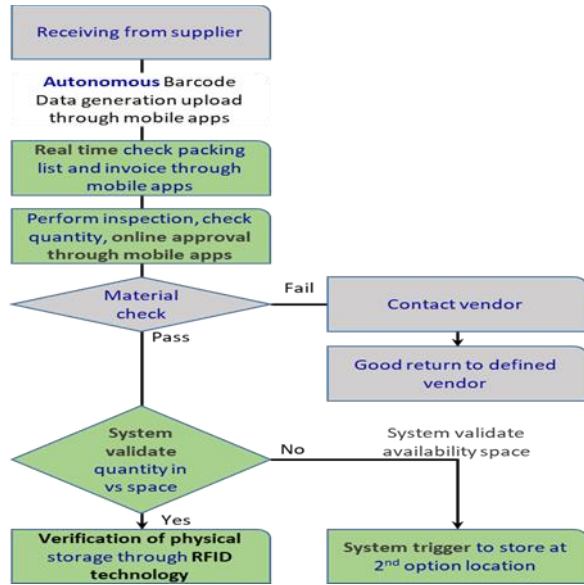


Figure 2: Material Receiving- Methodology (After / Propose Solution)



Findings

Objective 1: To Study The Existing Mobile Application User Demographic For Smart Warehouse Management System (Smart Wms)

The study on factors influencing the acceptance of mobile applications involved surveying 14 users to collect their perspectives. A sample survey form can be found in Appendix A, and the list of respondents is included in Appendix B.

Gender

Table 1: Gender

Gender					
		Frequency	Per cent	Valid Percent	Cumulative Percent
Valid	Male	5	35.7	35.7	35.7
	Female	9	64.3	64.3	100.0
	Total	14	100.0	100.0	

Figure 3: Gender

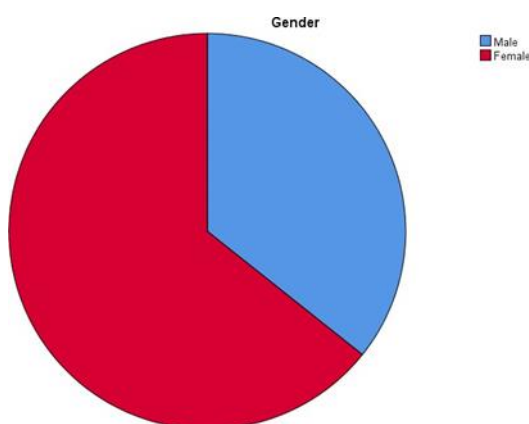


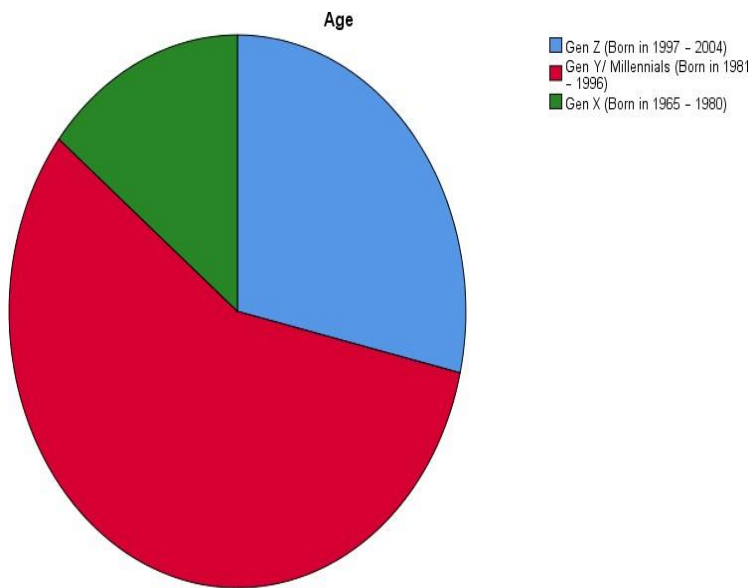
Table 1 and Figure 3 illustrate the gender distribution of the respondents. Male respondents constitute 35.7% of the sample, while female respondents represent 64.3%. This indicates a significantly higher number of female respondents in this study.

Age

Table 2: Age

Age		Frequency	Per cent	Valid Percent	Cumulative Percent
Valid	Gen Z (Born in 1997 – 2004)	4	28.6	28.6	28.6
	Gen Y/ Millennials (Born in 1981 – 1996)	8	57.1	57.1	85.7
	Gen X (Born in 1965 – 1980)	2	14.3	14.3	100.0
	Total	14	100.0	100.0	

Figure 4: Age



In Table 2 and Figure 4, the outcomes of respondents' age groups are depicted. There are a total of 5 categories in the age group: Gen Z (born in 1997 – 2004), Gen Y/Millennials (born in 1981 – 1996), Gen X (born in 1965 – 1980), and Boomers (born in 1946-1964). According to the results, the largest group of respondents falls into the Gen Y/Millennials category (born 1981 – 1996), comprising 57.1% of the total respondents. Gen X (born 1965 – 1980) accounts for 28.6%, and Gen Z (born 1997 – 2004) makes up 14.3% of the respondents.

Race

Table 3: Race

Race		Frequency	Per cent	Valid Percent	Cumulative Percent
Valid	Malay	14	100.0	100.0	100.0

Figure 5: Race

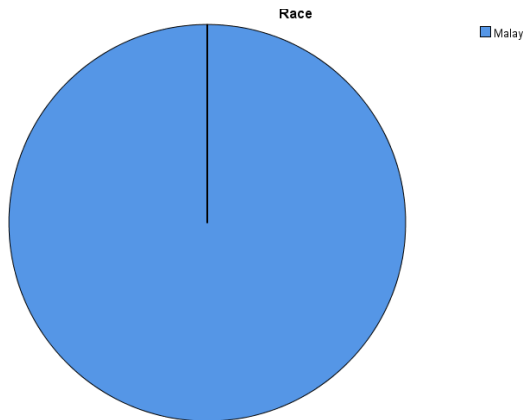


Table 3 and Figure 5 present the distribution of respondents by race. The respondents are categorised into Malay, Chinese, and Indian. According to the results, all respondents belong to the Malay group, making up 100% of the total sample.

Highest Education Level

Table 4: Highest Education Level

Highest education level					
		Frequency	Per cent	Valid Percent	Cumulative Percent
Valid	STPM/ Diploma/ Matriculation	1	7.1	7.1	7.1
	Bachelor's Degree	11	78.6	78.6	85.7
	Master's Degree	1	7.1	7.1	92.9
	Doctorate / PhD	1	7.1	7.1	100.0
	Total	14	100.0	100.0	

Figure 6: Highest Education Level

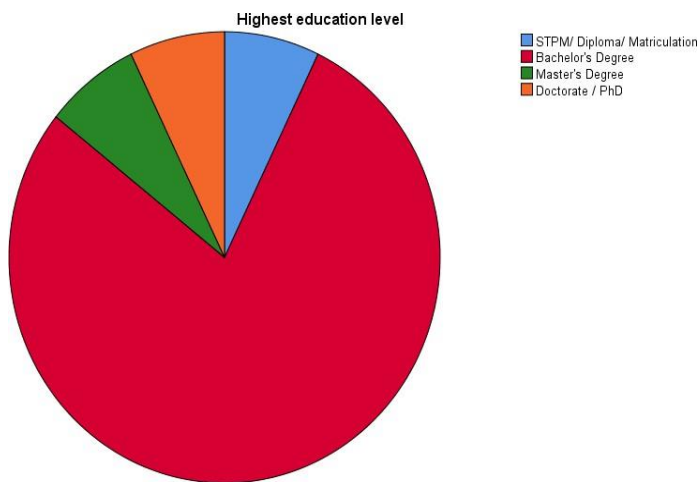


Table 4 and Figure 6 illustrate the respondents' education levels. Most respondents, 78.6%, have attained a bachelor’s degree. The remaining respondents are evenly distributed across three other education levels, constituting 7.1% of the total: STPM/Diploma/Matriculation, master’s degree, and Doctorate/PhD.

Category of respondent

Table 5: Category of Respondents

Category of respondent		Frequency	Per cent	Valid Percent	Cumulative Percent
Valid	Academician	1	7.1	7.1	7.1
	Industry Practitioner	8	57.1	57.1	64.3
	Student	5	35.7	35.7	100.0
	Total	14	100.0	100.0	

Figure 7: Category of Respondents

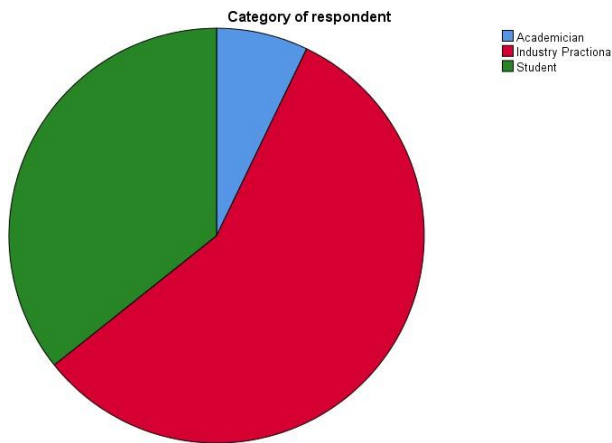


Table 5 and Figure 7 show the distribution of respondents by profession. The majority, 57.1%, are industrial practitioners. Students comprise 35.7% of the respondents, while academics account for 7.1%.

Objective 2: To Analyse the Acceptance and Use of Mobile Applications for Smart Warehouse Management Systems (Smart Wms)

This section summarises the perspectives on the acceptance and use of mobile applications for the Smart Warehouse Management System (Smart WMS) and their potential impact on daily activities. The responses from mobile application users were analysed and summarised as follows.

Performance Expectancy

Table 6: Performance expectancy using mobile applications for Smart Warehouse

No	Performance expectancy using a mobile application	Strongly Agree (%)	Agree (%)	Neutral (%)	Disagree (%)
1.	I find smart warehouse applications useful for my work	57.1%	21.4%	14.3%	7.1%
2.	Using smart warehouse applications increases my chances of achieving important tasks	57.1%	21.4%	14.3%	7.1%
3.	Using smart warehouse applications helps me	57.1%	21.4%	14.3%	7.1%

	accomplish my work more quickly				
4.	Using smart warehouse applications enhances my productivity in executing my job	57.1%	21.4%	14.3%	7.1%
5.	Using smart warehouse applications in the workplace would make it easier to do my work	50%	35.7%	14.3%	-
6.	Overall, I would find smart warehouse applications to be advantageous	57.1%	28.6%	7.1%	7.1%
7.	I assume that smart warehouse applications would be useful in my working environment	50%	42.9%	-	7.1%

Table 6 illustrates the acceptance and performance expectancy of using a mobile application. According to the results, most users (57.1%) strongly agree that using the mobile application is beneficial for implementing a smart warehouse. Only 7.1% disagree with the performance expectancy of using the mobile application.

Effort expectancy

Table 7: Effort expectancy using mobile applications for Smart Warehouse

No	Effort expectancy using a mobile application	Strongly Agree (%)	Agree (%)	Neutral (%)
1.	Learning how to use smart warehouse applications is easy for me	35.7%	50%	14.3%
2.	My interaction with smart warehouse applications is clear and understandable	57.1%	21.4%	21.4%
3.	I find smart warehouse applications are easy to use	42.9%	28.6%	28.6%
4.	It is easy for me to become skilful at using smart warehouse applications	50%	35.7%	14.3%
5.	I find smart warehouse applications to be flexible to interact with	42.9%	42.9%	14.3%

Table 7 presents the acceptance and perceived effort expectancy of using a mobile application for a smart warehouse. According to the results, most users agree that the mobile application is easy to use and flexible for managing a smart warehouse, with 50% indicating their agreement. Only 14.1% of users are neutral regarding the effort expectancy of using the mobile application.

Social influence

Table 8: Social influence using a mobile application

No	Social experience using a mobile application	Strongly Agree (%)	Agree (%)	Neutral (%)	Disagree (%)
1.	People who are important to me think that I should use smart warehouse applications	28.6%	35.7%	28.6%	7.1%
2.	People who influence my behaviour think that I should use smart warehouse applications	35.7%	35.7%	21.4%	7.1%

3.	People whose opinions I value prefer that I use smart warehouse applications	35.7%	35.7%	21.4%	7.1%
4.	I think I am more likely to use the smart warehouse applications if my colleagues use them	50%	28.6%	21.4%	-
5.	My colleague's suggestion and recommendation affected my decision to use smart warehouse applications	50%	28.6%	14.3%	7.1%
6.	I would use smart warehouse applications because the proportion of my colleagues use smart warehouse applications	50%	28.6%	14.3%	7.1%

Table 8 shows the acceptance and social influence of using mobile applications for smart warehouses. According to the results, most users strongly agree that using a mobile application is easy and flexible for smart warehouse operations, with 50% of respondents supporting this view. Only 7.1% of users disagree on the impact of social influence on using mobile applications in a smart warehouse context.

Facilitating condition

Table 9: Facilitating conditions using a mobile application

No	Facilitating conditions using a mobile application	Strongly Agree (%)	Agree (%)	Neutral (%)
1.	I have the necessary resources to use smart warehouse applications	35.7%	28.6%	28.6%
2.	I have the necessary knowledge to use smart warehouse applications	28.6%	50%	21.4%
3.	Smart warehouse applications are compatible with other technologies I use	28.6%	57.1%	14.3%
4.	I can get help from others when I have difficulties using smart warehouse applications	42.9%	50%	7.1%
5.	Using the smart warehouse applications fits into my working style	35.7%	57.1%	7.1%

Table 9 shows the acceptance and facilitating conditions for using mobile applications in smart warehouses. According to the results, most users strongly agree that using mobile applications is beneficial and compatible with smart warehouses, with 57.1% supporting this view. Only 7.1% are neutral about the facilitating conditions that may affect mobile application users in smart warehouses.

Hedonic motivation

Table 10: Hedonic motivation using a mobile application

No	Hedonic motivation using a mobile application	Strongly Agree (%)	Agree (%)	Neutral (%)
1.	Using smart warehouse applications is fun	28.6%	50%	21.4%
2.	Using smart warehouse applications is enjoyable	35.7%	50%	14.3%

3.	Using smart warehouse applications is very entertaining	28.6%	42.9%	21.4%
4.	Features in smart warehouse applications entertained me	28.6%	57.1%	14.3%
5.	I feel excited about using smart warehouse applications	35.7%	50%	14.3%

Table 10 shows the acceptance and hedonic motivation for using mobile applications in smart warehouses. According to the results, most users agree that using mobile applications in smart warehouses is fun, with 57.1% supporting this view. Only 14.3% of users are neutral about the hedonic motivation that may affect them while using these applications.

Price value

Table 11: Price value of using a mobile application

No	Price value using a mobile application	Strongly Agree (%)	Agree (%)	Neutral (%)
1.	Smart warehouse applications are reasonably priced	28.6%	28.6%	21.4%
2.	Smart warehouse applications have a good value for the money	14.3%	71.4%	14.3%
3.	I have never regretted purchasing smart warehouse applications	14.3%	64.3%	14.3%
4.	The benefits obtained from using smart warehouse applications are comparable to the costs incurred	21.4%	64.3%	14.3%

Table 11 shows the acceptance and perceived price value of using mobile applications for smart warehouses. According to the results, most users agree that using a mobile application is reasonably priced and provides good value for money in smart warehouse operations, with 71.4% of respondents supporting this view. Only 14.3% of users are neutral about the price value of using the mobile application for smart warehouses.

Habit

Table 12: Habit of using a mobile application

No	Habit using a mobile application	Strongly Agree (%)	Agree (%)	Neutral (%)
1.	The use of smart warehouse applications has become a habit for me	28.6%	50%	14.3%
2.	I am addicted to using smart warehouse applications	28.6%	24.9%	14.3%
3.	I must use smart warehouse applications	28.6%	57.1%	14.3%
4.	Using smart warehouse applications has become natural to me	21.4%	57.1%	21.4%
5.	Using smart warehouse applications is something I can do without thinking	21.4%	50%	14.3%

Table 12 shows mobile application acceptance and customary use in smart warehouses. According to the results, 57.1% of users agree that using mobile applications feels natural and becomes a habit after using smart warehouse applications. Only 14.3% remain neutral regarding the habit-forming nature of these applications.

Behavioural intention

Table 13: Behavioural intention using a mobile application

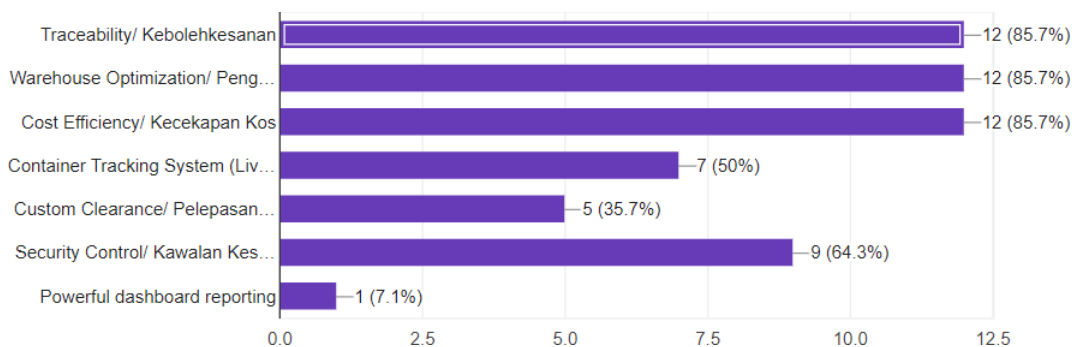
No	Hedonic motivation using a mobile application	Strongly Agree (%)	Agree (%)	Neutral (%)
1.	I intend to continue using smart warehouse applications when executing my job in the future	42.9%	57.1%	-
2.	I always try to use smart warehouse applications in my daily work	42.9%	50%	7.1%
3.	I plan to continue using smart warehouse applications when executing my job frequently	35.7%	64.3%	-
4.	As soon as I am able, I use the smart warehouse applications while executing my job	28.6%	71.4%	-
5.	I recommend others to use smart warehouse applications in executing their jobs	57.1%	42.9%	-

Table 13 illustrates the acceptance and behavioural intention level concerning mobile application use in smart warehouses. The results reveal that most users strongly agree they continue using these applications, with 71.4% of respondents expressing this view. In contrast, only 7.1% of respondents are neutral about the behavioural intentions that may influence their use of mobile applications for smart warehouses.

Objective 3: To Find Out the Factor That Needs To Be Embedded In Smart Warehouse Mobile Application Features

This section summarises perspectives on the key parameters and factors that should be incorporated into smart warehouse mobile application features, which may influence users' daily activities. The responses from mobile application users regarding these factors were analysed and summarised as follows.

Figure 8: Factors that need to be embedded in smart warehouse mobile application features



Based on Figure 8, the most important parameters or factors that need to be embedded in smart warehouse mobile application features, which may affect daily activities, are traceability, warehouse optimisation, and cost efficiency, with the highest percentage at 85.7%.

Following this, 64.3% of respondents agree that security control should be embedded in the application features. The container tracking system (Live Location) factor is also significant, with 50% of respondents in favour. Lastly, customs clearance and powerful dashboard reporting have the lowest percentages of respondents who agree that these factors must be embedded in smart warehouse mobile application features, with 35.7% and 7.1%, respectively.

CONCLUSION

This factor analysis explored the acceptance and use of mobile applications for the Smart Warehouse Management System (Smart WMS) and their impact on daily operations. The study assessed user perceptions of the essential features that should be included in smart warehouse mobile applications and their influence on everyday activities. Merchants provided varied responses when surveyed about the utility and applicability of a new mobile application for Smart WMS. The survey results indicated that nearly 70 per cent strongly agreed on the value and usability of the mobile application for Smart WMS.

The advantage of a web-based Smart WMS is its ability to synchronise real-time data access across the supply chain. This data infrastructure offers real-time information for all stakeholders, enabling swift decision-making and supporting inventory management and demand-based planning.

In comparison, this system improves inventory control and simplifies the submission of regulatory compliance assessments using real-time data. Unlike traditional systems that require access through computers and servers, data with Smart WMS can be accessed anytime and anywhere via electronic devices.

The convenience of Smart WMS is highlighted by its ability to be installed on any device, allowing users to interact with the system outside the organisation. This access to relevant information is maintained throughout business processes, including offline.

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