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ỨNG DỤNG CỦA CÔNG NGHỆ RFID TRONG QUẢN LÝ KHO HÀNG: TRƯỜNG HỢP CỦA WALMART VÀ ĐỀ XUẤT CHO CÁC DOANH NGHIỆP BÁN LẺ HÀNG TẠP HÓA VIỆT NAM

Nguyễn Linh Ngọc[1], Trịnh Thị Minh Ngọc, Trần Hương Giang

Sinh viên K61 Logistics và Quản lý chuỗi cung ứng – Viện Kinh tế &Kinh doanh quốc tế

Trường Đại học Ngoại Thương, Hà Nội, Việt Nam

Nguyễn Thị Yến

Giảng viên Bộ môn Logistics – Viện Kinh tế và Kinh doanh quốc tế

Trường Đại học Ngoại Thương, Hà Nội, Việt Nam

Tóm tắt

Ngành bán lẻ Việt Nam đang tăng trưởng mạnh mẽ, dự kiến đạt quy mô thị trường trên 350 tỷ USD vào năm 2025, nhưng đang đối mặt với những thách thức lớn trong quản lý kho bãi như hiệu suất thấp, hạn chế về khả năng hiển thị hàng tồn kho, và nhu cầu ngày càng cao từ khách hàng về tốc độ phục vụ cũng như sự minh bạch. Công nghệ RFID (Radio Frequency Identification) đã nổi lên như một giải pháp cách mạng trên toàn cầu, giúp cải thiện độ chính xác kiểm kê, nâng cao hiệu quả hoạt động và tối ưu hóa chuỗi cung ứng. Nghiên cứu này phân tích thành công của Walmart trong việc áp dụng RFID, tập trung vào cải thiện quản lý kho, giảm thiểu sai sót và đảm bảo theo dõi hàng tồn kho theo thời gian thực. Bằng phương pháp nghiên cứu trường hợp định tính, nghiên cứu chỉ ra các yếu tố thành công của Walmart, bao gồm triển khai theo giai đoạn, sáng kiến đào tạo nhân lực, và tích hợp công nghệ mượt mà. Những phát hiện này được điều chỉnh phù hợp với bối cảnh Việt Nam, nơi chi phí cao, khó khăn trong tích hợp và thiếu chuyên môn kỹ thuật là những rào cản chính khi áp dụng RFID. Nghiên cứu nhấn mạnh rằng các nhà bán lẻ tại Việt Nam có thể vượt qua những trở ngại này thông qua việc tận dụng hỗ trợ từ chính phủ, triển khai thí điểm ở các khu vực có tác động cao, và ưu tiên đào tạo nhân viên. Việc áp dụng chiến lược RFID sẽ mang lại cơ hội hiện đại hóa quản lý kho, giảm chi phí và nâng cao sự hài lòng của khách hàng, đảm bảo lợi thế cạnh tranh trong ngành bán lẻ đang phát triển.

Từ khóa: RFID, ngành bán lẻ Việt Nam, quản lý kho, hiệu quả chuỗi cung ứng, Walmart

[1] Tác giả liên hệ, Email: k61.2211530033@ftu.edu.vn

APPLICATION OF RFID IN WAREHOUSE MANAGEMENT: A CASE STUDY OF WALMART AND RECOMMENDATIONS FOR MERCHANDISE RETAILER ENTERPRISES IN VIETNAM

Abstract

Vietnam's retail industry is rapidly expanding, projected to reach 350 billion USD in market size by 2025, yet it faces critical challenges in warehouse management, including inefficiencies, limited inventory visibility, and rising consumer demands for faster service and greater transparency. RFID (Radio Frequency Identification) technology has emerged globally as a transformative solution, enhancing inventory accuracy, operational efficiency, and supply chain visibility. This study examines Walmart's pioneering adoption of RFID, focusing on its success in streamlining warehouse operations, reducing errors, and ensuring real-time inventory tracking. Using a qualitative case study approach, the research identifies Walmart's phased implementation, workforce training initiatives, and technology integration as key enablers of its success. These findings are contextualized for Vietnam, where high adoption costs, integration challenges, and a lack of technical expertise hinder RFID deployment. The study emphasizes that merchandise retailers in Vietnam can address these barriers by leveraging government support, initiating pilot projects in high-impact areas, and prioritizing employee training. Strategic adoption of RFID offers Vietnamese businesses opportunities to modernize warehouse operations, reduce costs, and enhance customer satisfaction, ensuring competitiveness in the evolving retail landscape.

Keywords: RFID, Vietnamese retail industry, warehouse management, supply chain efficiency, Walmart

1. Introduction

In the era of rapid economic transformation, especially in the aftermath of the COVID-19 pandemic, logistics and supply chain management as a sector has evolved significantly. From the list of transforming technologies at the forefront of these industries, Radio Frequency Identification (RFID) is arguably one of the important technologies involved in improving warehouse management.

Walmart has been one of the largest retail companies in the world and its resources enable it to be an early adopter of the RFID technology. By enhancing inventory tracking, improving accuracy, and reducing labor-intensive processes, Walmart was able to ensure the high level of warehouse productivity. This report aims at examining how Walmart has successfully applied RFID in its warehousing systems, the effects it had on the operational efficiency, and useful lessons that can be used by Vietnamese businesses.

This report has three objectives: (1) identify and discuss how RFID technologies have changed Walmart's warehousing management; (2) assess how RFID brings value as well as the drawbacks it presents; and (3) to provide practical recommendations for enterprises in Vietnam aiming to enhance their warehouse and supply chain operations.

Thanks to the growing penetration of e-commerce as well as changes in the tastes of Vietnamese customers, adopting modern devices such as RFID is no longer a choice but a

necessity. This report looks at how Walmart Implemented its strategy and how it can be adapted to the logistics environment of Vietnam in order to develop specific methods that Vietnamese companies can apply to stay competitive in the future.

2. Theoretical framework

2.1. Warehouse management

2.1.1. Warehouse definition

Warehousing is a very strategic supply chain service in that it allows firms to store their purchases, work-in-process and finished goods, as well as perform breakbulk and assembly activities, while allowing for faster and more frequent deliveries of finished products to customers, resulting in better customer service when the system is designed and managed correctly (Wisner *et al.*, 2014).

Warehouses are used to support purchasing, manufacturing, and distribution. Firms place orders for raw materials, parts, and assemblies, which are typically shipped to a warehouse near or within the buyer's location and then transferred to the buyer's various operations as needed. In a retail setting, the warehouse may be regionally located, with the retailer receiving bulk orders from many suppliers, breaking these down and reassembling outgoing orders for delivery to each retail location, and then moving orders to the retail locations using a private fleet of trucks or for-hire transportation providers. When manufacturers deliver bulk shipments to regional market areas, similar distribution centers are used to break these down and ship LTL order quantities to customers (Wisner *et al.*, 2014).

2.1.2. Warehouse management definition

Warehouse management is “a combination of the planning and control systems and the decision rules used for inbound, storage, and outbound flows” (Faber, *et al.*, 2013, p. 1232), to support “process-oriented businesses centered on managing the flow of material and abstract resources, between a point of origin and point of destination” (Mahroof, 2019, p. 177). Warehouse management is inherently an information-intensive process because it focuses on coordinating activities related to goods and orders and a human-centered process that necessitates the use of a skilled human workforce.

2.2. RFID in warehouse management

2.2.1. Definition of RFID

Radio Frequency Identification, or RFID, allows for the identification and tracking of objects, animals or people remotely through radio waves. RFID consists of three main elements:

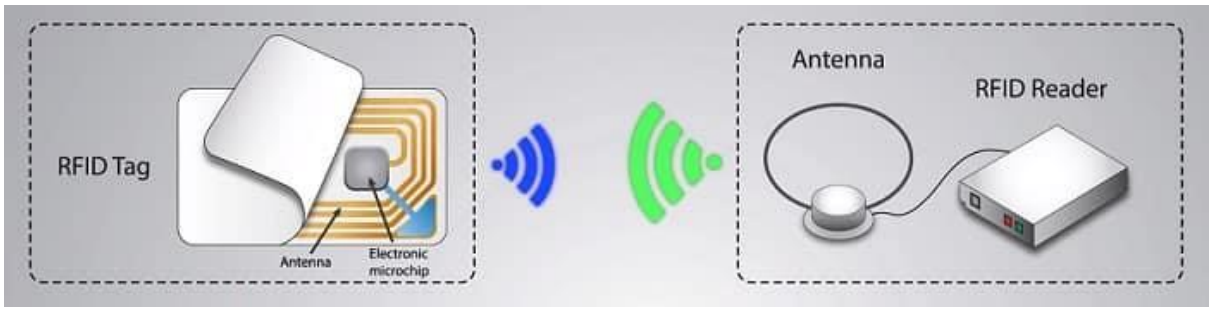

Figure 1: RFID components

Source: rfpage.com

RFID Tags: These are small units implanted with a microchip and an antenna where electronic data about the products to which they are attached is stored and transmitted. RFID tags can be classified into two primary types; the first is active tags, which come with a battery and the second type is passive which does not carry a power source but gets power from the reader's signal to activate its response. There are identification tags that are unique to each item, and therefore data capture can be made without the need for contact.

RFID Reader: A reader is any device that has an antenna used to transmit radio waves aimed at the RFID tags. When a tag is within the reading distance of the antenna, it is stimulated by the antenna's signal and releases the information it holds. The data read by the reader can be used to know in real time where tagged items can be found.

Middleware: Middleware is the software that links the RFID system with the host or database. It combines, prepares, and controls data collected by different readers and distributes the data streams to each reader to make the system balanced. Middleware is critical in processing the unprocessed data gathered by the readers and converting it into appropriate information for applications such as inventory control and logistics.

Applications of RFID technology in inventory, logistics and security have numerous benefits that allow for real time tracking and data capturing with little manual intervention. Such functions reduce human resources, enhance fidelity of the inventory systems, and assist in decision making in supply chain management activities.

2.2.2. Types of RFID

RFID systems are categorized by their frequency ranges, which affect their read range, data transfer speed, and suitability for various applications. There are three different systems:

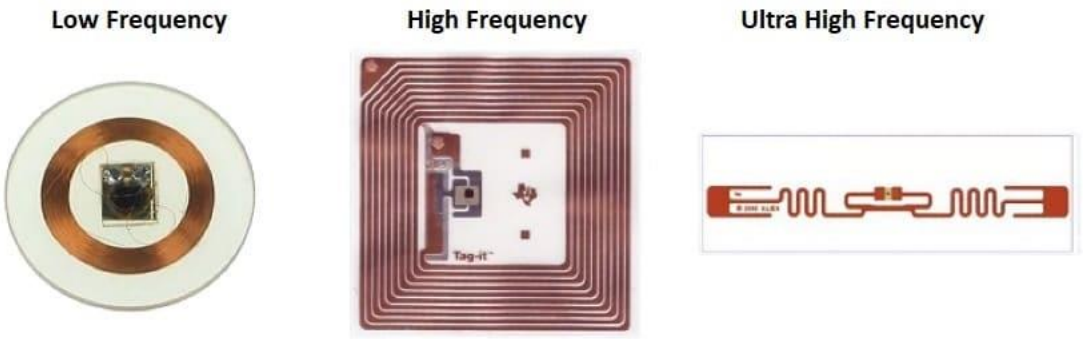

Figure 2: RFID types

Source: rfpage.com

Low-Frequency (LF) RFID: Operating around 125-134 kHz, LF RFID has a short read range (typically up to 10 cm) and is used for applications such as animal tracking and access control. LF systems are less sensitive to interference from materials like metal and water, making them reliable for close-range, low-cost applications.

High-Frequency (HF) RFID: HF RFID operates within the 3 MHz to 30 MHz range, with most systems using 13.56 MHz. HF systems typically have a read range from 10 cm to 1 meter and offer moderate resistance to interference. HF RFID is widely used for applications like ticketing, contactless payments, and data transfer.

Ultra-High-Frequency (UHF) RFID: UHF RFID operates from 300 MHz to 3 GHz, with most UHF Gen2 systems functioning within 860-960 MHz. Although UHF frequency ranges vary by region, most systems operate between 900 and 915 MHz. Passive UHF systems can achieve read ranges up to 12 meters and support faster data transfer than LF or HF, making them suitable for applications that require long-range, high-speed data transfer, such as retail inventory management and supply chain logistics. UHF RFID is extensively used across various applications, from managing retail inventory to anti-counterfeiting in pharmaceuticals. Its cost-effectiveness and scalability have made it the fastest-growing segment within the RFID market, supporting a wide range of industries and operations.

Each RFID type is chosen based on the application's specific requirements for range, cost, and data transfer speed, allowing organizations to tailor their RFID systems to their needs.

2.2.3. Principle of RFID

The principle of RFID operation is based on the interaction between a tag, an antenna, a reader, and a host system. An RFID tag, attached to an item, contains data relevant to the item's identity and characteristics. The system uses an antenna to transmit RF signals between the reader and the RFID tag. The reader, equipped with a transceiver, generates RF signals and receives transmissions from the tags within its range. This communication enables the tag to send its stored data back to the reader. The reader then passes the collected data to a host system for processing. This automatic data exchange allows real-time tracking and monitoring, offering benefits such as labor savings, increased accuracy, automated data generation, and reduced

paperwork, as evidenced in industries like shipping and defense for tracking assets and inventory.

2.2.4. Application of RFID in warehouse management

In warehouse management, the application of RFID technology plays a crucial role in enhancing inventory control, operational efficiency, and real-time data processing. RFID systems are used to classify items in the warehouse by attaching RFID tags to individual products or materials. These tags, when scanned, provide real-time information about the quantity, location, and category of items, allowing managers to track and display data on control systems for efficient oversight. This technology significantly improves inventory accuracy, with studies indicating that RFID can increase location accuracy rates from around 72.8% to as high as 99% (Wendt, 2023). Moreover, the automation facilitated by RFID reduces processing times for incoming and outgoing goods, thus streamlining the overall workflow (Soesanto et al., 2024). With IoT-enabled RFID systems, continuous data collection supports better decision-making and quicker responses to potential issues (Soesanto et al., 2024). While there may be initial challenges, such as training costs, the long-term benefits of RFID-like increased accuracy, faster processing, and enhanced data availability-make it a valuable tool in modern warehouse management.

3. Analysis of RFID in Walmart's warehouse management

3.1. Overview of Walmart

Walmart is an American multinational operating a chain of hypermarkets (also called supercenters), supermarkets, discount and department stores, grocery stores, and neighborhood markets. The company also owns and operates Sam's Club retail warehouses.

On July 2, 1962, Sam Walton opened the first Walmart store in Rogers, Arkansas. By 1969, the company was officially incorporated as Wal-Mart Stores, Inc.. It grew rapidly and reached $1 billion in annual sales in 1980, faster than any other company at that time. Walmart was spread throughout the United States in the 1980s with the introduction of Walmart Supercenters, combining general merchandise and a full-scale supermarket to provide one-stop shopping convenience. It entered the international market in 1991 and has since become a global retail giant.

Today, Walmart operates more than 10,600 stores and clubs in 19 countries and eCommerce websites. The company is not only the largest retailer in the United States with domestic revenue exceeding $500 billion but also the largest retail chain in the world with more than $600 billion in global revenue (Statista, 2024). This publicly traded family-owned business is also the largest private employer in the world with 2.1 million employees.

The Walmart mission statement is "to save people money so that they can live better" while the vision statement is "to be the destination for customers to save money, no matter how they want to shop." Walmart realized that saving money is one of the universal goals of all customers across all socioeconomic backgrounds. As a result, the company follows Everyday Low Price

(EDLP) strategy, which ensures that customers get the best value for their money on every purchase.

In order to achieve EDLP strategy, Malwart soon recognized the significance of supply chain efficiencies to keep costs, and therefore prices, down. RFID is the latest technology that Wal-Mart has identified to achieve incremental gains in supply chain efficiency.

3.2. RFID application in warehouse management of Walmart

Walmart utilizes RFID technology across four key steps in warehouse management—receiving, put-away and inventory management, picking, and value-adding services—to enhance stock visibility and operational efficiency. RFID readers are strategically placed at critical points, including the receiving docks, backroom storage areas, the transition doors to the sales floor, and the box-crushing area. This integration enables real-time tracking of goods as they move through the supply chain, reducing overstocking, cutting OOS sales losses, and improving overall inventory accuracy. By leveraging RFID, Walmart ensures seamless operations from the arrival of merchandise to its final placement on store shelves, solidifying its position as a leader in warehouse and supply chain management.

3.2.1 Receiving

Walmart integrates RFID technology at the receiving dock to streamline and optimize its inbound logistics processes. By using RFID readers to scan the tags on arriving pallets, cartons, or individual items, Walmart can automate the verification of shipments against purchase orders, ensuring that the correct products are delivered in the appropriate quantities. This automation significantly reduces the need for manual data entry, minimizing human errors and expediting the receiving process. Furthermore, the RFID system immediately updates the WMS with real-time information, enabling precise inventory tracking from the moment goods arrive.

In addition to improving accuracy, RFID integration at receiving docks enables faster throughput, which is particularly beneficial for high-volume operations like Walmart's. The system also supports predictive analytics for supply chain planning, allowing Walmart to anticipate and avoid potential delays or disruptions. This capability further enhances supply chain resilience, ensuring timely and efficient operations.

3.2.2 Put-away and Inventory management

a. Put-away and Storage

In the backroom storage areas, Walmart utilizes RFID technology for continuous and accurate inventory tracking. RFID readers monitor item locations in real time, providing unparalleled visibility into stock levels. This enables proactive inventory management, ensuring items are optimally stored and high-demand products are quickly accessible. By reducing manual product searches and minimizing stock discrepancies, Walmart enhances operational efficiency and maintains accurate records.

The RFID system supports data-driven inventory placement decisions, optimizing storage space and reducing inefficient retrieval times—critical for Walmart's large-scale operations.

b. Inventory management

Walmart employs RFID technology to enhance efficiency and accuracy in tracking stock levels. By enabling real-time inventory monitoring, RFID reduces errors associated with manual processes and facilitates automated data collection. This helps Walmart maintain optimal inventory levels and streamline supply chain operations.

Real-Time Inventory Tracking:

Walmart integrates RFID tags across its supply chain for continuous, automated stock monitoring. RFID readers in warehouses, backrooms, and stores capture tag data, providing immediate visibility of stock levels. This ensures quick responses to demand fluctuations, preventing stockouts and overstocking (Erlangga et al., 2022). Automated tracking significantly reduces human errors and enhances operational accuracy. Just-in-time inventory management minimizes storage costs while ensuring products are available when needed.

Cost and Efficiency Considerations:

Despite high initial implementation costs, RFID reduces labor expenses and improves inventory turnover in the long term (Sharma, 2021). Active RFID systems, with greater range and reliability, ensure effective coverage of large warehouses, improving real-time inventory accuracy (Soltanirad et al., 2022).

Integration with IoT:

Walmart's RFID system integrates with IoT devices to create a smart supply chain. This combination enables real-time data analysis, predictive demand forecasting, and proactive inventory adjustments, improving customer satisfaction and minimizing costs (Soltanirad et al., 2022).

3.2.3 Picking

Walmart uses RFID readers at stockroom-to-sales-floor transitions to precisely track merchandise movement. As products pass through, the system updates inventory records in real time, ensuring accurate stock tracking and eliminating delays or discrepancies. This reduces shrinkage by detecting unauthorized movements, keeps shelves well-stocked to prevent out-of-stock situations, and enhances customer satisfaction.

Integrated with automated replenishment systems, RFID aligns inventory with demand forecasts while strengthening loss prevention and operational efficiency.

3.2.4. Value-Adding Services

Walmart employs RFID technology in the box-crushing area, where empty packaging materials are disposed of, as an additional safeguard to prevent inventory losses. By scanning RFID tags on empty cases before they are discarded, the system verifies that all merchandise has been properly removed, thereby minimizing the risk of accidental product disposal. This process not only helps Walmart protect its inventory but also highlights the company's commitment to operational efficiency and waste reduction. Additionally, the data collected from these RFID scans can be analyzed to optimize packaging processes, ensuring sustainability and reducing material waste.

3.3. Succeed of RFID application in warehouse management of Walmart

3.3.1. Early adoption and challenges

In June 2003, at the Retail Systems 2003/VICS Collaborative Commerce conference, Walmart announced its RFID initiative, starting with a pilot program that required its top 100 suppliers to apply RFID tags to cases and pallets of incoming shipments. This enables Walmart to track large quantities of products efficiently. In 2005, the company expanded its RFID mandate to include all suppliers, further enhancing supply chain visibility. This bold step made it one of the largest RFID implementations in the world at the time.

But, the early days had problems. The tech was new. Wal-Mart suppliers and information technology vendors were apprehensive at the time of the announcement because of the perceived challenges in manufacturing, standardization and pricing of RFID tags and systems (Vijayan, 2003). WalMart, on the other hand, forecasted that the RFID initiative would provide major benefits. It anticipated a 5% inventory reduction, a reduction in the rate of stock-outs with a corresponding increase in sales, and reduced store and warehouse labor costs (Seideman, 2003). As a result, it worked with suppliers and experts to make RFID work better.

3.3.2. Later successes and greater expansion

RFID has brought big wins for Walmart. In 2008, Walmart reported significant improvements in inventory accuracy and a reduction in out-of-stock instances as a result of RFID implementation. As a result, Wal-Mart could increase sales by $287 million per year by fixing just 10% of its inventory problems using RFID technology.

A study conducted by the University of Arkansas RFID Research Center (now the Auburn RFID Lab) on Walmart's use of RFID revealed that stores that incorporated RFID reduced the level of out-of-stock merchandise by 30% over non-RFID locations. The study also showed that out-of-stock items with RFID were replenished 3 times faster than items using standard bar-code technology. It is also demonstrated in the study that RFID-enabled stores were 63% more effective in replenishing out-of-stock products than control stores not equipped with the technology. Essentially, this meant fewer total out-of-stock items and fewer occurrences of empty shelves when the merchandise was in the backroom, providing improved on-shelf availability of items for customers. As a result, Walmart customers were finding the items they wanted in stock on shelves more often in stores that were using RFID technology with embedded electronic product codes, compared with those that were not. Beyond improvements for in-stock merchandise, Walmart also experienced an approximately 10% reduction in manual orders placed by stores resulting in a reduction of excess inventory throughout the supply chain, which is important to drive down costs, according to the university report.

Therefore, RFID technology has helped Walmart manage its stock better, cut down on overstocking and running out of items, and make shopping better for customers.

Walmart has now added more departments to use RFID. It started with clothes and now includes many other items. Starting February 1, 2024, suppliers in these areas need to use RFID tags:

- Stationery
- Media & Gaming
- Cameras & Supplies
- Automotive
- Hardware
- Paint
- Lawn & Garden
- Crafts
- Books
- Apparel
- Electronics
- Home goods
- Sporting goods
- Toys

Special buys, non-basic, and seasonal items also need RFID tags. This shows Walmart trusts RFID to make things run better, cut down costs and improve customers' shopping experiences.

4. Lessons learnt for Merchandise retailer enterprises in Vietnam

4.1. Current RFID warehouse practices of Vietnam's Merchandise retailer enterprises

In Vietnam, general merchandise retailers such as Aeon Mall, Lotte Mart, WinMart, Co.op Mart, and E-Mart are at various stages of adopting RFID technology within their warehousing and supply chain operations. RFID improves inventory accuracy, enhances supply chain visibility, and streamlines operations. However, their approaches vary based on their operational scale, investment capacity, and business models.

Aeon Mall, a Japanese-origin retailer, is at an advanced stage of RFID implementation. Aeon uses RFID extensively to manage inventory in warehouses and stores, integrating it with real-time analytics to track stock levels, minimize shrinkage, and ensure just-in-time replenishment. RFID also supports self-checkout systems, reflecting Aeon's focus on technological innovation and seamless customer experience.

Lotte Mart, a South Korean retailer, uses RFID to optimize inventory tracking and reduce labor costs. Currently scaling, Lotte applies RFID to high-turnover products like fresh produce, ensuring timely replenishment and reducing spoilage. Unlike sectors such as apparel retailing, where RFID focuses on theft prevention, Lotte prioritizes efficiency in managing perishables.

WinMart, a leading local chain, is in the early stages of RFID adoption, focusing on pilot programs in select warehouses and stores. Efforts center on tracking high-value items and

enhancing inventory audits. Challenges like high implementation costs and limited expertise slow their pace, but their phased approach aligns with gradual modernization goals.

Co.op Mart, one of Vietnam's largest domestic retailers, employs RFID primarily in central distribution centers to track shipments, ensure product availability, and reduce stockouts. Their emphasis on supplier collaboration integrates RFID tagging at the supplier level, enhancing visibility and strengthening partnerships. Unlike other industries, Co.op Mart focuses on inventory control and agility.

E-Mart, a South Korean retailer, applies RFID to monitor inventory levels and automate receiving and dispatching processes, reducing errors and accelerating throughput. RFID data is integrated with predictive analytics to forecast demand trends and optimize stock allocation, tailoring their application to enhance retail supply chain responsiveness.

In general merchandise retailing, RFID technology is predominantly used to manage high-volume, fast-moving inventory and to improve supply chain efficiency. This contrasts with other fields, such as manufacturing or healthcare, where RFID is often used for tracking fixed assets, ensuring regulatory compliance, or managing complex production processes. Retailers like Aeon and Co.op Mart leverage RFID to enhance customer experience and supplier collaboration, while industries such as automotive or aviation utilize it for precision tracking of high-value components. These differences underscore the adaptability of RFID technology to meet the specific needs of each sector.

4.2. Challenges of Vietnam's enterprises in applying RFID in warehouse operations

RFID technology offers substantial potential for improving inventory management, reducing labor costs, and increasing supply chain transparency. However, Vietnamese retail enterprises face challenges in adopting RFID due to technological, operational, financial, and human resource constraints, hindering full implementation.

4.2.1. High costs and uncertain ROI

Adopting RFID in warehouses requires significant investment, creating challenges for Vietnamese enterprises. Costs include RFID tags, readers, antennas, printers, and servers, with tags ranging from $0.10 to $1.50 each. The tags' reusability mitigates some of the financial burden, as they can be removed and reused multiple times due to their data read or write capabilities. For instance, purchasing 10,000 tags at $0.50 each and 100 readers at $1,000 each results in an initial outlay exceeding $100,000.

Beyond hardware, enterprises must either purchase middleware or develop custom software to integrate RFID with their existing WMS, with integration costs ranging from $50,000 to $150,000 depending on the scale and complexity of the RFID system. Ongoing costs, such as hardware maintenance, recalibration, software updates, and employee training, further strain budgets.

Although RFID offers long-term benefits, including reduced labor costs and improved inventory accuracy, the high initial investment and delayed ROI deter adoption, particularly for enterprises with tight profit margins.

4.2.2. Integration challenges and data processing

Integrating RFID systems into existing warehouse operations is particularly challenging for Vietnamese enterprises due to issues of system compatibility. Many businesses still rely on outdated WMS that lack compatibility with modern RFID solutions. To bridge this gap, advanced middleware is required, but this can lead to data discrepancies and inefficiencies if not implemented correctly. Furthermore, retailer chains often use multiple software systems for various processes such as inventory management, order processing, and shipping. This fragmentation complicates the seamless integration of RFID data across platforms, increasing the risk of operational bottlenecks.

Additionally, RFID generates vast amounts of data that need to be processed and analyzed in real-time. Without robust IT infrastructure, businesses may struggle with data silos or the storage of irrelevant information, reducing the effectiveness of RFID implementation and limiting its potential benefits.

4.2.3. Human resource and expertise gaps

The implementation of RFID systems in Vietnam faces significant hurdles due to a lack of skilled human resources. There is a shortage of trained RFID specialists capable of conducting essential tasks such as site surveys, system installation, and troubleshooting technical issues. This scarcity increases reliance on external vendors, leading to higher costs and prolonged implementation timelines. Besides,Warehouse staff require significant training in operating RFID systems, including configuring readers and managing data, which demands time and resources. Retail chains with high employee turnover face even greater challenges in maintaining a consistently trained workforce. Additionally, many warehouse operators' unfamiliarity with RFID creates a steep learning curve, increasing the risk of operational errors during early adoption and complicating the transition.

4.2.4. Resistance from employees and supply chain partners

Adopting RFID systems often encounters resistance from employees and supply chain partners, hindering smooth implementation. Among warehouse staff, they may fear job displacement due to automation or find RFID technology overly complex, requiring change management to build trust and ensure buy-in. Comprehensive change management programs are required to address these concerns, build trust, and ensure employee buy-in.

On the supply chain side, partners not adopting RFID can create data gaps, as reliance on barcodes limits inventory visibility. These limitations reduce the overall effectiveness of RFID, especially in interconnected networks where seamless data flow is crucial.

4.2.5. Infrastructure limitations

Vietnam’s infrastructure presents notable barriers to the deployment of RFID systems in warehouse operations. Reliable internet connectivity, which is essential for real-time RFID data transmission, remains inconsistent in many areas, particularly in rural or remote locations. Frequent power outages in some regions pose challenges to maintaining uninterrupted RFID system functionality, especially in warehouses lacking backup solutions such as generators or UPS systems.

Furthermore, Vietnam's transportation and logistics infrastructure is often inefficient, delaying the deployment of RFID systems and disrupting the flow of RFID-tagged goods. These infrastructure limitations not only hinder the implementation process but also reduce the overall efficiency and reliability of warehouse operations, making RFID adoption a more complex undertaking for Vietnamese enterprises.

In summary, while RFID technology offers significant advantages in enhancing warehouse efficiency and productivity, its implementation poses considerable challenges for Vietnamese enterprises, particularly in retailer chains.

4.3. Lesson learnt from Walmart's succeed in applying RFID in warehouse management

General merchandise retailers in Vietnam looking to adopt RFID technology in their supply chain management face certain challenges, including high costs and uncertain ROI, integration challenges, lack of technical expertise, resistance from stakeholders, and limited infrastructure. Walmart's successful implementation provides actionable lessons that can guide Vietnamese businesses to overcome these barriers in applying this technology to supply chain management. Below are seven detailed lessons tailored for Vietnam's context.

Starting small with pilot programs and gradual scaling

Walmart began its RFID implementation with a pilot program, requiring its top 100 suppliers to tag cases and pallets. It also started using RFID technology with clothes first and then expanded the items being used. This allowed Walmart to test RFID's capabilities, refine its approach, and evaluate ROI before expanding the program across all suppliers and stores. Gradual scaling minimized disruptions while ensuring the system was tailored to operational needs. General merchandise retailers in Vietnam, like WinMart, should consider a phased approach to RFID adoption like Walmart, starting by piloting RFID in specific areas, such as tracking high-value or fast-moving items. Once benefits like improved stock accuracy and reduced waste are demonstrated, the program can be expanded to other categories or warehouses.

Investing in workforce training programs and change management

Walmart's success hinged on its investment in comprehensive workforce training to equip employees with the skills to effectively operate and manage RFID systems. Simultaneously, the company employed change management strategies to address employee concerns and foster acceptance of new technology. As a result, Vietnamese businesses, such as WinMart, must ensure that their staff is well-trained in RFID technology and its applications. In order to do that, they should establish partnerships with educational institutions and technology providers to design training programs. These should include hands-on workshops for warehouse staff to operate RFID readers, troubleshoot basic errors, and use real-time data dashboards. Management-level training can focus on interpreting RFID data to drive strategic decisions.

Simplifying seamless integration into existing systems

Walmart integrated RFID with its WMS and IoT platforms to enable real-time data processing and visibility across the supply chain. The integration ensured RFID data was actionable, supporting better inventory decisions. As a result, Vietnamese businesses, like E-

Mart, should simplify RFID integration by working with vendors to select middleware compatible with their current systems. For instance, Vietnamese supermarkets using barcode-based systems can upgrade to hybrid models that accept both barcode and RFID data during the transition phase. Businesses can also automate replenishment systems by linking RFID data to inventory thresholds, for example, triggering automatic reordering when stock falls below a set level.

Leveraging government and external support

One of the most significant challenges to general merchandise retailers in Vietnam when implementing RFID is the cost of technology adoption. To address this challenge, Vietnamese businesses should seek government funding programs for technological innovation, such as grants for SMEs or tax incentives for adopting advanced supply chain technologies. Retailers could collaborate with trade associations to access pooled funding or technical expertise. Furthermore, partnering with global RFID providers can also offer retailers like Lotte Mart cost-sharing options and access to proven implementation models, ensuring cost-efficient and high-quality deployment.

Collaborate across the supply chain

Walmart's RFID success relied on engaging suppliers in the process, in order to create end-to-end visibility. Vietnamese retailers must encourage supply chain partners to adopt RFID for better coordination. Co.op Mart's strategy of integrating RFID at the supplier level exemplifies this. Collaborative tagging can enhance traceability, improve inventory audits across the supply chain and reduce resistance from supply chain partners.

Customizing RFID solutions to business needs

Walmart tailored its RFID applications to different stages of its supply chain. Vietnamese businesses, like Lotte Mart and Aeon Mall, should identify specific pain points, such as inventory accuracy or replenishment delays, and customize RFID applications to address these issues. For example, using RFID for tracking perishable goods can reduce waste and enhance freshness.

Addressing infrastructure limitations

Vietnamese enterprises should ensure stable internet connectivity and power supply in warehouses to support RFID operations. Additionally, upgrading logistics infrastructure can enhance RFID efficiency. In order to do so, they should allocate resources for improving connectivity and backup systems. They also need to advocate for public-private partnerships to address broader infrastructure gaps.

5. Conclusion

The application of RFID technology in warehouse management has proven to be a transformative tool, as demonstrated by Walmart's success in enhancing its supply chain efficiency, inventory accuracy, and operational productivity. By leveraging RFID, Walmart has optimized real-time inventory tracking, reduced manual errors, and achieved a seamless flow of goods through its extensive network of warehouses and retail outlets. These advancements

have positioned Walmart as a global leader in supply chain management, offering a valuable blueprint for other retailers.

For general merchandise retailers in Vietnam, the adoption of RFID technology presents significant opportunities to address long standing logistical challenges, such as high operational costs, limited inventory visibility, and inefficiencies in warehouse management. However, the successful implementation of RFID requires overcoming barriers, including high initial investment costs, lack of technological expertise, and the need for a supportive regulatory environment.

Based on Walmart's experience, Vietnamese retailer enterprises can learn several key lessons. First, a phased approach to RFID adoption, starting with pilot projects in high-priority areas, can help mitigate risks and demonstrate value. Second, collaboration with technology providers and training initiatives can build the necessary technical expertise. Finally, aligning RFID adoption with broader digital transformation strategies will ensure long-term competitiveness in an evolving retail landscape.

In conclusion, while the implementation of RFID in Vietnam's retail sector is still in its early stages, its potential to revolutionize warehouse management is undeniable. By drawing on lessons from Walmart and addressing local challenges strategically, Vietnamese retailers can harness RFID to drive efficiency, reduce costs, and enhance customer satisfaction. This transformative journey requires commitment and collaboration but offers immense benefits for Vietnam's retail industry in the long run.

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