Influence of IoT on Warehouse Management Performance in the Global Context: A Critical Literature Review

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Abstract *- This systematic research paper explores the impact of Industry 4.0 technology, specifically the Internet of Things (IoT), on Warehouse Management Performance (WMP) in the worldwide logistics sector. IoT serves as a pivotal component in the paradigm shift towards Industry 4.0, facilitating the seamless storage, packaging, and distribution of commodities. By harnessing interconnected devices and data-driven insights, warehouses have undergone significant transformations since the inception of IoT technology. This study reviews state-of-the-art literature on the influence of IoT on WMP, emphasizing the vital role warehouse operations play in ensuring the smooth functioning of the supply chain management process. Warehouse operations encompass aspects ranging from planning and layout to receiving, order picking, shipping, and distribution. To optimize warehouse operations, we conduct a comprehensive literature assessment using Scopus as our primary database. The findings from this systematic review indicate that the integration of IoT technologies such as RFID, QR codes, scanners, and Warehouse Management Systems (WMS) can substantially enhance warehouse management performance. These technologies provide real-time data, predictive maintenance, and improved inventory accuracy, resulting in increased operational efficiency, reduced operational expenses, and improved customer satisfaction. Additionally, the IoT framework combines big data, blockchain, cloud computing, and wireless sensor networks to tackle key challenges related to data storage, retrieval, and utilization. This integration significantly improves the effectiveness of the warehouse management process and facilitates data-driven decision-making. Furthermore, IoT's communication capabilities enhance efficiency and reduce costs in warehouse operations. In conclusion, this systematic review underscores the transformative potential of IoT technology in the global logistics sector. It highlights the importance of technological integration, data-driven decision-making, and smart packaging solutions. Recognizing the disruptive effects of IoT on the logistics industry, it emphasizes the need for companies to adopt and leverage IoT technologies to remain competitive and agile in the evolving global supply chain landscape.*

***Keywords*:** Warehouse Management, IoT, Warehouse Management Performance, Logistics, Supply Chain Management and Warehouse.

I. INTRODUCTION

Concerns surrounding the global warehousing industry of the logistics sector, the emerging technology of IoT plays a vital role in enhancing the performance of warehouse management. An industry that has been growing continuously and is becoming more significant on a worldwide scale is logistics because of the trillion-dollar revenues and the 10.3 million citizens that were employed in the time span of 2018 to 2023 when focusing on the European market size. Assessing how relevant them to the global economy is, in-house warehousing and third-party logistics have processes like acquisition, storage, and transportation of resources to their intended destinations

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consisting of 30% market value and representing the highest cost components in warehousing (Perotti et al., 2022).

Warehousing is an essential component of supply chain management because it helps manage the tangible commodities that business-to-business companies or consumer enterprises that sell to retail end users hold in their possession. Retail and e-commerce businesses can purchase wholesale goods in bulk from warehouses that may not fit in a physical store but can be sold to customers online. Companies can store their inventory close to where it is needed in warehouses, cutting costs associated with shipping and minimizing delivery delays. Furthermore, warehouse management Activities include inventory management, receiving and order processing, packaging, and information systems. Third-party logistics support companies in different industries by taking their extra burden by managing logistics activities. Therefore, the growth of the warehousing industry is a national and essential need.

Because it has become a crucial component in the coordination, and optimization of all different warehouse operations because the warehouse is the center stage of opinions and challenges. It's a necessity to identify the overall performance of warehouse processes. A steady warehouse management system, it provides real-time and reliable data in scheduling, packaging, and monitoring without losing any data and it will facilitate the convenience in access to inventory and shipping data in the warehouse management performance. The efficiency of a warehouse is influenced by several factors, including worker productivity, the efficiency of material handling, and the warehouse management system (Kodithuwakku et al., 2022).

Assuring that a warehouse operates effectively and efficiently while meeting the aims and objectives of the business is the primary objective of warehouse management performance. Aligning warehouse operations with the company's goals is the ultimate objective of warehouse management performance, which will help the firm succeed. The future of business in the digital era consists of Industry 4.0 technologies and big data capture, collect, store, and analyze the interpret information. Supply chain management has always depended heavily on technology and data, and this demand will continue to increase in the future. In addition to that, the Internet of Things (IoT) has emerged as a revolutionary technology in this context. IoT can be defined as a network of hardware, software, devices, databases, things, sensors, and systems that all serve human beings.

With the usage of IoT devices, supply chains can significantly reduce the cost of acquiring information. The deployment of digital technologies like IoT allows businesses to save on total operating expenses and reduce costs associated with data and information management. These technologies are poised to revolutionize supply chains, offering a wide range of advantages (Senior et al., 2019). Advances in technology and automation have revolutionized the way warehouses operate, making them more streamlined and efficient. The adoption of WMS and automated material handling technology has enhanced the efficiency of warehouse management by allowing managers to instantly access vital data on inventory levels, order status, and employee productivity.

By lowering the time and manpower necessary for processes like picking, packaging, and shipping, automation technologies like robotics, conveyors, and automated storage and retrieval systems (Automated Storage (AS) /Retrieval Systems (RS)) have significantly improved warehouse management performance. IoT integration in warehouse management can offer real-time inventory visibility, allowing businesses to always monitor the products. In addition to increasing order fulfillment efficiency and supply chain visibility, this can also lower the cost of carrying inventory. Despite the potential advantages of IoT in warehouse management, A few studies have been conducted on its influence on the effectiveness of warehouse management in the warehousing industry (Jarašūnienė et al., 2023).

This study intends to close this gap by exploring the influence of IoT on warehouse management performance in the warehousing industry, with an emphasis on how companies interpret IoT. This study aims to develop a better understanding of the application of IoT technologies in the WMP by providing various clarification schemes for studies and offering directions for future research in this field for both practitioners and researchers. The study provides insights into the latest research done in the IoT and WMP domains, offers a deeper understanding of the evolution, research gaps, and ongoing trends, and suggests future research scope in this domain on a single platform. We structured our research in accordance with this objective, providing a thorough analysis of the relationship between IoT and WMP, addressing recent advancements and research gaps, and emphasizing ongoing trends. Our review stands out by not only summarizing the existing literature but also by focusing on the distinct subtleties and emerging viewpoints within the IoT and WMP domains. Therefore, the warehousing industry looking to leverage IoT to enhance their warehouse management performance will find value in the research findings.

II. METHODOLOGY

The methodology of this study involved conducting a comprehensive literature review to explore the influence of IoT on warehouse management performance in the global warehousing industry, with a focus on leveraging technology to optimize operations and enhance efficiency while reducing costs and improving customer service. The search for relevant literature was conducted using the Scopus database, including Science Direct, Pearson, IEEE, Emerald Insight, Willey e-books, Taylor and Francis, Research Gate, and Google Scholar. A total of 50 articles were initially selected for review, with 36 articles ultimately included in the analysis, while 14 were excluded.

To conduct this literature review, specific keywords were employed to refine the search and focus on the influence of IoT on warehouse management performance. These keywords included "Warehousing Industry," "Warehouse Process," "Warehouse Management Performance," "IoT, and "Supply Chain Management." This approach enabled a thorough examination of the topic's global context and contributed to a comprehensive understanding of the subject matter. The research was conducted within the specific domain of "Business and Management, IoT, and SCM" and was limited to articles published between the years 2015 and 2023. This timeframe ensured that the study captured the most recent developments and trends in the field of IoT and warehouse management.

The literature review integrated findings from past research to provide a holistic understanding of how IoT impacts warehouse management performance across key warehouse processes, including receiving, storing, picking, packing, and shipping. The primary IoT technologies, such as QR codes, barcodes, and RFID, were examined in detail, and their applications in different warehouse processes were categorized and analyzed.

The results of this study were triangulated with findings from previous research to validate and strengthen the outcomes. The aim was to inform the warehousing industry about the advantages and challenges associated with implementing IoT in warehouse management, thereby guiding decision-making processes regarding IoT adoption in logistics operations. Ultimately, this research contributed to the existing body of knowledge on the influence of IoT on warehouse management performance in the warehousing industry, offering insights and guidance for future developments in this field.

III. RESULTS

A. Receiving with Using IoT

The following sections provide a brief discussion of each article that provides details about the IoT performance in warehouse processes. The receiving process is the offloading and inspection of goods to ensure the correct quality and quantity of delivered orders. When in the receiving process they use the Advanced shipping notification technology which is enabling the purpose of receiving a notification from suppliers and shippers before a delivery arrives at the warehouse. SKUs which are known as stock-keeping units give the ability to store and handle products in an appropriate manner and from that it allows planning sufficient space to unload the delivery before it arrives (Abushaikha et al., 2018). A framework for smart warehousing that permits an effective communication model between the warehouse objects and the web was proposed in past research. A framework for adopting IoT in a warehouse to order fulfillment and how it affects the entire supply chain was put forward by Mostafa et al. (2019) and Lee et al. (2018), who suggested the framework of an entire smart WMS was one of the notable works about the infrastructure. A framework for the integration of IoT architecture was proposed by Uviase & and Kotonya (2018).

Therefore, the receiving process involves offloading and inspecting goods to ensure correct quality and quantity. Advanced shipping notification technology is used to receive notifications from suppliers and shippers before delivery arrives. A smart warehousing framework enables effective communication between warehouse objects and the web. To carry out warehouse operations effectively and efficiently, several technologies are used. In today's businesses and sectors, Radio Frequency Identification (RFID) technology is a common IoT technology. RFID tracking is a forerunner of the Internet of Things. By enabling remote internet access to the data, RFID's advantages can be increased. Organizations like the US Department of Defense and Walmart have delegated, the usage of RFID (Al-Fuqaha et al., 2015; Asghar et al., 2015; Atzori et al., 2010; Whitmore et al., 2015). RFID technology was defined by Mishra, (2010) as an automatic wireless identification that uses electromagnetic waves to concurrently detect and track things or persons. Among other IoT technologies, RFID's low cost and simplicity of use may be the reasons it is selected. For instance, auto-ID (automatic Identification) technologies (such as RFID tags, Quick Response (QR) codes, and scanning devices) can be used to follow the transportation of goods in real-time, inform supply chain partners immediately, and change production in response to the demand. These initiatives improve the pull manufacturing and Just-In-Time (JIT) manufacturing systems' efficacy and efficiency. The ability to identify market trends and enhance communication and transaction processes, both of which are crucial for global logistics systems, is made possible by cloud computing and big data analytics. Using real-time traffic and weather information, Intelligent Transportation System (ITS) can be used to track the location of cargo and assist transporters (such as truck drivers) on the best routes.

Tracking technology can be used to detect quality issues and track vital quality indicators like air pressure and temperature in product storage spaces in real time. According to past studies, smart logistics solutions for perishable food goods use tracking and sensing technologies to efficiently monitor product quality across the supply chain

(Nantee & Sureeyatanapas, 2021). Another illustration from Barreto et al. (2017) represents how an Intelligent Transportation System (ITS) uses the idea of virtual technology integration to analyze various types of transportation-related data (such as travel speed, traffic conditions, driver behavior, and other risk factors), revealing that it can significantly reduce the frequency of accidents.

Moreover, by using RFID tags, QR codes, scanning devices, and ITS those are helped to enhance warehouse operations by providing data via distant internet access, can be used to track the movement of items in real-time, rapidly update supply chain partners, and alter output in response to demand. As well as, tracking technology enables real-time monitoring of air pressure and temperature in product storage areas, enabling efficient routes and identifying quality issues for cargo and transporters.

B. Storing with Using IoT

Prior to IoT, RFID had been incorporated into the warehousing industry. It is utilized to communicate and exchange data with supply chain participants in various sectors such as production, transportation, and warehousing. RFID uses tags, radio waves, and readers to automatically identify items and collect data. This represents that "machines, infrastructure elements, materials, and products can get connected to the information technology infrastructure" in an organization (Reaidy et al., 2015). RFID tags are used to store data. RFID is replacing barcode technology, wherein tags can hold more information than barcodes can. Li et al. (2017) described the IoT structure to the storage procedures within warehouses and RFID technology as a key method for obtaining real-time information on the location as well as the quantities of the various products or goods preserved or consumed there.

For instance, W. Ding (2013) suggested a concept that combined the usage of RFID and barcode tags. Hardware that was part of the system infrastructure constituted handheld electronic barcode readers, electronic shelf tags, and fixed readers. The defined process is as follows: Each freight box has a barcode label on it. Then, for each department, a fixed reader and an electronic tag were placed next to each storage shelf. To record when items entered and exited storage, a human operator utilized a handheld electronic barcode label reader. To complete the product inventory, the human operator then wrote the storage information to the RFID tags. Each storage shelf's fixed reader is connected to the management host system to read real-time inventory data, which could then be instantly updated in the database.

Because the goal of this study was to build a whole warehouse management system based on IoT, it can be argued that both barcode and RFID tags, as well as handheld and stationary readers, were used. The steps showed how the RFID were working in the storing process. By using RFID technology, the storage operations inside warehousing is a crucial way to obtain real-time information about the location as well as the quantity of the various products or goods preserved or consumed in a warehouse. Consequently, these technologies aid in maintaining data accuracy and time management. The WSN primarily belongs to the network layer and is a component of the IoT architecture. It is linked to other wireless or wired networks using RFID technology. As described by Chibuye & Phiri (2017), this enables information to be transmitted between the RFID tag and reader to track the availability and specifics of the finished or incomplete products in the storage space. The RFID reader can use the WSN to automatically activate the transponder on an RFID tag to gather or communicate data about the stored item, pallet, or piece of equipment. This makes it possible to convey information regarding the movement to the proper location.

The WSN links RFID technologies, enterprise resource planning (ERP), and cloud computing (CC). Without WSN, a cloud cannot be constructed or run efficiently. (Lee et al., 2018). As observed before, readers are dispersed around the warehouse to cover the entire area and connect with the tags wherever they are. Transmission of data and receipt may occur automatically for the reader because both processes are communicating wirelessly using a WSN (Reaidy et al., 2015). By resolving the major issues associated with storing, retrieving, and using the data detected by IoT, IoT technology collaborates with cloud computing, big data, and blockchain to support streamlining the process and increase its efficiency (Y. Ding et al., 2021). IoT is utilized in smart warehouse operations to monitor supplies in real-time, trace material receipts, and identify stock-outs (Affia & Aamer, 2022).

IoT-based smart warehouse monitoring system created for inventory management. The design prototype's hardware components included a Raspberry Pi 3, humidity sensor, piezo sensitive sensor, fire sensor, light-dependent resistor, and infrared sensors, while the software was custom-made using the Phyton programming language. They created a system that, anytime an environmental change takes place, quickly sends a mobile messaging alert to the stakeholders. Their clever warehouse design could reduce storeroom operational mistakes or failures in this method (Mohanraj et al., 2019). Instead of connecting all the various communication ways to the devices, advise storing the data on numerous devices and then communicating it via a wired connection, such as Local Area Network (LAN). A wireless network could be used to bundle and transfer the data together. Since it is not real-time, this would slow down (Lee et al., 2018). A cloud computing (CC) platform acts as a hub or SharePoint for several people, organizations, and products. Without the complexity of many technical characteristics, program languages, or development environments, it promotes communication for humans, machines, or software. It is becoming more vital for CC to use established deployment strategies like equipment as a Service - RFID tags or readers because of the increasing amounts of data being processed, stored, and analyzed (Chibuye & Phiri, 2017).

As having "high reliability, scalability and autonomy to provide ubiquitous access, dynamic resource discovery, and composability required for the next generation Internet of Things applications"(Gubbi et al., 2013). Accordingly, WSN is one of the crucial technologies that help to improve the productivity of other IoT technologies, which are ERP systems, RFID systems and all.

C. Picking with Using IoT

Order picking, which is the procedure of obtaining things from storage locations to fulfill a customer order, has drawn more attention lately. Many authors assume that order picking is one of the internal logistics procedures that require the greatest manpower and time and that it frequently accounts for more than 50% of a warehouse's operating costs. Picking and storing items are interconnected processes. The one dimension that significantly affects order picking is the designation of the storage location. Since the goal of picking is to shorten the picker's route, properly selecting the storage locations is essential to successful picking (Franzke et al., 2017). Use IoT technologies to perform the picking in order to minimize the number of touch points and employees’ expenses. There is no need for additional staff because technology is used to conduct the picking process. The usage of automation throughout the entire process is one of the benefits for all warehouse activities, including the picking. Utilizing IoT technologies given the difficulties and time-consuming obstacles with the picking process, can lead to improvements (Trab et al., 2015). The order-picking process is intertwined with the storage process, and the better the storage process is done, the more efficiently the order-picking may proceed. Accordingly, incorporating IoT innovations like RFID scanners and tags improves both the picking and storing operations and decreases errors that may arise with paper documentation (Zhang et al., 2019). In the AR (Augmented Reality) picking process, RFID solutions eliminate the risk of human error (Perotti et al., 2022). In conclusion, Order picking and storage are intertwined, and efficient storage improves order picking efficiency. IoT technology, like RFID tags and readers, enhances selection and storage processes, reducing errors in paper documentation.

Automated documentation is far more accurate and detailed than barcodes. Additionally, the disorganized placement of goods makes managing the selection process more difficult. RFID scanners enable the picker (human or machine) to always know where the item remains, regardless of whether it is in the buffer zone or on the route to the destination location. A further advantage of RFID is that a product that must be picked just needs to have data transmitted to the reader telling it exactly where to be picked up from. This is helpful if there are several goods with similar physical characteristics and the selector finds it difficult to distinguish between them (Zhang et al., 2019).

In the IoT framework, the CC exposes itself as an analysis of all data that has been received from the RFID system. By leveraging data on the location or characteristics of the product, these systems or networks make it possible to analyze the optimum picker route. CC is also connected to the main ERP system to collect orders and send them to the relevant human picker or equipment utilizing the proper routing (Lee et al., 2018). Other advantages of the IoT system for the decision-making process include connectivity and communication between people and equipment. Along with the pallets, everything utilized in a warehouse, including forklifts and even humans, is marked. The picker-to-part systems are simplest to utilize when the picker drives to a location in an order-pick vehicle. This picking provides easier processes and implies better communication. (Chibuye & Phiri, 2017). Hence, the RFID assists in locating the precise spot where the picker needs to go to select the products and aids in lowering the overall number of movements per day. The improvement of service quality and reduction of processing time are the key objectives of different order-picking methods. As a result, resources are limited in terms of manpower, equipment, and capital (Niyato et al., 2016). The most expensive logistical process is routing inside a warehouse. Voice picking is a technique used to boost productivity and enhance operational efficiency. Collection and separation chores are carried out by using voice commands. Traditional paper picking is being replaced by technology since it is error prone.

Managing warehousing operations becomes simple by the built-in storage and picking capabilities of voice-picking solutions. Employing an IoT framework for both the choosing and storage procedures has several advantages overall. Because of that, they both benefit from the tight relationship. (Azanha et al., 2016). Pickers can do their work faster and error-free by using voice picking as a sophisticated technology for the picking process.

Robotic pick and place are an automatic procedure in which picking, and placement are accomplished precisely and quickly, increasing production rates. End-of-arm tooling choices come in a variety of forms in this generation. Robots that pick and put goods are the ones that can be customized to a certain production's needs. These robots can transport a variety of products in factory lines, including small, large, heavy, or awkward-to-handle manufactured goods. Pick and place robots come in a variety of shapes and sizes, including spherical robots with one linear and two rotational movements, cylindrical robots with movement in all three axes (vertical, horizontal, and rotational), SCARA robots (fixed robots with three vertical rotary arms), and articulated robots. These robots are speedier and can perform tasks more quickly. Additionally, the working environment is becoming safer, and these robots can perform a lot more difficult tasks. The pick-and-place robot is created in this work for the automatic warehouse management system (Sobhan & Shaikat, 2021). Instead of sending the employees to go and pick the appropriate products, robotics might be used to guide them as they pick them, speeding up the picking process. Picking accuracy can be increased and paperless order picking can be made easier with the use of Pick by Light devices. The tags can be activated with any device and are typically mounted on shelves. Once an order has been chosen, it is feasible to quickly collect items by combining different colored LED lights and numbers. A wireless pick-by-light device for quick item localization during the picking process in logistics warehouses. The suggested solution provides long-term and low maintenance expenses (Song et al., 2021). In the future, using these Pick by Light devices will make it possible to pick many orders quickly and accurately. Therefore, determining should be done in a productive manner.

D. Packing with Using IoT

The progression of the IoT has resulted in notable advancements in diverse sectors, including packaging. This review delves into the most recent trends and applications of IoT in packaging. In recent years, the use of IoT in packaging has become increasingly popular due to its ability to improve efficiency and save money on the process. IoT is the driving force behind smart packaging as it enables communication between packages and consumers. This communication delivers an array of information, ranging from freshness and safety to promotions and usage guidelines (G. Ding et al., 2018) Through real-time tracking and monitoring of products, IoT enables the packaging industry to take a proactive approach to supply chain management.

In particular, the IoT has prompted the development of new antenna designs that are low-cost, lightweight, and insensitive to orientation. Inspired by the Antenna on Package (AoP) concept in the semiconductor industry, these designs seek to save cost and space for applications of IoT by integrating antennas into the package that provides cover and protection for electronics (Y. Ding et al., 2021). Furthermore, IoT sensors can be used to detect the presence of harmful bacteria or other contaminants in food products. This reduces the chance of contracting a foodborne illness and helps assure that the products are safe for consumption. IoT-enabled packaging involves integrating various sensors and tracking devices to monitor the location, temperature, and condition of goods in real time (Zikria et al., 2019). This article provides a comprehensive review of smart packaging solutions for food freshness and safety, including the use of IoT sensors and devices to monitor the condition of food products during transport and storage. According to a review of the applications, challenges, and future trends of smart packaging, it can also monitor the shelf life of products. As an illustration, Time-Temperature Indicators (TTIs) can be incorporated into the packaging to track the time-temperature history of items and notify companies and customers when products have reached their expiration date (Wang et al., 2015).

To enhance the quality and safety of food goods, this has been applied to food packaging. In the food industry, it is crucial to ensure that products are fresh and free from contamination, and IoT can help achieve this. To keep tabs on the state of the goods during storage and transportation, temperature and humidity sensors can be incorporated into the packaging. These sensors can aid in assuring that food items stay within acceptable temperature ranges and prevent spoilage. By gathering data and alerting companies when temperatures or humidity levels exceed safe levels, these sensors can further optimize the supply chain and assist businesses in maintaining the quality of their products. This allows them to detect areas where improvements can be made to reduce spoilage and waste (Zikria et al., 2019).

Consequently, by using TTIs throughout the packing process, it helps to ensure product quality and as a result, can increase customer satisfaction. To increase productivity and reduce expenses, IoT devices other than RFID tags can be incorporated into the packaging. IoT devices can be used, for instance, to automatically replenish goods when stock levels are low and track inventory levels in real-time. This helps to ensure that businesses never run out of essential supplies and eliminates the need for manual inventory management (Zikria et al., 2019). In addition to sensors, RFID tags, for instance, can be used to track the movement and location of commodities across the supply chain. By deploying swarm drones for various applications such as package delivery, public safety, search and rescue, tracking, and monitoring, the IoT enables businesses to know where their products are at any given time and helps to minimize losses due to theft or misplacement. Li et al. (2017) proposed re-encryption schemes for enhancing the security of IoT applications that involve RFID tags. These schemes include the use of re-encryption authentication to prevent the leakage of location privacy and a one-time re-encryption method for ensuring the anonymity of RFID tag information.

Robot packing issues are a new class of bin packing problems that call for specialized solvers, or what refer to as robot packing algorithms. The issue is resolved in two steps. Two steps are taken to resolve the issue at hand. The first stage of the problem-solving process involves computing an optimal or nearly optimal solution to the issue at hand. For humans, the answer is practical, but for robots, it is frequently impractical. Dedicated solvers are needed for the novel class of bin packing problems known as robot packing problems, which we refer to as robot packing algorithms (Aggoun et al., 2016). Robotic packing may help significantly reduce employee-caused faults. Therefore, businesses can readily access the business market and offer consumers high-quality finished goods.

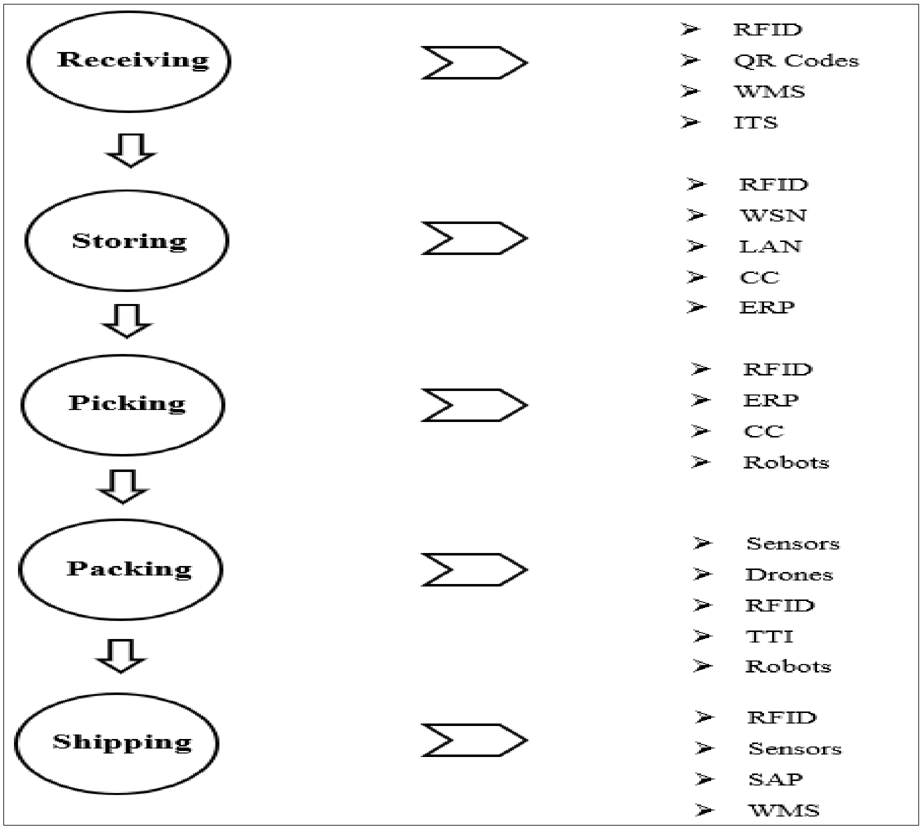
E. Shipping with Using IoT

To track products and manage inventories, Tejesh and Neeraja (2018) suggested a framework for Small and Medium-sized Enterprises (SMEs). This framework comprises IoT devices like RFID and sensors. Like this, warehouse management systems are built on the IoT that interfaces with shipping carriers to offer real-time tracking and optimize shipment routes (Mostafa et al., 2018). A report by the United States government in 2017 analyses the role of IoT in supply chain management. According to the survey, supply chain organizations frequently utilize RFID tags and IoT devices to monitor inventory management. IoT gadgets are also used to keep an eye on the temperature, humidity, and pressure of packages as they travel. Traditional Systems Applications and Products in Data Processing (SAP) and WMS software packages that relate to IoT are extensively employed, according to a Malaysian study done by Jarašūnienė et al. (2023). RF readers are employed in warehouses for material management, shipping operations, route planning, and dispatch. For operational purposes in real-time radio communication, RF smart devices are used. Studies have suggested frameworks and evaluated the efficiency of IoT-based warehouse management systems in streamlining shipping procedures. Jarašūnienė et al. (2023) conducted a case study on a significant retail organization that used an IoT-based warehouse management system.

The technology, according to the report, increased inventory management accuracy and decreased shipment times (Tanaka et al., 2019). Additionally, some research has looked at the difficulties in integrating IoT in warehouse management systems by conducting a thorough investigation of the possible applications of IoT in warehouse management, including shipping procedures. The authors talk about the advantages and difficulties of applying IoT in warehouses and offer a framework for assessing IoT solutions, including the high cost of IoT devices and the requirement for effective data security measures. Similar difficulties with integrating IoT devices with current warehouse management systems were covered by Zikria et al. (2019). One of the critical steps in warehouse operation is shipping. To shorten the lead time, firms might do so by employing the most recent technologies.

IV. ANALYSIS OF RESULTS

Figure 7. IoT technologies in warehouse processes



Source: Authors' compilation.

V. DISCUSSION

The research study highlights the significant influence of IoT on warehouse management processes. Based on existing research articles, it emphasizes that IoT is transforming warehouse management, and it has a major effect on performance. By providing real-time data, enabling predictive maintenance, enhancing inventory accuracy, and lowering operational costs, IoT technologies are revolutionizing warehouse management. This article narrates that each business must determine for itself which IoT technology is ideal to implement in their warehouse. Although recommendations can be provided and come with benefits and drawbacks, the company is ultimately responsible for making the choice.

Real-time inventory tracking is one of the IoT's most important effects on warehouse management. Companies may keep track of inventory levels and the flow of items into and out of warehouses using IoT-enabled sensors. The time and effort needed to locate and retrieve things can be decreased by using this article to optimize warehouse layout and increase operational efficiency. The use of IoT technologies in both theory and practice is explained holistically in this article. The risk of errors can be decreased, and the time needed for human inventory checks can be cut down by using RFID and barcode scanners to identify products rapidly and accurately. Additionally, by lowering the likelihood of stockouts and overstocking, businesses may increase customer satisfaction and cut down on waste.

In summary, this article exemplifies that by delivering real-time data, enhancing inventory accuracy, enabling predictive maintenance, and lowering operating costs, the deployment of IoT technology in warehouse management can, all in all, significantly improve performance. By anticipating continued expansion in the application of IoT in the warehouse management sector in the years to come, businesses that adopt IoT are likely to gain a competitive advantage in the market.

V. CONCLUSION

This study explores how IoT affect WMP in the worldwide logistics sector. Despite the widespread adoption of IoT technology in supply chain management, less focus has been placed on how it specifically affects WMP. To cut costs and enduring client relationships, logistics management must be effective. A vital aspect of supply chain management, warehouse performance management entails keeping a close tab on enhancing the operational effectiveness and efficiency of warehouses through inventory management, labor management, warehouse layout and design, and the use of technology, including WMS and automated material handling systems.

Warehouse operations have been transformed by technology and automation, and the IoT has emerged as a troublesome technology that can further revolutionize WMP. The objective of this study is to evaluate secondary data from the literature already in existence and comprehend how IoT has affected WMP in the worldwide warehouse sector. It intends to provide readers with a thorough grasp of the pros and cons of IoT deployment, thereby educating them about the benefits of IoT usage in logistics operations and assisting them in making better decisions. It is evident that barcodes and RFID tags, as well as mobile and desktop readers, were all combined to develop an entire IoT-based warehouse management system. To tackle key problems with storing, retrieving, and utilizing data discovered by the IoT, the IoT framework combines big data, blockchain, cloud computing, and wireless sensor networks. This integration improves the effectiveness of the warehouse management process. The connectivity and communication capacities of the IoT also facilitate the decision-making process, and smart packaging solutions employing IoT sensors and devices may monitor product conditions during shipping and storage, enhancing efficiency and lowering costs.

In conclusion, the integration of IoT technologies such as RFID, QR codes, scanners, and Warehouse Management Systems (WMS) has the potential to significantly enhance warehouse management performance in the global logistics sector by providing real-time data, predictive maintenance, and improving inventory accuracy while lowering operational expenses. These advancements can lead to more efficient warehouse operations and optimized warehouse architecture, resulting in higher customer satisfaction and reduced waste. However, it's essential to acknowledge several limitations and implications in this context. Firstly, while IoT offers substantial benefits, its implementation requires a considerable initial investment in technology and infrastructure, which can be a barrier for smaller logistics companies. Additionally, the security and privacy of the data collected through IoT devices pose significant concerns, making it imperative for companies to invest in robust cybersecurity measures. Moreover, the reliance on IoT systems necessitates skilled labor and ongoing training, which can be a challenge for some organizations. Lastly, the environmental impact of increased technology use should be considered, as the disposal of electronic components can contribute to electronic waste issues. Therefore, while IoT holds great promise for warehouse management performance, it is crucial for companies to carefully assess its costs, security measures, and environmental implications before widespread adoption. This critical analysis under the topic, "Influence of IoT on Warehouse Management Performance in the Global Context," underscores the need for a balanced evaluation of IoT's potential in the logistics sector.

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