Working Paper 2024.2.3.7
- Vol. 2, No. 3

ỨNG DỤNG TỰ ĐỘNG HÓA KHO HÀNG TRONG VIỆC QUẢN LÝ CHUỖI CUNG ỨNG CỦA AMAZON VÀ BÀI HỌC CHO CÁC DOANH NGHIỆP THƯƠNG MẠI ĐIỆN TỬ VIỆT NAM

Trần Minh Nguyệt[1], Cù Thảo Ly

Sinh viên K60 CLC Kinh tế đối ngoại - Viện Kinh tế & Kinh doanh quốc tế

Trường Đại học Ngoại thương, Hà Nội, Việt Nam

Nguyễn Hà My, Trần Khánh Linh, Đoàn Thanh Xuân

Sinh viên K60 CLC Kinh doanh quốc tế - Viện Kinh tế & Kinh doanh quốc tế

Trường Đại học Ngoại thương, Hà Nội, Việt Nam

Lê Phan Thế

Sinh viên K61 CLC Kinh tế đối ngoại - Viện Kinh tế & Kinh doanh quốc tế

Trường Đại học Ngoại thương, Hà Nội, Việt Nam

Nguyễn Thị Yến

Giảng viên Bộ môn Quản lý chuỗi cung ứng - Viện Kinh tế và Kinh doanh quốc tế

Trường Đại học Ngoại thương, Hà Nội, Việt Nam

Tóm tắt

Thị trường tự động hóa nhà kho trên thế giới đang tăng trưởng nhanh chóng sau đại dịch COVID 19, khi mà việc kinh doanh của các sàn thương mại điện tử lớn bùng nổ. Dù đã áp dụng hệ thống robot và phần mềm quản lý vào các nhà kho trong nước, các tập đoàn thương mại điện tử Việt Nam vẫn đang gặp khó khăn trong việc bắt kịp với xu hướng tự động hóa nhà kho trên toàn cầu. Mục đích của tác giả là tìm hiểu phân tích quá trình áp dụng tự động hóa vào nhà kho của Amazon qua các năm bằng cách thu thập dữ liệu từ các tài liệu của công ty cùng với những nghiên cứu trước đây. Thông qua phương pháp định tính các nguồn thứ cấp, nhóm tác giả khám phá phương pháp áp dụng các robot và phần mềm quản lý kho hàng tự động, thậm chí là trí tuệ

[1] Tác giả liên hệ, Email: k60.2112150129@ftu.edu.vn

nhân tạo , tại các nhà kho của Amazon. Từ đây, nhóm nghiên cứu đưa ra những đề xuất để cải thiện việc quản lý kho hàng cho các doanh nghiệp thương mại điện tử Việt Nam để thành công áp dụng công nghệ tự động hóa làm gia tăng năng suất của các nhà kho trong nước.

Từ khoá: Amazon, Thương mại điện tử, Tự động hóa nhà kho.

APPLICATIONS OF WAREHOUSE AUTOMATION IN SUPPLY CHAIN MANAGEMENT - A CASE STUDY OF AMAZON AND LESSONS FOR VIETNAMESE E-COMMERCE ENTERPRISES

Abstract

The world's warehouse automation market size is growing rapidly after the COVID 19 pandemic, when the business of major E-commerce platforms boomed. Despite having applied robot systems and management software to domestic warehouses, Vietnamese e-commerce corporations are still having difficulties keeping up with the global trend of warehouse automation. The author of this study aims to analyze the process of applying automation to Amazon's warehouses over the years by collecting data from company - published documents along with previous research. Through the qualitative method of secondary sources, the authors explored the methods of applying robots and automated warehouse management software, even AI, at Amazon warehouses. From there, the research team made recommendations on improving warehouse management for Vietnamese e-commerce companies to successfully apply automation technology and increase the productivity of domestic warehouses.

Keywords: Amazon, E-commerce, Warehouse automation.

1. Introduction

In the post-COVID world, e-commerce accounts for a growing amount of all commerce, and customer expectations are higher than ever (THL, 2023). Therefore, getting the right products to the right consumers at the right time in the right place and in pristine condition

provide a real competitive edge for e-commerce. The need for automated storage solutions to ensure precise, quick, and efficient storage is increasing exponentially.

Amazon, the global e-commerce giant, has been at the forefront of embracing warehouse automation systems. With its acquisition of Kiva Systems in 2012, Amazon introduced thousands of robots to streamline warehouse processes, enhancing their warehouse productivity (Go Freight, 2023). Looking back to our country, despite the increasing global market size of warehouse automation, Vietnamese e-commerce enterprises still face struggles when applying the automation technologies into local warehouses. This research delves into the application of warehouse automation, such as AWS, FBA and the SLAM technologies of Amazon. Through an in-depth case study of Amazon, this paper draws some valuable insights and recommendations for Vietnamese e-commerce enterprises that seek faster and more cost-effective warehouse solutions.

This research paper “Applications of Warehouse Automation in Supply Chain Management - A Case Study of Amazon - and Lessons for Vietnamese e-commerce enterprises” aims to answer 3 key questions: (1) What is the current situation of Amazon’s

warehouse management system? (2) What are the strengths and weaknesses of the warehouse automation applications? and (3) What recommendations can be derived from the case study to effectively integrate into Vietnamese enterprises to optimize their supply chain management process?

2. Theoretical framework

2.1. Supply chain management

2.1.1. Definition of supply chain management:

The Council of Supply Chain Management Professionals in 2010 defines supply chain management as: "The planning and management of all activities involved in sourcing and procurement, conversion and all logistics management activities. Importantly, it also includes coordination and collaboration with channel partners, which can be suppliers, intermediaries, third-party service providers and customers.". SCM is a broader term compared to Logistics Management, which only involves warehousing operations, order and delivery management. Supply chain management includes management activities related to production, storage, transportation, and distribution. The goal of SCM is to increase productivity, reduce costs, improve product quality and meet customer needs (Viindoo, 2023).

2.1.2. Importance of supply chain management in e-commerce

Typically, supply chain management would create an effective business operation foundation, ensuring consistency in progress and quality as well as minimizing the risk of returns, saving operating costs, and increasing net profit.

With the utilization of digitalization, a new term for the action of buying and selling has emerged, known as Electronic Commerce, or e-commerce for short. E-commerce is the digitization process of the commerce activity, which is to conduct the trade of buying and selling through the internet by using telecommunication devices such as computers, smartphones, and tablets. The question is, how different is the role supply chain management in e-commerce compared to traditional business? The pathway of traditional SCM is straightforward, not allowing for a lot of flexibility. It focuses on allocating products, manufacturing large volumes, and working to deliver it to customers. In e-commerce, SCM involves a more complex and interconnected system due to the digital nature of transactions. Because online consumers expect fast and affordable delivery, efficiency and speed are vital in e-commerce supply chains. This led to the need for modern SCM systems, which rely on advanced data and technology to cater to consumers' needs and expectations. Modern SCM employs logistics to help make operations run smoothly and efficiently. It also takes into consideration a larger network of providers that can offer faster and more affordable options for production and fulfillment throughout the supply chain (Flexport, 2022).

2.2. Warehouse management

2.2.1. Warehouse management definition:

Warehouse management encompasses the principles and processes involved in running the

day-to-day operations of a warehouse. (Netsuite, 2020). Warehouse management lies in the second phase of supply chain management, which involves (1) Supply management (2) Inventory management or warehouse management (3) Logistics management (4) Product flow management (5) Information management. In this stage, modern technology such as the Internet of things (IoT), artificial intelligence (AI), machine learning and blockchain are used to optimize activities and increase efficiency of the whole supply chain.

2.2.2. Importance of warehouse management for e-commerce supply chain management activities

A Warehouse Management System (WMS) is vital for optimizing supply chain operations, ensuring efficient inventory management, accurate order processing, and improved overall productivity. A robust WMS is needed for the following reasons:

Figure 1: The importance of WMS for Supply chain

Source: Unicommerce, 2023

2.3. Warehouse automation

2.3.1. Warehouse automation definition:

Warehouse automation is the process of automating the movement of inventory into, within, and out of warehouses to customers with minimal human assistance. As part of an automation project, a business can eliminate labor-intensive duties that involve repetitive physical work and manual data entry and analysis (Netsuite, 2020). Warehouse automation offers a wide range of compelling benefits, including fewer human errors, improved productivity, reduced processing time and higher customer satisfaction.

2.3.2. Types of automation technologies in warehouse management and their application

There are various types of warehouse automation technology, including Goods-to- Person (GTP) systems, Automated Storage and Retrieval Systems (AS/RS), Automatic Guided Vehicles (AGVs), Autonomous Mobile Robots (AMRs), Pick-to-Light and Put-to-Light Systems, Voice Picking and Tasking, and Automated Sortation Systems (CYZERG, 2022).

GTP systems use conveyors, carousels, and vertical lift systems to increase efficiency and

reduce congestion. AS/RS systems use material-carrying vehicles, tote shuttles, and mini-loaders for high-volume warehouse applications with space constraints. AGVs have minimal onboard computing power and are limited to large, simple warehouse environments. AMRs use GPS systems and advanced laser guidance to create effective routes and are easy to program and implement quickly. Pick-to-Light and Put-to-Light Systems use mobile barcode scanning devices to direct warehouse pickers, while voice-directed warehouse procedures use speech recognition software and mobile headsets to create optimized pick paths. Automated sortation systems are used in order fulfillment for receiving, picking, packing, and shipping.

2.3.3. Trend forecast of automation in supply chain management

The size of the warehouse automation market worldwide is projected to grow significantly from 2023 to 2027. According to Statista, the global warehouse automation market is expected to reach $44 billion by 2028, with a compound annual growth rate (CAGR) of 15% between 2023 and 2028.

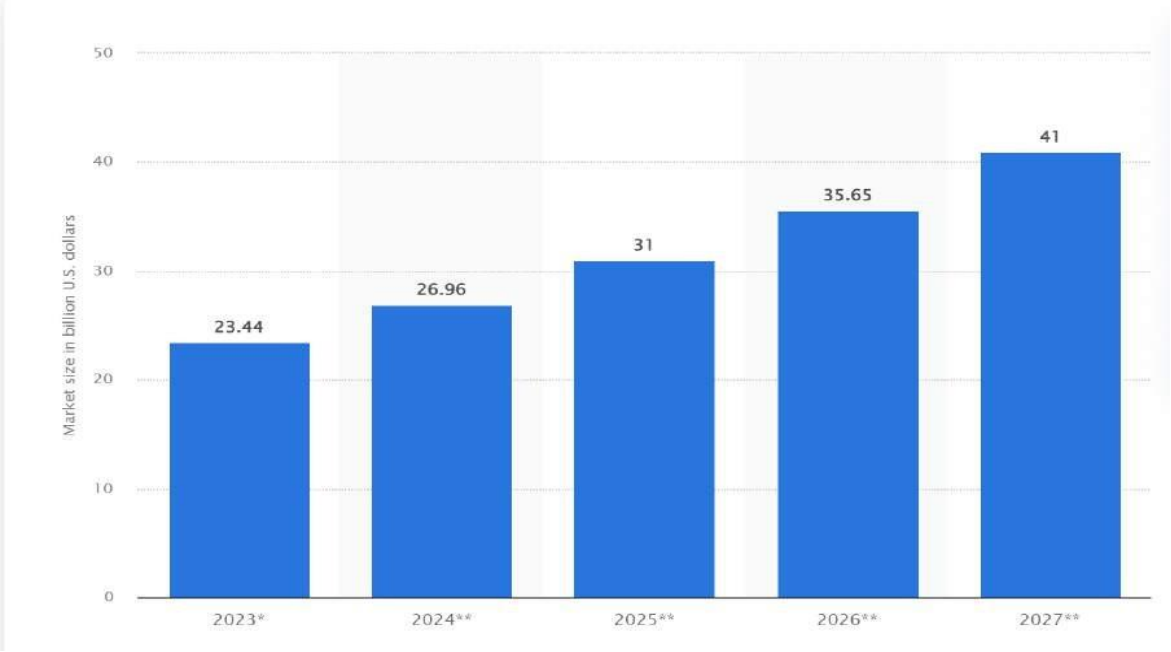

Figure 2: Size of the warehouse automation market worldwide from 2023 to 2027

Source: Statista, 2024

This growth indicates a remarkable expansion in the adoption of warehouse automation technologies across various industries such as e-commerce, general merchandise, grocery, apparel, food & beverage, pharma, and 3PL. Being a warehouse automation top-one market, e-commerce anticipates increasing demand for efficiency, accuracy, and cost-effectiveness in warehouse operations is driving this market expansion.

3. Analysis of Amazon warehouse automation applications in supply chain management

3.1. Overview of Amazon and the company supply chain

3.1.1. General information

Amazon is the world's largest online retailer, founded in 1994 by Jeff Bezos, based in Seattle, Washing DC, the U.S. The company quickly expanded by massively investing in technology with an aim to improve warehousing and distribution, which allows them to provide better services to their customers. After 29 years of development, Amazon has continuously branched out, providing customers with expanded product lines including apparel, auto and industrial items, beauty,.... It also manufactures innovative services, namely electric devices (Alexa and Echo, Fire TV), Amazon Prime and entertainment platforms (Amazon Originals, Prime Video, Audibel).

Amazon's financial performance has been remarkable, with consistent revenue growth and increasing profitability. In 2023, Amazon's revenue reached a staggering $574.79 billion, marking an impressive 11.83% year-over-year increase (Macrotrends, 2023). This growth is largely driven by the company's dominance in e-commerce, cloud computing and digital advertising.

Vision and mission: Amazon strives to be the world's most customer-centric company. This goal is reflected in the company's mission statement: "to be Earth's most customer-centric company". Amazon provides their customers with a wide selection of products at competitive prices and delivered with exceptional speed and convenience.

3.1.2. Overview of Amazon's supply chain

The core of Amazon's success lies in its massive network of fulfillment centers, with 110 active centers in the US and 185 centers globally, including North America, Europe, Asia, and Australia. Warehouses are typically built near major highways, airports, and other transportation hubs to assist efficient movement of goods in and out of the facilities. This ensures an effective connection from the distribution system manufacturer to the customer.

Beside warehouse management, Amazon tries to maintain optimal inventory. The conglomerate uses advanced forecasting models to predict demand and prevent stockouts, while minimizing unnecessary storage costs. This is due to automation, which allows workers to do more complex tasks, increasing Amazon's productivity.

3.2. The situation of applying automation in warehouse management of Amazon

3.2.1. Factors leading to Amazon's adoption of warehouse automation

Amazon's automated warehouses, also known as fulfillment centers, powered by a blend of advanced technologies, are pivotal in achieving efficient storage, retrieval, and order fulfillment processes. Amazon's operations are tailored to handle the high volumes of small orders synonymous with online retail. This strategic alignment underscores Amazon's commitment to swift order processing and customer satisfaction.

Starting the company as a simple online bookstore, Bezos believed that the key to success was to "get big fast." Since the mid-90s, the amount of storage has expanded from a few shelves in their Seattle, WA office to over 175 warehouses across North America and Europe today. Amazon.com warehouses are named "Fulfillment Centers" because their service does not just include storage, but also includes distribution. In 2006, Amazon.com took its first major step into cloud computing with the public launch of Amazon Web Services, which allows

businesses to use Amazon.com storage space and computational power. Around the same time, the Fulfillment by Amazon program was launched, which allows third-party sellers to store their products at Amazon.com warehouses and sell through Amazon.com. Due to increasing demand, Amazon.com was compelled to invest in automation to make their Fulfillment Centers more efficient (Laber, Thamma and Kirby, 2020).

Amazon's initial venture into automation within their Fulfillment Centers originated from the necessity to enhance efficiency and manage the increasing demands of their rapidly expanding e-commerce enterprise. As their operations grew, they realized the importance of employing technological solutions to optimize their supply chain processes and improve the speed and accuracy of order fulfillment. Consequently, they began integrating some degree of automation to streamline certain tasks and boost productivity. In 2010, Amazon made a significant move by acquiring Diapers.com, a company already utilizing Kiva Systems' robots in its warehouse operations (Yodai Takeuchi, 2024). This acquisition not only expanded Amazon's e-commerce dominance but also introduced them to advanced robotics technology used in warehousing.

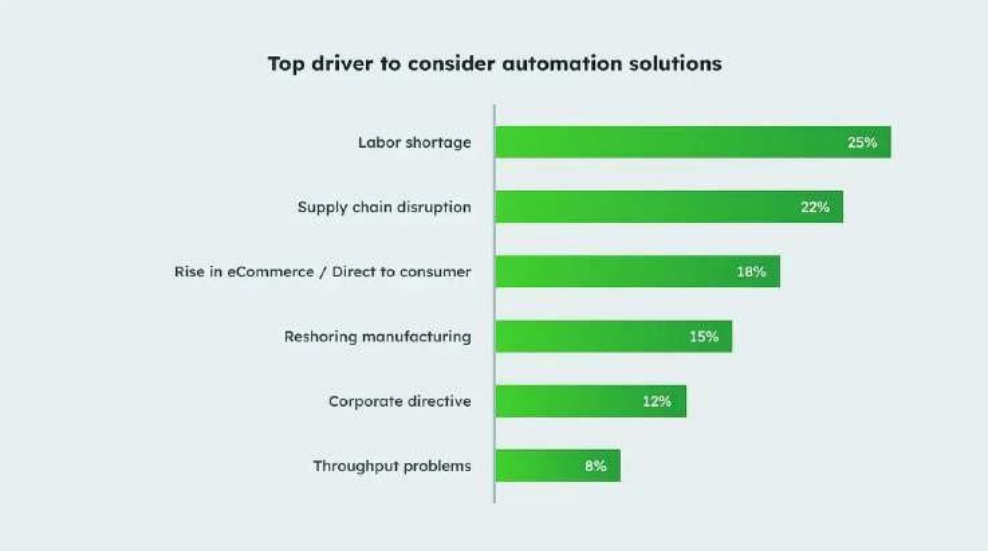

Figure 3: Drivers to consider automation solutions

Source: Vecna Robotics (2023)

3.2.2. The automated management process inside Amazon warehouses

At the core of Amazon's operational prowess lies a meticulously choreographed symphony of cutting-edge technology and human expertise. The Amazon Robotics Sortable Fulfillment Center, one of over 50 such facilities globally, serves as a testament to this integration. Here, advanced automation systems seamlessly collaborate with skilled associates to ensure the swift and accurate fulfillment of customer orders, embodying Amazon's unwavering commitment to delivering exceptional service.

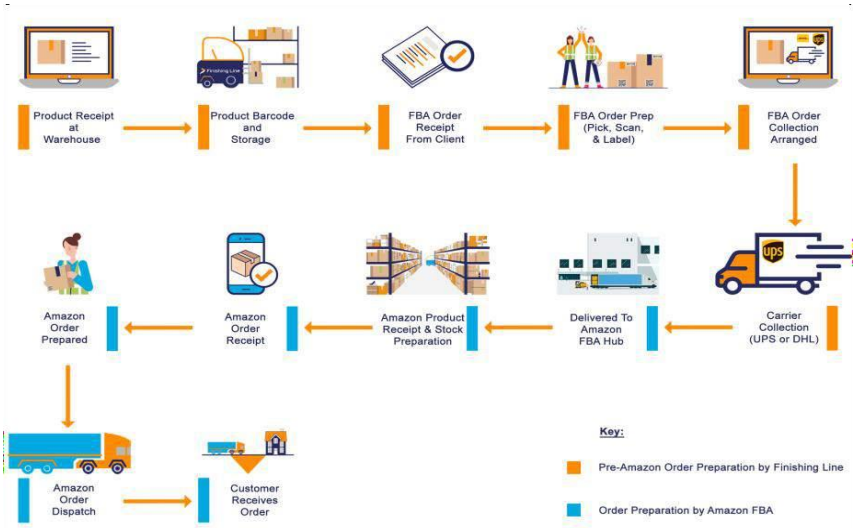

Figure 4: Amazon FBA (Fulfillment by Amazon) & SFP (Seller Fulfilled Prime) Preparation & Fulfillment

Source: Finishing Line

Amazon's management system at its fulfillment centers is a marvel of modern logistics, blending innovative technology with human expertise to efficiently process and deliver orders to customers worldwide. It begins with a robust focus on customer satisfaction and employee safety, as demonstrated by the implementation of advanced thermal camera systems for temperature screening. This proactive approach ensures a safe working environment while also prioritizing the timely delivery of orders to customers.

In the realm of logistics, Amazon leverages the power of AWS's forecasting engine to handle an astonishing volume of over 400 million products daily (Amazon Web Services, 2021). This sophisticated system enables accurate prediction and planning of inventory requirements, ensuring that the right products are available when customers need them. By utilizing cutting-edge technology for forecasting and ordering processes, Amazon optimizes its supply chain operations to meet customer demands effectively.

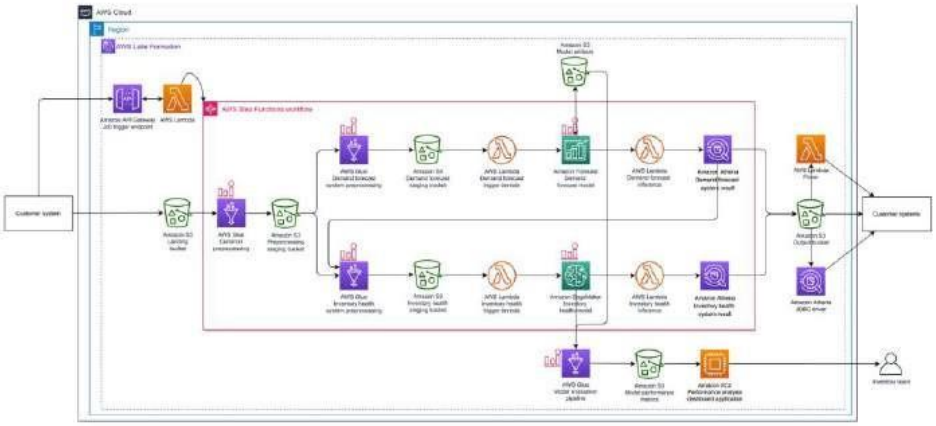

Figure 5: AWS in Warehouse Management

Source: Amazon Web Services (2023)

The automated management process at Amazon's fulfillment centers comprises several key components, each playing a crucial role in orchestrating the seamless flow of operations.

a. Inventory Management:

Upon the arrival of shipments at fulfillment centers, meticulous attention is given to the receiving, staging, and stowing of items. This process involves a harmonious collaboration between human workers and advanced technology. Amazon Aurora serves as the backbone for managing inventory transactions, while Amazon Neptune maintains a comprehensive history of inventory data. The seamless integration of technology allows for efficient and organized handling of millions of items within the fulfillment centers.

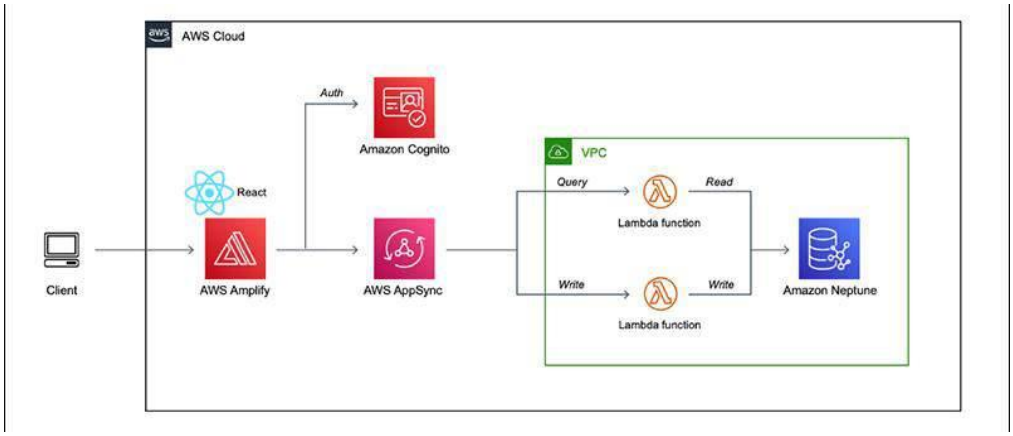

Figure 6: Graph application with Amazon Neptune

Source: AWS Database Blog, 2021

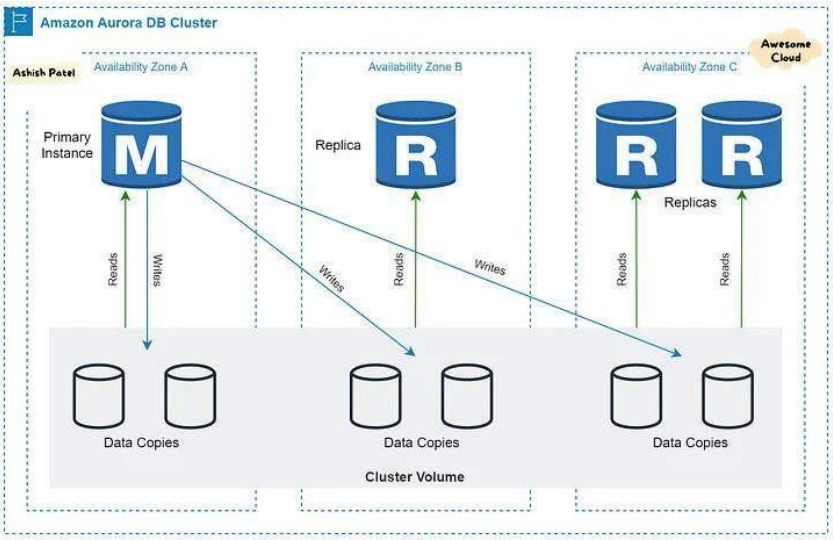

Figure 7: Amazon Aurora DB Cluster

Source: Ashish Patel (2021)

Automation plays a pivotal role in streamlining operations within Amazon's fulfillment centers. Computer vision technology guides associates in the stowing process, ensuring that items are stored accurately and efficiently. Additionally, the deployment of thousands of robots within designated areas facilitates the movement of shelves of products, enhancing operational

efficiency. This combination of automation and human labor enables Amazon to fulfill customer orders with precision and speed.

Figure 8: Robotized Amazon pods at an Amazon Robotics (AR) facility.

Source: Ken (2021)

b. Order Fulfillment Optimization:

Order fulfillment at Amazon entails precise picking and packing processes to ensure accuracy and efficiency. Robots locate inventory pods for associates, who are then guided by machine-generated data to fulfill orders accurately. Machine learning algorithms optimize shipping methods, considering factors such as delivery time and cost-effectiveness. This intelligent approach to order fulfillment enables Amazon to meet customer expectations while minimizing shipping costs. In 2017, Amazon was granted a patent for a packing robot concept designed to collaborate with human order pickers.

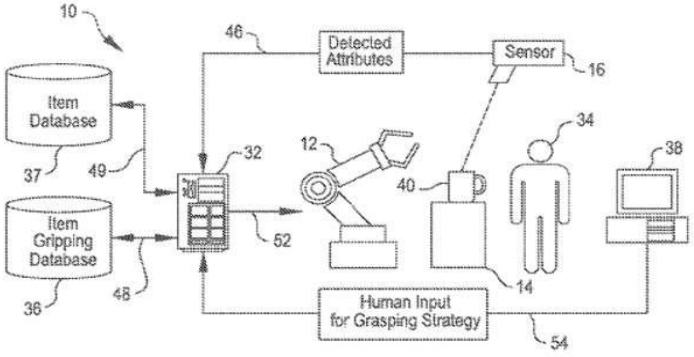

Figure 9: Amazon's Patented System for Robotic Order Packing

Source: SCDigest (2017)

c. Shipping Automation:

The SLAM (Scan, Label, Apply, Manifest) technology employed by Amazon streamlines the shipping process, automating the application of shipping labels based on machine-generated data. This ensures that each package is accurately labeled and ready for shipment to customers. Quality control measures, including weight verification, further enhance the reliability of Amazon's shipping process, guaranteeing that only high-quality items reach customers.

Figure 10: The SLAM (Scan, Label, Apply, Manifest) technology

Source: Amazon (2023)

Central to Amazon's operational efficiency are the over 200,000 robotic drive units deployed throughout its fulfillment centers. These robots, operating within dedicated zones encompassing approximately 65% of each facility's total square footage, collaborate seamlessly with human associates to fulfill customer orders with unmatched speed and precision. With a lifting capacity of up to 450 kilograms and speeds of approximately 3 miles per hour, these robots significantly enhance order picking efficiency and warehouse throughput. In 2014, the total number of robotic workers inside Amazon's warehouse was roughly 15000. In the period of 9 years, at the end of 2023, Amazon was using more than 750,000 warehouse robots, which was a significant increase, as you can see from the graph below:

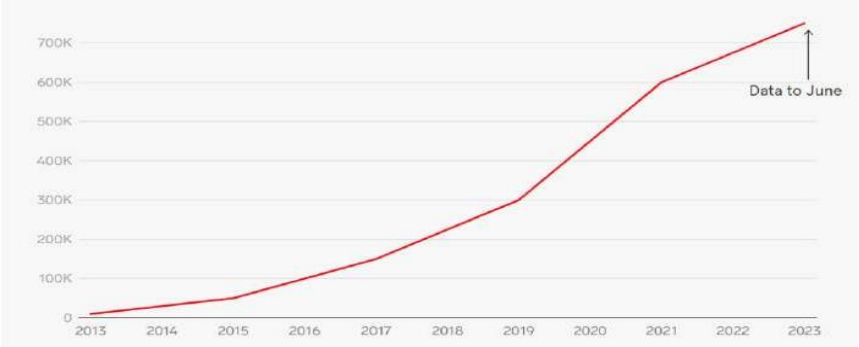

Figure 11: Numbers of Robotic Workers Inside Amazon's Warehouse

Source: Amazon (2023)

Amazon Robotics, formerly known as Kiva, encompasses a range of robotic systems designed to enhance efficiency within Amazon's fulfillment centers. The flagship Robo-Stow, a palletizer robot equipped with a six-ton robotic arm, adeptly handles goods off conveyor belts and arranges them on pallets, with the ability to move merchandise up to 7.3 meters between levels. Supporting a payload of up to 1360 kg, Robo-Stow exemplifies the robust capabilities of Amazon's robotic fleet. Additionally, Amazon introduced two new models in 2019: Hercules and Pegasus. Hercules boasts a shorter stature and increased lifting capacity compared to its predecessor, while Pegasus features a conveyor belt for added functionality. Complementing these models is Xanthus, a modular robot capable of stacking containers and performing sorting tasks. With over 100,000 drive units deployed across fulfillment centers, Amazon Robotics leverages advanced technology and machine learning algorithms, supported by AWS services like IoT Greengrass, to continually refine operations and predict equipment failures, setting the standard for operational excellence in the e-commerce industry.

Figure 12: Amazon RoboStow

Source: Amazon Press Center (2023)

3.3. Evaluation of automation application in Amazon warehouse by periods

3.3.1. Strengths and weakness

Warehouse automation has brought some major benefits to Amazon’s supply chain.

First, one of the primary advantages of adopting warehouse automation is the significant increase in efficiency and accuracy it offers. Automated systems can handle tasks such as picking, packing, and sorting with greater speed and precision than manual labor alone, reducing processing times and minimizing errors (Kosta Mitrofanskiy, 2024).

Figure 13: Advantages of warehouse automation

Source: Supriya Bajaj (2024)

Second, the employment of robots to do repetitive and heavy lifting duties has increased worker safety in Amazon's warehouses.

Third, warehouse automation makes greater use of Amazon's available warehouse space. Amazon can maximize vertical space utilization by storing things in a more compact and orderly manner with the implementation of automated storage and retrieval systems (AS/RS). As a result, Amazon can stock a wider range of goods without shrinking the total area of its warehouses.

However, there are still challenges that Amazon had to overcome when applying automation.

One major drawback is the initial high cost of implementing automation technologies. For example, the acquisition of Kiva Systems alone was a substantial financial commitment which cost Amazon nearly $800 million (Maaz Khan, 2023).

Beyond the financial aspect, integrating these sophisticated robotic systems into an existing supply chain framework is complex. The integration is not just about installing robots but also about rethinking warehouse layouts, optimizing workflows, and ensuring that the new systems communicate effectively with existing supply chain management software.

Another challenge is the potential impact on human workers. While robots can improve the speed and efficiency of warehouses, they can also displace human workers who may no longer be needed. This has led to concerns about the impact of automation on jobs and the economy as a whole. As Amazon continues to expand its robotic fleet, which reportedly includes over 750,000 units, the concern is not just about the reduction of jobs but also about the shifting nature of warehouse work (Jason Del Rey, 2023).

3.3.2. Evaluation of automation application in Amazon warehouse by periods

- ***The 1st period: Labour-based warehouse operation***

In 1997, Amazon had a single 93,000-square-foot warehouse in Seattle. Amazon's

warehouse management was characterized by a combination of manual labor and some automation. Workers were responsible for tasks including shipping, packing, and sorting. They also often used paper records to keep track of orders and inventory. One of Amazon's main issues was the increasing demand for faster shipping times and more accurate order fulfillment.

- ***The 2nd period: Acquiring some basic machinery***

Ever since it built five vast warehouses in 1999, Amazon.com has boasted of the wonders of the machinery inside them -- 10 miles of conveyor belts and myriad other gadgets. The primary goal of these early systems was to increase productivity and accuracy for operations like order fulfillment and inventory management. Amazon was worried about the number of workers it took to operate those machines, especially during the holiday rush. In 2000, for example, Amazon had to hire 7,200 temporary workers to supplement the 4,400 people working in its warehouses in the United States (NYT, 2002). In 2001, Amazon's sales grew at only half the rate it predicted at the beginning of the year, dragged down by the recession, the aftermath of Sept, 11 and some of the company's own missteps.

We can see that Amazon faced many financial and labor challenges when they began acquiring automated robotics. Employees overload and lost revenue was Amazon's main problem in this period.

- ***The 3rd period: Acquiring more complicated automated machineries***

When Amazon paid $773 million to acquire Kiva System in 2012, it was a major step forward for warehouse automation. Since then, Amazon has made significant financial investments in the creation of sophisticated robotic systems equipped with LiDAR technology and machine learning algorithms, which are subsequently placed at fulfillment facilities. Subsequently, Amazon unveiled Proteus, Cardinal and Sparrow. The company then launched Sequoia, which allowed Amazon to identify and store inventory received at its fulfillment centers up to 75% faster than before.

- ***The 4th period: Fully automated warehousing system***

The application of automation in Amazon's warehouses has progressed significantly over the years, reflecting the company's commitment to innovation and operational efficiency. As of 2023, Amazon had over 750,000 robots working collaboratively with its employees. This transformation represents a continuous process of innovation and improvement, with the goal of making Amazon's operations more efficient, safer for employees, and more responsive to customer needs. Amazon's automated warehouse and shipping network ranks as the largest and most advanced globally, with the capability to process and dispatch millions of orders daily with remarkable speed and precision.

4. Lessons for Vietnamese e-commerce enterprises

4.1. Current warehouse management of Vietnamese e-commerce enterprises

4.1.1. Current situation of the application of automation in big e-commerce enterprises in Vietnam

In Vietnam, e-commerce enterprises have adopted automation in their warehouse management and are in the race of warehouse automation to improve efficiency and customer experience. For example, Shopee, one of the leading e-commerce companies in Vietnam, utilizes an integrated WMS analyzing delivery locations, classifies goods, and arranges them in warehouses, with an accuracy of up to 99.97%, thanks to the automatic goods classification system (ASM). Lazada in 2023 established the Lazada Logistics Park with a Merchandize Sorting Center, capable of handling 1 million daily deliveries. The center uses AI and machine learning, achieving a 99% automation rate, enhancing warehouse efficiency and meeting the increasing buyer demand. (Thanh Luan, 2023).

4.1.2. Challenges of technology application in Vietnamese e-commerce enterprises' warehouse management system

Though the warehouse management system of Vietnamese e-commerce enterprises is improving day by day, there are still many challenges harming the further development of e-commerce supply chain management, particularly the warehouse efficiency.

- *Lack of skilled labor in warehouse management:* In Vietnam logistics, the survey results of the Ho Chi Minh City Institute for Research and Development show that up to 53.3% of businesses lack a team of staff with professional qualifications and logistics knowledge; 30% of businesses have to retrain their employees, and only 6.7% of businesses are satisfied with the professional qualifications of their employees, especially staff from SMEs (Thuy Duong, 2023).

- *Insufficient automation warehouse:* As for the increase in demand, the fulfillment rate of logistics warehouses usually passes 90% (Moc Minh, 2022). Currently, Vietnam is considered to still have a shortage of logistics warehouses. The reason is that the rental price for industrial land is still quite high because rental demand is still increasing strongly, while land funds for rent in industrial zones are becoming more and more scarce (The Vinh, 2023).

- *Cost barrier:* With traditional automation, investment costs are high and available space continues to be a major drawback for many warehouse operations. For example, the cost of setting up robots for an average warehouse operation ranges from $2-4 million for 50-100 robots, from $15-20 million for 500-1000 robots in a large warehouse operation, which is a significantly high amount to invest, according to research from BIS Research (Tan Phat Automation, 2023).

In conclusion, the current application of technology in warehouse management of Vietnam e-commerce indicates a great step towards development still with challenges. Applying the level of Amazon warehouse automation on Vietnam's current scale, Vietnam's automation picture now seems to be equivalent to the case of Amazon by the year 2012. Although there is an advance in warehouse automatic management by intelligent systems such as belts, conveys, sorting and packing systems, robotic systems,... besides highly technology invested ones, the level of manual processing is still high in warehouses. And Vietnamese enterprises' warehouses have not been able to develop sophisticated systems of robotics, machine learning, and AI relative to Amazon, as there is little research introducing the mentioned technologies.

4.2. Recommendations on improving warehouse management for Vietnamese enterprises

After researching and analyzing the automation in warehouse management of Amazon, compared with the current case of Vietnam, the authors recommend some solutions to improve the warehouse management for Vietnamese e-commerce enterprises.

4.2.1. Implement automation system in warehouse management

Using cloud-based WMS: The WMS (Warehouse Management System) is a popular warehousing solution in Vietnam and is applied by many big companies in e-commerce. In Vietnam, the big e-commerce companies are widely using WMS in their warehouse management, for example Shopee, Lazada. Many companies have solutions for a management system but a large portion of 38.6% companies being surveyed shows little information. As Amazon's key factor to success is AWS (Amazon Web System), the big firm should adopt a system to manage the warehouses.

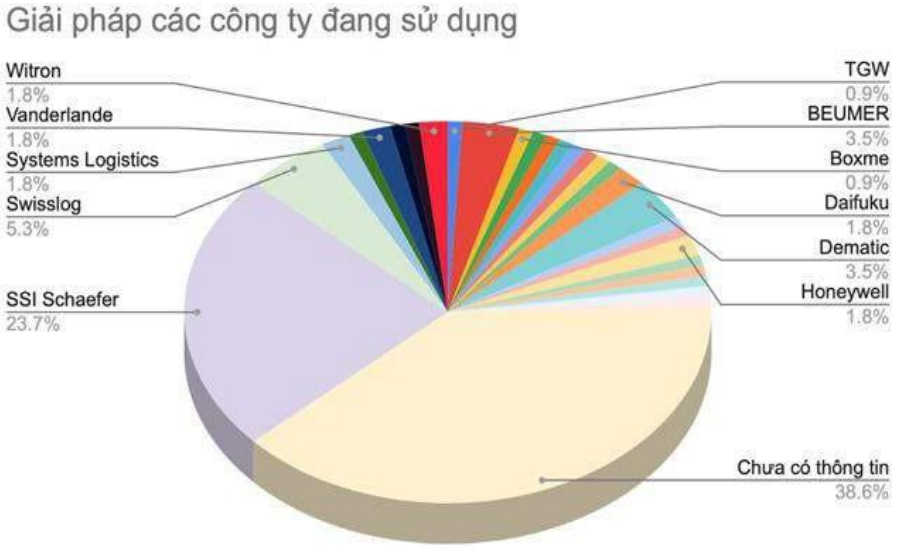

Figure 14: Solutions for warehouse management of logistics companies Source: HOPEE, 2023

Robotics application in warehouse management: Many big firms in Vietnam such as Shopee, Lazada, Tiki..., as mentioned above, have already used robotic systems in warehouses. This obviously shows the increase of efficiency in the process of warehouse tasks, cut costs and time way more than traditional manual methods. It is also important to learn from the experts to develop a modern system of robots for specific warehouse tasks. The market for warehouse automation is prevailing in Vietnam and making steps towards global technologies. As learning exactly from Amazon's intelligent and complicated robotic system is difficult, there are several robots that can serve simple tasks, which are popularly applied in warehouses and suits current potential of Vietnam

- Cobot: collaborating with human to complete labor-required or single task
- Autonomous Mobile Robot: automatic moving goods on pallet
- Autonomous Guided Vehicle: autonomous moving the goods

4.2.2. Training staff on using new technologies

Staff quality is very important in the planning, implementation and controlling of automation. Enterprises should train the available staff focusing on core professions to apply modern automation technologies and recruit experts in automation, robotics, AI or machine learning.

5. Conclusion

This research paper has analyzed the process and effectiveness of the applications of automated management systems inside Amazon warehouses, as well as providing some recommendations for Vietnamese e-commerce enterprises in order to achieve the level of

success of Amazon's supply chain. The automation of Amazon's warehouses holds great promise for bolstering the supply chain's resilience. This resilience is crucial, especially in light of the challenges posed by the COVID-19 pandemic and other global upheavals. The benefits observed in terms of increased efficiency, optimized inventory management, contributing to a more streamlined and cost-effective operation, suggests that these technologies have revolutionized supply chain management and drive competitive advantages, especially in the case of Amazon.

After analyzing the practical case of Amazon, the author proposes that Vietnamese corporations use cloud-based WMS technology for warehouse automation and focus on proper training of their human resources.

References

Amazon (2022), "Look back on 10 years of Amazon robotics", *US About Amazon*, Available at: https://www.aboutamazon.com/news/operations/10-years-of-amazon-robotics-how-robots-help-sort-packages-move-product-and-improve-safety (Accessed 10 April 2020).

Amazon (2024), "Who we are", *Amazon*, Available at: https://www.aboutamazon.com/about-us.

Bajaj, S. (2024), "Warehouse Automation: Definition, Types, Benefits & Best Practices", *SoftwareSuggest Blog*, Available at: https://www.softwaresuggest.com/blog/warehouse-automation/.

DC VELOCITY (2023), "Amazon tests latest warehouse fulfillment robot models, Sequoia and Digit", *DC Velocity*, Available at: https://www.dcvelocity.com/articles/58906-amazon-tests-latest-warehouse-fulfillment-robot-models-sequoia-and-digit.

Del Rey, J. (2019), "Amazon's warehouse robots and their complicated impact on workers", *Vox*, Available at: https://www.vox.com/recode/2019/12/11/20982652/robots-amazon-warehouse-jobs-automation.

ETEK (2023), "Warehouse automation: Trend forecast for 2023", Available at: https://tpa-fas.com.vn/Tin/tu-dong-hoa-kho-hang-du-bao-xu-huong-nam-2023.

Flexport Editorial Team. (2022), "Traditional Versus Modern Supply Chain Management", *Flexport Blog*, Available at: https://www.flexport.com/blog/traditional-versus-modern-supply-chain-management/.

Gamio, L. & Goodman, P.S. (2021), "How the Supply Chain Crisis Unfolded", *The New York Times*, 6 Dec. Available at: https://www.nytimes.com/interactive/2021/12/05/business/economy/supply-chain.html.

Hansell, S. (2002), "Amazon Ships to a Sorting Machine's Beat", *The New York Times*, Available at: https://www.nytimes.com/2002/01/21/business/technology-amazon-ships-to-a-sorting-machine-s-beat.html.

HOPEE (2023), "Assessing Warehouse Management Systems in Vietnam: A HOPEE's Report", Available at: https://hopee.com.vn/blog/report/assessing-warehouse-management-systems-in-vietnam-a-hopees-report/

Jenkins, A. (2020), "How to Manage Your Warehouse", *Oracle NetSuite*, Available at: https://www.netsuite.com/portal/resource/articles/erp/warehouse-management.shtml.

Jenkins, A. (2020), "Warehouse Automation: The How, When & Why", *Oracle NetSuite*, Available at: https://www.netsuite.com/portal/resource/articles/inventory-management/warehouse-automation.shtml.

Jun, Nguyen. (2023), "Quản lý chuỗi cung ứng là gì? Phân biệt SCM và logistics", *Công ty Cổ phần Công nghệ Viindoo*, Available at: https://viindoo.com/vi/blog/quan-tri-doanh-nghiep-3/quan-ly-chuoi-cung-ung-la-gi-.

Kantrowitz, A. (2020), "How Amazon Automated Work and Put Its People to Better Use", *Harvard Business Review*, Available at: https://hbr.org/2020/09/how-amazon-automated-work-and-put-its-people-to-better-use.

Ken (2021), "All About Being an Amazon Stow Associate – Warehouse.ninja", *warehouse.ninja*, Available at: https://warehouse.ninja/all-about-being-an-amazon-stow-associate/.

Khan, M. (2023), "How Amazon Robotics is Revolutionizing the Fulfillment Industry", *LinkedIn*, Available at: https://www.linkedin.com/pulse/how-amazon-robotics-revolutionizing-fulfillment-industry-maaz-khan-/

Koizumi , H. & Ishio, C. (2021), "Build a graph application with Amazon Neptune and AWS Amplify", *AWS Database Blog*, Available at: https://aws.amazon.com/blogs/database/build-a-graph-application-with-amazon-neptune-and-aws-amplify/.

Laber, J., Thamma, R. & Kirby, E. (2020), "The Impact of Warehouse Automation in Amazon's Success", *IJISET - International Journal of Innovative Science, Engineering & Technology*, 7(8), Available at: https://ijiset.com/vol7/v7s8/IJISET_V7_I8_07.pdf.

Line, F. (n.d.), "Amazon FBA & SFP Preparation & Fulfilment", *Finishing Line UK*, Available at: https://www.finishingline.co.uk/what-we-do/amazon-fba-sfp-preparation-fulfilment/.

Lui, J., Narsalay, R., Afzal, R., Sharma, I.N. & Light, D. (2022), "Research: How Do Warehouse Workers Feel About Automation?", *Harvard Business Review*, Available at: https://hbr.org/2022/02/research-how-do-warehouse-workers-feel-about-automation.

Macrotrends (2023), "Amazon Revenue 2006-2023 | AMZN", *Macrotrends.net*, Available at: https://www.macrotrends.net/stocks/charts/AMZN/amazon/revenue.

Mitrofanskiy, K. (2023), "Warehouse Automation Technology In Supply Chains", *Intellisoft*, Available at: https://intellisoft.io/warehouse-automation-systems-revolutionizing-supply-chains-for-unprecedented-efficiency/.

Moc Minh (2022), "The need for warehouse storage continues to increase sharply", *VN Economy*, Available at: https://vneconomy.vn/nhu-cau-kho-tru-hang-lien-tuc-tang-manh.htm.

Patel, A. (2021), "AWS — Amazon Aurora Overview", *Awesome Cloud*, Available at: https://medium.com/awesome-cloud/aws-amazon-aurora-overview-what-is-amazon-aurora-rds-introduction-f6f2e053bc62.

Placek, M. (2024), "Warehouse automation market size 2012-2026", *Statista*, Available at: https://www.statista.com/statistics/1094202/global-warehouse-automation-market-size/.

Quinlivan, J. (2023), "How Amazon deploys collaborative robots in its operations to benefit employees and customers", *US About Amazon*, Available at: https://www.aboutamazon.com/news/operations/how-amazon-deploys-robots-in-its-operations-facilities.

Riemann, C. & Johnson, W. (2023), "Closing the Gap on Warehouse Automation", *Deloitte United States*, Available at: https://www2.deloitte.com/us/en/blog/business-operations-room-blog/2022/closing-the-gap-on-automated-warehousing.html.

Robotics, V. (2023), "Warehouse Automation Statistics: The State of the Market in 2023", *Vecna Robotics*, Available at: https://www.vecnarobotics.com/resources/warehouse-automation-statistics/.

SCDigest (2017), "Supply Chain News: Amazon Receives Patent for Packing Robot Concept that would Work in Tandem with Human Order Pickers", *www.scdigest.com*, Available at: https://www.scdigest.com/ontarget/17-02-21-1.php?cid=11987.

Sunol, H. (2022), "Types of Warehouse Automation to Increase Productivity", *articles.cyzerg.com*, Available at: https://articles.cyzerg.com/8-types-of-warehouse-automation-to-increase-productivity.

Takeuchi, Y. (2024), "History of e-commerce: The rise of warehouse robotics and automation", *Medium*, Available at: https://yodai.medium.com/history-of-e-commerce-the-rise-of-warehouse-robotics-and-automation-13036ddbd4ef#:~=The%20year%202012%20was%20a.

Thanh Luan (2023), "Lazada Logistics inaugurated an automatic goods sorting center in Binh Duong", *Young People's News*, Available at: https://thanhnien.vn/lazada-logistics-khanh-thanh-trung-tam-phan-loai-hang-hoa-tu-dong-tai-binh-duong-185230323163214429.htm

The Vinh (2023), "Fierce 'war' for market share in warehousing and logistics services", *VN Business*, Available at: https://vnbusiness.vn/viet-nam/khoc-liet-cuoc-chien-gianh-mieng-banh-thi-phan-kho-bai-va-dich-vu-logistics-1095645.html

THL. (2023), "The World at our Fingertips: How Automation Fuels E-Commerce", Available at: https://thl.com/articles/ep-5-automation-in-action-the-world-at-our-fingertips-how-automation-fuels-e-commerce/

Thuy Duong (2023), "Vietnam's logistics industry needs to focus on human resources", *Vietnam Logistics Review*, Available at: https://vlr.vn/vietnam-s-logistics-industry-needs-to-focus-on-human-resources-13324.html

Unicommerce, T. (2022), "Top 10 Reasons Why a Warehouse Management System is Important for Supply Chain", *unicommerce.com*, 25 Nov. Available at: https://unicommerce.com/blog/top-reasons-why-warehouse-management-system-is-important-for-supply-chain/.

Wessling, B. (2022), "How Amazon developed precision autonomy for Proteus", *The Robot Report*, Available at: https://www.therobotreport.com/how-amazon-developed-precision-autonomy-for-proteus/.

Zhou, A. (2023), "Advancements in Warehouse Automation Systems", *GoFreight*, Available at: https://www.gofreight.com/blog/industry-insights/advancements-in-warehouse-automation-systems.html