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Possibilities of Augmented Reality in Intralogistics in Vietnam

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<p>The target of this thesis is to study how augmented reality (AR) can streamline warehousing processes and intralogistics solutions in logistics companies operating in Vietnam. Although AR technology has become widely common in some industries such as video game and medical science, this has not yet been the case in logistics. Comprehending the technology application to logistics, therefore, is challenging, yet intriguing. Interviews with six logistics managers have been conducted regarding warehouse activities, plus there was an inspiring trip to an actual warehouse.</p> <p>Theoretical framework of this thesis is built on the general observations of Vietnamese logistics industry as well as practical opportunities and challenges. Most important socio-economic and technological trends and innovations in logistics are introduced as well more detailed information about augmented reality and how it is applied to intralogistics.</p> <p>This thesis is based on a qualitative research and the main methodological approach is conducting structured interviews in 6 companies from April to June 2020. Target of the data analysis was to form a better idea of the activities in warehouses in Vietnam at the moment, how and where in the process AR technologies could be utilized and the level of willingness of the warehouse managers to implement this kind of technology in the future.</p> <p>The last part of thesis gives some recommendations of AR implementation to some companies in the survey. This is essential when the competition among these companies has become more intense. The findings might, therefore, be applied to other companies in the industry and even to the ones outside Vietnam</p>	
Keywords	Warehouse Operations, Warehouse Activities, Augmented Reality, AR, Intralogistics, Intralogistics Solutions

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1 Introduction

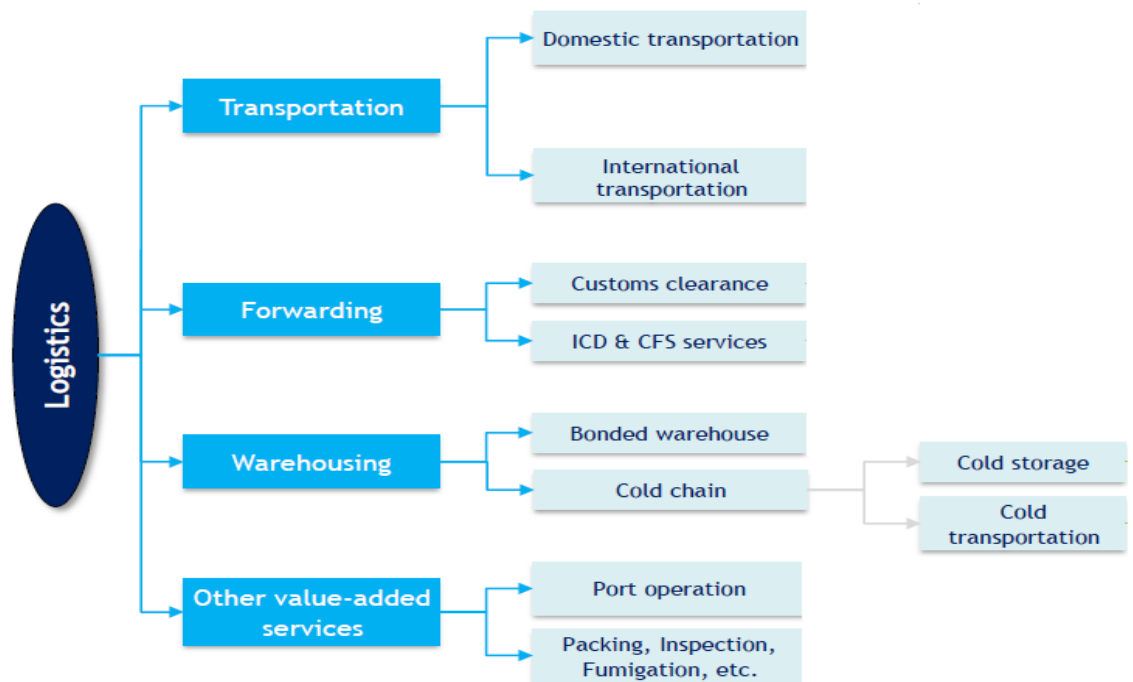
As a part of supply chain management, logistics involves the process of planning and monitoring the resources from the point of origin to the point of consumption. Logistics was defined primarily as a branch of military science (Oxford English Dictionary); however, it becomes the branch of engineering improving people system nowadays. Its primary purpose is to improve the efficiency in transportation and storage the resources with the support of technology advancements. (Michigan State University 2019).

With the rapid increase of trade agreements among several countries around the world, logistics has become the key industry creating the multi-cultural markets, in which the commercial suppliers can keep pace with the demand of customers in other countries and extend its market share globally. According to Research and Markets 2019, the report of "Logistics Market: Global Industry Trends, Share, Size, Growth, Opportunity and Forecast 2019-2024", the total value of logistic market in global was US\$ 4,730 billion in 2018 and is expected to increase up to US\$ 6,300 billion by 2024 (Research and Markets 2019).

1.1 Logistics industry in Vietnam

Vietnam is a developing country, which has high demand for logistics since its strategy is to improve the import and export business of its agricultural and industrial products. It is seen that this can lead to many opportunities for logistics industry in the coming years. Beside China, Vietnam is also known as an important country whose manufacturing has been outsourced. Therefore, more and more foreign companies have a desire to penetrate this promising market. This development leads to the growth of warehousing and transporting services. Although there are many constraints related to the infrastructure of the underdeveloped Vietnamese logistics service market and higher logistics service costs than what the foreign competitors offer, there is still great potential

for those Vietnamese logistics service providers, which are capable of investing in innovations.



Source: FiinGroup

Figure 1. Structure of logistics sector in Vietnam (FiinGroup 2019)

It can be seen from Figure 1 that transportation, forwarding and warehousing are three main elements structured in the logistics sector in Vietnam (FiinGroup 2019). Specifically, forwarding is the segment that local logistics companies are proactively performing most while transportation segment is penetrated more by the large international players such as Maersk Logistics or NYK Logistics. Moreover, warehousing segment with cold chain storing and transportation are the most attractive categories for both domestic and foreign enterprises.

The emergence of e-commerce contributes to the improving of customers' satisfaction through value-added logistics services. Based on the report of Google and Temasek - "e-Conomy" (Le 2019), Vietnam is considered as the runner-up in the growing of the e-commerce space among countries with the expectation to reach US\$ 15 million by 2025. Many large companies such as Lazada, Amazon and eBay have attempted to enter Vietnamese market in the recent years. Along with the increasing number of foreign enterprises, many domestic business-to-customer (B2C) e-commerce companies such as

Tiki, Giao Hang Nhanh have been established and they provide their own warehouses and aim at offering better experiences of logistics services.

According to Mr. Tran Quoc Khanh (2018), Deputy Minister of Industry and Trade in Vietnam, in addition to the higher demand of transportation services, bigger number of trade agreements and the fast pace of economic growth along with the high rate in total turnover of import and export (over US\$ 400 billion), there are a lot of opportunities for logistics industry in Vietnam. Additionally, investments to some larger ports allow ships carrying over 100 000 tons recently. Furthermore, many international flight paths have been established to meet the requirements of fast, reliable and overseas services. The more prosperous this industry becomes, the more beneficial the local people get in terms of job opportunities. This contributes to higher living standards, and saves time and money for the customers who want smooth delivery services and convenient e-commerce shopping platforms. (Customs News 2018),

In terms of the national economy, the more international companies invest in the Vietnamese market, the higher the Foreign Direct Investment (FDI) rate for Vietnamese economy becomes. What is most valuable that FDI bringing to Vietnamese market is modern technologies, experience and advantage of personnel and capital of foreign companies (Pham 2019).

Due to the speedy acceleration of both industrialization and modernization, logistics industry in Vietnam has taken a great leap forward and become an essential industry supporting other industries, especially agriculture and manufacturing. However, Vietnamese logistics companies cover only approximately 25% of the domestic demand related to the most fundamental services of the value chain by 2020. This is triggered by both internal and external challenges of those companies (Xuat Nhap Khau Le Anh 2020).

What comes to internal economic aspects, most of the domestic enterprises are small and medium-sized companies (SMEs). There are more than 3000 domestic companies in Vietnam. While 90% of the companies is SMEs with the total market value less than VND 10 billion, another 5% of them ranges between VND 10 billion and 20 billion, and the remaining has over VND 20 billion. Due to poor infrastructure and inconsistent

management systems as well as the shortcomings in capital, experience, technologies and labour qualifications, the competitiveness of the Vietnamese logistics industry is much lower compared to the global. Another disadvantage in doing business in Vietnam is high logistics service costs, which are around 21 to 23 % of GDP whereas the value of world average varies from 12 to 14 % of GDP. This has led to higher prices of the Vietnamese products and services (Research and market 2019).

Turning to the external challenges, the threats come from the rivals, trading agreements with other countries and natural decrease and workforce. Firstly, the most concerning rivals are foreign logistics companies like DHL and Maersk, which have state-of-the-art technologies and can offer reasonable transportation fees due to professional management of logistics processes. Therefore, they dominate the Vietnamese logistics market by gaining over 70% of the total revenue of the market (Research and market 2019). Secondly, the risk might occur due to the restrictions for the quality of the imported and exported products. Thirdly, there are trading limitations due to the pandemic. To be specific, Covid-19, also known as Coronavirus, is spreading around the world since the beginning of 2020, which causes negative effects on the global economy and Vietnam is not an exception. Viet Nam News 2020 reported that agricultural products such as durian, sweet potato and dragon fruits could not be exported to China during the Coronavirus, which triggered the high rate of inventory and the reduction of prices. Finally, Vietnam is known as the source of labour. However, in most universities and colleges in Vietnam, logistics is not offered as a major. This has led to insufficient training and lack of skills and knowledge about international trading regulations (Xuat Nhap Khau Le Anh 2020). As a consequence, these risks can cause extreme losses for logistics industry specifically and to the whole economy in general.

1.2 Research objectives and scope

The general objective of this thesis is to provide an overview of the Vietnamese logistics market with both opportunities and obstacles for domestic and foreign firms, and then to conduct a research among Vietnamese logistics industry to provide better understanding of the current status of the infrastructure, operations and the opportunities to develop the industry with help or new technology. The main objective of the thesis was to focus on how technologies like Augmented Reality (AR) are applied in intralogistics to optimize warehousing, and achieve better productivity and efficiency of the logistics processes.

Augmented Reality devices can be used in any functional departments of whichever industry to streamline the effectiveness of the operations. Regardless of its large scale in use, the scope of this research is narrowed down to spacing inside warehouses, which involves in all of the fundamental activities such as the procedure of receiving and delivering parcels as well as picking, packing and storing.

This thesis consists of qualitative method and analysis of secondary and primary data sources. Secondary data sources such as academic books, e-books, official websites and reliable reports are used to provide reliable information about the logistics sector in general and in Vietnam. Six logistics companies were chosen based on scales, including three domestics and three internationals, to be examined more closely. The managers and staff members working in the warehouses of these companies were invited to an online interview in their spare time to collect more practical information about the current status of the companies and of the development needs as well as their opinions about new intralogistics technologies, especially the augmented reality. More detailed questions asked in the interview can be found in Appendix 1. The research results are analysed in more detail in chapter 7.

Only one interview was conducted in each company and the target interviewees were managers and perennial workers as they have deep understanding about the process of their companies. Main interview questions can be summarised based on the research objectives:

- Which warehousing technologies are currently used in the logistics companies in Vietnam?
- Which activity occupies the highest cost and effort of warehouse operation?
- What benefits could new technologies like AR bring to the warehousing activities?
- What are the main challenges in applying new technology?
- How could these challenges be overcome?

1.3 Methodology

In literature review reliable articles and reports and scientific search engines were utilized. One of the most useful engines is Google Scholar allowing to access scientific articles freely. Moreover, Coc Coc is also a locally helpful search engine to figure out the

information of Vietnamese companies. Additionally, company reports, feasibly accessed from the websites, cover the company profiles and press releases associating to technologies, innovations and financial statements. The main keywords applied to reach the appropriate information were: "augmented reality", "Vietnamese logistics companies", "augmented reality in warehousing", "warehouse activities", "warehouse operations", "intralogistics", "immersive wearable devices", "AR devices". As a result of this search some articles and reports were found and are referred to. Regarding analysis part, interviews were conducted to examine how augmented reality affects warehouse operations in both domestic and international logistics firms in Vietnam. The data, consequently, was collected and the opportunities and challenges in upgrading their processes were analysed.

During my time in Vietnam, I had a chance to visit a local medium-scale warehouse located in the rural of Ho Chi Minh City. The warehouse manager showed the working process and explained each stage in detail for the visitors to help to gain more understanding. Moreover, it is considerably useful to have discussion and idea sharing with the staff as primary data of their assigned tasks and solutions to unexpected problems. Therefore, representatives of six logistics companies in Vietnam were interviewed to get a deeper insight. Specifically, I have interviewed one operation director of company A, one vice director of company Y, one senior worker of company Z, one assistant manager of company X and two warehouse managers of the remaining companies. Most of the interviews last from 30 to 45 minutes. The language used is mainly Vietnamese and only the interview with Mr. J from company Y was conducted in English. Due to the ongoing pandemic of coronavirus, the interviews could only be implemented online via Skype and Zoom applications with a list of questions related to company scales, their current technologies and their perspective of AR advancements (See Appendix 1 for more detailed interview questions).

1.3.1 Reliability and Validity

Reliability relates to the consistency of a measurable method and involves in three types: test-retest reliability measures the consistency of a construct to ensure that it will not change across time; internal consistency reliability means the consistent responses of people across different questions about a topic and inter-rater reliability refers to the consistent judgments and comments among various observers to an issue (Carmines & Zeller 1991).

To ensure the reliability of this research, I tried to approach the relevant interviewees who have been willing to give accurate and detailed answers with their real experiences. Moreover, the reliability is enhanced when most interviewees are willing to show their companies' reports and news related to their operations, which have been public on their websites. However, the result might be changed across the time. In reality, the companies are able to be more developed and broadened their scales due to the potential of this industry in the coming years. Hence, their operation could be modified to be suitable for their customer needs. Furthermore, since only one interview per company, the internal consistency reliability and inter-rater reliability could not be evaluated in different perspectives. Additionally, some collected data related to the warehouse activities was just estimates made by the interviewees without the accurate statistic reports due to the confidentiality.

Validity is the accuracy of a measure and it consists of three fundamental types: face validity relates to the shape of a research such as lay-out and arrangement (Robson 2010); content validity means the research should involve enough important contents in order to generate the accurate results (Carmines & Zeller 1991); criterion validity is the measurable method for testing the consistency between the current result and the objective result which matched with the gold standard (calculated by the correlation coefficient of both results from two different methods) (Robson 2010).

In terms of validity aspect, the research has two clear main parts, consists of literature review and results of analysis with some recommendations. Moreover, a meticulous preparation of question list was made with as many questions as possible to ensure that no critical information is missing. Although there are only six samples, the result reflects the current situation of logistics companies in Vietnam, in which the science and technologies have not been developed as expected.

2 Trends and innovations in the logistics industry

It is undeniable that fast pace of technological innovation and the diversity of technology advancements has significantly contributed to the development of many industries, and logistics is definitely not an exception. DHL Logistics Trend Radar 2018/2019 (see Figure 2) indicates how logistics industry is impacted by social, business and technological trends and what those trends are.

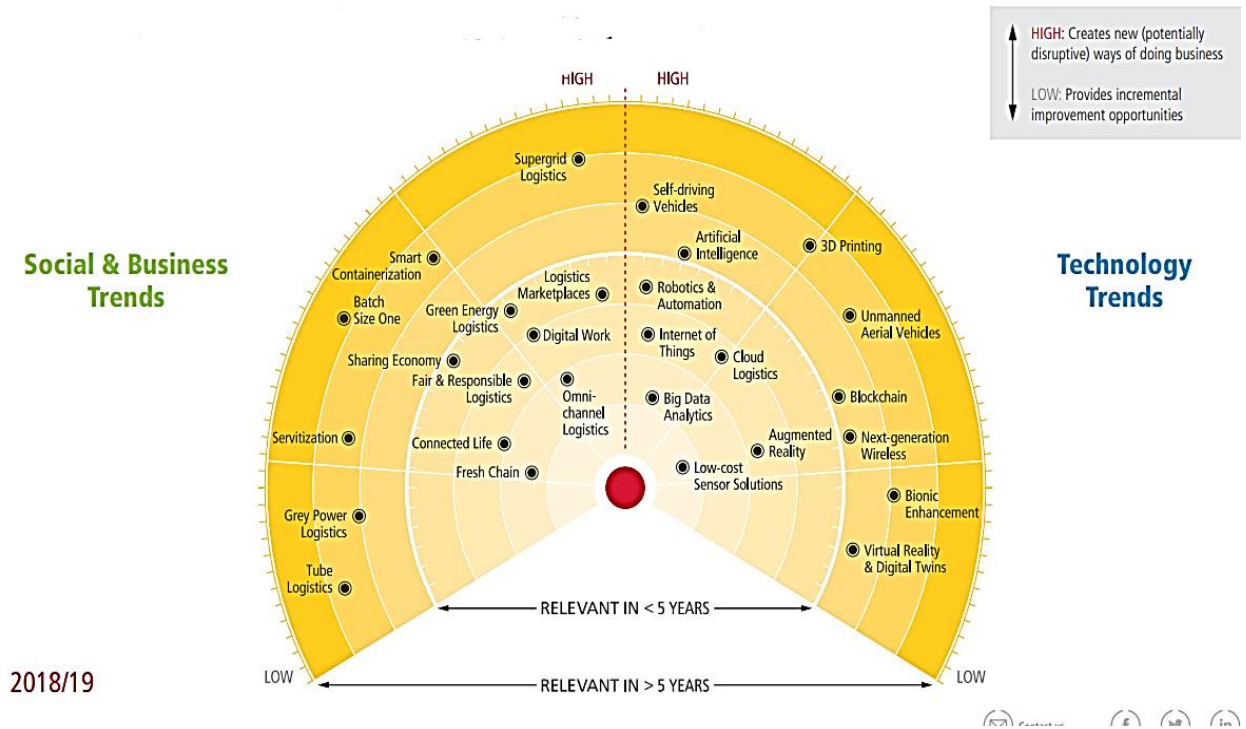


Figure 2. Logistics trends radar (DHL 2018)

By synthesizing four main sources of Megatrends, Microtrends and Start-ups, DHL customers, as well as Industry Experts and Research Partners, several trends have been eliminated or combined in this latest edition. Recently, the Logistics trends can be divided into two main groups: Social & Business trends and Technology trends, which contribute to the revolution of Logistics industry with lots of innovative inventions (DHL 2018)

2.1 Social & business trends

Social & business trends involve several evolutions that have already been emerged in Logistics industry such as connected life, fresh chain, grey power logistics, logistics marketplaces, sharing economy and so on. To be more specific, logistics radar trends report has clearly showed how those trends have developed.

With the “always-connected” lifestyle nowadays, connected life trends has been creating a great number of chances for Logistics industry to optimize the process of delivery, picking-up or warehouse as well as to enhance the satisfaction of customers. For instance, to eliminate the inconveniences in delivery service such as missing or late deliveries, most of suppliers has applied tracking system as a useful platform that allows customers to track their parcels and estimate the lead time for picking-up. Moreover, smart devices can monitor and predict the leverage of products, which are automatically replenished when goods are at the emergency level of low stock. This kind of technologies is appropriate to be applied in warehousing. In spite of the benefits of increasing transparency and saving costs, there are still the challenges of database privacy and complicated adoption (DHL 2018).

Quality management has become an essential factor of online shopping, especially for groceries and food deliveries. Along with the significant growth in the demand of online shopping during these recent years, is the expectation in fresh chain solutions for improving the quality of groceries and opening new business opportunities such as enhancing the quality of fresh food by packing items with the innovation called temperature-controlled packaging, which controls the humidity, oxygen and pressure keeping the freshness of food. However, the shipping fee might be costly due to the complexity of supply chains (DHL 2018).

According to the DHL report (2018) the population aging is getting older in the following decades, especially the share of those born in the 60´s will reach approximately 25 % of the world´s population by 2050. Under that circumstance, grey power logistics trend concentrates on creating values to serve this key customer by providing logistics services delivering medicine with online prescriptions or establishing a user-friendly shopping platform, where the elderly can find any utilities they need in the area of shopping, entertaining, healthcare and so on.

Sharing economy is a trend that has been used widely during the past few years. A well-known example of sharing economy is famous mobility companies like Uber and Grab. Sharing economy creates various valuable benefits for the users with better cost of transportation and delivery as well as reduces the harmful carbon footprint emitted into the environment by sharing the assets. Moreover, it also widens the functions of

delivering, which involves not only the transportation of human, but also of goods in general. In addition, the parcels can easily be tracked by using mobile applications, hence helps to avoid non-transparency (DHL 2018).

2.2 Technology trends

Technology has become the mainstream in our daily life, which shapes our future and makes life easier. Imagining that without technology innovations, everything will be out of track. For instance, long-distance travelling is impossible without aircrafts, cruises or trains and the relationship between people will be apart without keeping in touch through smart phones or communication platforms. In terms of logistics field, a huge number of new values have been brought to businesses for recent years with the development of robotics & automation, artificial intelligence, blockchain, reality, and so on.

To pursue the effectiveness of process in warehouses well as to boost the productivity in procurement and supports the workers in some complex activities, the trend of robotics & automation has brought an intralogistics solution with the automatic robots that support workers in picking, packing, sorting as well as analysing the information of each parcel. Hence, this innovation benefits the businesses with cost efficiency, safety and health improvement for workforces. In practical, DHL in the US has already developed an order fulfilment robotics solution, which increases double of productivity in warehousing (DHL 2018).

Artificial intelligence (AI) is defined as a programmed machine has human intelligence with the aims of learning, reasoning and perception, developed by the basis of big data and internet of things. Also, it is used in diverse industries to solve both simple and complex tasks. For instance, updating customer information to ensure the delivery process work smoothly, enhancing customer satisfaction and experience by automatic chatbot applications, or forecasting and planning the inventories to make sure warehouses have the minimum level of merchandises to catch the demand of customers. Beside its benefits, it requires high capital cost to invest in implementing and improving AI systems (Frankenfield 2020).

Blockchains are one of the most globally impacted trends, which goes along with the initial largest cryptocurrency named Bitcoin. Additionally, it is a trusted and transparent system that helps to avoid the errors and maximise the customer satisfaction by allowing

related parties involve in the supply chain from viewing the good process to checking status of trading documents such as digitalized bill of lading. Moreover, DHL and its partners already applied blockchain technology in identifying counterfeit drugs, which ensure the quality of the medicines from the factories to the end-consumers and enable the customer to check it via the system (DHL 2018).

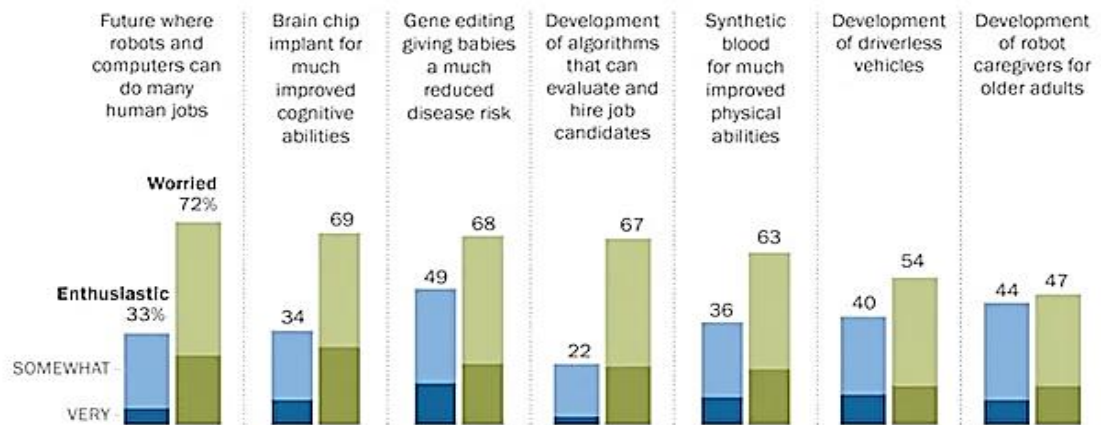
The combination of artificial intelligence with the sensors and vision technologies has contributed to developing self-driving vehicles trend that upgrades the traditional transportation to the new levels of efficiency, quality and safety. To be more specific, autonomous vehicles such as automated stackers, pallet trucks and forklifts, has already been applied in warehouses of Amazon. Hence, they help to minimise labour cost by extending working time up to 24/7 with lower cost in maintenance as well as reduce carbon emission by using green fuel. However, they still face the challenge of safety due to the fraud in coding, which can trigger dangerous consequences (DHL 2018).

The development of technology always goes along with the altering of human behaviours as its advancements have become an essential part in human lives as well as made our life more convenient by supporting us in every daily task. However, Technology is a double-edge sword, which has both negative and positive impacts on human behaviours, especially children if we do not control and use it in the smart way.

Beside the physical influences, our behaviours toward mental problems are our most concern. The first issue is about our attention span, which went down from 12 seconds to 8 seconds according to recent research. This decrease occurs due to the variety distracted options, coming from technology tools such as mobile phone and laptop. Secondly, our ability in memorize would be reduced due to the reliance on available sources of information through the Internet. Moreover, the way people are building relationship has also been changed. In fact, it is easier to keep-in-touch with friends and

relatives around the world; however, the lack of face-to-face meetings cannot eliminate our loneliness in some situations (Walden University 2020).

% of U.S. adults who say they are enthusiastic or worried about ...



Note: Respondents who gave other responses or who did not give an answer are not shown.

Source: Surveys conducted March 2-28, 2016 and May 1-15, 2017.

From "U.S. Public Wary of Biomedical Technologies to 'Enhance' Human Abilities" and "Automation in Everyday Life"

PEW RESEARCH CENTER

Figure 3. The reaction of US adults towards technology advancements (PEW research center 2016).

According to the survey that was conducted between March 2nd and the 28th 2016 and May 1st and 15th 2017 about the reactions of the US adults to seven features of technology advancements. Surprisingly, more worry than enthusiasm due to the unexpected consequences from the very newness of technologies. Moreover, they believed that human abilities outstrip the performance of algorithms, which means the machine cannot estimate and measure the emotional intelligence and intangible assets. However, the technology supporters argued that the worry will be relieved if people get used to using them. Furthermore, they are positive about the future that technologies bring to us. For instance, some of the jobs that have hazardous or "dirty" environment should be replaced by automatic robots. The development of gene editing would contribute to avoiding serious illnesses for babies. In brief, the goal of technologies is bringing the better life for human and by acknowledging the drawbacks, we will know how to maximise its efficiency and continue to improve it (Funk, Rainie & Smith 2018).

3 Augmented Reality (AR)

Apart from Virtual Reality (VR), which is the digital technology that creates a completely simulated environment with full auditory and visual functions, Augmented Reality is considered to be a digital interface, integrating the real-world environment with virtual layers to enhance the valuable experience of interaction between human and objects (Cappgemini 2018). AR is one of the technology trends that raises our life to a higher standard with its benefits in a variety of industries from manufacturing to aviation industry. Figure 4 shows the global AR revenue in the period of 2012-2017 in different market segments (Glockner, Jannek, Mahn & Theis 2014).

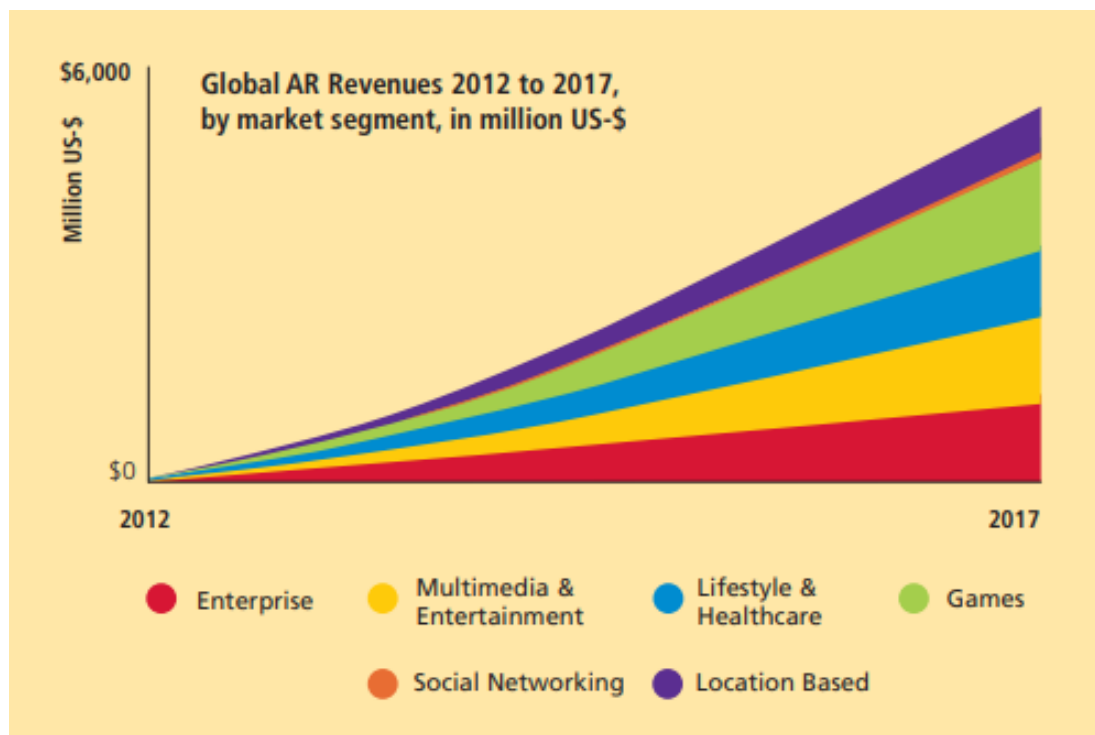


Figure 4. Global AR revenues 2012-2017 (Glockner, Jannek, Mahn & Theis 2014)

Market value of immersive technology is predicted to reach the amount of US\$ 108 billion by 2021 with approximately 80% of market share belonging to AR. It is expected to expand continuously in the following years with a tidy sum of financial investments into Research & Development budgets for developing useful and practical inventions of AR technology (Ruby Garage 2020).

3.1 History of Augmented Reality

Even though the term “Augmented Reality” was first coined in the early 1990s by a Boeing researcher named Tom Caudell, the idea could be traced back to the first head-mounted AR display system invented in 1968 by Ivan Sutherland, a Harvard professor and computer scientist. A large number of AR inventions have been developed since then and they marked a momentous turning point for technological development, as described in Figure 5.

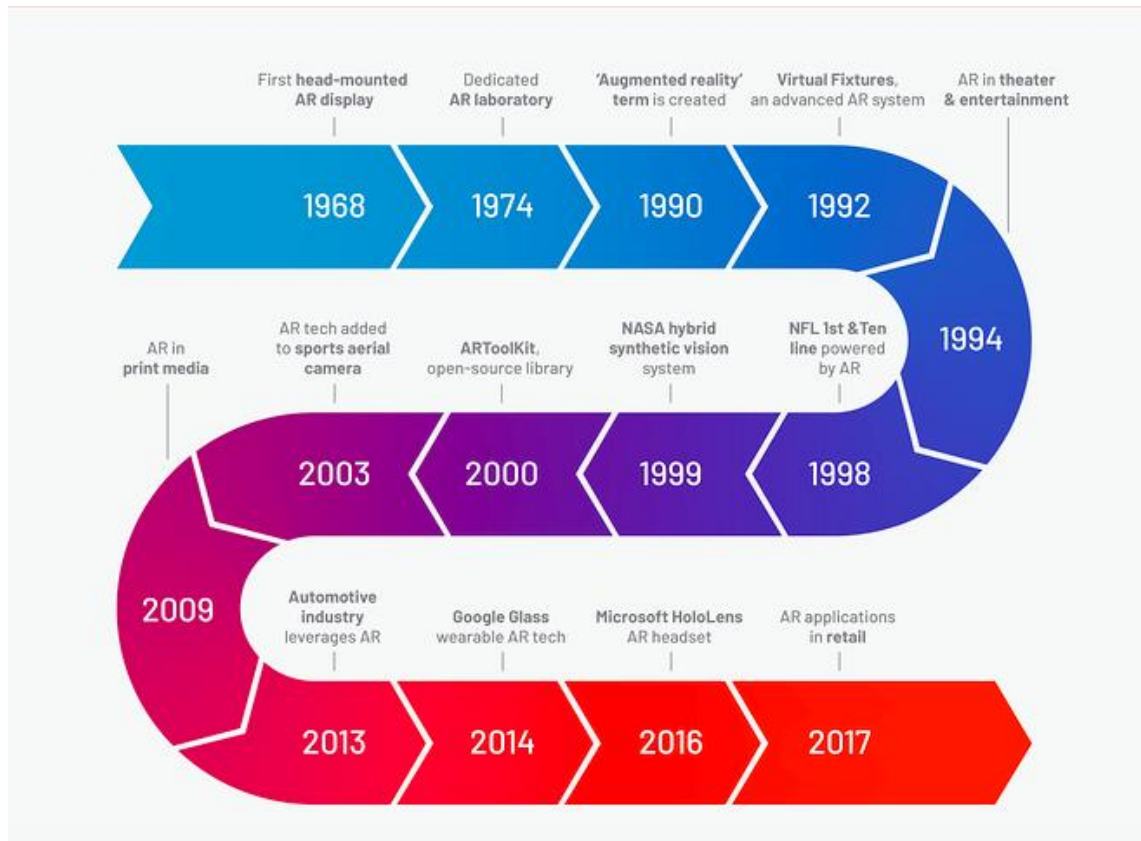


Figure 5. The history of Augmented Reality (Poetker 2019)

Since the term AR was created in 1990, the technology has been applied in diverse industries. For instance, the first functional AR systems called “Virtual Fixtures” was created in 1992 by Louis Rosenburg, known as a researcher of USAF Armstrong’s Research Lab. The system was applied for military training system, guiding US Air Force pilots in performing flying tasks in a safe way. In the next 2 years, entertainment industry fascinated the audiences with this technology by an amazing show that integrated virtual details with acrobats dancing on a physical stage. Another invention, which is still used today, is the virtual 1st & Ten graphic system, which is also defined as the yellow yard

line. It is used in super bowl games, allowing the audiences to follow the fact that which team gets a first down in advance in any climate conditions, especially on snowy days. In the end of the 90s, NASE successfully developed a hybrid synthetic vision technique for the X-38 aircraft that supported the pilots in navigating better while testing flights with detailed map data display (Poetker 2019).

Stepping to the 21st century, greater AR inventions have been created and used wisely in daily life. Starting with ARToolKit, i.e. the open-source software library developed by Hirokazu Kato, it was used to develop the AR tracking library software programs that cover real life with virtual images and graphics in order to track book flows more easily. Nine years later, Esquire Magazine made its first attempt to bring joy for the readers by making the alive magazine's pages augmented, i.e. when the cover was scanned by the AR tool, it would speak to the reader. In 2013, MARTA mobile AR application was unveiled by Volkswagen to guide the technicians in fixing the break-down systems with detailed step-by-step instructions. This innovation was a great step in utilization of AR technology, as it could be applied in diverse industries for the purpose of saving time and cost while still maintaining smooth processes. A year later, Google debuted its first Google Glass headset that connected the users to the internet so that they could have immersive experiences via Google applications such as Google Maps, Gmail, and so on. With the same idea of wearable AR devices, Microsoft developed the HoloLens on Window 10 with more functions than the Google version in 2016. Being sold at the price of US\$3,000, this innovation brought an advanced experience by creating the visual details based on the real environment, combined with the interactions through gesture, gaze and voice control and reconstructing the environment in real-time with the use of different optical and non-optical sensors. In the same year, Pokemon Go gained popularity in the gaming community due to the actualization of previous version of Pokemon games. In fact, gamers become a part of the game when their surrounding environments become the themes with the layers of virtual images of Pokemon monsters and their descriptions. In the following year, IKEA developed an AR mobile application named IKEA Place, which allows the customers to virtually furnish their spaces with IKEA products before making a purchase (Poetker 2019).



Figure 6. Hololens developed by Microsoft. (Lunden 2017)

Up to now, more and more AR inventions have been created and upgraded for contributing to the development of the humanity. With this innovation many companies have surprised their customers and exceed customer expectations.

3.2 Different types of Augmented Reality Applications

With a long period of history, "Augmented Reality" term has become commonly deployed in diverse industries these days. Due to the expansion of AR market along with its multiple useful functions, more and more companies have a desire to explore the potential of this technology and develop their own creative AR mobile application for improving their interactions with customers, enhancing customer satisfaction, and gaining a competitive advantage. In addition, there are four types of AR mobile application development, which are marker-based AR, marker-less AR, projection AR and superimposition-based AR that fit the purposes of the developers (Gupta 2019).

Image recognition or recognition-based AR is another name of marker-AR, which focuses on recognition of the objects by markers that can be considered to be a junction to connect between real world with virtual world. Supported by the increasing availability of smartphones, users are able to detect the objects with the descriptions on the screen when the phone's camera scans the markers, which are marked in the real space. Aside from that, users are capable of rotating the 3D images to observe the objects in different angles (Gupta 2019).

When it comes to ScanLife barcode scanner application, it could be viewed as a typical marker-based AR invention, which allows to scan various types of barcode such as Datamatrix or QR to get real-time information of price comparison and customer reviews from different online retailers. Additionally, ScanLife Code Management Platform was used by large companies, i.e. Coca-Cola and Volkswagen for generating promotion and discount codes for customers. Moreover, one of its commonly used functions is to create personal codes for individual contact and social networking profiles (PR Newswire 2010).

Marker-less AR, known as location-based AR, determines any parts of physical environment as the base for the virtual details and integrates with functions of smartphones to navigate the locations. This advantage mainly supports travellers by identifying their destinations as well as suggesting tourist attractions. It uses mobile GPS, accelerometer and digital compass. Moreover, some of marker-less AR systems have ability to store and generate the information about the surrounding spaces for later usage. Hence, it is preferred over marker-based AR system, and it is applied in various fields according to market demand (Levski 2017).

Layar is one of the unique AR mobile applications that use location-based AR technique as it allows other developers to add more value to the app. Apart from that, it is an easy-to-use platform with clear sections listed by name and description. Moreover, Laylar is going to expand their existing platform by merging 3D objects or audio into its layers (Roark 2009).

One of the simplest types of AR is projection AR, which is operated by directly overlaying immersive light onto flat surfaces, where users are able to interact by touching on the projected surface. Specifically, the integration between machine vision technology and visible light cameras with 3D sensing systems could create digital projections that can be displayed onto any surface of physical world. Additionally, this technique is mostly used to create the illusion of position and depth of an object for supporting the developers to deploy more AR experiences by using different virtual objects with various structures (White 2018)

Microsoft has improved its Xbox 360 gaming console by adding a motion sensor system called Kinect, which allows users to interact directly with the natural user interface

without any intermediary devices. Aside from that, Kinect was applied in a hospital in Toronto in 2011 to prevent the risks of contamination as well as delays during operations. By January 3 2011, it was recorded as the fastest-selling consumer electronic device by the Guinness World Record due to the sales of 80 million units within two months (Rouse 2011).

Superimposition-based AR is implemented based on the entire or partial replacement of original images with virtual images for providing an “alternate” view of the target objects. This technique is widely applied in medical field, especially to superimpose an X-ray on bodies of patients. Moreover, this technology has been used in an exhibition to create value-added for the artefacts with historical descriptions and structural details. (Karnes 2018)

3.3 Use of Augmented Reality

A huge number of AR innovations with their perks have been clarified based on types of AR technology. However, most people thought that AR inventions mainly concentrated on entertainment and games industries. In fact, many industries such as medical sciences, engineering, education and even military benefited from them as well. In this part, that how AR is making some modifications to itself to catch up with the new information demand in our lives and what we can expect from it in coming years, will be described. Noted that this part will not involve the innovations of AR in Logistics or Supply Chain Management since it will be described in details in part 5.

Military

AR has been adopted in military mostly for training purposes. By creating immersive simulations of dangerous situations, such as bomb disposals, battlefield combats and aircraft flights, safety is maximised by removing the risk of death and injury, and it is also less costly than the traditional training methods. Furthermore, battlefield medical response simulations train soldiers on how to react if they get injured and how to perform first aid on the wounds from bullets or shrapnel. Additionally, AR is also used for treating post-traumatic stress disorder for the soldiers who have psychological issues triggered from combat trauma, to teach how to cope with any unexpected situations (CxocARd 2019).

Medical Sciences

With the high rate of exactitude, AR becomes an efficient aid for doctors. One of the outstanding apps is Mole Detective that analyses images to recognise the pathogen of skin cancer. In addition, the combination of AR and modern equipment allows the visualisation of graphics of patient medical issues. Additionally, it is also used in minimally invasive surgery by inserting a small camera into a patient's body to visualize his or her brain as well as to highlight the location and the severity of fractures. Apart from that, another benefit is creating simulations of the live motion of anatomical joints or the process of giving birth to detect the possible complications (Digit n.d).

Manufacturing

The process of producing an aircraft is extremely challenging and requires a tremendous amount of effort and skills in assembling detailed parts together. Hence, the assistance of heads-up display headset (HUDset) is essential. Precisely, HUDset is used to display in a clear way the 3D location of an object, i.e. a drill hole inside the airplane, HUDset allows users to observe the hole from different perspectives along with the description of size and depth (Digit n.d).

Shopping

Shopping is one of the most applicable fields for AR, since it can be used for tremendous benefit both by customers and sellers. Despite the advances of online shopping, most people tend to visit brick-and-mortar shops for trying and seeing products before making purchases. Moreover, some customers are expecting to find suitable clothes without being willing to try them on. For those reasons, some shopping malls leveraged the ability of AR technology to create "virtual trial rooms" allowing the shoppers to try as many outfits as they want, until the best one is chosen without actually wearing it. This app works by capturing images of the customers, then superimposing the virtual clothes and accessories over their bodies with ideal sizes. Due to the convenience and time-saving, customer satisfactions and loyalty are improved. Retail stores that use AR and have online shopping attract wider customers bases than the traditional ones (Digit n.d).

Tourism

AR has already been applied in tourism for a long time, as mentioned above with the innovative apps that guide and instruct the travellers in finding recommended places.

The superimposition-based AR technology is adopted in tourism to describe the historical heritages in order to make the tour more interesting and meaningful instead of visiting for capturing pictures only. In addition, the barrier of language is inevitable while traveling, especially, to foreign countries. Therefore, an AR translation app is an essential assistant that translates all contents to user preferred languages without typing on the screen, as the way it works is that the desired text is scanned by using the phone's cameras (Digit n.d).

Education

In the future, AR will be in a key role for the development of education, especially in nurseries and primary schools. An example for that is replacing the traditional teaching methods by visualizing objects to give students real experiences through all the senses. Specifically, it is difficult for children to approach wild animals without organizing a zoo tour, which would need a detailed plan, a considerable amount of time and a budget. As a result, a simulation of the zoo is the best method to create an interesting and attractive study space for students. Besides, other subjects such as Chemistry and Physics require safety in experiments; hence, teachers are able to use AR technology to simulate chemical reactions or physics phenomena, which encourages the curiosity and passion of students in sciences (Digit n.d).

3.4 Challenges of Augmented Reality

In spite of the advantages, AR technology still has many limitations to overcome. At first, most AR innovations are dependent on smart phones, and they have small-scale screens and limited processing power, which leads to the inconvenience in utilizing this technology. Therefore, wearable devices such as Google Glass and HoloLens were invented to expand the user experience of the real world. However, the more benefits it brings the higher cost it has. Secondly, the problem is related to the size of the markers. For instance, if a part of the markers is covered by users' hands or other objects, the virtual details will disappear. Additionally, lighting conditions also have an effect on tracking the markers, as they create reflections, as well as glare spots that blur the marker squares (HITLab n.d). Thirdly, there is that AR raises the same issue as smartphones, which is addiction. To be more specific, the overreliance on AR applications might lead to disconnection of relationship between people, e.g. the tourist might prefer using an AR mobile app by themselves to participate in a tour, discouraging networking and real interaction. Furthermore, the AR app depends on GPS system. Nevertheless,

these technologies have a need of being upgraded for usability and accuracy. In some cases, AR app becomes useless when GPS signal is lost (Digit n.d). Lastly, privacy is one of the most controversial concerns due to the aftermath of various security flaws and exploits as well as confidential information being disclosure. As most AR apps are combined with image-recognition software allowing users to scan the surrounding spaces, even strangers can access the phones of others more easily by using their social media, or other online profiles accounts, to bypass the protection of the phone (Blog Spot n.d).

3.5 The evolution of Augmented Reality in the future

After a long period of development, AR technology combined with other technology trends such as Artificial Intelligence (AI) and Virtual Reality (VR), is promising to bring more benefits in the coming years by development of large-scale projects. Specifically, Apple has shared its experience of new format for detecting objects called universal scene description, which is expected to be more open for third-party software. Moreover, all of the limitations mentioned above are widespread, not concentrated in only a few companies, desiring to improve tracking issue or to enhance the security of personal databases. Although there are many forecasts related to the growth of the market value of AR with various rates, all researchers have generated the same result that shows the beliefs in the development of this technology. Main factors contributing to the development of AR are the increase of the availability of smart AR devices along with the advancements of 5G wireless internet (Ratnottar 2019).

Quickly worth mentioning also is the emergence of XR, which is a form of extended reality, is expected to converge all of the advancements of augmented reality, virtual reality and mind reality to avail the ability of these reality for the prosperity of various industries (Microsoft 2018).

4 Intralogistics

4.1 Warehousing

Warehousing is a vital part of supply chain to ensure the movement of products and raw materials from the input to the final customers. Especially in the exponential growth of high quality and faster delivery demand. Hence, a “smart” warehouse with automated system is an effective assistant to boost the productivity with lower cost.

Fundamentally, warehouse plays the role as a distribution centre, where storing the products as well as fulfilling orders. A warehouse basically includes shelving systems allowing the maximum of storage capacity, a climate-controlled storage warehouse for special merchandises such as frozen products and laboratory chemicals and a synthetic data system with product detailed information and physical assets such as forklifts, pellet jacks or conveys (Lopienski 2018).

In spite of the difference in conducting the processes in various warehouses for creating their unique values, all warehouse operations involve the similarity of key processes (Walker 2018). It is precisely illustrated in the Figure 7.

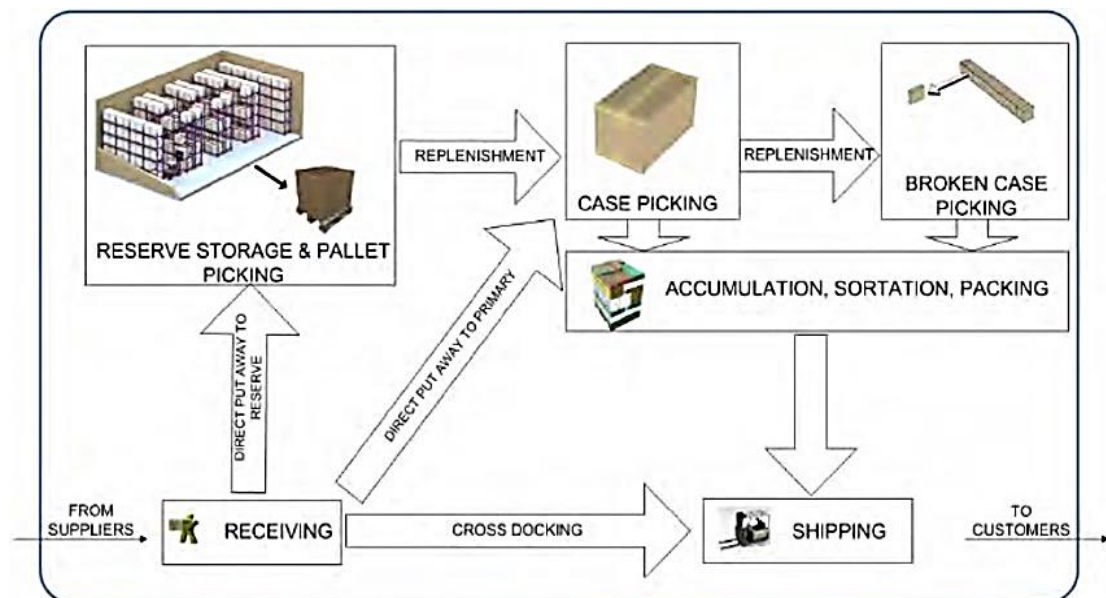


Figure 7. Typical warehouse operation (Tompkins 2003)

Receiving

Receiving is the act of unloading merchandises and materials into warehouses and simultaneously checking the quality, labelling products with barcodes or nametags as well as updating its information on the database management system by using barcode scanning tools. The products can be single objects, packets, litres or large pallets. Ideally, the Advance Shipping Notice (ASN) must be sent to the warehouse in advance for preparing the next stage of products whether cross-docking directly or put-away to the reserve storage, depending on customer requirements (Walker 2018).

Put-Away

After scanning barcodes or identifying the products in case of lacking barcodes, forklifts and pallet jacks are used to transport the merchandises into the pointed slots indicated by the management systems or move directly to marshalling area for replenishment. The following step is to record the stock location to ensure the system is capable of identify the product positions (Walker 2018).

Picking

Order picking is the most important phase among the value chain of warehouse operation, divided into two main types: primary and secondary picking.

Regarding the primary picking, the products are delivered directly to packing area for customizing and finalizing, then loaded onto the containers or trucks. On the other hand, secondary picking is applied where the merchandises need to be sorted to whether full container load (FCL) or less than container load (LCL), which can be taken from reserve storage or picking location. In fact, due to the across borders transportation, corporations prefer secondary type to the remaining one. Specifically, once the real-time orders are received, the parcels are delivered immediately; in contrast, "waves" orders are dispatched to the destinations in specific times and routes according to determined criteria. With the high volume of shipping demand, picking process uses a huge amount of resources with over 60% of workforces (Walker 2018).

Packing

Some merchandises can be shipped without packing while others are compulsory to go through packing process or rewrap with specific requirements. Firstly, quality check must be performed all the time to figure out if any flaws or broken goods, which are directly classified and moved to fault products handling area. Secondly, all of information related

to expiry dates, barcodes and origins of goods have to be clear and sufficient. Thirdly, the changeable location of goods within warehouse needs to be real-time updated to ensure the accurate database. Finally, sorting and packing into different characteristics such as sizes, quantity, toxicity, fragility, hygiene, temperature, and so on, is also an indispensable step for safety and convenience during the transportations (Walker 2018).

Dispatching

After packing process is completed, the goods are transferred to dispatch area, ready for marshalling and loading to the transport vehicles such as lorries, trains, ships or airplanes to deliver to customers. Once goods departed to the final destinations, the management system is updated and received feedback report with relevant information (Walker 2018).

Returns

Return area is responsible for the returned products, which do not meet the customer demand. Moreover, the returns are mandated to follow strict rules; for example, the reasons for returning need to be clarified with relevant supporting documents and invoices, which should be recorded into the system. In addition, companies should foster a clear post-returning process with specific actions to handle the returned products, such as returning to stock, repairing, destroying, recycling or turning back to manufacturers (Walker 2018).

Value-Adding Services

Value-adding is a key factor to make a business unique and competitive among others. It might involve the implement of kitting, assembling, relabelling and modifying to enhance the value for products. In fact, it is usually considered as a complicated process, asking for various advances in core technology and business strategy. One of the most common problem arising along with value-adding process is changing the nature of components or combining different ingredients to form a new product (Walker 2018).

4.2 Common types of warehouse "waste"

Although most warehouses have their own practices to manage and control the flow of goods, warehouse "waste" still exists giving a negative influence on enterprises' profit and consuming a large amount of resources, time, and effort. Hence, the emergence of

intralogistics solutions is a great leap that helps to enhance the quality of products as well as the efficiency of warehouse operation (Bowles 2020).

Excessive production waste

This issue arises when the supply exceeds the demand triggering the significant increase in the amount of inventory along with the over-head costs. The reason lies in the inefficiency of machinery and the over-dependence on historical databases instead of fostering a forecast system on demand with various perspectives (Bowles 2020).

Excessive processing waste

It is hard to assess and recognise an excessive processing waste. In reality, it is occurring due to the ambiguity and inconsistency of process standards, which leads to the rise of repeated and valueless works (Bowles 2020).

Transport waste

The unnecessary transportations inside the warehouse is defined as transport waste, which causes the increase in energy cost and over-head cost relating to renting or purchasing unused warehouse space. Several factors may involve in this kind of waste such as the disorder of warehouse layout, double handling and the illogical in allocating the goods (Bowles 2020).

Waiting waste

Time is considered as precious resource; nonetheless, waiting waste is unavoidable in most of warehouses. For instance, the time spent on waiting for a machine to be installed or a product going through a process will lead to the postpone in shipping. The improvement on workforce efficiency, well-standard process, well-organised work schedule, and reduced set-up time could be the solutions for this problem (Bowles 2020).

Inventory waste

Inventory waste is resulted from all of the unnecessary accumulation of raw materials, work-in-process materials and broken or fault product, which also impacts to the carrying costs such as rental and interest rates. As a result, it is vital that the corporations manage the manufacture flexibly in order to balance the inventory amount (Bowles 2020).

Defective waste

Lack of training and unclear procedures will cause the defective waste, including incorrect order database, flawed products during the manufacture or missing deliveries (Bowles 2020).

4.3 Intralogistics

The term "Intralogistics" is commonly used as a logistics solution, with the purpose of optimizing and utilizing the productivity in managing and automating the flow of merchandises in warehouses with the integration of technology advancements, labour and facilities. Moreover, it is also a method for companies to eliminate or reduce the warehouse "waste" and enhance the efficiency of warehouse activities. For instance, warehouse management system (WMS) is considered as an intralogistics solution to improving the flow of goods inside the warehouse, saving working time and effort in handling products. (The supply chain consulting group 2018).

Technology is a crucial key of intralogistics solutions to ensure the efficiency in warehouse operations. Intralogistics is considered as technology-based solutions to design a "smart" supply chain management, which mainly can involve the fundamental mechanical systems composed of various advanced tools, such as conveyors, and packing machines or more advanced tools as management systems, which automatically control the process associated with updating and analysing the databases in real-time. By bringing more value to the logistics industry, more and more warehouses are going to apply these advanced tools and technologies as an upgrading method for their operations for improving their competitive advantage. (The supply chain consulting group 2018).

Jorn Remmem, Director of Plant Operations and Engineering of Old Dutch Foods company has showed his satisfaction towards their logistics systems. He said the conjunction of enterprise resource planning (ERP) system and WMS has met their objectives, i.e. enhancing their capacity up to two times, removing the flaws of the process and recognising the traceability of the products. Replacing the manual processes with the software-driven systems has helped to improve the production flow due to the accuracy and efficiency in real-time dealing with the unexpected issue and as a result the customer satisfaction is increased (The supply chain consulting group 2018).

Despite the advantages, intralogistics still has its limitations in managing energy efficiency. Along with endless advantages, however, modern automated processes lead to a significant growth of operation costs as most of automation requires a constant energy to run these intelligent monitoring devices. Fortunately, this limitation has been adjusted by technological companies, which invested in Research & Development department to update the operation systems with lessening energy consumption. Additionally, the emergence of E-commerce and the globalization has also affected the logistics operations. Due to the development of E-commerce, the customers expect to have higher-quality services with short-time deliveries and 100% availability of products. In addition, the huge demand is not based only on local but also global demand because of the globalization. Companies have to adapt to the more interconnected and competitive world with the scarcity of raw materials. Therefore, the intralogistics solutions have to be upgraded to solve both domestic and across-borders issues (The supply chain consulting group 2018).

4.4 Technology advancement in warehousing

Due to the high demand on online shopping, every warehouse needs to be equipped with modern facilities and new technology to improve the efficiency and productivity of warehouse operation. Zebra report of Warehousing 2020 has ranked the top ten technology advancements based on the percentage of usage in managing the warehouse processes (Zebra 2020).

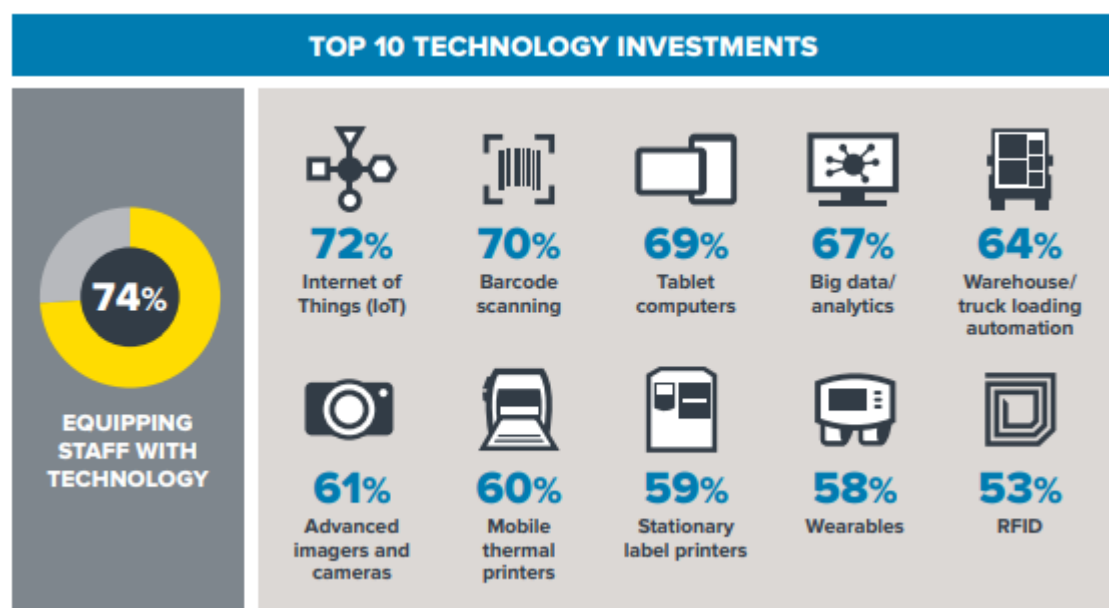


Figure 8. Top 10 technology innovations using in warehouse.

According to this report, 74% of staff is equipped with technology to reduce the manpower put into most of procedures. Internet of Things (IoT) is among the top high-tech that connects the big data sources to control the database system and generate the real-time interaction with customers via the delivery tracking system. The next commonly used devices are barcode scanning, tablets and computers, which occupy 70% and 69% respectively over the period of next five years. With these devices, the speed and automation in loading and unloading processes of inbound and outbound inventory are improved. Moreover, the data entry process is upgraded by using portable tablets or smartphones instead of the manual process conducted with paper and spreadsheets (Zebra 2020).



Figure 9. The functional convergence of Warehouse Management System (Biztrak n.d).

Besides, most of "smart" warehouses nowadays have their own warehouse management systems (WMS) for tracking and controlling the flow of products inside the warehouse.

When the work is overloaded and the inventory is beyond the standard rate, WMS is a solution to these situations. The system is a timely and costless solution through an easy-to-use interface with high-functionality integration, including operation, reporting and transporting for inbound and outbound procedures. Through this system, the manager is able to supervise the inventory based on different warehouse elements. One of them is stock keeping units (SKUs) that involves in product information and automatic labels. The second element is the storage information, such as types, locations and capacities of storages. Along with that, other management functions, i.e. planning, organizing, staffing and controlling, are also well-harmonized to be a supportive tool for the managers. Regarding planning activity, based on the historical database of daily workload and processed orders, the company is capable of estimating workforce and time needed for each orders. In terms of organizing process, it is logical to rearrange the orders according to its priority. Moreover, creating an appropriate flow would contribute to simplifying the monitor process and reducing the last-minute requests. If planning and organizing processes are well planned, staffing and controlling processes will be, therefore, more efficient (Orgit n.d).

Moreover, warehouses have a tendency of being environmental-friendly to adapt the sustainability goals of companies. Green initiatives consist of using biodegradable materials for packing or recycling the used packaging, trimming down the overuse of energy by purchasing more efficient machines and designing efficient delivery route to reduce the carbon footprint and greenhouse effect phenomena (Biztrak n.d).

5 Augmented Reality in Warehousing

Technology development has contributed to the optimization of a 'smart' warehouse as well as sharpen the preparation for penetrating the Industry 4.0 – the Industrial Internet of Things (IIoT). Industry 4.0 is not all about the technology, but the revolution in the way that businesses grows and connects with the real-time data. To be more specific, Industry 4.0 creates the interconnectivity between the physical technology and digital technology, which provides better access across departments, partners, vendors and products. As a result, the businesses will have an in-depth of their operations for better management and improvement (Epicor n.d). Therefore, the deployment of virtualization becomes a priority intralogistics solution to handle the challenges and minimise the warehouse "waste". One of the best virtualization methods is Augmented Reality, in which is the focus of this thesis in terms of supply chain.

5.1 How Augmented Reality contributes to the logistics industry

Before getting the deep learning about how AR changes the way warehouse works, it is essential to gain an understanding of its benefits for the whole supply chain operation such as transportation, last-mile delivery and value-added services (Glockner, Jannek, Mahn & Theis 2014).

Transportation

For a long period of time freight transportation has been improved significantly with the assistance of technology. To have further optimization in freight transportation, the combination of scanners, 3D depth sensors and AR advantages has created a wearable immersive device, which quickly determines the volume of parcels and pallet in short-time to be ready for the shipments as well as detects faults in any merchandises. Moreover, it can be used in documentation by checking and correcting words in contracts or automatically translating into necessary languages (Glockner, Jannek, Mahn & Theis 2014).

Due to the complexity of existed traffic jams, road transportation has a negative influence on wasting time and efforts in deliveries. Hence, an AR driver assistance app is the best solution to notice the drivers with real-time information about the current road congestions or construction; meanwhile guiding a new direction. Furthermore, AR devices are possible to replace the manual cargo planned lists and transport instructions

by displaying the information directly on the AR interface (Glockner, Jannek, Mahn & Theis 2014).

Last-mile delivery

Last-mile delivery is the last stage of the supply chain as well as the key point to bring satisfaction for the final customers. In fact, it is estimated that drivers spend over 40% of their time to determine the correct parcels for the next shipment. As a result, each driver can be equipped with an AR device to save their time in figuring out a specific parcel with the information of weight, final destination addresses and its characteristics. Also, it is possible to work as a Google map to guide the shipper to the exact provided address; otherwise, the AR device is capable of placing a marker for the following delivery times. Last but not least, by using the AR device to identify the receivers, personal information would be secure and private in case of delivering the high-value merchandises (Glockner, Jannek, Mahn & Theis 2014).

5.2 Augmented Reality in warehouse management

AR is a potential technology for improving the operation in a warehouse, which occupies approximately 20% of total logistics cost. Among a lot of AR innovations, a wearable device is the most commonly used in most warehouses because of its convenience and no need for additional resources. The figure 10 illustrates how worldwide wearable immersive devices are used in Warehousing and Manufacturing area (Robinson n.d).

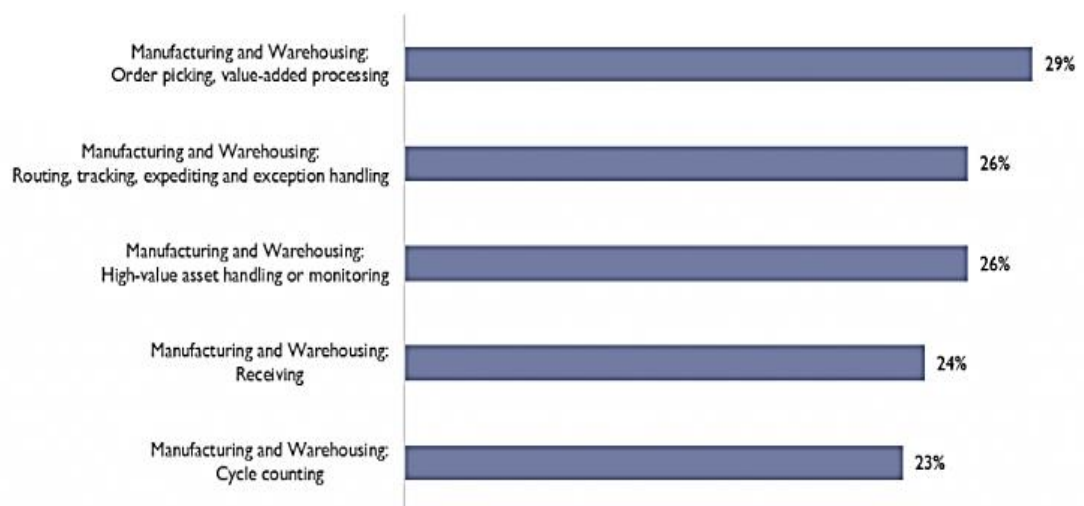


Figure 10. The use of wearable devices in Supply Chain and Manufacturing (Robinson n.d).

As shown in the figure, AR wearable technology covers over 20% of work capacity in either individual supply chain or manufacturing process, which indicates the high-potential of such devices in improving time and cost of warehousing. The following paragraphs will take a deep look at how AR and its inventions contribute to the efficiency of warehouse processes, especially in order picking, warehouse planning and inventory management aspects (Glockner, Jannek, Mahn & Theis 2014).

Order picking

As the key role of warehousing, order picking consumes a large amount of time and resources, and is accounted for approximately 55% of the total operation cost. Moreover, the demand of fast and high-quality deliveries is enhanced day-by-day in this technology-powered era, leading to the pressure in streamlining its picking process. However, most warehouses throughout the world still handle products by a manual process with paper-based approach. In addition, this type of work is usually undertaken by short-term workers, who might lack experience and skills in implementing without making flaws. In consequence, a number of AR innovations have been applied for large warehouses, where the goods flow is overloaded during the peak seasons. An AR wearable device such as smart glasses, is the most preferable due to its several benefits.

The key benefit of wearable picking devices is the provision of hands-free digitalization while handling other manual work. The device works as an AR overlays glass, integrating all of other tools such as scanners, object recognition, and navigation with the big data of WMS. Its aim to guide the workers to pick up the correct items with the shortest travel time despite the lack of training, language barriers for foreign workers and fewer errors up to 40% compared to pick-by-paper method. For instance, when the workers navigate the right location, the automatic barcode scanner will generate the description of goods in details with quantity, then the new data will be updated on the system right after the picking is completed.

Warehouse planning

Obviously, a warehouse is described as a storage or distribution centre. Nowadays, more and more value-added services, ranging from packing, labelling, assembly and repair have been integrated inside this hub. Henceforth, this centre has to be planned logically or even redesigned to carry out the workflows smoothly. Therefore, a digital warehouse

simulation on the real environment is visualised, allowing the experiment of the rearrangements and plans for additional service areas. Based on that sample preview, the planner is able to modify and adjust the design on the real warehouse space to get the ideal plan, matched with the workflows. With this method, planning and redesign costs of warehouse along with wasted-time will be reduced.

Value-added services

One of the critical factors to enhance the customer satisfaction is value-added services, i.e. assembly, packing or repair. Therefore, more and more warehouses put a lot of efforts in training their staff. However, due to the high-quality requirements, it takes time and money for accomplishment. As the same way AR used in the military to train the soldiers, it can be applied for training warehousing staffs. With the lower cost, individual staff is possible to be trained in flexible time and venues with the stimulation of firm's warehouse; moreover, AR system is able to ensure the quality by evaluating every work step with high standards and possibly detect the errors immediately with fixed instruction. Turning to customer services, DHL has already developed a prototype of AR apps, allowing end-customers to estimate the suitable size and fee of the parcels for ordering the right shipping options.

Inventory management

Inventory management is one of the most challenging features that needs a lot of time to deal with. Besides, the benefits of the smart wearable device has brought to both order picking process and inventory management, the appearance of AR robotics with artificial intelligence and machine learning algorithms is expected to be "a wind of change" in Logistics industry. Instead of using the manual workforces to undertake the routine works every day, coded robots are able to learn and carry out perfectly various repetitive tasks in a specific time without human involving (Joshi 2019).

As in the early stages of testing, AR devices still exist a lot of limitations. Security is the most challenging issue due to the inconsistencies in creating the device and lack of regulation to control the confidentiality. This might lead to the leak of an internal plan or strategy if a company uses mistrustful and counterfeit products. Moreover, this kind of product is inappropriate with small and medium scale warehouses with fewer workflows since the operation cost will increase along with the high price of AR

innovations instead of going down as larger warehouses with high volume of workflows (The app solution n.d).

6 Analysis of results

The online interviews were conducted for over two weeks from 8 May to 27 May 2020 and sufficient primary data for analysing was obtained. As mentioned, the interviewees were warehouse managers or senior workers of six logistics or e-commercial logistics companies, which were three domestic enterprises and three foreign enterprises in Vietnam. Due to confidential requirements, all companies as well as the representatives remain anonymous (such as A, B, C for domestic firms and X, Y, Z for international ones), shown in Table 1.

Table 1. The background of interviewees

Company	Interviewee	Position	Main responsibility
A	Mr. Tr	Operations Director	Managing and evaluating the business operation.
B	Mr. S	Operations Manager	Ensuring the operation works smoothly.
C	Mr. T	Warehouse Manager	Monitoring and controlling all of the activities in the warehouse.
X	Mr. A	Assistant Manager	Supporting the manager in preparing documentations, doing research and collecting necessary information.
Y	Mr. J	Vice Director	Being responsible for the warehouse improvements in each activity.
Z	Mr. M	Senior Staff	Taking care of put-away and picking processes.

6.1 General company data

The first company (A) is one of the largest state-owned domestic logistics companies in Vietnam. Since its establishment in 1989, company A has been developing a great number of logistics services such as warehousing, container yard and other added-value services. These services constitute for over 85% of the market share in the South of Vietnam and approximately half of national share. In addition, A owns over 20 modern warehouses of different types, such as bonded warehouse, temperature-controlled warehouse, dangerous goods warehouse and container freight station, with over 32 hectares of total area located mainly in Ho Chi Minh City, Binh Duong, Dong Nai and Ba Ria – Vung Tau (Website of company A).

The second company is a Vietnamese e-commerce logistics company (B) that was founded in 2010. Five years after that, B has one of the five e-commerce websites that were the most popular in the Vietnamese market with up to 6,000 square metres of warehouse located in Hanoi and Ho Chi Minh city. At the present, B concentrates on improving the reliability and 2-hour-delivery-services to catch up with the customer demand (Website of company B).

The third local logistics company, C, has been operating as a partner of e-commerce companies since 2014 with a mission of delivering the best value to the customers in the safest and fastest way. Additionally, it has three main warehouses with over 4,000 square metres and 15 distribution points throughout Vietnam to meet the demand of over 1000 B2B customers (Website of company C).

First of the international companies, X, is one of the worldwide leading logistics companies, originally established in Bremen, Germany in 1890. Since 2014, it has become one of 100% FDI companies in Vietnam with four branches and over 70,000 square metres of warehouses. Its main services are sea freight, air freight, road freight and warehousing, combined with the logistics solutions to improve customer satisfactions (Website of company X).

Same as company B, company Y, is also one of the e-commerce companies, whose headquarter is located in Singapore and owned by Alibaba Group. Moreover, it provides more than 500,000 different types of products of fashion, electronics or cosmetic, and so on. In 2016, Y had two main warehouses in Ho Chi Minh city covering 12,100 square metres and in Hanoi. Additionally, it is planning to have another warehouse in Danang to response to the customer demand in the Central Vietnam (Website of company Y).

The third international company is also a large logistics company (Z) that has more than 25 years of expertise in Vietnam with various services from air & ocean freight to other delivering solutions addressing to a specific demand for global projects, removals and industrial packing. Moreover, it owns more than 31,000 square metres of total warehouse spaces located mainly in Ho Chi Minh city (Website of company Z).

The interviewees were asked about the company size and based on the answers the companies were classified on their number of personnel and turnover in the previous year. Table 2 illustrates the size and turnover of each company.

Table 2. Interviewed company sizes and turnovers

	Company	Number of employees	Turnover (Million USD)
Domestic	A	> 250	> 50
	B	> 250	< 10
	C	< 250	< 50
International	X	> 250	> 50
	Y	> 250	> 50
	Z	> 250	> 50

In terms of number of employees, only company C belongs to medium-scale enterprises (< 250) while the remaining are large-scale companies' employees exceeding 250. Even though company B has over 250 its turnover in recent years has not met the requirement of above 50 million USD. Its manager said that company B's turnover has been declining over the three consecutive years due to the enormous investments in its marketing projects. He also stated that the e-commerce market has been more competitive with new rivals. Hence, they wanted to focus on raising customer consciousness about their brand and quality. Fortunately, they also got a huge amount of investment from Chinese investors to maintain the operations. Regarding the large size, global companies obviously have a high number of employees and gain over 50 million USD per year thanks to their contracts with large manufacturing and fast-moving consumer goods industries. The most remarkable point is that company A's turnover exceeded 5 billion USD in 2019, increased by 12% compared to the previous year due to its great share of Vietnamese market, as being mentioned previously. Last but not least, company C's turnover of last year was approximately 15 million USD and is expected to grow by 10% in coming years with the increase of customer quantity.

The warehouse process of both local and global companies has fundamental activities including receiving, storing and picking. However, larger companies might have more added-value services such as knitting, assembling or packing. It depends on their products as well as customer demand. Moreover, the working time used in each activity might vary among the companies, which is illustrated in the Table 3. It must be noted

that the proportion is estimated by the managers' perspectives based on their experiences.

Table 3. The working time used in some activities of six companies

Company	Receiving (%)	Put-away (%)	Picking (%)	Packing (%)	Other activities (%)
A	25	15	20	30	10
B	40	15	10	30	5
C	35	10	35	15	5
X	25	20	20	30	5
Y	30	15	20	30	5
Z	25	15	25	30	5
Average percentage	30	15	21.7	27.5	5.8

According to the collected data, most companies have spent a lot of efforts and working time on receiving stage. The main reason can be that receiving process contains a chain of activities involving in the quality and quantity checking, space arrangements and types of preservation, labelling and updating product information in the system. Hence, it occupies around 30% of the total working time used in warehouse, which is also the highest rate among other activities. The following rate is packing stage constituting approximately 27.5%. According to some managers, in practice, most of the products are packed manually instead of using automation machines because of the differences in product shapes and sizes. As a result, it consumes huge efforts and time of the workers. However, company C shows a high percentage of time consuming in picking stage instead of packing stage, i.e. 35%. The manager explained that all merchandises have already been packed before arriving to its warehouses for storing and delivering only. Finally yet importantly, other activities such as monthly sterilizing, maintaining and handling the returns as well as administrative activities, which accounted for 5.8% of working time, adequately smoothen other processes.

The cost allocation of warehousing activities has been shown in the Table 4.

Table 4. The cost allocation for each activity of six companies

Company	Receiving (%)	Put-away (%)	Storing (%)	Picking (%)	Packing (%)	Other activities (%)
A	20	10	15	15	30	10
B	30	10	15	10	25	10
C	30	10	10	25	15	10
X	20	15	15	15	25	10
Y	25	10	15	15	25	10
Z	20	10	15	20	25	10
Average percentage	24	11	14	17	24	10

Same as the working time used in warehouse, the cost of each activity was also estimated by the interviewees. Having been calculated from the data of Table 4, Figure 11 below gives a detailed look about the average percentage of cost of each activity among six companies.

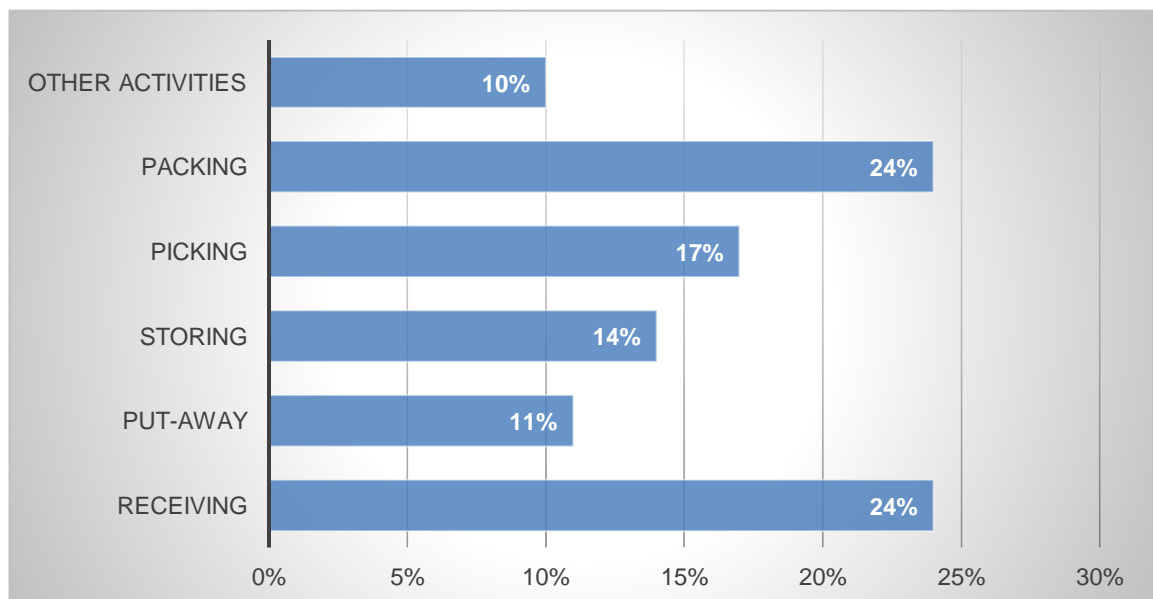


Figure 11: The average percentage of cost allocated for each activity in warehouse of interviewed companies

As can be seen in Figure 11, packing stage consumes the highest cost, covering in average 24% of the total cost of warehouse operation. One of the reasons is possibly that the stage requires more staff to handle manually the enormous volume of products in different sizes and shapes, especially for the e-commerce companies, which usually

have over 100,000 different types of products to manage every day. The following stage that occupies around one fifth of total operation cost is receiving activity. With many activities involved in the receiving process, a huge budget needs to be prepared for paying the staff salaries as well as for purchasing machines such as barcode scanning devices and labelling machine. Put-away and picking costs can be considered as handling expenses, which hold approximately 30% in total of warehouse cost. These high expenses are triggered by using large number of workers to handle a huge volume of merchandises every day. Despite the lower percentage compared to most of processes, storing expenses are also the vital concern of most of the companies. Specifically, the longer period of inventory leads to the higher storing expense.

Regarding warehouse "waste", all of interviewees said that their companies had already attempted to eliminate the "waste" that caused unnecessary costs and effort; however, it would be a complicated and long-term process. Take company A as an example, it has used the "First-In, First Out" (FIFO) method to reduce the inventory and waiting waste. This method helps to improve the inventory cost by ensuring the smooth flow of goods and trimming down the waiting time of oldest inventories. In terms of transport waste, company Y had implemented a prototype of portable device, which is able to show the location of specific products and classify the orders based on its priorities with aims of saving time and avoiding double handling. For the defective waste, company X, Y and Z always have monthly training and inspection to advance the quality of staff.

Most of the companies have not had any solutions to cut down all the expenses. Nevertheless, they had put efforts in investing into traditional technologies such as forklifts, conveyors, and so on. Moreover, the large companies, i.e. company A, X, Y, Z have attempted to manage the movements of inventories and the information flow among all functional departments by integrating the SAP warehouse management systems with the SAP enterprise resource planning software, in order to reduce the unexpected cost and guarantee the operation to work smoothly. Besides, to handle a huge amount of orders per day, company Y has tried to use its own portable devices to control the customer orders and navigate the product locations so that the staff is able to pick the orders at real-time. As a result, it met the expectations of reducing working time and cost in picking activity. In contrast, the local ones like company B and C

manually manage the warehouse activities by paper-based method or basic computer software such as Microsoft Excel due to small warehouse and limited range of products.

6.2 Technology used in warehousing and the awareness of AR technology

This chapter focuses on the technologies that are currently in use in the warehouses of the case companies as shown in Figure 12.

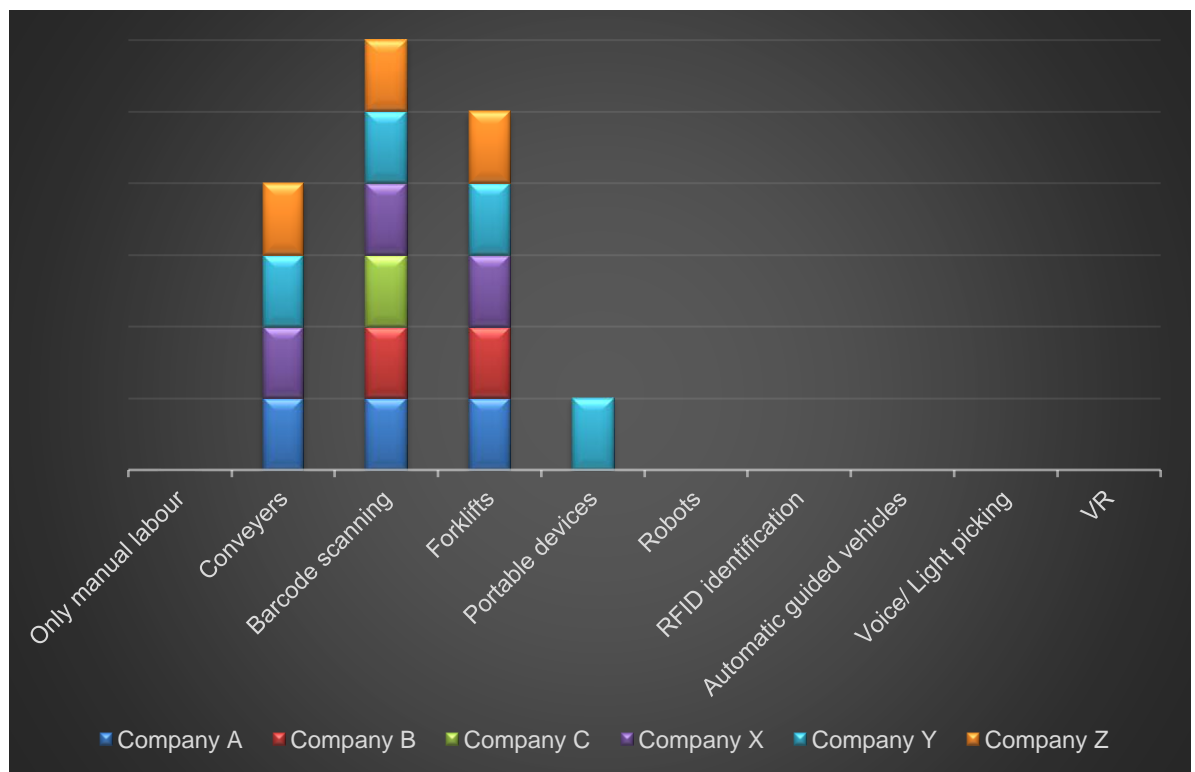


Figure 12. The technologies used in the warehouses of the case companies

As can be seen in Figure 12, most companies do not use the new warehouse technologies involving robots, RFID identification, automatic guided vehicles, voice-picking, immersive devices or only manual labour for processes in warehousing. All of them are applying traditional technologies such as conveyers, barcode scanning or forklifts. All six companies need to manage a great volume of merchandises per day. Hence, barcode scanning is the essential device to update the information of products in real-time as well as to trim down the working time of receiving activities. Moreover, using forklifts and conveyors minimises the time spent on the movement of products inside warehouses. For this reason, company A, B, X, Y, Z have utilized the forklifts to transfer large pallets and only A, X, Y and Z have used the conveyors to move the picked products automatically to packing area. In terms of new warehouse technology, only company Y

is using the portable devices for the picking process. According to Mr. J, Vice director of warehouses of company Y, his company has been successful in applying a portable device functioning as a management system. Subsequently, the products are filtered and arranged in sequence based on the level of priority, so that the operations enhance the performance and efficiency.

On the other hand, there are still several drawbacks of the current warehouse technologies, that the six companies have already experienced based on the answers from the interviewees. At first, barcodes are usually the main issue as it is easy to get damaged and scratched, which might not be recognised while scanning. Moreover, only basic information of products is involved in each barcode and it is unable to adjust or add more details. Secondly, conveyor systems are unable to be relocated as it is fixed in place. In fact, a warehouse needs to be upgraded and rearranged to match with the increasing volume of products, so this system might become a challenge. Lastly, the third disadvantage is related to forklifts. Most of the companies have already used electric version instead of diesel one. Although they produce less noise and emission, the battery could be an issue. For instance, leaving the battery uncharged accidentally might cause productivity decrement the following day.

Despite the bottle necks and costs of the currently used technology, most companies have not implemented any changes yet. There are two main reasons explained by the managers. First of all, small companies cannot afford to invest into modern technology as well as to upgrade the facilities of the warehouses. Next point, there is no need to apply for new technology at the moment due to the low labour cost in Vietnam. According to Mr. T, warehouse manager of company C, the total labour cost was less than the amount of money purchasing and maintaining robots or other smart devices. Additionally, Mr. A, manager's assistant of company X stated that some of new technologies had already been applied in the European warehouses. However, it more time is still needed to adapt these in the Vietnamese market. Nonetheless, all interviewees said that if their companies were expanded in scale, they would consider applying the advanced technologies to enhance their productivity and efficiency. For instance, company A is planning to replace barcode scanners with RFID identification to improve the drawbacks and to enhance the confidentiality.

The interviewees were asked about their awareness of AR technology. The results are shown in Figure 13 .

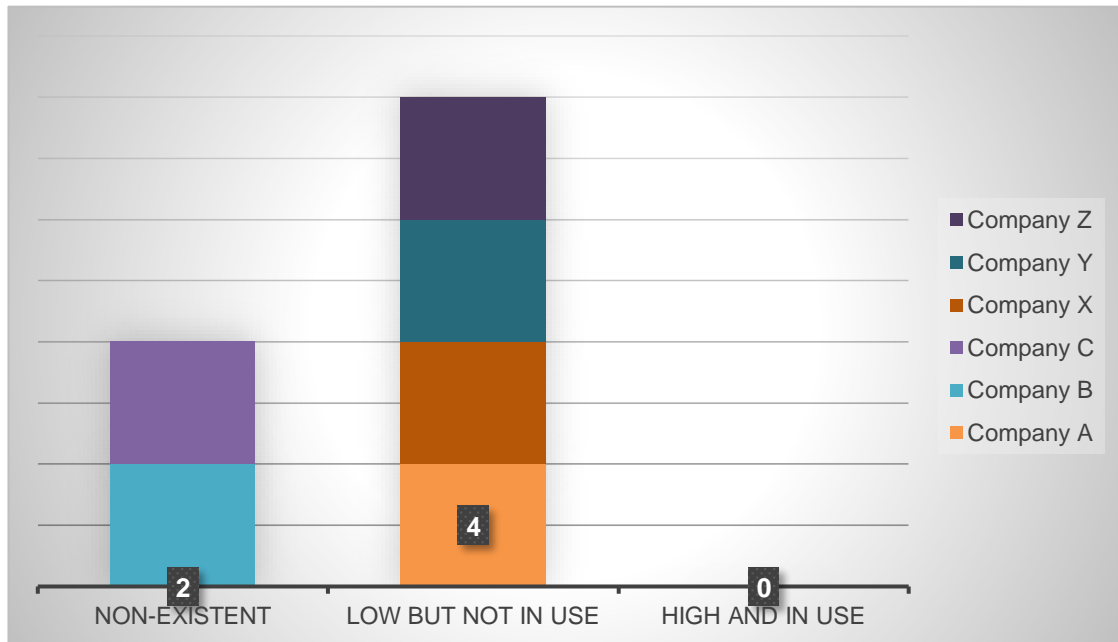


Figure 13. The awareness of interviewees about Augmented Reality

As was shown in Figure 13, most interviewees answered that they know about AR technology. Specifically, Operation Director of company A said: "We used to be invited to some workshops related to new technologies in Singapore to have an in-depth information for our future needs". Meanwhile, other global companies' interviewees answered that they have received the information from their head-quarters or from other foreign branches. Only two interviewees from company B and C said that they had no idea about neither AR nor VR technology. Fortunately, I had prepared a five-minute presentation about the general definitions, types and benefits of Augmented Reality for these two managers. After the short brief, they acknowledged the technology benefits and would like to have more details about AR.

In Table 5, it has shown the answers of interviewees about their expectation when applying AR in their warehouses. The expected aspects were ranked from 1 to 4, with 1 is the most important aspect and 4 is the less important one.

Table 5. The expected benefits of AR were ranked by the interviewees

	Company A	Company B	Company C	Company X	Company Y	Company Z
Time-saving	1	2	2	2	2	2
More accuracy	3	3	3	3	3	3
Cost saving	2	1	1	1	1	1
Less workers	4	4	4	4	4	4

Based on the answer table, the Figure 14 illustrates the rank order from the top (most important) to the bottom (less important) of four elements.

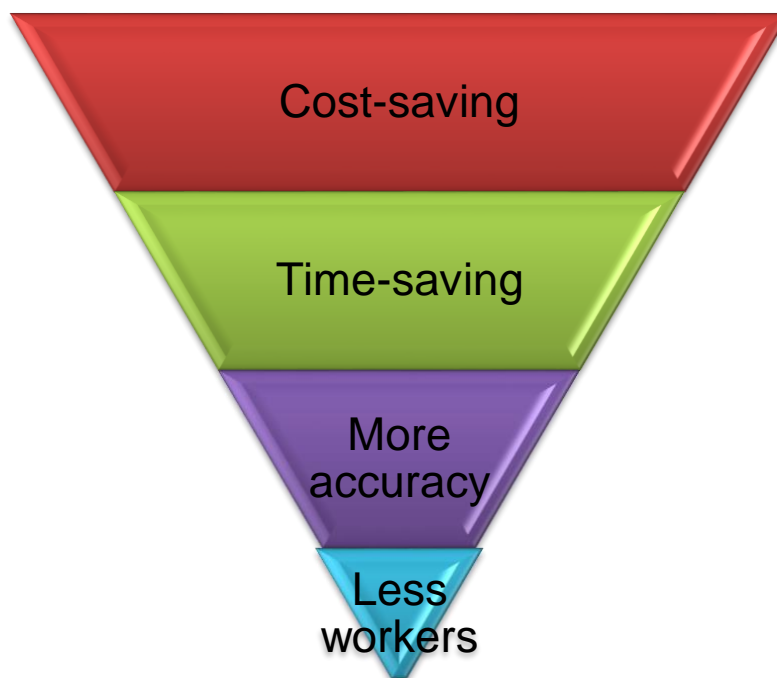


Figure 14. Expected benefits from utilizing AR in interviewed warehouses

Based on the collected data, Figure 14 illustrates the hierarchy of AR benefits according to the expectation of the interviewees. Cost-saving is the priority aspect that most companies expected AR to bring to their operations. The following benefit is timesaving. This is understandable since most companies desire to have productive operation with less "waste" activities so that they have more time to handle more products. In addition, AR is expected to cut down the flaws and delays during the processes that manual

methods might cause. For instance, a staff might pick up incorrected products due to lack of training or heavy workload. Regarding the number of workers, most of the managers agreed that although they ranked it at a lower level, it has a significant impact on the labour expense, contributing the most to total expenses.

In spite of the benefits of AR technology, there are several restrictions, that might influence the company decisions of adopting this new technology. In Figure 15, it indicates precisely that implementation cost is the most restriction to prevent the companies in applying AR.

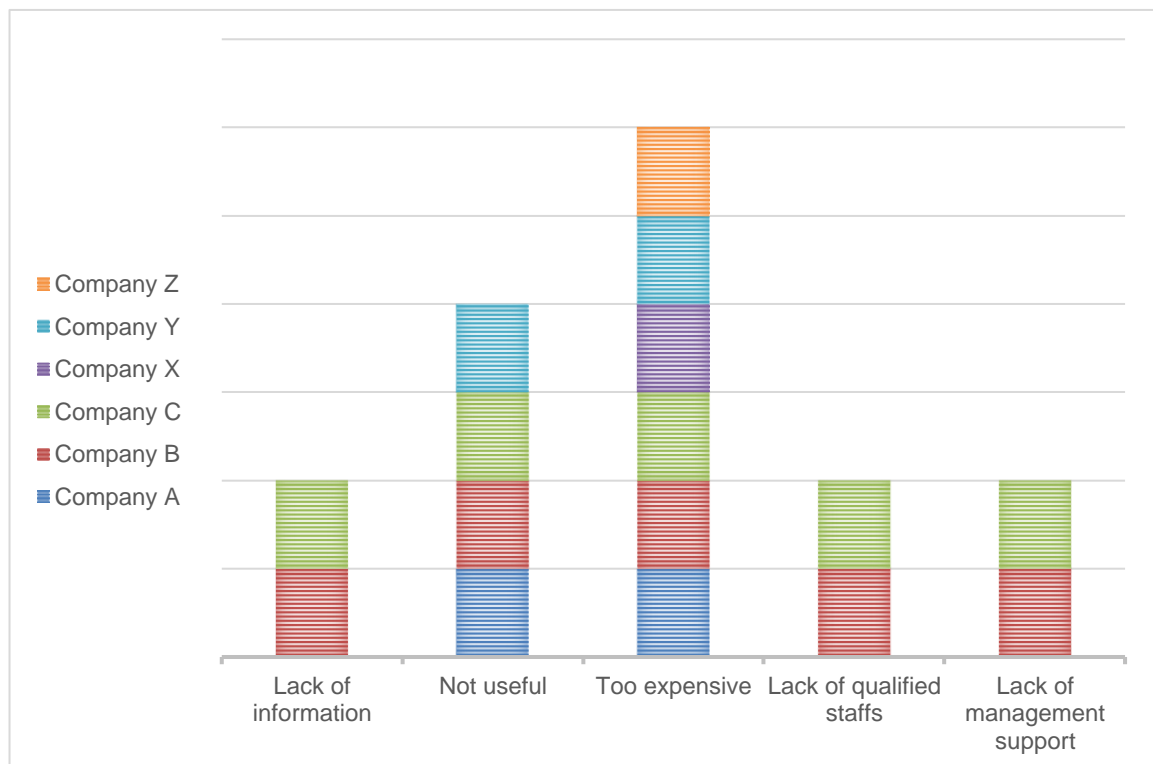


Figure 15. Main restrictions of not investing or using AR

The cost of investing in AR technology is likely the most challenging that all companies concern. All managers pointed out that this cost might exceed the universal value if the goods flow is unchanged. Precisely, with the same amount of workload, they preferred manual labour to new technology as it consumes a lot of time and effort to implement the new innovations. As a result, company A, B, C and Y thought that AR is not suitable for their business because of the company size and not useful for their current needs. However, company X and Z could consider applying, if they were able to expand their warehouses. For the remaining reasons, domestic companies such as company B and C,

still need time to do more research and to improve their management support. Moreover, lacking qualified staff is also their main issue as most of the workers are not familiar with the modern facilities.

To adapt better technology and overcome these restrictions, all companies expected to have financial support from investors. Moreover, they need to be supported so that they get more detailed information about AR technologies and how it is applied with minimised cost and effort. In addition, the willingness of staff to try new working methods is also the motivation for the business to implement AR devices.

7 Conclusions and recommendations

In brief, the main goal of this thesis is to figure out how it is possible to apply augmented reality technology to the warehouse of logistics companies operating in Vietnam. The research has started with the literature review, including the definition of AR, logistics trends and intralogistics along with the general overview of Vietnamese logistics market. The second main part is the analysis part with some key findings after analysing the primary data from online interviews and the last part is to sum up the main points of the results with some recommendations.

From the results, in most cases companies have spent too much effort and money on receiving and packing processes. One of the reasons is that these processes have been executed manually to handle a huge volume of goods. Another reason is that there are a lot of existed warehouse "wastes" in those companies. While some companies already had their own solutions to cut down the "waste" such as company A with FIFO methods and company Y with their new portable devices, the other companies have been struggling to eliminate those "waste", especially inventory, transport, and waiting waste. According to "Augmented reality in warehousing" part, one of the main benefits of AR is improving the movement inside warehouses without double handling. It also allows the staff to navigate the product locations for easier picking, which will lead to the possibility of trimming down the transport time as well as bettering the flow of inventories. Therefore, AR would be a potential innovation for modern warehouses shortly. Nonetheless, most of the interviewed companies are using traditional technologies such as conveyors, forklifts, and barcode scanning instead of the advanced ones. Only company Y has been applied to new technology, i.e. portable devices in their warehouse to improve the efficiency in the picking process. Although the AR wearable devices have the same benefit as portable devices, it has been more advantaged. Firstly, with wearable devices, the users are able to be hands-free for driving forklifts, picking up the products, or other purposes. Secondly, the devices will guide the staff to the exact location of the product instead of providing only the information of product location. It would be easy for the long-term staff to navigate the products by the basic information (such as warehouse 4, zone B, and shelf no.5); however, it is a big challenge for the temporary or seasonal workers. Lastly, the wearable devices allow the staff to scan the barcodes of products to have real-time updates on the management system about product status. After having a deep understanding of AR technology, companies'

representatives had ranked their expectations in case of applying AR technology in their warehouses. Consequently, cost-saving and time-saving are the most important values that case companies have expected AR would bring to their operations. In spite of the advancements of AR, all interviewed logistics companies in Vietnam have not implemented AR innovations yet due to several barriers. Such barriers are that the AR technology does not match with their current operations, and there is a lack of budget and qualified staff. Most of them are using traditional warehousing methods and technology instead of the innovative ones. One of the main reasons is that they need to have financial supports to implement new technology. Moreover, they found the current processes suitable for their scale of operations as well as to the competency of labour. Soon, when the business is broadening, AR technology will be more applicable. For company B and C, due to a lack of in-depth knowledge about AR, qualified staff, and management support, it might take time for them to do more research as well as improve their operations.

After determining the restrictions and expectations of AR application in the case companies, some recommendations can be made. The first point is that the companies should analyse their operations to have a better understanding about their drawbacks in warehousing so that a clear strategy could be drawn with detailed revenue and growth forecast. Along with that, doing some relevant research on the external aspects such as the logistics trends, Vietnamese market demand, and even the innovations in foreign markets, is a crucial basis to have a well preparation for operating strategy. Henceforth, companies could possibly consider AR as an intralogistics solution to deal with these disadvantages and catch up with the market demand. However, it would take more time and effort to implement this long-term strategy.

The companies could also call for capital from financial institutions, angel investors or investment banks to expand their operations. Take 'Shark Tank' show as an example, which is a beneficial opportunity for small companies to raise their capital. To explain in more detail, Shark Tank is a business reality television series, where the entrepreneurs have a chance to express their potential ideas to persuade investors or 'sharks' to invest in their companies. The show has already been in Vietnam since 2017 and have supported many start-ups as well as small-scale companies to be on track. For instance, SuperShip was one of the logistics companies that conquered Shark Vuong to gain over

two billion VND for expanding market share to the North of Vietnam. In 2024, SuperShip has been expected to become a publicly held company and implement initial public offering (Cafebiz 2019). Personally I think that, SuperShip has more chances to implement more modern facilities and technologies with this expansion. Therefore, capital calls would be a stable stepping stone for companies to develop.

As one more recommendation, some immersive technology workshops would be a helpful place to broaden the knowledge of AR. Along with that, it is possible to have a one-month-trial of wearable AR devices in a specific area to have a physical experience with this technology. While doing research about AR technology, I found that DHL is the only company that has a 'vision picking pilot program' with the Google's smart glasses and the result has been noticeably improved as the worker productivity has increased by 15%. Although the technology has not been applied for DHL Vietnam yet due to the difference in the scale of operations, it is necessary to test the possibility of implementing AR in Vietnamese warehouses for future needs (Forde 2019).

The last recommendation is that it would be helpful to have an internal training related to the logistics trends so that the staff is able to express their feelings and reactions. In fact, the companies cannot apply any modern facilities or IT systems if their staff is unqualified. For the foreign companies, outstanding staff should be trained abroad in order to learn and apply the new working methods and the technology advancements.

For the reliability, the result of the research might be altered across time due to the fast pace development of interviewed companies. Moreover, it should be more than one interviewee per company to evaluate the internal consistency of the primary data of each company. Not only that, but there had also been some data had been estimated by the interviewees without reliable sources. However, all of the interviewees have a deep understanding of their businesses in order to point out what their strengths and drawbacks are and share trustworthy information. Regarding validity, the structure of the research has been arranged logically with two main parts, i.e. literature review and analysis of results, along with some recommendations. Additionally, there are sufficient contents of theories to analyse the primary data. Still, the sample size is too small to assess the overview of the logistics market in Vietnam.

Besides, the thesis still exists some limitations that need to be improved. At first, despite the meticulous preparing for the interview, it is hard to gather sufficient essential information since most of the vital information is confidential. Consequently, the collected data might not grasp all the aspects for analysing. Secondly, the interviews might last for over 30 minutes, which is not convenient for the interviewees due to their busyness. Finally, the research is expected to have over 10 case companies to enhance the validity aspect; however, only 6 companies have been willing to participate in the interviews and share information.

To sum up, AR technology does have potentiality to contribute to Vietnamese logistics market. However, there are still many disadvantages in applying AR at the moment. When the companies recognise and find the key to their weaknesses, they will possibly flourish in the future and have a better operating system with modern technical equipment.

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Appendix 1. Interview Questions

The interviewees involve six managers from six logistics or e-commerce logistics companies, i.e. three domestics and three global. The interviews were conducted online via Skype or Zoom during the period of 8 to 27 May 2020.

Background information about the company and its warehousing activities

1. What is the size of your company?
 - a) < 50 employees
 - b) < 250 employees
 - c) Above 250 employees
2. What is your company's turnover?
 - a) < 10 million USD
 - b) < 50 million USD
 - c) > 50 million USD
3. Who are the owners of the company and is the majority of the ownership based on domestic or international shareholders and owners?
4. How many warehouses does your company have? Where are those warehouses located? What is the capacity of each warehouse?
5. What are the current processes that take place in your warehouses?
6. What is the % share of working time used for the following activities: receiving, putting-away, picking, packing and other activities?
7. What is percentage of cost allocated for the following activities: receiving, putting-away, storing, picking, packing, other activities?
8. Do you have any improvements or developments to cut-down working time and cost? Why?
9. How do you plan, follow and control your warehousing activities?
10. Do you have some ERP-system in use?
 - a) If yes - what?
 - b) No- why not? How do you do plan and control?
 - c) Any need for development? BOTH yes and no

11. Do you have a WMS in use?

- a) If yes - what and is it linked to your ERP-system?
- b) How is it working? Any need for development?

Technologies used in warehousing

12. What kind of warehousing technologies and IT-systems are you using in your warehouse?

- a) Only manual labour, no technology at all
- b) Traditional warehousing technology like
 - forklifts
 - conveyers
 - bar code scanning
- c) New technology like
 - Robots designed for warehousing activities? For which activities and what robotics technology if they use them?
 - RFID identification
 - Automatic guided vehicles
 - Voice-picking, light-picking
 - Virtual reality - if yes where and for what activities

13. What are the advantages and disadvantages of your currently applied technologies?

14. What are your development needs regarding the technology used in your warehousing activities?

15. If your company has not implemented any changes to current process or invested into new technology, what are the reasons?

Augmented Reality

16. What do you know about Augmented Reality?

- a) Nothing
- b) We are aware of the technology applied in warehousing but not using it yet
- c) We are using AR in some extent in our warehousing activities already

17. What are the main restrictions of not investing or using AR yet?

- a) Lack of information about AR
- b) This is not useful for our current needs and size of operations and business
- c) Lack of management support to invest into AR and other new technology
- d) Too expensive technology for our company
- e) Lack of qualified staff to use AR, need for more time to adapt the processes and train staff
- f) Other reasons. What?

18. If you are familiar with AR and interested to utilize it in the future, how do you think it could be applied to your warehouse operations?

19. What benefits do you expect from utilizing AR in your warehouse operations?

Mark (x) in the feature showing your opinion (Ranking from 1 – the most important to 4 – less important)

	1	2	3	4
Time-saving				
More accuracy				
Cost saving				
Less workers				

20. What kind of support would you need to be able to adapt better to new technologies and overcome challenges, especially AR?

- a) Financial support
- b) Support for training and more information about the benefits and costs and possibilities of AR
- c) Motivated staff are willing to test and try new working methods
- d) Larger warehouses
- e) Other. What?