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The influence of automated processes on warehouse efficiency; a study on 3PL warehouses in Sri Lanka

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Abstract

Warehousing is one of the primary value adding elements in a supply chain and effective warehouse operations are likely to minimize issues such, labor shortages, high truck turnaround times, manual errors and inventory inaccuracies. Moreover, it is the most commonly outsourced function in Sri Lanka.

Automation of basic processes in a 3PL warehouses such as receiving, storing, inventory management and order picking opens up opportunities for driving towards operational efficiency. Multiple means of automated processes under warehousing context exist globally, even though Sri Lanka is at its infancy. Similarly, the number of studies which has been carried out considering the use of automated processes in Sri Lankan 3PL warehouses is very limited.

This study preliminary focuses on determining the impact of four main automated processes; AGVs, drones, WMSs and RFID, identified through literature on warehouse efficiency. Secondly, factors contributing to warehouse efficiency has been explored. Finally a primary study has been carried via in-depth interviews and a questionnaire survey to determine the impact of automated processes on warehouse efficiency amongst Sri Lankan warehouses. Questionnaire survey has been carried out amongst management level employees of manufacturing and producing companies who has already outsourced their warehousing service and who are with the potential of outsourcing.

Key words: automated process, warehouse efficiency, AGV, Drones, RFID and WMS

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List of acronyms and abbreviations

3PL **:** Third Party Logistics

AGV : Automated Guided Vehicles

GRN **:** Goods Receipt Note

GDN : Goods Dispatch Note

WMS : Warehouse Management System

UAVs : Unmanned Aerial Vehicles

RFID : Radio Frequency Identification

CAGR : Compound Annual Growth Rate

NRI : Network Readiness Index

GDP : Gross Domestic Product

EDB : Export Development Board

GPS : Global Positioning System

ROI : Return on Investment

SKU : Stock Keeping Unit

FMCG : Fast Moving Consumer Goods

1.0. Introduction

1.1. Business opportunity

Warehousing has been considered as a significant element of the modern supply chain which further plays the strategic competitive role of improving organizational performance (Karunarathna, et al., 2019). Traditional warehousing which involves a higher human intervention has resulted in higher prone to error percentage, operational inefficiencies, lack of space optimizations and escalated cost factors (Dujmesic, et al., 2018). It is important for warehousing service providers to adapt to highly innovative technological norms to eliminate the associated inefficiencies (Karunarathna, et al., 2019).

In Sri Lankan context, warehousing is the most commonly outsourced function to third party logistics (3PL) service providers, even though its adaption of automated processes and technological implications are in its infancy (Hettiarachchi & Ranwala, 2015). Sri Lankan logistics services contributes to 2.5% of Gross Domestic Product (GDP) (Export Development Board Sri Lanka [EDB], 2021) and it expects a compound annual growth rate (CAGR) of 4% during the years 2016 to 2026 (Modor Intelligence, 2021).

However, Sri Lanka has been considered as an under achieving nation in terms of Network Readiness Index (NRI), ranked at 83 out of 134 economies which measures performance in terms of technology, people, governance and impact (Portulans Institute, 2020) and 12 sub pillars underneath which is further evident from Figure 1 herein. Figure 2 herein depicts Sri Lanka's standings across the 4 pillars and it was evident from the NRI report that the rankings are dominated by high income countries with the first three standings being achieved by Sweden, Singapore and Netherlands.

Nevertheless, Sri Lanka has been ranked 46 in future technological adaption sub pillar from 121 countries considered, which is depicted under Figure 3.

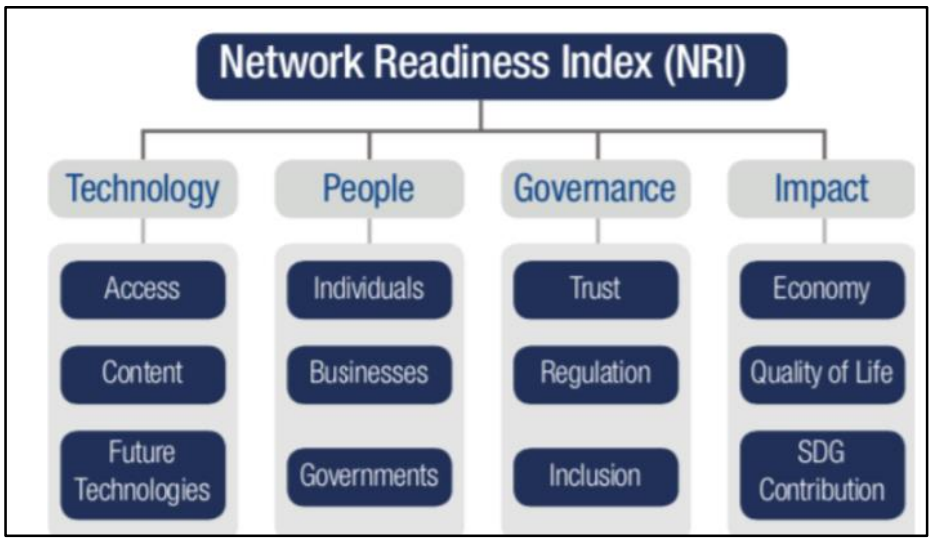

Figure 1- Network Readiness Index: 4 pillars and 12 sub pillars

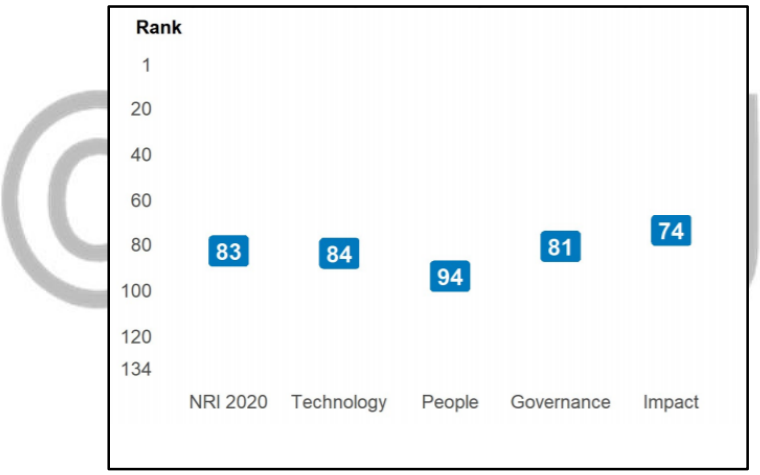

Figure 2 - NRI ranking of Sri Lanka overall and by pillar (Portulans Institute, 2020)

Sub-pillar	Rank	Sub-pillar	Rank
SDG Contribution	39	Content	93
Future Technologies	46	Economy	95
Inclusion	57	Quality of Life	95
Governments	72	Trust	96
Regulation	87	Individuals	99
Access	88	Businesses	114

Figure 3 - NRI sub-pillar rankings of Sri Lanka (Portulans Institute, 2020)

Report of McKinsey and Company elaborates that warehousing is the element in the supply chain with the highest degree of automation (Dekhne, et al., 2019), even so Sri Lanka it is still at a premature stage. However, understanding the importance of automation on overall warehouse efficiency creates a significant business opportunity for 3PL warehouses (Hettiarachchi & Ranwala, 2015).

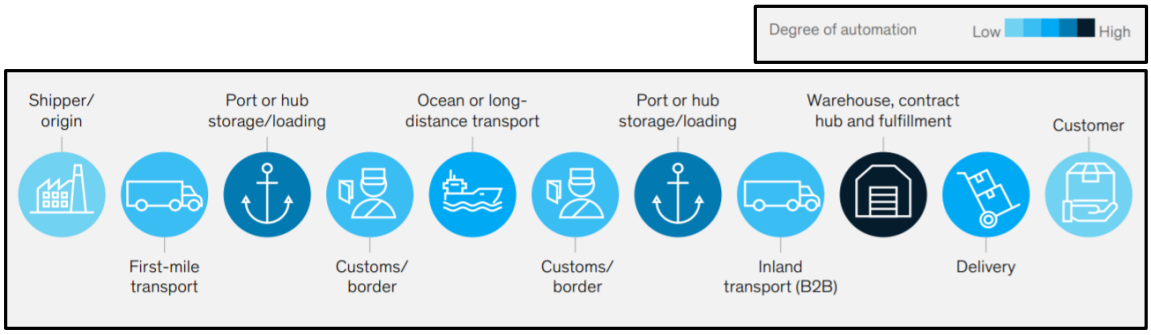

Figure 2 - Degree of automation across the global supply chain (Dekhne, et al., 2019)

Study attempts to determine the level of technological adaption and the business opportunities it has awaken with the impact on efficiency improvement considering five major 3PL warehousing service providers in Sri Lanka; Logicare Private Limited, EFL 3PL, Hayleys Advantis, John Keells Logistics and Spectra Logistics. From a preliminary review, it was evident that afore companies are driving towards automated processes such as Robotic Process Automation (RPA) (EFL 3PL, 2021), warehouse management systems (WMS) (Logicare, 2021) and Radio Frequency Identification Technologies (RFID) (Advantis, 2021) for gearing efficiency and performance.

Similar to Logicare and EFL, John Keells have deployed a tier 1 WMS which has resulted in creation of greater visibility and control over the customer's cargo and seamless integration across multiple enterprise resource planning systems (ERP) of clients to improve decision making (John Keells Logistics, 2021). Moreover, spectra logistics too aims at improving their competitive position in the industry through their own integrated warehouse and transport management system (TMS) (Spectra Logistics (Private) Limited, 2020).

1.2. Research problem

Sri Lanka is aimed at becoming the transshipment hub for the South Asian region and the country aims at transforming in to Asia's leading maritime and distribution hub by

leveraging its logistics processes (Jones Lang LaSalle IP, Inc., 2020). According to the Sri Lankan Shippers' council, adaption of technologies and automated processes is vital to build future resilient supply chains (Abeysekera, 2019). Lack of effort to adapt automated means by industries are likely to hinder their operations and up-scaling of supply chains (Gupta, et al., 2020, p. 104819). Gupta et al. (2020), further states that it diminishes opportunities of driving towards a sustainably innovative supply chain.

At global context studies have been conducted to identify the impact of automated processes on warehouse efficiency (Motafa, et al., 2019) and technological norms such as IT solutions and automated tracking and control systems have been identified as significant factors affecting cost efficiency, space optimization and overall warehouse efficiency (Aminoff, et al., 2002). Report of Michael Badwi (2021) elaborates that deployment of a WMS is likely to improve warehouse utilization by 10% to 40%, shipping accuracy up to 99% and picker productivity up to 50%. Similarly deployment of Radio Frequency Identification (RFID) technology too has created opportunities for companies with minimization of labor cost by 40% and cycle count times by 75% to 92% (advance mobile group, 2014).

Dr. Ashok et al. (2021) has concluded in their study, that inventory accuracy of Amazon supply chain improved up to 99.99% with the use of automated guided vehicles (AGVs). Similarly, Amazon has benefited in terms of cost of delivery and picking efficiency with deployment of unmanned aerial vehicles (UAVs) (Sudbury & Hutchinson, 2016) . It is evident that multiple studies exist at global level which discusses the relationship between deployment of automated processes and warehouse efficiency, however, the number of studies which has been conducted to determine the relationship between the two variables under the Sri Lankan context is minimal (Karunarathna, et al., 2019).

1.3. Research question

Does **automated processes** have an impact on **warehouse efficiency**?

Through a comprehensive review of literature author of this study has identified four processes associated with automation; WMS for management of warehouse related activities, AGVs for cargo picking and cycle counting, UAVs/drones for cargo picking and RFID technology for cargo tracking and enhancing visibility. Further, from the literature review, it was evident that the afore processes are important for

building future resilient supply chains through improved space optimization, increased inventory accuracy, minimized labor costs and sharpened picking accuracy. Hence, author attempts to conduct a primary study and determine the manner in which the identified processes could actuate on warehouse efficiency under Sri Lankan context.

1.4. Research objectives and aims

1.4.1. Research objectives

Objective One: To explore the concepts; automated processes and warehouse efficiency and their relationship using existing literature.

Objective Two: To understand contributing factors for warehouse efficiency.

Objective Three: To determine the impact of automated processes on warehouse efficiency amongst Sri Lankan warehouse.

1.4.2. Research aim

The study will be conducted with the aim of determining the relationship between automated processes and warehouse efficiency in the Sri Lankan context. It attempts on determining the manner in which the automated processes shall gear efficiency in daily warehouse operations comprising of preparation of Goods Received Notes (GRN)/Goods Dispatch Notes (GDN), order picking, record keeping, vehicle turnaround times and cargo dispatching.

Findings of the study are intended towards warehouse service providers in Sri Lanka and professionals in the industry who seeks on means of gearing service efficiency and for academics who are interested in the study area.

1.5. Research rationale

Though automated processes connected with warehousing is new in the Sri Lankan context, these technologies and processes has been already implemented in developed countries reaping successful results; improved operational efficiency, increased productivities and profitability. It further enhances the opportunities for handling higher cargo volumes and densities (Balk, et al., 2017). Automated processes have resulted in effective floor planning, cargo handling and faster response times, followed by benefits such as enhanced convenience, safety and ultimately escalated levels of customer satisfaction (Stoltz, et al., 2017; Lu, et al., 2016). Moreover, it

results in overcoming challenges associated with conventional warehousing; inventory inaccuracies, poor space utilization, high labor costs, process redundancies and shipment delays, and becoming sustainable in its operations (Buntak, et al., 2019).

Though technologies associated with warehousing have been proved as safe, reliable and efficient, 60% of the global companies fail to take complete advantage of its benefits (Skerlic, et al., 2017). Moreover, companies that fails to reap benefits associated with automation finds it more difficult to adapt themselves to cater the modern customer needs in the supply chain and in long run, it would create a disadvantage against the competitors and the demanding global logistics industry (Skerlic, et al., 2017). Similarly, in Sri Lankan context major players in the warehousing industry could focus on determining the optimal ratio between improving warehousing efficiency and satisfying customer needs which would enhance competitiveness and paves path for becoming the leading maritime and distribution hub of Asia with leveraged logistics processes (Jones Lang LaSalle IP, Inc., 2020).

1.6. Research Limitations

Time is the main limitation identified by the author. Time allocated to carry out the research is 12 weeks which does not permit in detail and depth analysis of the subject area of interest unlike a comprehensive study carried out across a period of one or two years. Moreover, the study aims at gathering data from five major 3PL warehousing service providers which is a significant challenge within a short period of notice. Especially with the prevailing pandemic conditions physical meetings for in-depth reviews are not pertinent, hence online discussion had to be arranged.

Similarly identifying the customers morefully falling under the customer portfolio of the warehouse service providers' selected for the study and gathering data through a survey too was a challenge while sticking to the stipulated time frame. Finally, limited availability of research papers which discusses on automated processes and warehouse efficiency under Sri Lankan context is minimal.

2.0. Literature review

2.1. Introduction

Aim of this literature review is to discuss the two concepts; automated process and warehousing efficiency and critically analyze the impact of automated process on warehouse efficiency. Pertaining to automated process four main aspects were discussed; WMS, AGVs, UAVs and RFID technology, whereas under warehouse efficiency, factors such as cost minimization, space optimization, picking efficiency and inventory accuracies were deliberated. Multiple secondary data sources ranging from peer reviewed articles, books, conference proceedings and industrial websites to reports were assessed and based on which the conceptual framework was developed. In addition, contributing factors for warehouse efficiency was identified through a systematic review of literature.

Below figure 5 simply elaborates the manner in which afore concepts shall be discussed in detail under the sub chapters of chapter two herein.

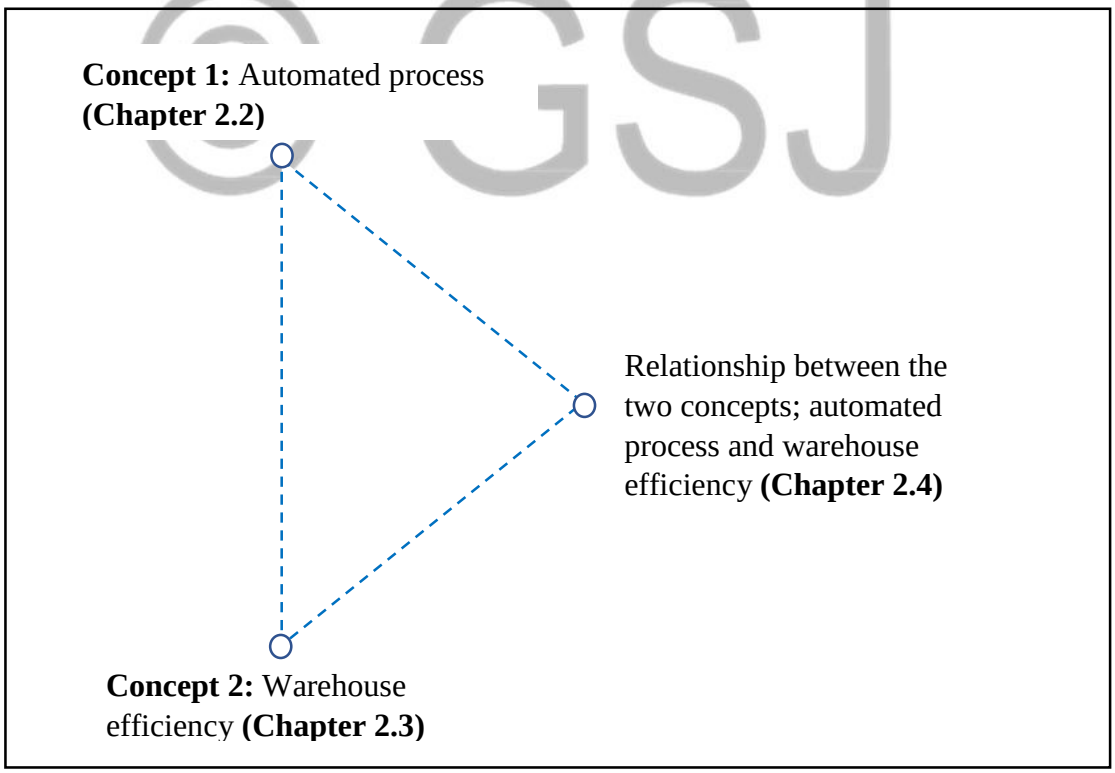

Figure 3- Concepts discussed under Literature Review (Author's work)

2.2. Automated processes

In the past production era of business, automation was explained as the use of robotics and artificial intelligence, but in the current era automation has evolved from merely technological developments to processes undertaken or implemented to increase operational efficiency and to enhance customer satisfaction (smartsheet, 2020). Automated processes could be defined as a strategy which an organization has deployed using technological means to organize operational workflows (smartsheet, 2020).

Kattepur (2019), has defined warehouse automation as the adaption of Industry 4.0 requirements to acquire monetary and performance benefits. Further, Kattepur (2019) has argued that the existing warehousing solutions are predominantly in line with Industry 3.0, which is labor intensive, requires centralized monitoring and static arrangements. Modern warehousing demands, sophisticated handling of concurrent activities in facilitating comprehensive problematic domains such as scheduling, planning and optimization (Hermann, et al., 2016). Analysis of work flow compositions and automation of high level requirements has been reflected as important in realizing solutions for issues in conventional warehousing (van der Aalst, et al., 2018). Supporting the argument, Atieh et al. (2016) has stated that deployment of automated processes in a warehouse is likely to result in exertion of less human effort, minimization of operational costs and increased operational functionality; planning and optimizing.

Path for implementation of automated processes in warehouses has been a result of the challenges faced by traditional warehousing and distribution followed by increased consumer demand (Li, et al., 2008). With globalization, number of partners and delivery points of businesses has grown, frequency of orders has increased, lead time for order receipts has become shorter and labor laws pertaining to drivers, warehouse operational personnel and other staff has become firmer which has created an escalated pressure on warehouse service providers to develop new means of overcoming such challenges (Babics, 2005). Moreover, development and identification of new technological and automated means are aimed at improving inventory management, cargo consolidation, transportation, order pickup and other accompanied warehouse operations and processes (Chen, et al., 2006).

Multiple trends exist associated with warehouse automation at present, out of which adopting to a warehouse management systems, use of drones and picking robots, investing on automated guided vehicles, usage of handheld devices and pick to voice systems has gained a significant importance (Bowles, 2020).

2.2.1. Warehouse Management Systems

Warehouse is viewed as a dynamic environment where multiple types of cargo are received and dispatched every day, and implementation of a WMS is essential to control each activity taking place in a warehouse with minimum labor involvement (Wei, et al., 2016). Primarily to control movement and storage of materials (Ramaa, et al., 2012). According to Pane et al. (2018), WMS is an effective strategy which aims at accelerating growth and reliability of the supply chain. Placement of a complex WMS creates the opportunity to optimize one or more warehouses and to have real time inventory visibility (tracking and tracing). In addition, it offers facilities such as value added logistics, transportation and dock door planning (Ramaa, et al., 2012).

Need for a warehouse management system has risen predominantly, to overcome the issues pertaining to incoherent warehouse utilization and manual handling related human errors (Seifermann, et al., 2014). Further, warehouse management system (WMS) enhances effective functionality of multiple warehouse activities (Lorente & Lorente, 2013). WMS could be a standalone system as well as it could be a module of an ERP which could be RFID technology based, paper based or a combination of both (Ramaa, et al., 2012). Pane et al. (2018) has concluded in their study that use of RFID technology based WMSs' to integrate operational aspects, result in amplified warehouse productivity, modernized work processes and minimized labor involvement.

Gartner has defined WMS as a software application that assists in managing operations of a warehouse including cargo receipt, put-away, stock locating, order allocation, order picking, labor management, material handling and furthermore (Coles, 2020). Figure 6 below depicts the Gartner's magic quadrant for WMS that portrays the best supply chain software technology providers in the current market. As illustrated in the figure herein, industry rivals have been evaluated using the criteria; completeness of vision and execution ability.

Figure 4- Gartner's magic quadrant for WMS (Coles, 2020)

Walmart and Amazon are among the top 20 biggest public companies categorized under Forbes global list of 2020 (Murphy, et al., 2021). Both the companies handle more than a million transactions a day and uses a cloud based WMS; Logiwa to manage their inventory across multiple warehouses and online stores facilitating real time inventory visibility to its clients (Logiwa, 2021).

2.2.2. Automated Guided Vehicles

Population increase and advances in technology has created multifaceted demands on warehousing industry (Mehami, et al., 2018). Use of internet technologies under Industry 4.0 has made warehousing processes more seamless, with less human intervention and allows systems to perform self-decision making (Zhong, et al., 2017). One of the core innovations that satisfy the above characteristics are automated guided vehicles. AGVs are smart vehicles which are used in transporting goods within a warehouse which is unmanned and the size, shape and operation depends on the task to which it has been deployed (Oleari, et al., 2014).

AGVs are navigated using control mechanisms; fixed and free route guidance. In fixed route guidance AGVs shall sense and follow a designated path or paths whereas

in free route AGVs use coordinates to identify locations similar to global positioning system (GPS) and vision guidance (Long & Zhang, 2012). Similarly, Menyhart and Szabolsci (2019) has stated that AGVs follow lines, wires or marks on the floor, magnets, machine vision solutions or lasers for navigation.

At the initial phase AGVs require a high capital investment, however it provides greater economic benefits such as lower maintenance costs in comparison with the conventional vehicles, 24/7 functioning ability with minimum human intervention followed by minimized labor costs and improved safety of operators and pedestrian workers (Dimitrios, et al., 2017). An article in Business Insider (Shead, 2017), has elaborated that upon identification of benefits associated with AGVs, Amazon; world's largest online retailer has deployed over 45,000 AGVs across 20 of its fulfillment centres.

However, Menyhart and Szabolsci (2019) disagrees with Dimitrios et al. (2017) on lower maintenance cost, stating that the batteries used in AGVs lack circuit protection which minimizes the life span resulting in additional costs on battery replacement. Another drawback associated with AGVs as identified by Monica and Ferrari (2021) is the likelihood of the magnetic field followed by AGVs being interrupted due to presence of electric motors operating within the same premises.

2.2.3. Unmanned Aerial Vehicles

Unit picking is one of the most labor intensive tasks in a warehouse and its automation using drones and picking robots brings wider benefits to the industries through improved efficiencies (Pašagić Škrinjar, et al., 2018). UAV has been defined as an aerial vehicle which does not carry a human operator and could fly autonomously or could be piloted remotely (Pašagić Škrinjar, et al., 2018). Drones or UAVs are been widely used for multiple civil applications including environmental protection, ensuring public safety and localization (Sorbelli, et al., 2018).

Apart from above, interest for the use of drones for order picking has risen with the increase of e-commerce orders and with the escalation of global competition (Sorbelli, et al., 2019). In addition, it received attention in the last decade due to its small in size and programmable features (Pašagić Škrinjar, et al., 2018). Order picking and inventory accuracy has improved with the deployment of UAVs as a mobile scanner in warehouses. It can fly vertically to scan barcodes using its frontal scanner (Škorput,

et al., 2019). Similarly, a Radio Frequency (RF) scanner could be used and inventory could be monitored where mismatches in physical and system inventory could be easy reconciled and cycle counts could be carried out with less hassle (Đurić, et al., 2018).

Figure 7 below depicts a comparison of the 2D movements of a drone and a human worker along 10 lanes of a warehouse (6 low cabinets and 4 high open racks). Drones has the ability of flying over the racks to the point in which cargo is placed in low cabinet areas and adjust itself and move through open racks of different heights while the human workers need to push the carts or drive the forklifts to extreme ends of an aisle to change a lane to pick cargo (Sorbelli, et al., 2019).

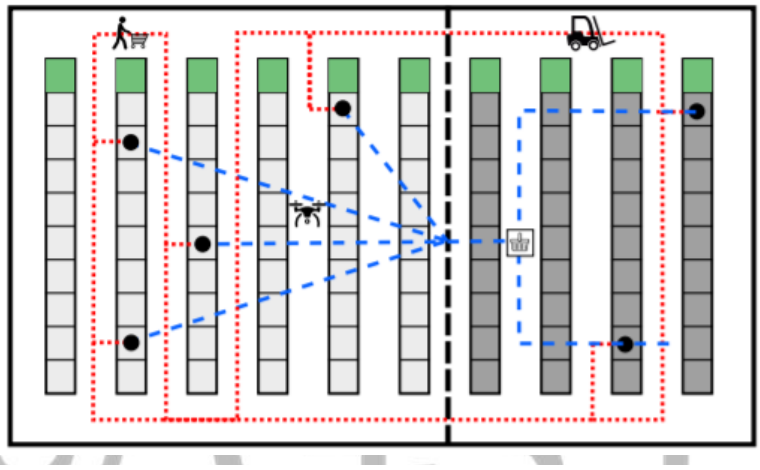

Figure 5- 2D view from the top of the warehouse: black dots are the cargo to be picked (comparison of a drone movement and human worker movement) (Sorbelli, et al., 2019)

Ability to inspect multiple inventory types from a single drone, improved inventory accuracy, reduced costs due to better inventory management and ability to operate even at night are few other benefits of deploying drones for warehouse operations (Đurić, et al., 2018). In contrast, Shavarani et al. (2019) has identified a number of drawbacks associated with drones; ineffective drone activities indoors (inside warehouses) due to weakness in GPS indoors, lack of self-awareness of drones on other moving objects such as forklifts and pickers which is likely to result in a collision and unfavorable to be used in warehouses with low ceilings, hanging lights and intrusive shelves.

Figure 8 depicts the approach of UAVs in outdoor inventory checking as modeled by Duric et al. (2018).

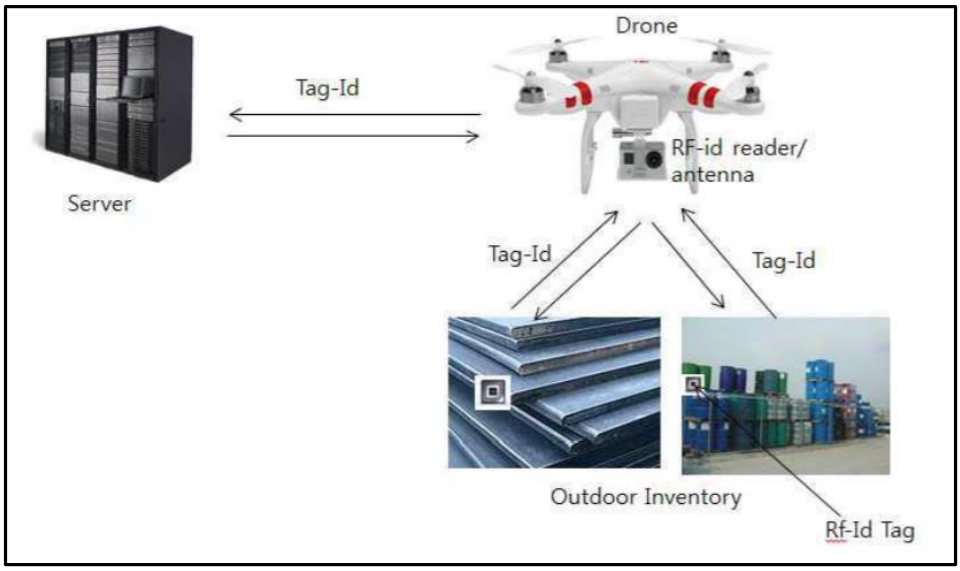

Figure 6- Approach of UAVs in outdoor inventory checking (Duric et al. (2018)

2.2.4. Radio Frequency Identification Technology

Radio Frequency Identification (RFID) is the other notion which has been identified as a significant development associated with warehousing by the author of this study upon critical review and analysis of multiple secondary data sources. RFID is a technology in which information is transmitted via radio waves between RFID tags and readers where the collected information shall be passed via a middleware to be used in business applications (Hunt, et al., 2007). RFID tags carry unique product identification details such as shipping details, item ID, expiry date, production date and furthermore which results in advantages such as, convenience in cargo identification for order picking, improved stock visibility and traceability followed by increased data accuracy and precise inventory counts (Lim, et al., 2013).

Qin et al. (2017), concluded in their study, that RFID is the best solution for the bull whip effect; which is the inaccuracy of inventory due to information distortions in the supply chain. Further, bull whip effect is likely to result in increased holdings and shortage costs. Use of RFID enables an organization to track and trace product information while allowing greater control over inventory throughout the supply chain (Ting, et al., 2013). It minimizes the labor involvement in operations significantly by streamlining the stock taking processes. In addition, it results in provision of better services and enhanced customer satisfaction (Ting, et al., 2013).

Although RFID has been identified as a potential mean of operational enhancement, adaption of technology by the businesses has been determined as slow, prominently

due to lack of standards and guidelines pertaining to the technology and its uncertainties on return on investment (ROI) (Ting, et al., 2013). Study of Choong et al. (2021) has identified lack of international standards for RFID tags, security of data stored in RFID tags and costs and potential risks of implementation as major concerns of managers with regard to use of RFID technology in businesses.

Ting et al. (2013), has further identified critical success factors classified under technological, managerial and social dimensions for effective deployment of RFID systems, which is as depicted in the table 2 below.

Table 1 - Critical success factors for effective deployment of RFID systems (Ting, et al., 2013)

Classification	**Critical Success Factors**
Technological Dimension	Selection of appropriate hardware and software
	Effective testing
	Sufficient technical support
	Clear process and data routing
	Clear performance measures
Managerial Dimension	Clear vision
	Good project management skills
	Good management skills
Social Dimension	Teamwork
	Effective communication

2.3. Warehouse efficiency

2.3.1. Warehouse definition and functions associated with warehousing

Logistics Bureau Group (2017) has defined warehouse as a ‘planned space for efficient storage and handling of goods and materials’. It plays an important role in a supply chain as it is the link between many parties comprising of customers, suppliers, production plants, shippers and furthermore (Ballestin, et al., 2016). Performance of a warehouse is likely to affect directly on the efficiency of the entire supply chain on to which it belongs, which is the reason behind warehouse operators’ persistently seeking for means of enhancing efficiency (Roodbergen, et al., 2015). Storing and retrieving of goods to meet customer orders is the main operational process within a warehouse which further comprises of multiple sub tasks such as

order picking, data entry, cargo staging, quality checking and value adding (Menendez, et al., 2017).

Warehouses are classified mainly in two categories as production warehouses and distribution warehouses (Ghiani, et al., 2004) and further based on the role within the supply chain they are classified as raw material warehouses, finished goods warehouses, work-in-progress warehouses, local warehouses and value added warehouses (Ramaa, et al., 2012). Irrespective of the type of operations handled in afore multiple warehouse types, functions of a warehouse as elaborated in Figure 5; receiving, put away, replenishment, order picking, value additions and shipping are distinctive.

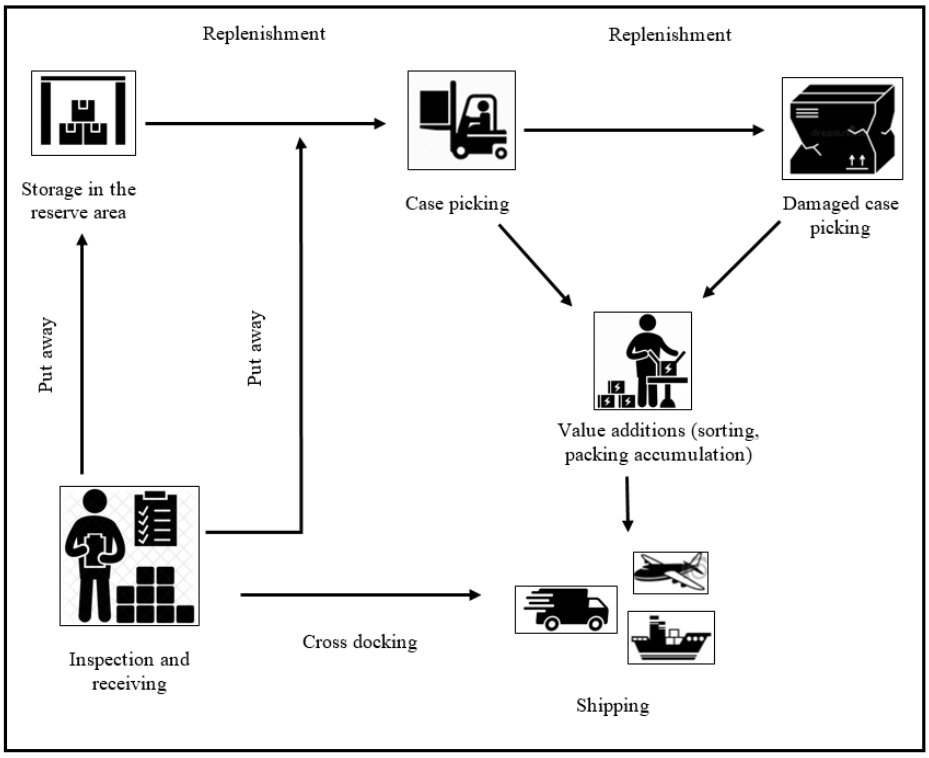

Figure 7- Basic functions of a warehouse (Ramaa, et al., 2012)

2.3.2. Factors affecting warehouse efficiency

According to Cano et al. (2017), success of managing a warehouse is considered to be dependent upon factors such as the effectiveness and efficiency of retrieving customer orders, accuracy of the inventory reports, response times and accurateness of deliveries to multiple locations in multiple volumes. Moreover warehousing is the highest cost incurring factor which accounts up to about 20% of the total cost within the supply chain due to labor and capital intensiveness (Rubrico, et al., 2008). Hence

better warehouse performance is required to ultimately result in better supply chain performance and to create a win-win situation to all participants within the supply chain (Gu, et al., 2007).

Study of Kolinski (2013), has concluded that efficiency of a warehouse depends on two factors; effects (warehouse activities) and spending. Moreover based on his derived efficiency equation, means of improving efficiency has been categorized as four fold as depicted in Table 1 here in.

$E = \frac{e}{s}$ *(e - effects and s - spending)*

Table 2- four folds of warehouse efficiency increasing means based on Kolinski's equation (Kolinski, 2013)

Efficiency (E)	effects (e)	spending (s)
increase	constant	lowering
increase	increasing	lowering
increase	increasing	constant
increase	increasing at a higher rate than spending	increasing at a lower rate than effects

Figure 6 below depicts objectives and tasks that affects warehouse efficiency which comprise of optimum utilization of warehouse capacity, efficient management of space, elimination of non-value adding tasks, monitoring of employee load times, competencies and skill levels and implementation of an effective information flow.

Objectives	Tasks
maximize use of storage space, achieved through appropriate measures in the design, construction and commissioning of the magazine and responding to current changes;	ensuring the availability of technical and personal resources to achieve the planned level of activity - only possible with close coordination with the leadership of the company;
	ensuring the flow of goods corresponding to the requirements for deliveries and shipments - requires cooperation warehouse with procurement and sales departments;
minimizing the use of manipulating operations - the first step eliminates redundant operations, and the second seeks to reduce the execution time of necessary activities	Solid planning, control and maintaining the use of all available resources - is made at the operational level and can be based on production schedules and orders placed with suppliers or sales plans and orders from customers;
	continuous monitoring, evaluation and improvement of the warehouse process according to established criteria - should be based on selected indicators and gauges reflecting the process

Figure 8- Objectives and tasks that affects warehouse efficiency (Kolinski & Sliwczynski, 2015)

Kolinski and Sliwczynski (2015), has further stated in their study that, beside the organizational factors described there are other factors that affects warehouse efficiency such as modern equipment, modern technology, automated systems and identification tools such as RFID and information systems for warehouse management (WMS).

2.3.2.1. Warehouse space optimization

Space utilization in a warehouse is a key factor that creates opportunities to save time, effort and costs (De Koster, et al., 2017). Three types of wastes associated with space in a warehouse as identified by Dehami et al. (2018) are *honeycombing waste*; pallet positions in a partially occupied lane that are unoccupied due to unavailability of all stock keeping units (SKUs), *unoccupied volume at the top of stacks*; occurs due to different stackable heights and different pallet heights, and *accessibility waste*; space dedicated to aisles are not occupied directly for pallet storage which is also considered as a waste. Studies have elaborated multiple mathematical models to identify the optimal aisle lengths, pallet and bin sizes along with block stacking heights (Venkitasubramony & Adil, 2017).

Organizations that are more concerned on technology driven aspects, use systems and applications to optimize space which results in multiple benefits (Derhami, et al., 2018). Increased employee productivity is one benefit of space optimization using technology in a warehouse as a result of assessing current work flow practices, suggesting changes and optimizing operations (Specialized storage solutions, 2021). Similarly, space optimization could result in an efficiency improvement in handling cargo as a result of categorizing cargo as slow moving, fast moving, dimension wise and based on period of storage, and planning space methodically (Specialized storage solutions, 2021).

2.3.2.2. Reduced manual handling and human errors

Manual handling could be defined as the use of physical forces to move, lift, retrieve and store goods. Manual handling does not involve the use of powered machines such as forklifts reach trucks, hence the operations are carried out in a slow pace in comparison with machine handling (Holloway Houston Inc. , 2019). Moreover, human involvement sums up to a significant cost component under the total incurred

costs by a 3PL warehousing service provider. It comprises of costs involved in recruiting skilled labor, conducting trainings, providing salaries and other benefits followed by being accountable at the event of an error or mishandling (Tomáš, 2017).

Use of machinery, equipment and systems creates the opportunity to make the operations more agile, faster and scalable. Use of systems and machinery fastens the repetitive and predictable activities and less prone to accidents and injuries (Schwartz, 2021). In addition reduction of manual handling is very unlikely to result in inventory inaccuracies. Hence lesser will be the additional costs which need to be incurred by the service provider (Carli, et al., 2020). Considering afore it is evident that minimization of manual handling and human errors as a factor leading towards warehouse efficiency.

2.3.2.3. Cost efficiency

Cost efficiency is defined as the way of saving money by changing a product or process to work in a better way (Krajcovic, et al., 2016). Improving the costs is one of the primary ways of achieving a competitive advantage in the industry. However, globally 40%-60% of the cost reduction processes associated with logistics have been unsuccessful (Fuskoa, et al., 2017). Hence it is important to systematically analyze the warehouse operational activities and determine the traditional approaches which could be eliminated from the process and/or transformed in to contemporary approaches with the aim of reducing the costs (Krajcovic, et al., 2016).

Few means of reducing warehouse costs as elaborated in the Industry today (2017) magazine are; *through space optimization* as a result of aisle space adjustments and using narrow and tall racking for storage, *inventory protection*; with the use of state of art security system and a rotational guard system to protect from theft, and control mechanisms such as RFID and voice directed picking (VDP), *implement the use of alternative energy sources*; natural light in the warehouse during day time and installation of solar panels to power machinery and equipment, and *invest and adapt technological means such as WMS and RFID*; which minimizes the associated labor costs as well.

2.3.2.4. Improved order picking efficiency

Among all warehousing functions; comprising of receiving, storage, packing and dispatching, order picking is the most time consuming and labor intensive operation

(Wang, et al., 2020). Order picking is defined as the process of selecting and arranging items from the stock to dispatch based on the dispatch order. An efficient order picking at the warehouse is important for smooth flow in the remaining supply chain process; packing, shipping, receipt at the customer's end and after sales activities (Giannikas, et al., 2017).

Single order picking, batch picking and zone picking are the most common manual order picking methods (APS Fulfillment Inc., 2018). Firstly, in single picking, picker is provided with a single order at a time whom shall be given another order based on completion of the order. Secondly, in batch picking, pickers pick SKUs required for multiple order at time. Finally in zone picking warehouse is divided in to a number of zones and a picker collects all SKUs from a particular zone before moving in to the next zone for collection of cargo. However, manual picking results in inefficiencies as elaborated in below Table 3 herein.

Table 3- Picking problems and impacts on productivity (Badwi, 2021)

Problem	**Impact**
Difficulty of tracking items on locations	• Inefficiency • Time wastage • Delayed orders • Customer dissatisfaction
Picking errors; wrong items in wrong volumes	• Time wastage • Incorrect dispatches • Refunds and replacement costs • Decline of profitability • Customer dissatisfaction
Difficulty of pick prioritization	• Important orders getting delayed to dispatch • Recent dispatch order being picked first by default
Labor intensive	• Increased labor effects the cost and profit • Overtime increases • Missed fulfillment deadlines
No staff tractability	• No accountability

	• Difficulty of managing • Lack of visibility • Reduced staff efficiency

2.3.2.5. Enhanced inventory visibility

In a data driven economy, enhancing visibility throughout the supply chain is important to be a head of competition. Similarly, inventory visibility is an important factor which impacts overall warehouse efficiency (Marc, et al., 2019). In simple, knowing the inventory which is available in the warehouse at which locations and in what quantities. Enhanced inventory visibility results in efficient use of time, improved predictability, improved control over quality and systematic allocation of resources (Leung, et al., 2017).

Lack of transparency on the inventory leads to many challenges such as discrepancies in stock counts, delays in arranging shipments, increased costs and customer dissatisfaction (Fozia Rajab, et al., 2017). Cross et al. (2017) suggests the use of technology, machinery and equipment such as RFID, WMS, Electronic Data Interchange (EDI) systems and material handling equipment (MHE) to manage inventory methodically. Methodical inventory management increases inventory visibility which further result in reduced cycle times and operational flexibility (Gresham, 2017).

2.4. Impact of automated processes on warehouse efficiency

Although a couple of studies exists to individually determine the impact of the identified automated process trends with warehouse efficiency (Atieh et al., 2016; Cannon et al.,2008), number of studies which has considered two or more of the trends and its impact on efficiency in a single study are limited.

2.4.1. Impact of WMS on warehouse efficiency

Many scholars have determined that a system could be automated using an Enterprise Resource Planning (ERP) system; a software for collecting, storing, managing and interpreting data belonging to multiple business activities. Implementation of a correct ERP system will provide easier coordination between units, eliminates waste and shall assist in making faster and better decisions (Atieh, et al., 2016). WMSs belongs to the category ERP systems which are being adopted by warehouse service providers with

the primary goal of managing the movement and storage of goods in an effective way. Moreover WMSs are designed to reduce costs through optimum space utilization and high inventory visibility (Lorente & Lorente, 2013). Addition to cost reductions, automation of common warehouse processes through a WMS results in time savings and escalated profits (Atieh, et al., 2016).

Miralam (2017), in his study has concluded that WMS results in increased inventory accuracy, and reduction in operations costs involving labor, supervision and paper work. Similarly, it provides the 3PL service providers with greater opportunity to serve the customer (Ariff, et al., 2012) through reduced cycle times and minimized errors. WMS results in better space optimization, improved receiving process and reduction of time spent on fulfilling customer order requirements (Halawa, et al., 2020).

2.4.2. Impact of RFID technology on warehouse efficiency

Technology advocates have recommended that RFID technologies will result in improved organizational and supply chain performance (Cannon, et al., 2008). RFID utilization in a production warehouse is likely to impact the financial performance both directly and indirectly (Green Jr., et al., 2009). Further, raw materials, work-in-progress and finished goods inventories could be efficiently managed to eliminate waste, minimize over/short supply via improved planning and better capacity utilization (Zelbst, et al., 2012). Integration and coordination with the WMS deployed in a warehouse, too is facilitated upon implementation of RFID technology (Green Jr., et al., 2009). Hence it is evident that adoption of RFID technology paves path for warehouse efficiency.

Sarac et al (2010), has outlined that deployment of RFID addresses many challenges associated with 3PL warehousing such as inventory inaccuracies due to theft and misplacements, bull whip effect due to information delays and ineffective replenishments due to miscommunications. Moreover RFID technology increases the visibility throughout the supply chain (Cannella, et al., 2015), enhances stock taking accuracies and results in a minimum number of errors associated with receiving and replenishment (Biswal, et al., 2018).

2.4.3. Impact of AGVs on warehouse efficiency

Both production and distribution warehouses have migrated towards automation at a significant rate in the last few decades with the aim of reducing costs and avoiding unsafe working conditions (Oleari, et al., 2014). Dexterity, efficiency and flexibility are few of the characteristics of AGVs which results in it being widely used for material handling inside a warehouse. Moreover it can easily be controlled through an intelligent computer system (Lacomme, et al., 2013). Important role played by AGVs is evident by considering the number of world renowned brands which has deployed AGVs to improve operational efficiency such as Amazon, Volkswagen, BMW, Deutz and Denso (Lee, et al., 2018).

It was evident from the study of Kabir and Suzuki (2018) that flexibility and efficiency of warehouse operations are achievable with the use of AGVs. Further, the volume of cargo handled during a peak season could also be improved. Lee et al. (2018) has identified numerous advantages associated with RFID deployment such as improved warehouse productivity, enhanced predictability of quality, improved receiving and dispatching process consistency, minimized labor involvement and reduction of errors.

2.4.4. Impact of UAVs on warehouse efficiency

Drones too have gained a significant importance pertaining to warehouse automation and the pace of adoption of warehouse drones have accelerated making warehouse monitoring, inventory management and order picking simpler, efficient and effective (Companik, et al., 2018). Bose (2016), in his article reflects that the warehouse inventory count process of Walmart, which has initially taken 30 days to complete has dropped to a single day with the adoption of drones. Drone implementation is likely to address warehouse inefficiencies and be amenable to automation through improved inventory accuracy, better cargo location, enhanced capacity utilization and order picking optimization (Companik, et al., 2018).

Kwon et al. (2020) has discussed that UAVs has multiple advantages over human labor as it minimizes the time and cost involvement and assists in successful stock counting and inventory inspections. UAVs provide more flexibility in motion inside warehouses in comparison with the conventional terrestrial vehicles (Patchou, et al., 2019). With improvements, reliability of UAVs have increased and they have the

capacity to operate for long hours with one battery charge or one fuel tank refilling which is cost effective for the warehouse service providers (Kille, et al., 2019).

In addition to the factors identified below Table 4 reflects benefits associated with the discussed automated trends as identified by multiple authors through a range of studies.

Table 4- Warehouse automation trends (Author's work)

Automation trend	**Associated benefits**
WMS	• Optimum warehouse utilization, minimization of manual handling and minimization of human errors (Seifermann, et al., 2014) • Improves order picking and stock locating accuracies (Coles, 2020)
Drones or UAVs	• Improves order picking efficiency and the ability of locating cargo at multiple heights (Sorbelli, et al., 2018)
AGVs	• Minimum human intervention and 24/7 functionality (Dimitrios, et al., 2017)
RFID	• Order picking accuracy improvement (Hunt, et al., 2007) and improved stock visibility (Lim, et al., 2013).

2.5. Summary of Literature Review

Author	Automated Processes				Warehouse Efficiency				
	Warehouse Management Systems (WMS)	Automated Guided Vehicles (AGVs)	Unmanned Aerial Vehicles (UAVs)	Radio Frequency Identification (RFID)	Space optimization	Reduced manual handling and human errors	Cost efficiency	Improved order picking accuracy	Enhanced inventory visibility
(Wei, et al., 2016)	X					X			
(Ramaa, et al., 2012)	X			X	X				X
(Pane et al.,2018)	X			X		X			X
(Seifermann, et al., 2014)	X					X			
(Mehami, et al., 2018).		X							
(Zhong, et al., 2017)		X				X			
(Oleari, et al., 2014).		X							
(Long & Zhang, 2012).		X						X	
(Menyhart and Szabolsci, 2019)		X							
(Dimitrios, et al., 2017)		X				X	X		
(Pašagić Škrinjar, et al., 2018)			X		X	X	X	X	X
(Sorbelli, et al., 2018)			X					X	
(Đurić, et al., 2018)			X	X		X	X		X
(Shavarani et al., 2019)			X						
(Hunt, et al., 2007)				X					
(Lim, et al., 2013)				X				X	X
Qin et al. (2017)				X				X	X
(Ting, et al., 2013)				X				X	X
(Choong et al., 2021)				X					
(Kolinski and Sliwczynski, 2015)	X			X					
(De Koster, et al., 2017)					X				
(Derhami, et al., 2018)					X				
(Venkitasubramony & Adil, 2017)					X				
(Specialized storage solutions, 2021)					X				
(Holloway Houston Inc. , 2019)						X			
(Tomáš, 2017)						X	X	X	
(Schwartz, 2021)						X		X	
(Carli, et al., 2020).							X		

Figure 9 - Summary of Literature Review (Author's work)

Author	Automated Processes				Warehouse Efficiency				
	Warehouse Management Systems (WMS)	Automated Guided Vehicles (AGVs)	Unmanned Aerial Vehicles (UAVs)	Radio Frequency Identification (RFID)	Space optimization	Reduced manual handling and human errors	Cost efficiency	Improved order picking accuracy	Enhanced inventory visibility
(Krajcovic, et al., 2016).							X		
(Industry today, 2017)	X			X	X		X		
(Wang, et al., 2020)								X	
(Giannikas, et al., 2017)								X	
(Marc, et al., 2019)									X
(Leung, et al., 2017)					X		X		X
(Fozia Rajab, et al., 2017)									X
Cross et al. (2017)	X			X					
(Gresham, 2017)							X	X	X
(Atieh, et al., 2016)	X								
(Lorente & Lorente, 2013)	X				X		X		X
(Ariff, et al., 2012)	X					X	X		
(Miralam, 2017)	X					X	X	X	
(Halawa, et al., 2020)	X				X	X		X	X
(Green Jr., et al., 2009)				X			X		
(Zelbst, et al., 2012)				X	X			X	X
(Sarac et al., 2010)				X		X			X
(Cannella, et al., 2015)				X					X
(Biswal, et al., 2018)				X				X	X
(Oleari, et al., 2014)		X				X	X		
(Lacomme, et al., 2013)		X					X		
(Lee, et al., 2018)		X				X	X	X	X
Kabir and Suzuki, 2018)		X				X	X		
(Companik, et al., 2018)			X		X	X	X	X	X
(Bose, 2016)			X					X	
(Kwon et al., 2020)			X			X	X	X	X
(Patchou, et al., 2019)			X			X			
(Kille, et al., 2019).			X				X		

Figure 10 - Summary of Literature Review Cont. (Author's work)

2.6. Conclusion and conceptual framework

3PL warehousing service providers are continuously working towards exploring and determining ways and means of improving overall warehousing efficiency. In the modern world highest focus has been placed on automation of processes which is a strategy where technology is deployed.

Under automated processes the author has placed her focus on four main aspects namely, WMS, AGVs, UAVs and RFID technology and has discussed warehouse efficiency in terms of five broad areas; space optimization, reduction of manual handling and human errors, cost efficiency, improved order picking efficiency and enhanced inventory visibility.

Most of the resources cited herein, have considered a single automated process and have determined the impact on a single factor under warehousing efficiency. From the conducted ground work, it is evident that automated processes such as RFID technology, drones, WMSs and AGVs has an optimistic effect on warehouse efficiency. However, in some studies it does not necessarily prove as such and is contradictory.

Based on the literature review the conceptual framework was drafted which is as depicted under Figure 11 herein. It shall be used in further carrying out this study; questionnaire building, selection of methodology and data collection techniques and finally in concluding the study.

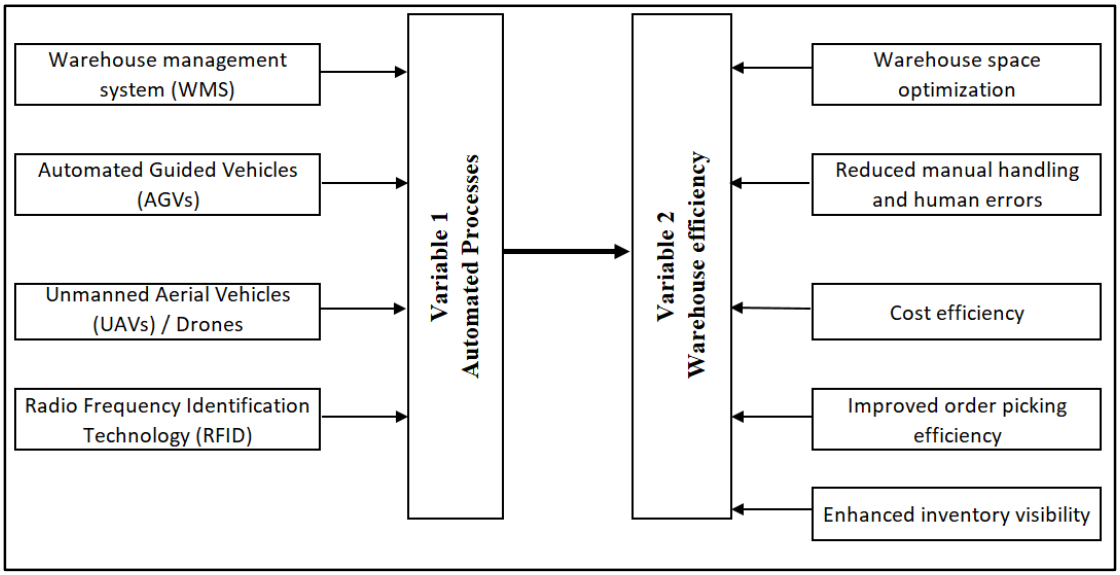

Figure 11- Conceptual Framework (Author's work)

3.0. Methodology

3.1. Introduction

Research Methodology is a key chapter in a research as it entails how the research was conducted, and the principles, procedures and guidelines that govern the study undertaken (Nayak & Singh, 2015). Under this chapter the informed choices made by the researcher with regard to methods, tools and techniques are justified to give a clear understanding to the reviewers (Saunders, et al., 2016).

Firstly the chapter outlines the research framework under which the philosophy, approach, strategies and data collection techniques followed by the author has been justified. Secondly the chapter discusses on how the author has rationally carried out the qualitative and quantitative study. Finally the chapter has been concluded by discussing the limitations faced during the study.

3.2. Research framework

Research framework outlines the logical and systematic approach that was followed by the author when conducting the study in terms of Saunder's (2016) Research Onion (Figure 12). It could be simply put forth as the manner in which the researcher aims at answering the research question (Saunders, et al., 2016).

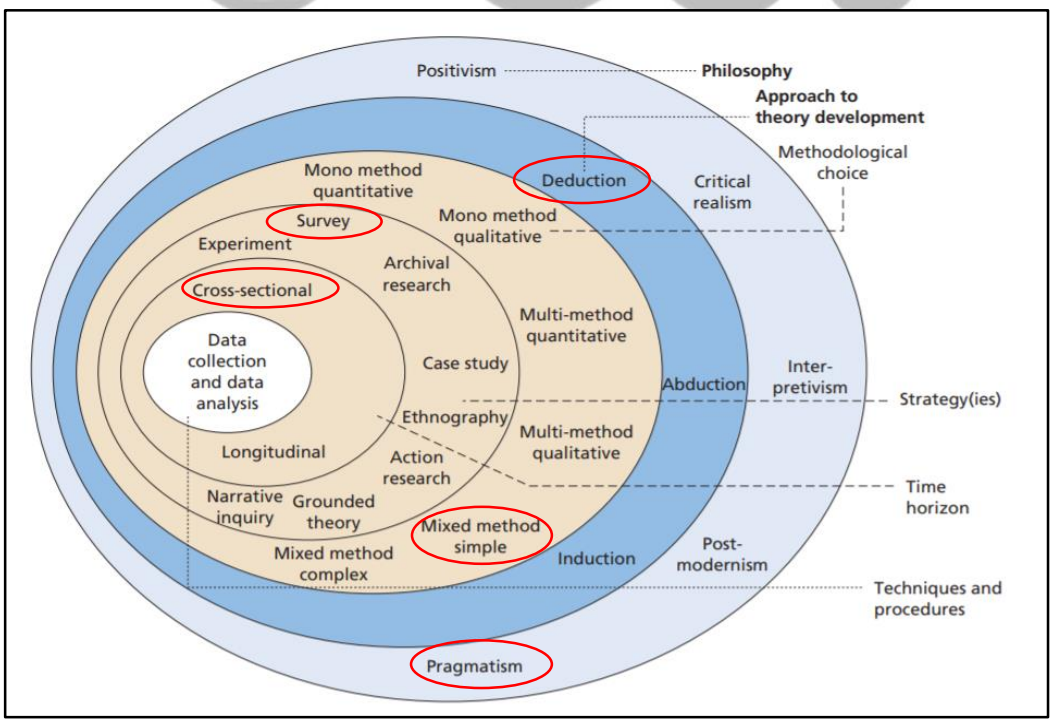

Figure 12 - Saunder's Research Onion (Saunders, et al., 2016)

3.2.1. Research philosophy

Research philosophy has been defined by Saunders et al. (2016) as a set of beliefs and assumptions about knowledge development. It makes the researcher constantly aware of the assumptions made and choices devised at every stage of the research. Further, based on Saunders et al. (2016) two core areas was focused by the author when making the philosophical choice; beliefs and assumptions associated with the study and major research philosophies available within business and management studies.

There are five major research philosophies; positivism, critical realism, interpretivism, post modernism and pragmatism (Saunders, et al., 2016). All research philosophies are encompassed with three common elements; axiology – beliefs about the role of values and morale, ontology – assumptions about the nature of reality and epistemology – the manner in which knowledge is acquired (Kaushik & Walsh, 2019). These elements shape the manner in which the research question is understood, methods were selected and the manner in which findings were interpreted.

Ontology (nature of reality or being)	**Epistemology** (what constitutes acceptable knowledge)	**Axiology** (role of values)	**Typical methods**
	Positivism		
Real, external, independent One true reality (universalism) Granular (things) Ordered	Scientific method Observable and measurable facts Law-like generalisations Numbers Causal explanation and prediction as contribution	Value-free research Researcher is detached, neutral and independent of what is researched Researcher maintains objective stance	Typically deductive, highly structured, large samples, measurement, typically quantitative methods of analysis, but a range of data can be analysed
	Critical realism		
Stratified/layered (the empirical, the actual and the real) External, independent Intransient Objective structures Causal mechanisms	Epistemological relativism Knowledge historically situated and transient Facts are social constructions Historical causal explanation as contribution	Value-laden research Researcher acknowledges bias by world views, cultural experience and upbringing Researcher tries to minimise bias and errors Researcher is as objective as possible	Retroductive, in-depth historically situated analysis of pre-existing structures and emerging agency. Range of methods and data types to fit subject matter
	Interpretivism		
Complex, rich Socially constructed through culture and language Multiple meanings, interpretations, realities Flux of processes, experiences, practices	Theories and concepts too simplistic Focus on narratives, stories, perceptions and interpretations New understandings and worldviews as contribution	Value-bound research Researchers are part of what is researched, subjective Researcher interpretations key to contribution Researcher reflexive	Typically inductive. Small samples, in-depth investigations, qualitative methods of analysis, but a range of data can be interpreted

Figure 13 - Comparison of the five research philosophies (Saunders, et al., 2016)

Ontology (nature of reality or being)	Epistemology (what constitutes acceptable knowledge)	Axiology (role of values)	Typical methods
Postmodernism			
Nominal Complex, rich Socially constructed through power relations Some meanings, interpretations, realities are dominated and silenced by others Flux of processes, experiences, practices	What counts as 'truth' and 'knowledge' is decided by dominant ideologies Focus on absences, silences and oppressed/ repressed meanings, interpretations and voices Exposure of power relations and challenge of dominant views as contribution	Value-constituted research Researcher and research embedded in power relations Some research narratives are repressed and silenced at the expense of others Researcher radically reflexive	Typically deconstructive – reading texts and realities against themselves In-depth investigations of anomalies, silences and absences Range of data types, typically qualitative methods of analysis
Pragmatism			
Complex, rich, external 'Reality' is the practical consequences of ideas Flux of processes, experiences and practices	Practical meaning of knowledge in specific contexts 'True' theories and knowledge are those that enable successful action Focus on problems, practices and relevance Problem solving and informed future practice as contribution	Value-driven research Research initiated and sustained by researcher's doubts and beliefs Researcher reflexive	Following research problem and research question Range of methods: mixed, multiple, qualitative, quantitative, action research Emphasis on practical solutions and outcomes

Figure 14- Comparison of the five research philosophies cont. (Saunders, et al., 2016)

This study would be based on pragmatism philosophy, which is concerned with action and change, and interplay between knowledge and action. Pragmatism could be stated as the appropriate choice for researches intervening in to the world rather than merely observing the world (Goldkuhl , 2012).

Justification behind author's philosophical choice in consistence with the elements ontology, axiology and epistemology is as below.

a. *Axiology:* values shall play a major role in result interpretation of results in this research and both subjective and objective opinions shall be considered.
b. *Ontology:* Author has refused metaphysical concept such as truth and reality, but is open for empirical inquiry (Creswell, 2011). Study shall begin with the opportunity for improving warehouse efficiency and assess means of automation to propose changes for traditional practices.
c. *Epistemology:* Knowledge shall always be based on experience where the author shall get involved and get an insight of the concepts (Morgan, 2014).

3.2.2. Research approach

Research approach is the second layer from outside in the research onion. Saunders et al. (2016) has discussed three main approaches; induction, deduction and abduction.

This study is based on the deductive approach where the research has started with theory where the literature review elaborates information pertaining to the two concepts under discussion and research strategy has been selected appropriately to test the theory. Moreover, the choice is justified through findings of Woiceshyn & Daellenbach (2018), details that deduction approach is used when there is an opportunity to start by entailing theory pertaining to concepts, analyze data gathered and stem substantial justification of the theory.

Theories extracted through literature pertaining to automated processes and warehouse efficiency has been used by the author to answer the research questions and derive at findings.

3.2.3. Research choice

Third layer standing from the outermost layer of the research onion is research choice. Methodological choice derives the manner in which the author shall carry out the study while focusing on the research design, participants, techniques, procedures and ethical considerations. Qualitative, quantitative and mixed methods are the three main choices available which has been sub categorized in to six methods by Saunders et al (2016) and is depicted in Figure 12.

Author has decided on mixed method as the research design was a combination of qualitative and quantitative elements (Saunders, et al., 2016) and as both qualitative and quantitative techniques were incorporated in data gathering and analysis. Questionnaire used to gather data is quantitative in nature whereas the structured interviews carried out as open ended questions to gather insights on warehousing under Sri Lankan context, are qualitative in nature. Hence the use of mixed method is justified.

3.2.4. Research strategies

Research strategies represent the fourth layer from outside the research onion. Choice of research strategy is guided by the research questions and objectives, and the rationality with the link to the research philosophy, approach, purpose, level of

existing knowledge on the area of interest and finally the amount of time and resources which could be extended to further test the theories (Saunders, et al., 2016). Eight main research strategies exist namely; experiment, survey, archival research, case study, ethnography, action research, grounded theory and narrative inquiry. These strategies could be deployed either individually or as a combination.

Author selected the survey strategy as it is consistent with the deductive approach and is considered as a common strategy in determining answers for questions involving what, where, how and when. Another reason being that survey gives more control over the research process while enabling the author to gather a standardized set of data economically. Questionnaires, structured observations and structured interviews are categorized under surveys (Saunders, et al., 2016) out of which author proceeded with a questionnaire and structure interviews.

Questionnaire was used by the author as it allows collection of a considerable volume of data and structured interviews was used to gain more insights from industry experts as the number of studies on automated processes and warehouse efficiency in Sri Lankan context is limited.

3.2.5. Time horizon

Time Horizon is twofold; as cross sectional and longitudinal, and it depends on researchers' choice of whether he or she wants to carry out the study in a snap shot of time or whether he or she wants it to take place over a period of time (Saunders, et al., 2016). Cross sectional studies take place in a single point of time (Solem, 2015, p. 205) whereas longitudinal studies are carried out along a wide time frame.

Time constraint is one of the main reasons for cross sectional studies to be popular among researchers (Saunders, et al., 2016). Author of this study also relies on cross sectional which is justified due to the limitedness of time.

3.2.6. Research methods for data collection

Under section 3.2.3., above it has been justified that the researcher proceeds with the research choice of mixed method (Saunders, et al., 2016). Hence data collection was carried out using both a qualitative and quantitative technique.

Researcher planned on initially carrying out the qualitative study via in-depth interviews and secondly a quantitative study was carried out via a questionnaire.

Researcher planned on in-depth interviews first as she believed that she could gain more insight pertaining to the warehousing industry in Sri Lankan context from the industry professionals and experts as the number of literature on Sri Lankan aspect was limited.

Using information gathered through the interviews and from the literature, questionnaire was constructed and was distributed among people who has experienced the warehousing service and who further belongs to the client portfolio of major 3PL warehousing service providers in Sri Lanka. Benefits associated with the choice of questionnaire survey to collect data are; it is cost effective, creates opportunity for comparing data and collecting a considerable amount of data within a short time span (Nayak & Narayan, 2019).

3.3. Qualitative study

According to Aspers and Corte (2019), qualitative study is the systematic search, identification and analysis of non-numerical data scattered across a multiple sources, to illustrate a definition in order to capture the core elements under consideration. In a qualitative study it is important to explore, analyze, synthesis and transform data gathered precisely in order to address the research objectives and answer the research question (Saunders, et al., 2016).

For the purpose of qualitative study, author carried out in-depth interviews to gather more insights pertaining to the topic.

3.3.1. In-Depth interviews

In-depth interviews need to be planned thoroughly in order to demonstrate the competence and credibility of the author and to gather confidence of the interviewees (Saunders, et al., 2016).

Depth interviews were carried out with a member of the senior management team of each service provider considered for the study. In addition, to gain a comprehensive understanding of the industry an interview was carried out with a supply chain consultant (refer Table 5 herein).

Due to the prevailing Covid-19 pandemic situation in the country, interviews were not physically conducted. However, it was successfully conducted via Zoom and Ms

Teams applications. Further, the interviews lasted for a period of 45 minutes to 1 hour.

Table 5- Interviewees, interview date and time period taken for the interviews (Author's work)

3PL Warehouse Service Provider	Designation	Interview date	Interview time period
Logicare Private Limited	Head of Operations	22nd of August 2021	45 minutes
EFL 3PL	Manager – Supply Chain Innovations & Systems	22nd of August 2021	45 minutes
Hayleys Advantis	Head of Marketing – Business Development and Logistics Solutions	28th of August 2021	45 minutes
John Keells Logistics	Manager – Solutions and Delivery	28th of August 2021	45 minutes
Spectra Logistics	Head of Logistics and Operations	31st of August 2021	45 minutes
Gayathri Karunanayake	Supply Chain Consultant	31st of August 2021	1 hour

3.3.2. Information recording

Prior conducting the interviews author of the study prepared a discussion guide with a set of questions and topics to be discussed with the interviewees. Discussion guide could be regarded as a reference tool for the discussion and it gives an understanding to both the parties regarding the flow of the interview (DJS Research, 2021).

All the interviews carried out were recorded by the researcher in Zoom and Ms Teams applications itself and was also written down as notes, upon seeking permission from the interviewees.

Data gathered was analyzed using content analysis upon systematic identification of trends, methods and facts. Moreover, data gathered from interviews were cross checked with data gathered from literature review to identify accords and controversies (Kyngas, 2020).

3.3.3. Challenges

Carrying out the interviews remotely was the main challenge faced by the author, as physical meetings would have been more productive and focused than virtual meetings.

3.4. Quantitative study

Quantitative study is associated with data which could be quantified using numbers, and analyzed using graphs and tables to illustrate the findings (Saunders, et al., 2016). Author conducted the quantitative study using a quantitative survey.

3.4.1. Quantitative survey

Quantitative survey is the process of collection of quantitative data from a sample which could be analyzed using descriptive statistics (Saunders, et al., 2016). Author carried out the survey among customers who are currently experiencing and have experienced 3PL warehouse services who more fully falls under the customer portfolio of 3PL warehouse service providers selected for the study.

3.4.2. Population

Population of interest for the quantitative study is the customers who has experienced and are currently experiencing the 3PL warehousing service in Sri Lanka. A list of population or a sampling framework cannot be presented as the population of interest is broad.

3.4.3. Sampling

A sample could be defined as a subset of population, selected to be a representative of the population of interest (Acharya, et al., 2013) as it could be not practical for the whole population which is broad to be considered for the study (Saunders, et al., 2016). There are two main sampling techniques according to Saunders et al (2016), as probability sampling and non-probability sampling.

This study is based on non-probability sampling as the probability of each customer in Sri Lankan who is experiencing and has experienced 3PL warehousing services, being selected in to the target population is unknown (Saunders, et al., 2016). Non-probability sampling is four fold as quota, purposive, volunteer and haphazard (Saunders, et al., 2016).

Out of the four, author selected purposive sampling as it is the technique which enables the author to select the sample which will be the best fit to answer the research question and to meet the research objectives (Saunders, et al., 2016). Further, it has been explained as the best technique associated with a small sample size from which more informative data could be obtained.

Researcher shared the questionnaire among 35 management levels employees belonging to manufacturing and production companies who have the potential to outsource their warehousing operation and among companies who have already outsourced their warehousing operation and is categorized under the client portfolio of the companies considered by the author for the study. However, only 34 were considered as valid responses as one has not been completed in-detail. Table below outlines the response summary.

Table 6 - Response Summary (Author's work)

Total number of questionnaires shared	Total number of responses	Total number of valid responses	Total number of invalid responses
35	35	34	1

3.4.4. Questionnaire

A self-rated questionnaire was developed by the author based on findings of the published studies which are cited under references herein and was fine-tuned using details gathered from in-depth interviews.

Questionnaire was developed using the application survey monkey and was shared among the sample, and responses of the respondents were automatically recorded in the application itself when responses were made. Data recorded was extracted from the application and fed in to Microsoft Excel to analyze descriptively and derive at findings.

3.5. Limitations

Study was carried out along a period of three months, which made author complete each phase of the study in an accelerated pace. Which has been the main reason behind limiting the sample size of the quantitative study to 35. If the time would have permitted sample size would have been increased which would have lowered the likely error in generalizing to the target population.

The other main challenge was conducting the in-depth interviews virtually due to travel restrictions imposed in the country. If the interviews were conducted physically, the sessions would have been more productive and focused than the remote sessions.

3.6. Conclusion

This chapter has primarily outlined and justified the choices made by the author of this study pertaining to research philosophy, methodological choice, approach, techniques and procedures, time horizon and data collection. In addition, it discusses the limitation and challenges faced by the author and the manner in which the data analysis and finding derivation was planned.

4.0. Findings and analysis

4.1. Introduction

This chapter will detail out the findings of this study. A primary research has been conducted through a survey which has been distributed among the target population elaborated under chapter 3. Primary data was also gathered through in-depth interviews which have been conducted by the researcher with members of the senior management team of service providers. Further, a secondary research has also been conducted through existing literature using books, peer reviewed journals, and industry related statistics and reliable websites. The literature gathered through this research is presented on Chapter 2 of this study. This chapter will focus on the identification of potential relationships between the primary and secondary research findings.

4.2. Analysis of qualitative study - in-depth interviews

4.2.1. 3PL industry and its growth

The industry has been kick started with one key player who commenced operations by introducing the first ever WMS system. From thereon, the industry has gained more traction with promotional activities conducted by the government on Sri Lanka. This has been further boosted by the growth of the apparel industry, who have mostly commenced warehousing operations with their own back of factory warehouses and later acted upon the need of outsourcing.

4.2.2. Automated processes

A common identification from the interviews is that with the growth of the industry, application of technology has increased. However, it was noted that due to related costs of technology, Sri Lanka is far behind in comparison to other countries.

As per the interviews, labor is identified to be cheaper in Sri Lanka, rather than. Therefore, companies explore opportunities of traditional warehousing with more focus on scale. This displays that more emphasis on cost rather than quality is placed. As such, companies face difficulties in implementing technologies. In questioning on the challenges of implementing automation processes, it was identified there are other challenges such as change management which poses difficulties in changing the mindsets of people in adopting technology, lack of support from the political environment and language barriers. There are also gaps in level of knowledge where best practices and new trends are not adopted which are caused by gaps in education systems.

4.2.2.1. WMS

It was evident that the industry is experienced with a few WMS technologies such as IFS, Infor and HighJump, stemming from globally renowned brands. As stated by the interview participants, WMS is considered as one of the most basic technologies, where customer relationship management is a key area served. It was noted that a key factor which challenges its adoption some organizations is the inability in assessing the real benefits gained by the customer in comparison to if the customer is ready to accept the investment in the form of pricing increases. This translates to the need of identifying if the 3PL organization itself is ready in making the investment. However, it is also important to note that there are various other support systems which need to work interactively in bringing about the real efficiencies required in a 3PL operation.

4.2.2.2. AGVs

AGVs are at a premature level in Sri Lanka, which is an important technology adopted in the global 3PL industry. The key reason behind this is the costs involved along with the lack of education and knowledge on the real impacts of such technologies. As such, it was mentioned that it is important that organizations take initiatives on investing in trainings, up skilling, change management and addressing

language gaps. Such initiatives ideally need to be driven from the leadership levels of organizations.

4.2.2.3. UAVs

It was noted that the adoption of UAVs in Asian countries is very less compared to European countries, where the feasibility of adopting them in warehouses has not been fully explored in Sri Lanka. This too is in relation to cost of deploying and the difficulties in affording such technologies by 3PL companies. Apart from cost, Sri Lanka is not developed enough to adopt drone technologies where air routes in different geographical parts of the country is a concern. Further, the implementation of strong monitoring systems is also a challenge. However, it has also been noted that adoption of drones within warehouses for activities such as cycle counting would make operations and quick and efficient, which could be enabled through barcode reading capabilities, a technology which is already adopted in warehouses. Beyond cycle counting, it was mentioned that the application of drones within a warehouse is a question which may be disrupted in the next 10-15 years. Companies such as DHL have adopted UAVs in delivering packages in global contexts, where the e-commerce vertical could be improved heavily using drones.

4.2.2.4. RFID

It has been noted on the interviews that RFID is a clear driver of efficiency in warehousing which will result in the reduction of labor costs. However, RFID tags are expensive as they need to be imported and it may not be financially feasible. However, if the tags are implemented from the manufacturer end itself, a smooth flow of information could be followed, where 3PL organizations could integrate their WMS in tracking the cargo. As such, RFID would possibly allow in the reduction of around 80% of manpower, where other equipment such as conveyor belts could be deployed within the process in eliminating manual checking of cargo.

4.2.3. Warehouse efficiency

In relation to warehouse efficiency, the followings findings could be evaluated through the interviews conducted.

4.2.3.1. Automated processes and efficiencies

It is evident that there are clear benefits through the adoption of automated processes on warehousing operations, where enhancement of warehouse efficiencies was

highlighted by all interview participants. A key benefit mentioned was the ability in eliminating the labor-intensive manual operations. Across situations where complete automation is unable to be performed, semi automation aspects are brought in by certain 3PL organizations which allow them in managing different client operations effectively. Efficiencies of inventory accuracy, accurate order entry and reporting are a few ways in which human errors are minimized. It also generates efficiencies through the speed up of processes, resulting in better operational performances across areas such as faster picking, timely generation of reports and quicker verification of inventory, which result in the ability of performing operations faster. According to the interview participants, this is evident in the apparel industry.

However, certain participants have mentioned that it is important to have relevant infrastructure of the warehouses set up such as Wi-Fi enabled environments, racked warehouses enabled with location controlling aspects, demarcated storage, staging and handling areas etc. Such areas also result in investments for 3PL organizations which is a challenge. Further, the culture of employees was also highlighted as a challenge where change management aspects are required. It was also highlighted that knowledge on the impact of automated processes on creating efficiencies in the warehouse needs to be improved. Finally, support from top management in driving enhanced efficiencies through automation was also mentioned as a requirement.

4.2.3.2. Warehouse space optimization

It has been stated that management of warehouse space is a tedious task for 3PL organizations, which is heavily impacted by the changing peaks and demands of customer operations. One of the 3PL professionals who was interviewed highlighted this as a challenge in managing space due to varied requests from customers which is commonly seen from apparel and FMCG related customers. As such, it was noted from the interviews that various measures are taken by 3PL operators in optimizing the space to ensure that there is minimal waste in the warehouse. Therefore, organizations use various systems, applications such as CLASS software, WMS systems, data and analytics etc. in looking at best possible ways of optimizing space.

The interview participants acknowledged that adoption of technological approaches in optimizing warehouse space result in benefits such as employee productivity,

optimization of workflow and best practices, improvement in handling of cargo along with better aspects of planning of space.

4.2.3.3. Reduced manual handling and human errors

Reduction of manual handling was highlighted as one of the main generators of efficiencies. It was identified that various machines such as powered forklifts, reach trucks and pallet jacks are used in reducing manual handling, as they impact on the reduction of labor involvement in operations and results in less human errors. An example was provided by one participant where using machinery, equipment and other systems in handling of operations result in speedy execution of repetitive and predictable activities such as picking and scanning, whilst also providing better opportunities of health and safety for employees as they would be less prone to workplace accidents and any injuries. Further, automated processes such as RFID scanning instead of manual cycle counting would result in better inventory accuracy. This was identified as one of the greatest achievements of automated handling processes.

4.2.3.4. Cost efficiency

A common identification across the interviews conducted was that cost efficiencies is a vital area for a warehouse provider, and this is generated with the constant pressure that customers face from their end consumers on pricing. It was mentioned that this will allow the 3PL organizations in being highlighted in the industry among its competitors and gain more business.

Few of the interview participants have highlighted that certain technologies such as RFID, voice picking, WMS, barcode scanning along with mechanical automation in loading and unloading have been adopted in their operations in primary levels. Such technologies result in cost efficiencies through faster and accurate results. As such, it was mentioned that it is vital for 3PL organizations in working with customers in understanding specific requirements which would bring about efficiencies in operations, with special references to cost benefits that could be passed on to customers as well.

4.2.3.5. Improved order picking efficiency

It was emphasized in a few interviews that order picking is a vital step in the entire warehousing process and often consumes the most time. Further, it requires large

labor involvement as it requires cross checking the physical inventory against the pick order received. As such, it was highlighted that it is one of the most vital steps which requires automation where efficiencies could be generated. An interview participant highlighted the need of order picking efficiencies especially in the apparel industry where raw material picking such as fabric rolls takes considerable time and effort, where if automated processes such as RFID are embedded, significant efficiencies could be gained. Such efficiencies could be passed on to the customer and result throughout the supply chain process.

It was identified on the interviews that a common inefficiency seen in manual picking processes is difficulties in tracking inventory on their designated locations. Further, there are also inefficiencies such as picking of wrong volumes. Both of such challenges are highlighted as could be solved through RFID, which is currently being explored across major 3PL players in the country. Further, there are multiple pick orders received from different customers, where prioritization of such picks have been highlighted as a tedious task. However, it has been realized that through the WMS, orders could be prioritized based on location control, order sizes and other parameters. Further, all interview participants have highlighted that labor-intensive operations result in extended working hours resulting in overtime which could be improved via technology adoption.

4.2.3.6. Enhanced inventory visibility

It was understood through the interviews that inventory visibility has been recognized as crucial in the supply chain process. Therefore, inventory accuracy impacts on warehouse efficiency levels. Therefore, it was stated that 3PL providers need to ensure that a track of all inventory against each location stored needs to be maintained to ensure that picking processes are conducted faster and efficiently.

Such efficiencies across inventory visibility is brought in through the adoption of technologies such as deployment of WMS where system generated inventory reports are generated. Further, RFID technology is deployed to ensure that accurate inventory details are captured so that inventory records are updated correctly. It was highlighted that such processes are adopted as there is a clear benefit to the warehouse providers through efficient processes.

4.3. Analysis of quantitative study - survey

4.3.1. Sample profile

Demographic data has been understood as an important factor adopted in the analysis of findings from a survey, as it provides data regarding the research participants. This is important in identifying if the participants form a representative sample of the target population (Hammer, 2011).

Table 7: Demographic analysis (Author's work)

Variable	Category	Frequency	Percentage (%)
Experience service from a 3PL warehousing service provider	Currently experiencing	9	26
	Have experience	17	50
	Looking forward to experience	2	6
	No experience	6	18
	Total	**34**	**100**
Industry of employment	Apparel	8	24
	Automobile	1	3
	Banking ATMs	1	3
	FMCG	5	15
	Logistics	6	18
	Logistics, FMCG	1	3
	Logistics, Manufacturing	1	3
	Manufacturing	6	18
	Manufacturing, Apparel	1	3
	Manufacturing, FMCG	1	3
	Pharmaceutical	1	3
	Tech	1	3
	Trading Architectural Hardware and Appliances	1	3
	Total	**34**	**100**

It is evident from above that the 50% of respondents were already having experience in receiving service from a 3PL warehousing service provider, whereas there were 26% participants who were currently experiencing service. Furthermore, 24% of the respondents were identified to be from the apparel industry, with 18% and 15% of respondents being from FMCG and Logistics industries. As such, key industries such as apparel, FMCG and manufacturing which contain higher volumes in terms of products have had strong experience with working with 3PL service providers in the country. Further, it also displays that logistics companies too have experience with being served by 3PL warehousing companies, where outsourcing of services within the industry is evident.

In relation to the demographics, having participants with strong experience with 3PL organizations through their own industries such as FMCG, Manufacturing, Logistics and Apparel depict that a sound balance of respondents have been selected for the study which would account to the reliability of data gathered and results presented.

4.3.2. Automation process

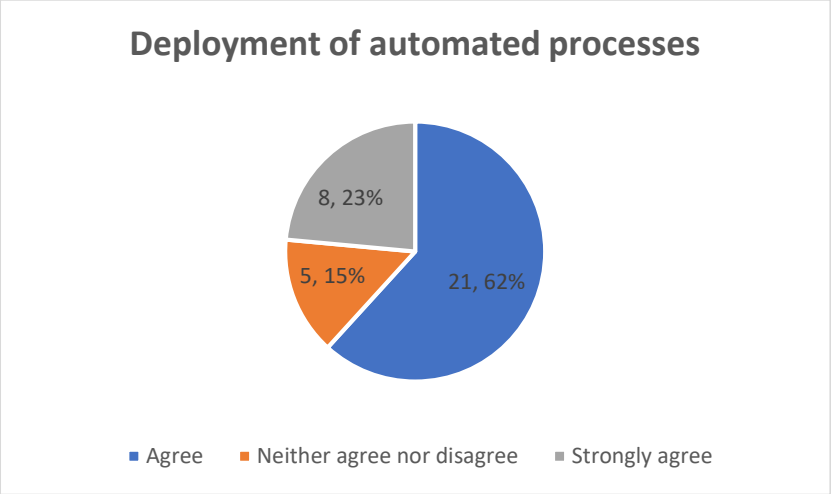

Figure 15: Deployment of automation processes (Author's work)

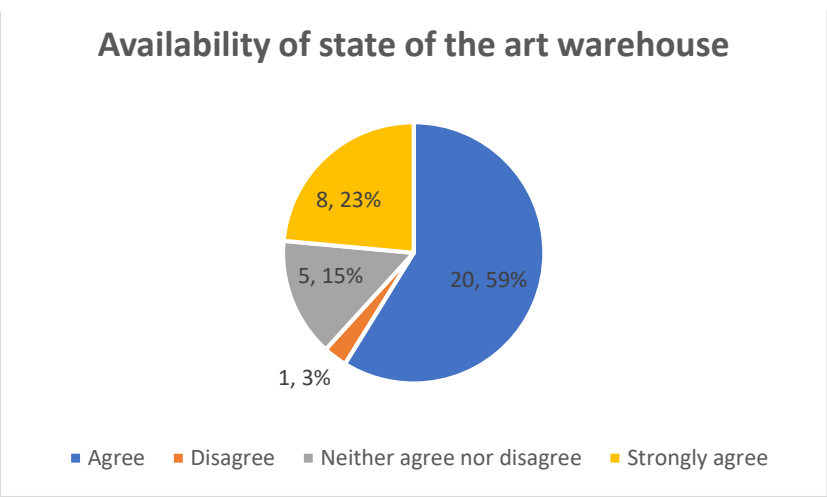

Figure 16: Availability of state-of-the-art warehouses (Author's work)

23% of the respondents and 62% of the respondents strongly agree and agree that automated processes are deployed in 3PL warehouses across the 3PL warehousing companies, accounting to 85% in total. This displays there is evidence of automation processes being followed in Sri Lankan 3PL organizations. 15% of the respondents have stated that they neither agree nor disagree, which could be due to the lack of awareness. 23% of the respondents and 59% of the respondents have stated that they strongly agree and agree that state-of-the-art warehouses are available across the 3PL

service providers. This accounts to 82% as a total. 15% of the respondents have stated that they neither agree nor disagree. However, 3% of the respondents have stated that they disagree.

In comparing the above two statements, a similar trend could be seen, where most respondents (over 80% of respondents) have agreed on both aspects. As a result, a relationship could be seen where the availability of state of the art warehouses would be impacted on the level of automation processes being deployed at the warehouses.

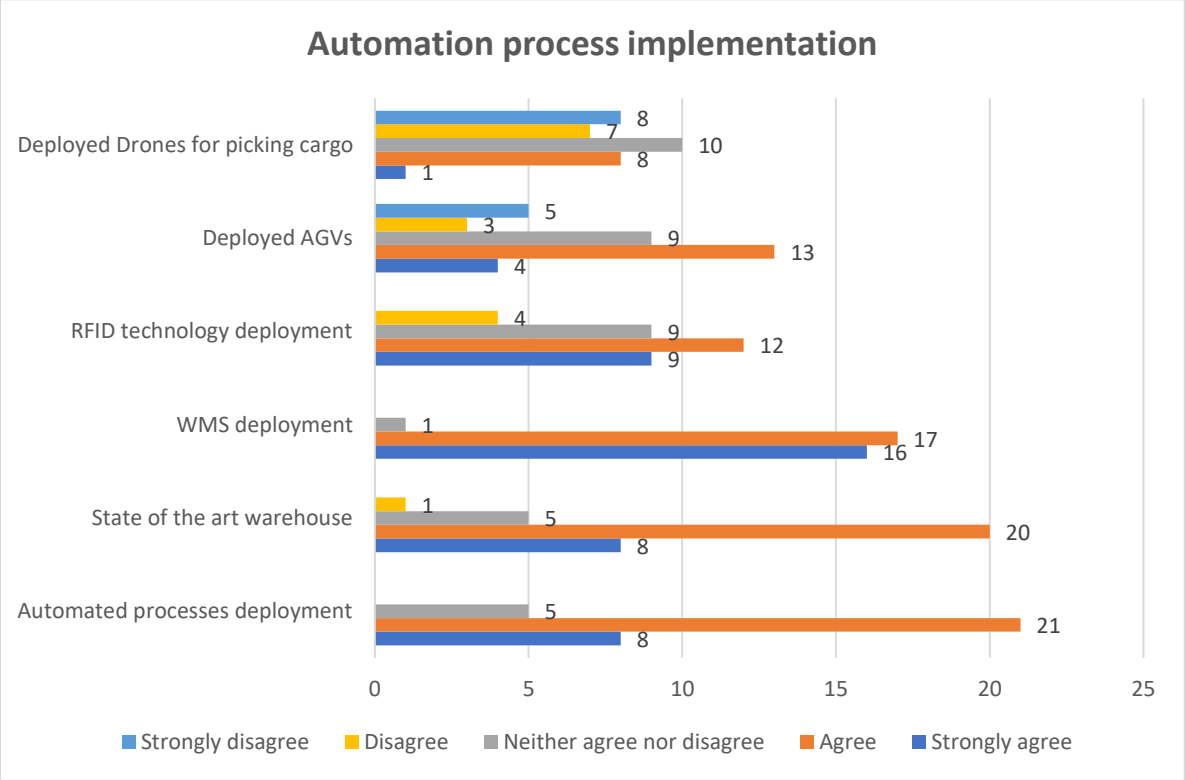

Figure 17: Automation process (Author's work)

It is evident from above chart that for WMS implementation at 3PL organizations is high with 97% as agreed. However, there is 1 response received as disagree for WMS deployment at 3PL warehouses, which shows that there are still organizations who have not deployed a WMS in their operations, which could be identified as lacking one of the basic requirements in a 3PL operation. RFID technology deployment is at 62% for the same responses whereas AGVs have received 50%. However, drones have been recorded at a rate of only 26% for the agreed option of response, where the majority of the responses has been recorded for neither agree nor disagree which is at 30%. This shows that the deployment of WMS, RFID and AGVs at 3PL warehouses in Sri Lanka are at a considerable level. However, RFID technology has been

received responses under disagree and strongly disagree options at 12%, AGV at 24% and drones at 44%. This displays that there is room for improvement for the implementation of these technologies in the 3PL industry of Sri Lanka.

In comparison to the level of deployment of these technologies against the statements of automated process deployment along with the availability of state-of-the-art warehouses, a similar pattern is evident where majority of the respondents have agreed to these statements.

It is evident that 100% of the respondents employed from the apparel and manufacturing related industries has agreed that WMS is deployed at 3PL organizations, whereas 68% of the respondents have stated the RFID has been deployed. 55% have stated that AGVs have been deployed and only 22% have stated that UAVs have been deployed. In relation to participants from the logistics industry itself, 100% have agreed on WMS deployment where no one has agreed on UAV deployment, displaying similar results. Further, even though 77% of respondents have stated that automation processes have been deployed in 3PL organizations, only 5 respondents depicting 15% have agreed that all 4 technologies have been deployed.

4.3.3. Warehouse efficiency

Warehouse space optimization

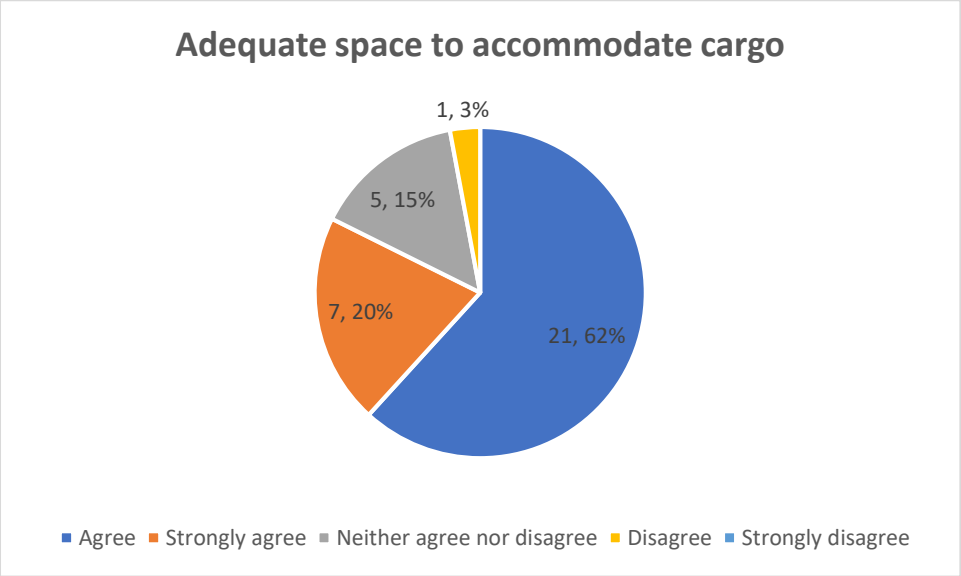

Figure 18: Availability of adequate space (Author's work)

It could be noted that 82% of respondents agree that there is sufficient space in 3PL warehouses in Sri Lanka in accommodating cargo. However, there is 1 respondent

who has rated as disagree, which displays 3% of the respondents feel that there is no adequate space. The fact that main industries with higher volumes of cargo in Sri Lanka such as apparel, FMCG and manufacturing are working with 3PL companies, the lack of sufficient space across the warehouses could have been created.

Reduced manual handling and human errors

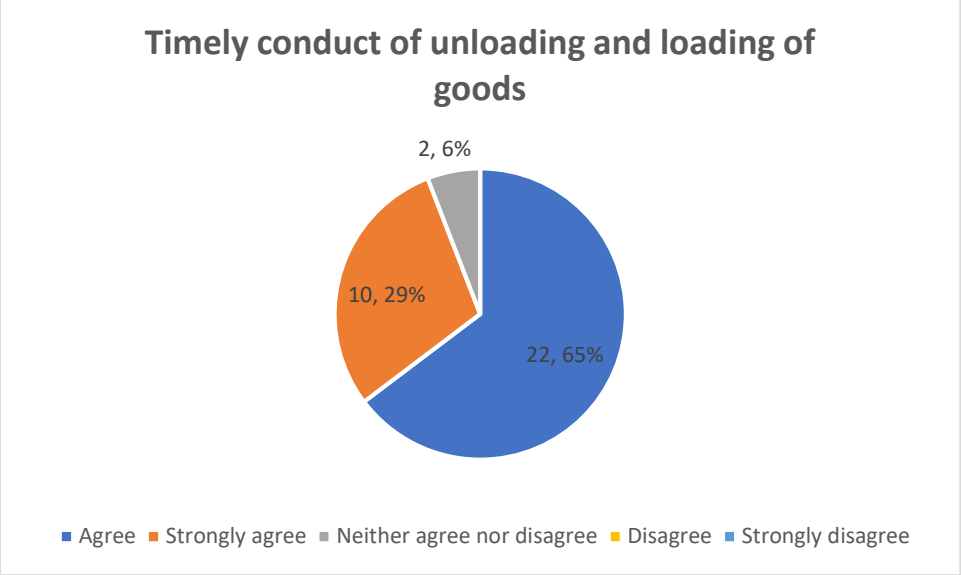

Figure 19: Timely conduct of unloading and loading (Author's work)

It is evident that 94% of the respondents agree that they experience timely conduct of unloading and loading of goods which is a favorable area in managing a 3PL operation. This could probably mean that there are already strong processes existing in the 3PL operations which is evident through no respondent having disagreed with the statement. However, 6% of the respondents have neither agreed nor disagreed which could be due to lack of knowledge on the topic.

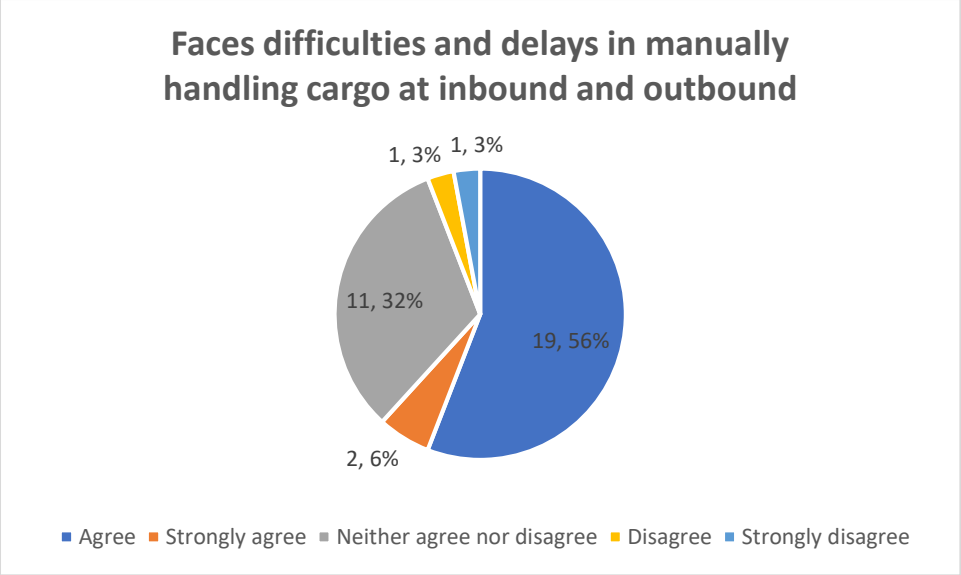

Figure 20: Faced difficulties and delays in manual handling (Author's work)

62% of the respondents agree that they face difficulties and delays in manual handling of cargo at inbound and outbound, which could be an area that could be automated in eliminating manual work-related delays. However, 6% of the respondents disagree. 32% of the respondents also neither agree nor disagree as well, which may be due to unawareness.

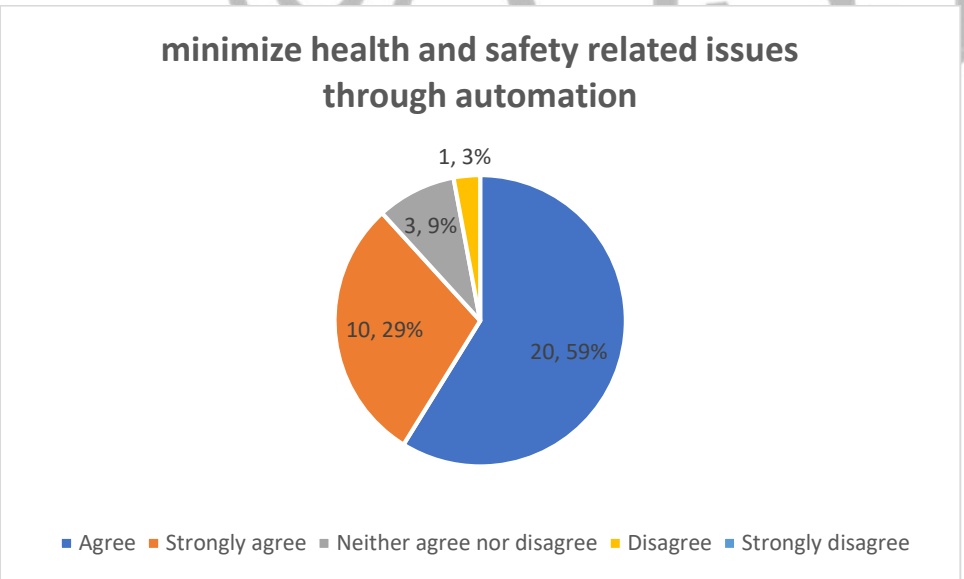

Figure 21: Adequate measures to minimize health and safety issues (Author's work)

It is evident that 3PL organizations take measures in minimizing health and safety related issues as respondents have agreed at 88%. However, 3% have disagreed where 9% have stated that they neither agree nor disagree. This proves that through

automation employee safety could be enhanced. Further, minimizes the repetitive actions involved in operations.

Cost efficiency

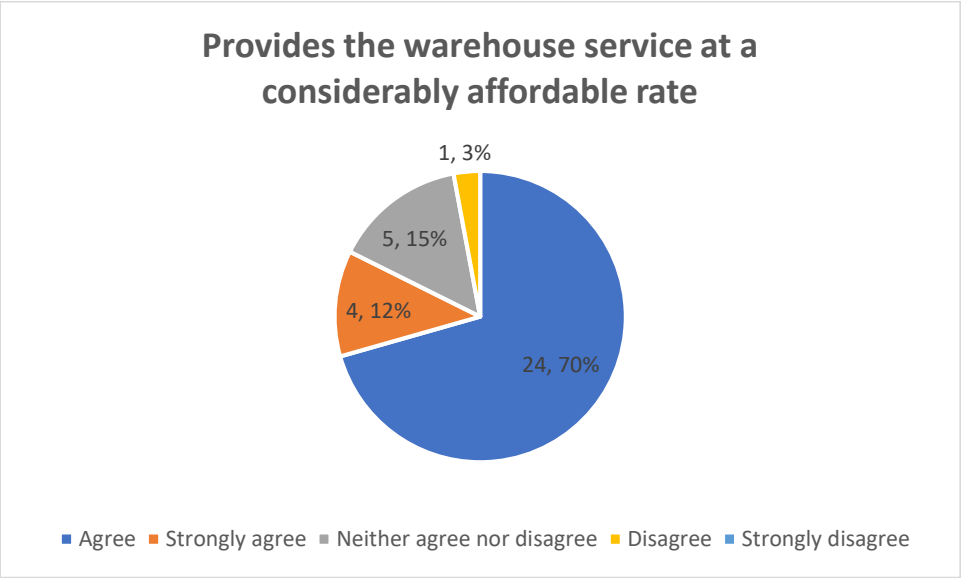

Figure 22: Affordable rates of warehousing (Author's work)

82% of the respondents have noted that 3PL organizations provide services at a considerably affordable rate where 15% have neither agreed nor disagreed and only 3% of the respondents have disagreed. Considering the majority of the responses, it could be noted that affordable rates are offered to customers. It could be elaborated that with the use of technology, process can be simplified and made efficient hence the minimized cost factor could be passed on to the customers.

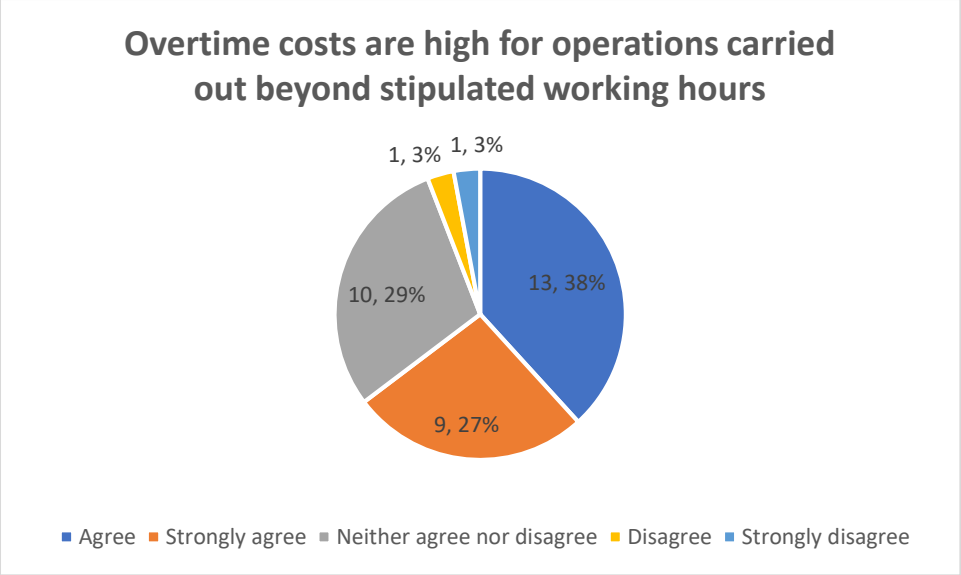

Figure 23: Overtime costs of warehousing (Author's work)

However, 65% of the respondents feel that overtime costs are high for operations carried out beyond working hours. 29% have stated that they neither agree nor disagree and 6% have disagreed. Additional hours of work is commonly generated with inefficiencies in the warehouses which is passed on to the customers as overtime costs. If the manual processes and repetitive tasks could be minimized by automating the processes the overtime hours could be minimized, similarly the costs would decrease.

Improved order picking efficiency

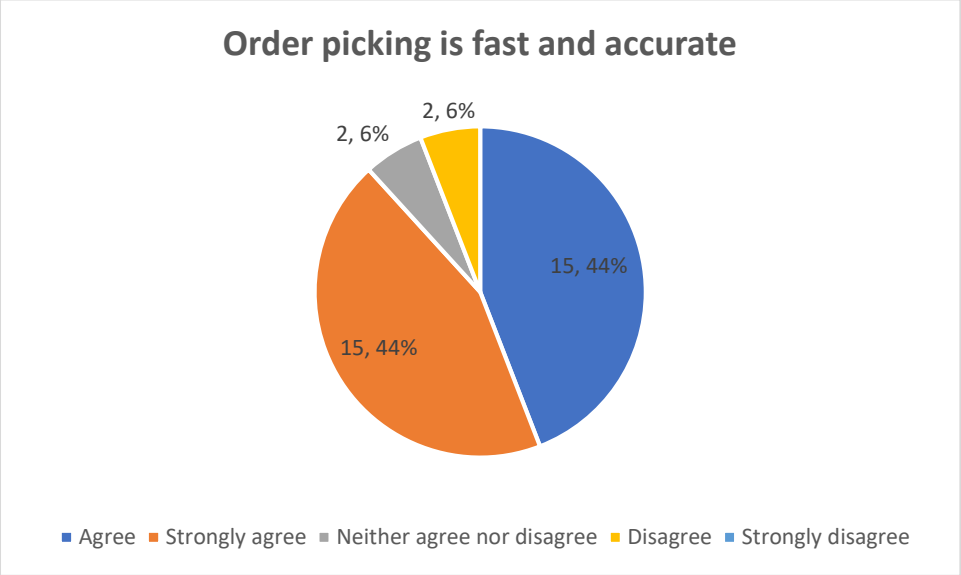

Figure 24: Perform value additional activities (Author's work)

6% of the respondents have disagreed on the fact that order picking is fast and accurately carried out by the service providers where 88% of the respondents have agreed on the statement. This means that order picking delays and inaccuracies takes places which is a drawback for a service provider.

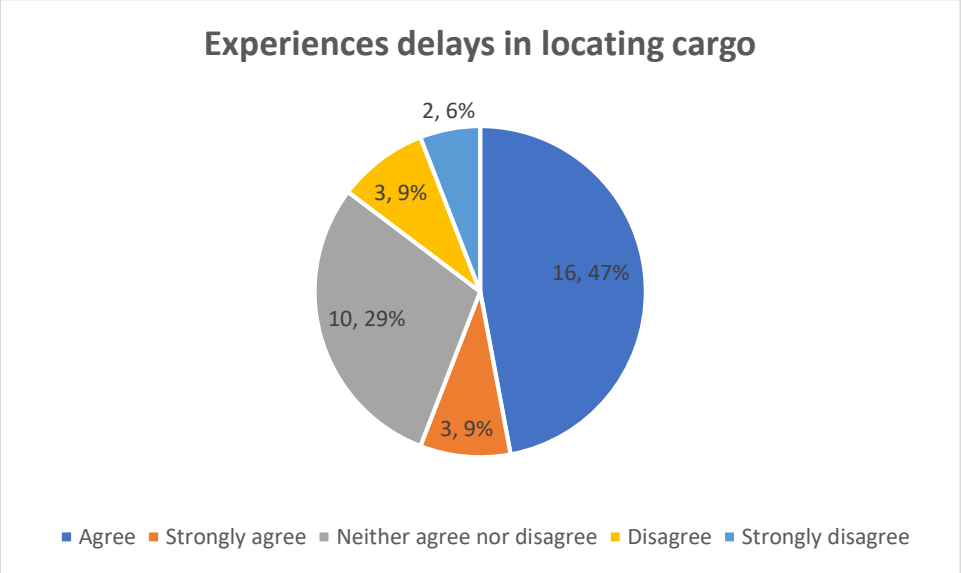

Figure 25: Experiences delays in locating cargo (Author's work)

56% agree that they have experience delays in locating cargo, where 15% have stated that they disagree. However, 29% have stated that they neither agree nor disagree.

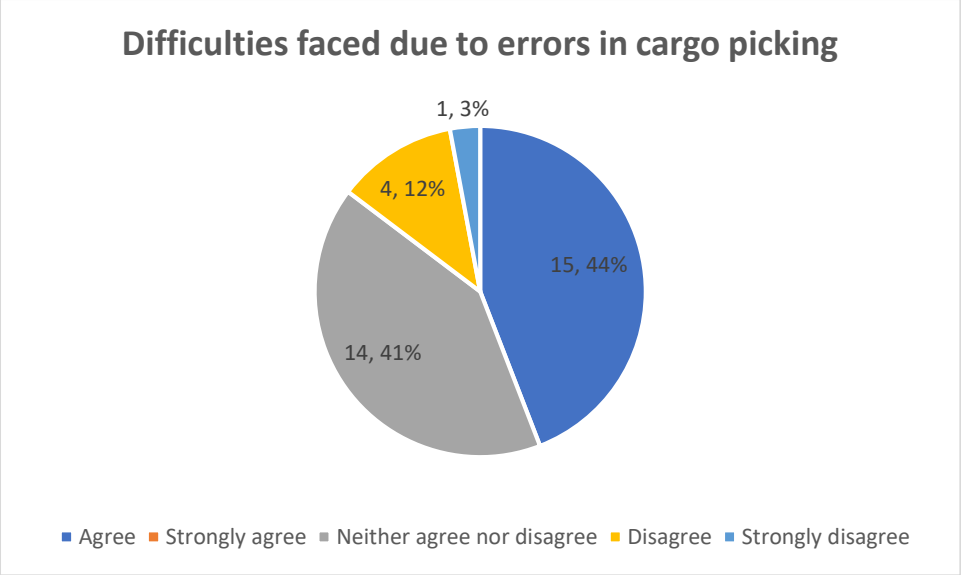

Figure 26: Difficulties in cargo picking (Author's work)

44% of the respondents agree that there are difficulties faced due to picking errors. However, 15% also rated as disagreeing with the statement which displays the presence of different levels of operational efficiencies across warehousing operators.

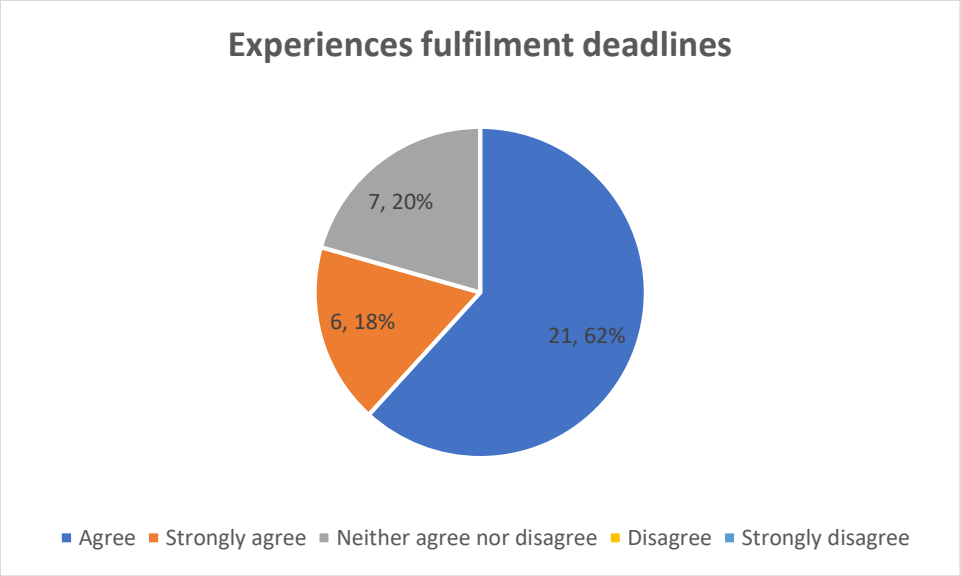

Figure 27: Experiences fulfilment deadlines (Author's work)

79% of the respondents have stated that they experience fulfilment deadlines from their 3PL operators, where 20% has stated that they neither agree nor disagree. No respondent has disagreed on this statement which means that required fulfillment deadlines are met. It could be noted that even though there are picking delays, the 3PL operators seem to be managing the fulfillment deadlines where loading and unloading operations may be more efficient.

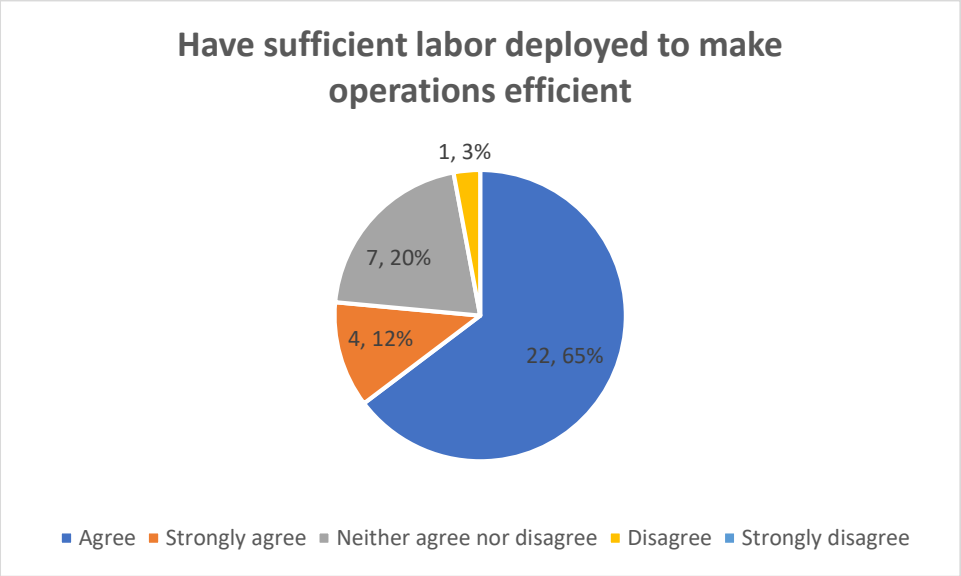

Figure 28: Deployment of sufficient labor (Author's work)

77% feel that there is sufficient deployment of labor in making operations efficient. 20% has stated that they neither agree nor disagree, however 3% has disagreed with the statement which displays that there is a minor level of inefficiencies that customers face in terms of labor deployment.

Enhanced inventory visibility

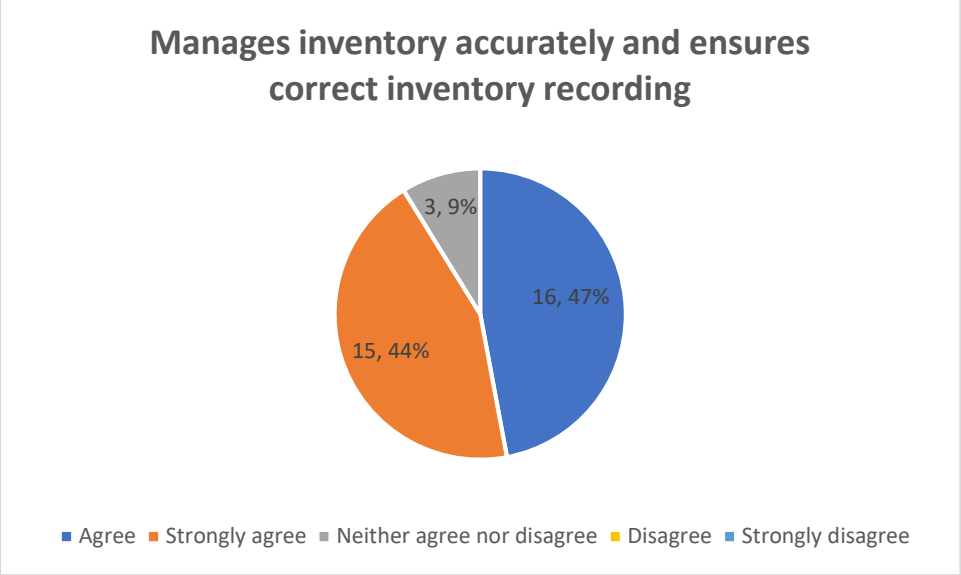

Figure 29: Accurate inventory management and recording (Author's work)

It has been stated by 91% of the respondents that inventory is managed accurately and ensures correct inventory recording. 9% has stated that the neither agree nor disagree. No respondent has disagreed showing that there is a successful rate of accurate inventory recording.

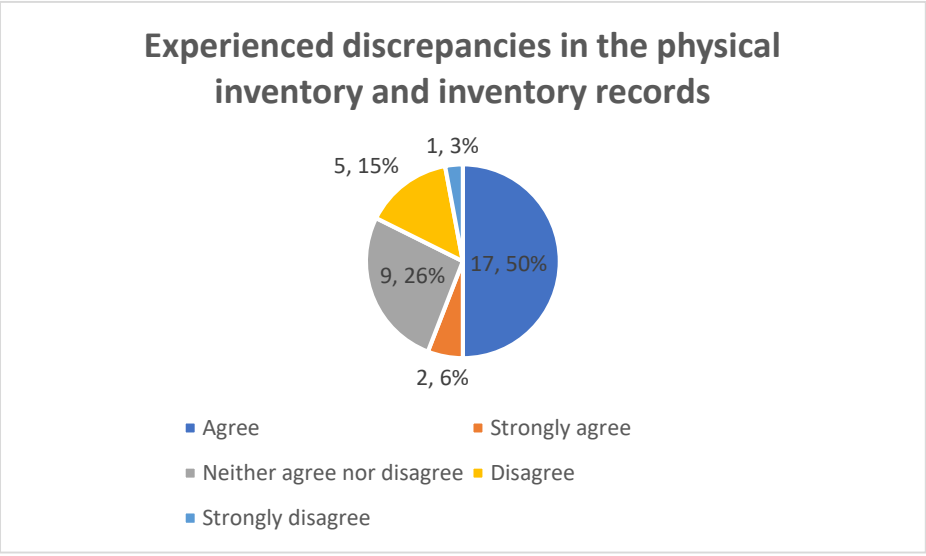

Figure 30: Discrepancies in inventory (Author's work)

56% of the respondents have stated that they experience discrepancies in physical inventory and inventory records which is a concerning area for 3PL operators. 26% have neither agreed nor disagreed, whereas 18% has disagreed. This displays that even though inventory records are maintained accurately, there are discrepancies wit the physical inventory.

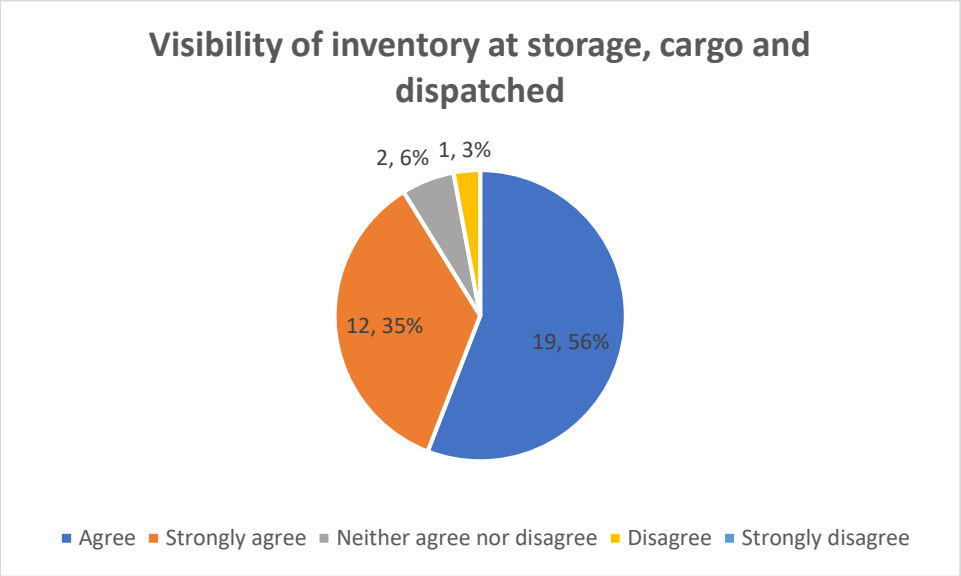

Figure 31: Inventory visibility (Author's work)

In relation to the majority of responses received, the statement of inventory visibility at storage, cargo and dispatched is at 91%, which is a positive aspect. Only 3% of the respondents have rated as disagreed.

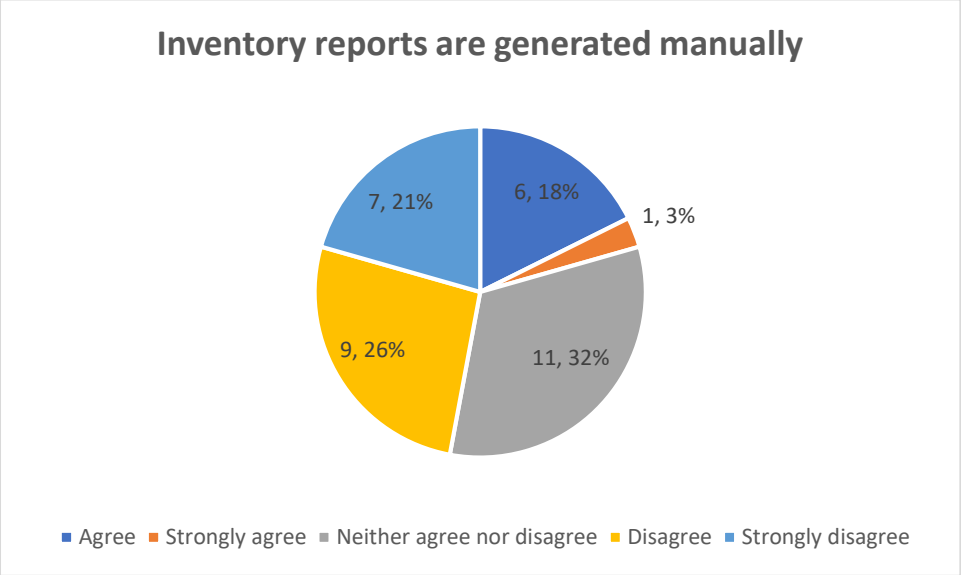

Figure 32: Manual inventory reports (Author's work)

21% of the respondents have agreed that inventory reports are generated manually where, 41% have disagreed. This means that majority of the 3PL operators probably use the WMS in generating reports in an automated manner. However, 32% of the respondents have stated that they neither agree nor disagree, probably as they are not aware of how the reports are generated.

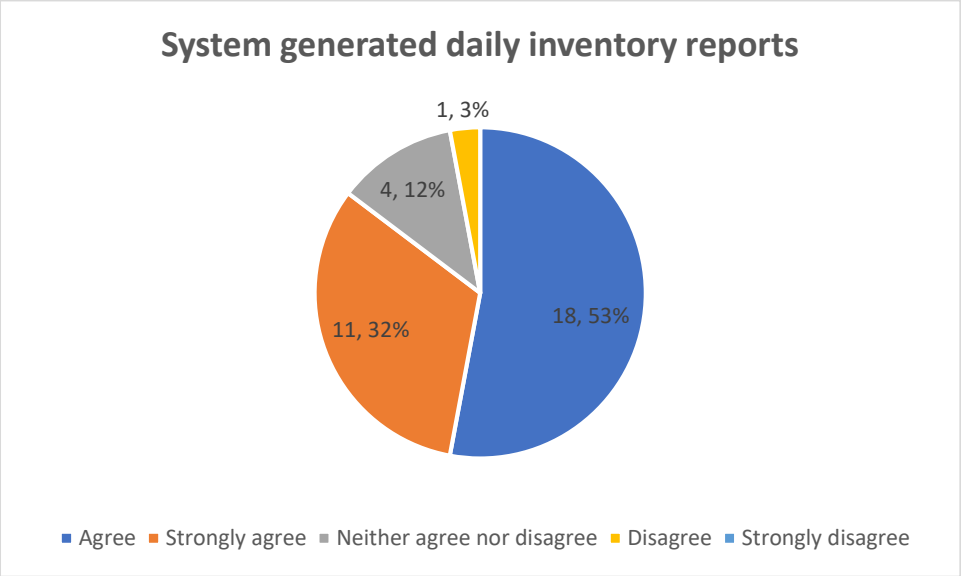

Figure 33: System generated inventory reports (Author's work)

In relation to above statement, 85% of the respondents have agreed that system generated daily inventory reports are shared by 3PL operators, where only 3% has disagreed with the same. As such, it could be noted that there is sufficient use of technology adopted by 3PL organizations in generating inventory reports to customers.

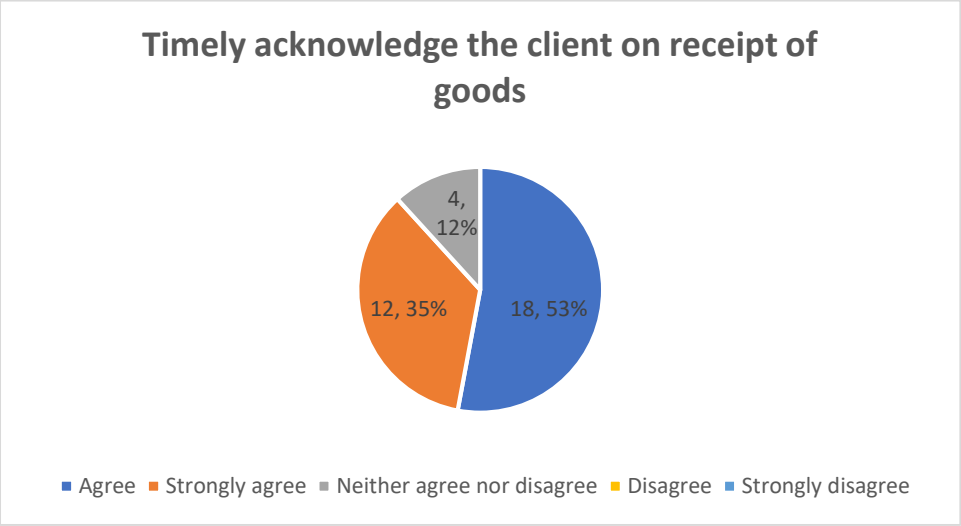

Figure 34: Timely acknowledge of cargo receipt

88% of the respondents have agreed that there is timely acknowledgement to client on receipt of goods to the warehouse. The highlighting point is that no respondent has disagreed with the fact that there is timely acknowledgement on receipt of cargo.

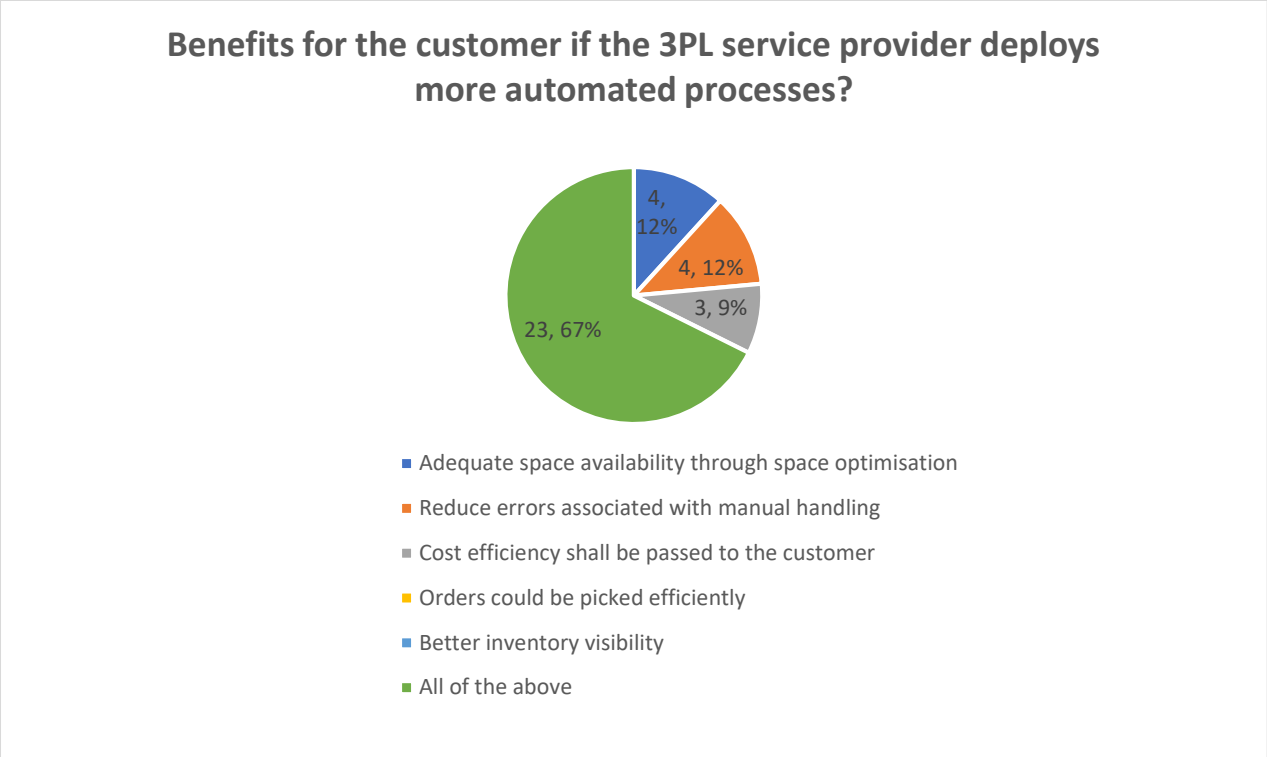

Figure 35; Benefits to customers (Author's work)

Above statements have been ranked as benefits which could be gained by the customers if the 3PL service providers enable more automation in their warehouses. It is evident that all of the above has been rated as a majority with 67% of the responses being rated. However, the benefits of space optimization, reduction errors with manual handling and cost efficiencies have also been individually rated as important by around 11% of the respondents.

Furthermore, in relation to the identification of relationships between each of the technologies and warehouse efficiencies, the following responses were received.

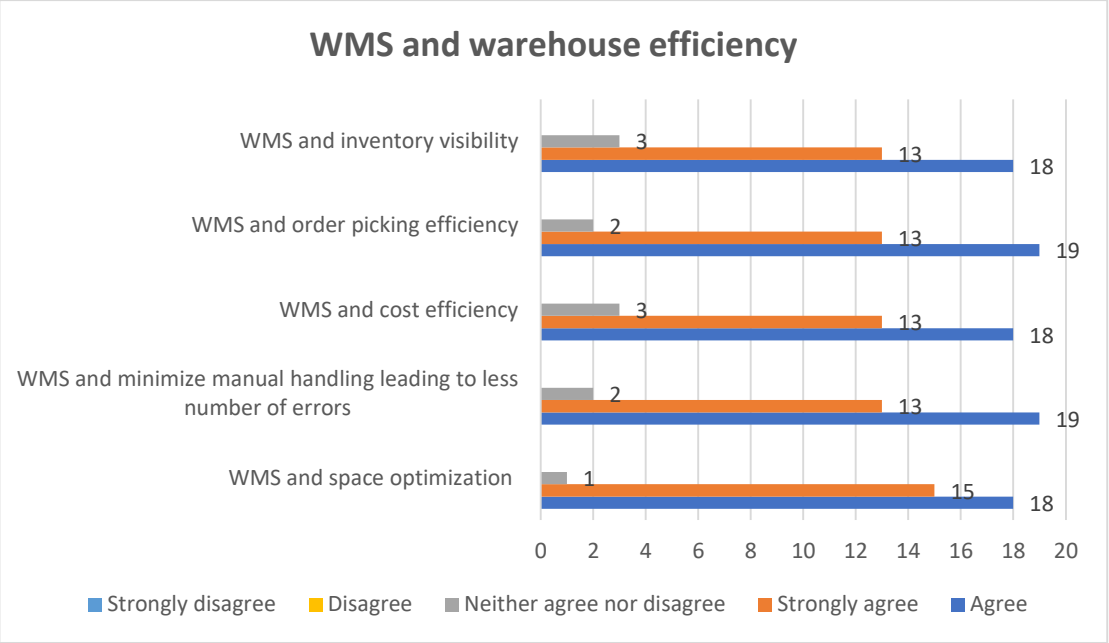

Figure 36: WMS and warehouse efficiencies (Author's work)

It is evident that majority of the respondents totaling over 91% agree that deployment of a WMS system would have a clear relevance in gaining warehouse efficiencies. Out of the efficiencies listed, space optimization has been rated the highest with 97% of the respondents agreeing to this statement. Order picking efficiencies and minimization of manual handling leading to less errors stand at 94% whereas cost efficiency is rated by 91% of the respondents.

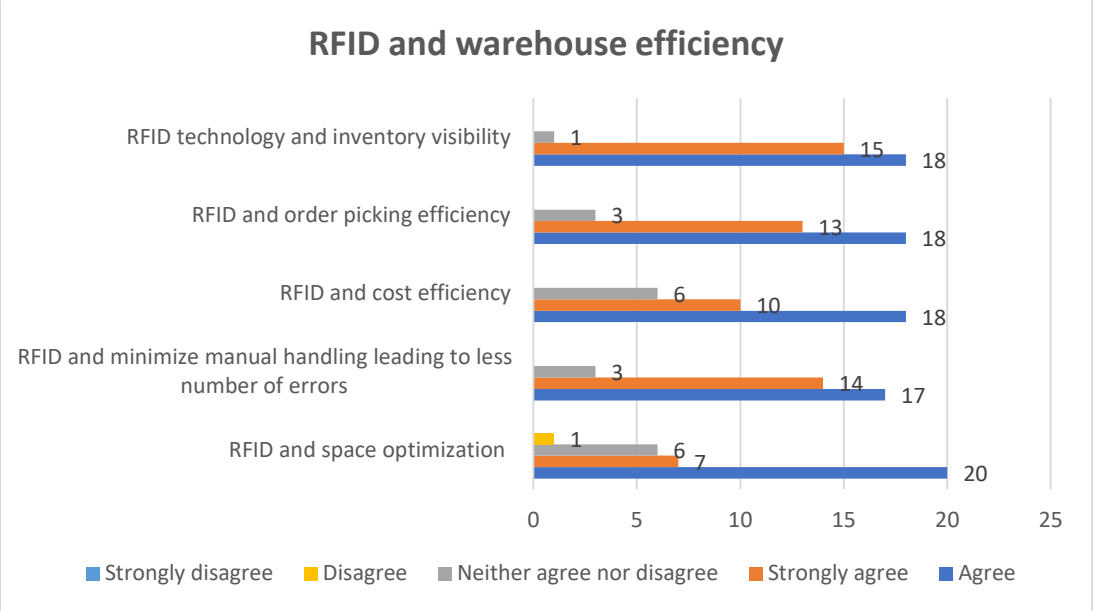

Figure 37: RFID and warehouse efficiencies (Author's work)

97% of the respondents agree that RFID would positively impact the inventory visibility. 91% of the respondents agree that there would be an impact on manual handling and errors along with picking efficiencies. 82% of the respondents have stated that RFID would impact on cost efficiencies. However, only 79% of the respondents have stated that it would impact on space optimization and 3% of the respondents have stated that there would be no impact of RFID on space optimization.

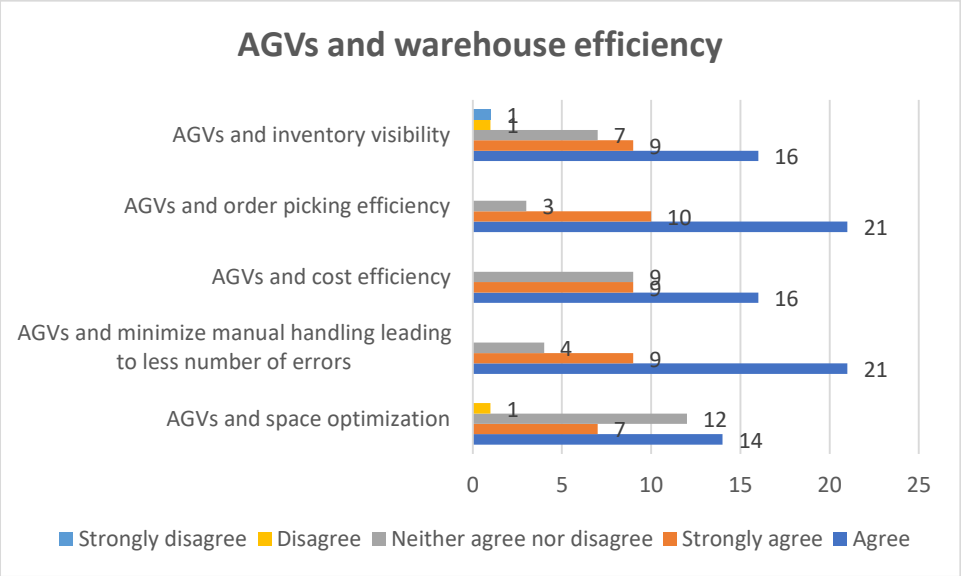

Figure 38: AGVs and warehouse efficiencies (Author's work)

91% have agreed that AGVs would impact on order picking efficiencies. 88% of the respondents agree that AGVs would positively impact on minimization of manual

handling resulting in less errors. 74% of the respondents agree that AGVs would impact positively on cost efficiencies and inventory visibility. However, space optimization as a benefit has been rated low at 62% in agreement, where 3% has been recorded as disagreed. There is also evidence of high responses having been recorded for the category of neither agree nor disagree, clearly displaying the ambiguity in the minds of the respondents.

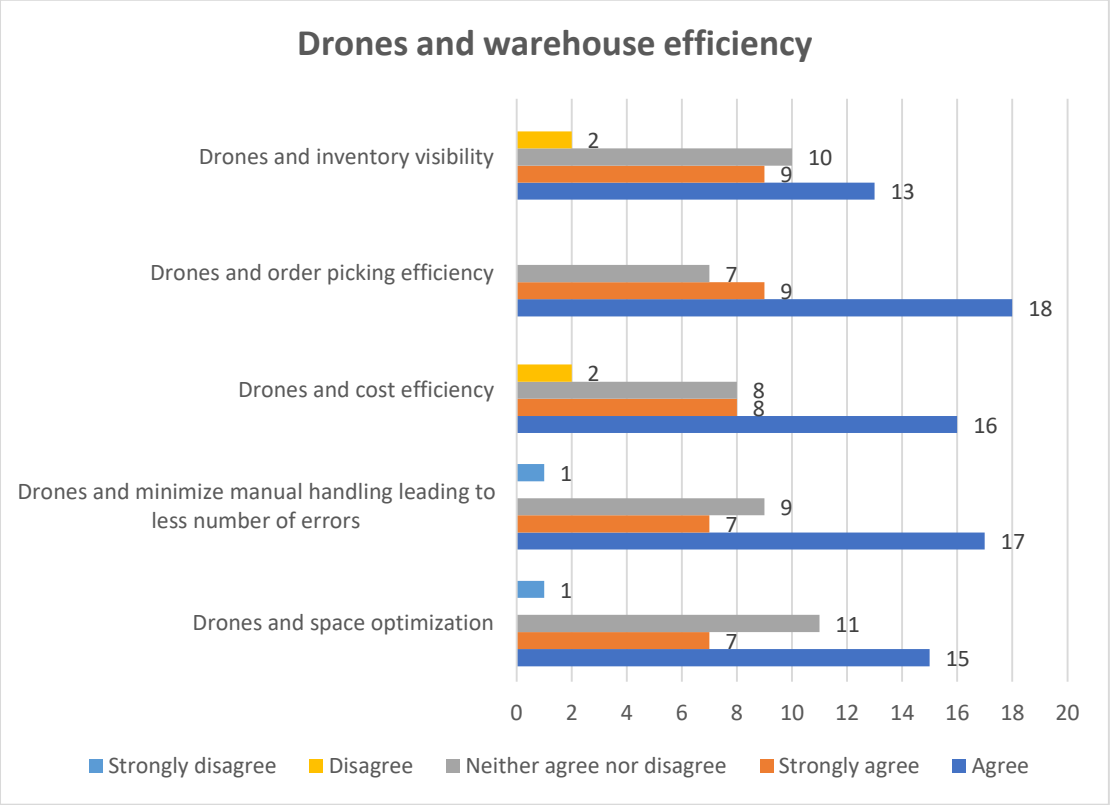

Figure 39: Drones and warehouse efficiencies (Author's work)

79% of the respondents agree that the benefit of picking order efficiencies could be gained via drones. 71% of the respondents agree that deploying drones would create the benefit of minimization of manual handling and hence reduction in errors and cost efficiencies. 65% of the respondents have stated that benefits of space optimization and inventory visibility would be lower. Space optimization and minimization of manual handling related errors have been rated as disagreed by 3% of the respondents. Similar to AGVs, drones have been stated as neither agree nor disagree at 9% on an average across the benefits, displaying the unawareness of respondents.

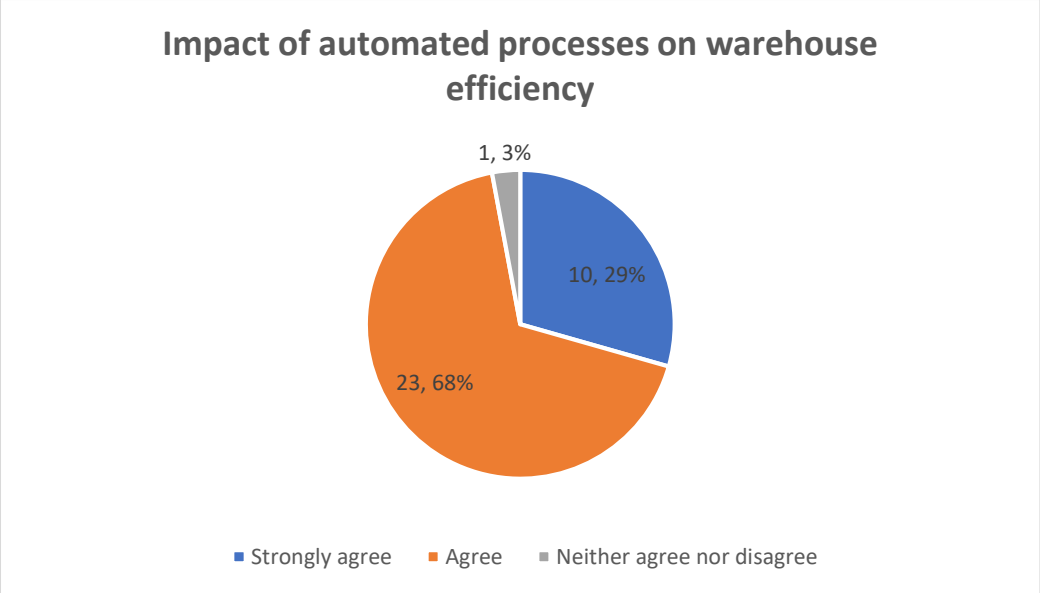

Figure 40: Impact of automation on warehouse efficiency (Author's work)

Finally, in relation to the final question, the common consensus was that the statement is true and hence agreed for. 97% of the respondents agreed or strongly agreed where only 1 respondent has stated as neither agree nor disagree. As such, a clear relationship over the two aspects from the customer point of view could be seen.

4.4. Discussion on findings

The 3PL industries present in other developed countries have grown with technology as its foundation, in generating warehouse efficiencies. It was evident through the interviews that technology adoption Sri Lanka has been commenced with WMS. However, there has not been much progress from there, where the level of technology adoption in the 3PL industry of Sri Lanka is at a stage of infancy to a greater extent. The interviews laid out that this is due to a few challenges in the industry such as availability of cheap labor, more emphasis on cost than quality due unaffordability, difficulties in changing the mindsets, lack of support from the political environment and language barriers. There are also gaps in knowledge and education systems where best practices and new trends are not adopted. However, with the progressive aspect of the industry, there is potential for automation.

It was identified through the interviews that a WMS is considered as a foundational technology required in a 3PL operation as stated on the literature presented by Wei, et al. (2016), which has a vital importance towards management of customer relationships through various engagements such as generation of inventory reports,

analytics and dashboards etc. which occur through a WMS. As such, it was evident through the surveys that most customers agreed that WMS systems are deployed in 3PL organizations. This could be due different efficiencies which are clearly generated from deploying a WMS such as space optimization, enabling picking efficiencies, minimization of manual handling leading to less errors and inventory visibility (Ramaa, et al., 2012; Lorente & Lorente, 2013). However, there are still certain 3PL organizations who have not implemented a WMS as identified on the survey, which could be due to the challenge of inability in assessing the real benefits gained by the customer whilst understanding if the customer is ready to accept a price increase as highlighted on the interviews.

RFID has been identified as a driver of efficiency on the interviews conducted as it impacts on the reduction of labor involvement and hence, labor cost related aspects. However due to cost constraints, the implementation of RFID is relatively low as depicted through the survey. Further, it would have impacts on areas such as enabling of inventory visibility, manual handling and errors and order picking. Further, it has been identified that RFID has the capability of enabling end of end tracking of an item throughout the supply chain, which would provide an important aspect of visibility in the process as identified on the literature put forward by Hunt et al. (2007). In relation to same, Qin et al. (2017) has identified the relevance of RFID as a solution for the bullwhip effect.

AGVs are a clear driver of efficiencies in 3PL operations which is evident through the literature (Dimitrios, et al., 2017). It is evident through the survey that AGVs generate picking efficiencies whilst impacting on the reduction of manual handling and errors. It would also provide accurate inventory visibility by transporting goods within the warehouse to accurate locations as mentioned on the literature (Zhong, et al, 2017). However, AGVs are at a highly premature level in Sri Lanka as identified through the interviews. Costs involved with AGVs has been identified as a major challenge (Dimitrios, et al., 2017), for its wider implementation across the industry. Further, gaps available in knowledge of such technology is also a key challenge which needs to be addressed.

In relation to drones, it was evident through the interviews that the adoption of same in Sri Lanka in warehousing is low, even though its global use has been discussed

widely (Sorbelli, et al., 2019). This was also noted to be a technology whose feasibility has not fully realized. This could be due to the cost factor involved, similar to most other technologies listed above, however, other challenges such as geographical routes, central monitoring system etc. have also been highlighted by interview participants. However, benefits in relation to using drones within warehouses have been explored where it has been stated that certain efficiencies could be generated which have also been highlighted on the literature (Đurić et al., 2018; Škorput et al., 2019). Faster order picking, minimal manual handling and errors and reduction in cost are some efficiencies highlighted on the survey.

It was evident that most survey participants employed in the apparel and manufacturing industries are aware of technologies discussed above, which shows that these industries are progressive. However, it was also evident that even though automation processes has been highlighted as important by many, only a very few have stated that all 4 technologies are important. This could be in relation to the lack of awareness and knowledge gap, which is also represented by the multiple "neither agree nor disagree" responses received throughout the survey.

Further, it was also evident trough the survey that a similar trend of responses was received on the availability of state-of-the-art warehouses and deployment of automation processes, where a relationship between the two factors was evident. This could be related to the fact that interview participants have also mentioned that required infrastructure such as Wi-Fi enabled environments, racked warehouses enabled with location controlling aspects, demarcated storage, and staging and handling areas, are required in deploying technology. This provides an outline on the type of investments required by a 3PL in adopting technology which poses as further challenges, which has also been presented through the literature (Cannella, et al., 2015).

It could be noted that automated processes in a warehouse is a tedious task as it requires multiple prerequisites to be put in place, out of which affordability of the organization in investing in the technology takes a highlighting position. However, in review of the findings, it could be noted that there are clear efficiencies which could be generated through adopting technological processes in a warehouse such as WMS, RFID, drones and AGVs on efficiencies across warehouse space optimization,

reduced manual handling and human errors, cost, order picking and inventory visibility.

4.5. Conclusion

This chapter has discussed the detailed findings which have been made through the primary research where findings from both qualitative and quantitative analysis have been presented.

5.0. Conclusion

5.1. Introduction

This chapter gives an overall summary of the study by evaluating the findings of the literature review, qualitative and quantitative study against the research objectives and research question outlined under chapter one.

5.2. Objective One

"To explore the concepts; automated processes and warehouse efficiency and their relationship using existing literature."

Objective one was achieved through literature which was evident under Chapter 2. The two concepts; automated processes and warehouse efficiency was individually explored and sub factors under each variable was identified through a critical review. Four factors were determined under automated processes namely, warehouse management systems, Radio Frequency Identification Technology, Drones and Automated Guided Vehicles. Drawbacks of conventional warehousing was initially set forth and then benefits and drawbacks associated with each element identified was discussed in detail. It was well evident from the statement put forward by Atieh et al. (2016), "deployment of automated processes in a warehouse is likely to result in exertion of less human effort, minimization of operational costs and increased operational functionality; planning and optimizing".

Under warehouse efficiency five sub factors were identified; space optimization, reduced manual handling and errors, cost efficiency, order picking efficiency and inventory visibility. Finally, the relationship between the two main variables were explored. Kabir and Suzuki (2018), Sarac et al. (2010), Miralam (2017) have

concluded that automated processes positively impact warehouse efficiency along with other authors cited in this study.

Literature summary table gives more clarity on the studies which have been reviewed by the author to discuss on the two concepts and their relationship.

However, number of sources on the two concepts under Sri Lankan context was less, hence author carried out a primary study to determine the relationship between the concepts among Sri Lankan warehouses.

5.3. Objective Two

"To understand contributing factors for warehouse efficiency."

Objective two was successfully achieved by the author.

Contributing factors for warehouse efficiency was initially determined through the literature review which was further verified through the findings of the in-depth interviews and questionnaire survey. Cano et al. (2017) have elaborated that warehouse efficiency depends on efficacy of retrieving customer orders, accurateness in inventory and prompt deliveries and dispatches.

Five factors identified as contributing to warehouse efficiency, articulated from literature is clearly depicted under the conceptual framework. During in-depth interviews it was evident that customers look forward to benefit from adequate space availability, minimized manual errors, lessened costs, improved order picking accuracies and enhanced inventory visibility. These individual factors are categorized under warehouse efficiency. Hence findings of the literature review was verified.

Results of the quantitative study further proved that warehouse efficiency is a collection of sub factors. Factors depicted under conceptual framework was further proven as contributing to warehouse efficiency.

5.4. Objective Three

"To determine the impact of automated processes on warehouse efficiency amongst Sri Lankan warehouses."

Objective three was successfully achieved from the primary study.

Literature review identified four automated processes and five factors under warehouse efficiency. Conceptual framework was developed accordingly. Primary research was carried out to check the applicability of the relationship between the two concepts under Sri Lankan context.

Both the qualitative and quantitative study proved that automated processes have a positive impact on warehouse efficiency in Sri Lankan context. However, it was clear that even though technologies such as AGVs and drones are deployed in developed countries to improve operations, Sri Lanka is in premature stage. Findings of in-depth interviews outlined minimum tech savviness, inexperience and knowledge gaps as few reasons. Results of the quantitative study too showcases the minimum awareness of respondents particularly on AGVs and drones.

But, it was proved from both the qualitative and quantitative studies that RFID and WMS are already deployed in Sri Lankan 3PL warehouses and are reaping associated benefits.

Finally, based on evidences gathered it could be concluded that automated processes have a positive impact on warehouse efficiency amongst Sri Lankan warehouses.

5.5. Research Question

"Does automated processes have an impact on warehouse efficiency?"

Considering the achievement of objective one through literature, it could be concluded that automated processes have a positive impact on warehouse efficiency.

Similarly, overall findings of the primary research has proven that automated processes positively impacts warehouse efficiency.

5.6. Conclusion

This chapter has discussed the impact of literature review, qualitative and quantitative study findings on research objectives and have further linked the findings against the research question.

6.0. Recommendations

Through this chapter author aims at delivering recommendations to the warehouse industry and for future research based on findings of the literature review and primary study.

6.1. Recommendations for the industry

6.1.1. Recommendation One: Enhance awareness of Sri Lankan 3PL warehouse service providers on new technological developments and incorporate them to improve efficiency

Sri Lanka aims at becoming the transshipment hub for the South Asian region and transforming in to Asia's largest maritime and distribution hub (cited under Chapter 1.2). Nevertheless, literature has outlined that level of technology adaption in Sri Lanka is at its infancy (Hettiarachchi & Ranwala, 2015), which has been further verified from the NRI ranking 83 out of 134 countries.

It was determined from the in-depth interviews that even though there are multiple 3PL warehouse service providers the real anatomy behind the concept has not been identified by many of the service providers. Moreover, the benefits of deploying automated processes have not been quantified in terms of money in the Sri Lankan context which could be considered as the reason for resistance along with the high capital investment as stated by all the interviewees.

However, it is clear from literature and primary study that automated processes have the potential of enhancing operational efficiency. To use these automated processes 3PL warehouse service providers should have the necessary knowledge and awareness on these processes and they should be up to date on contemporary developments taking place globally. In addition, the efficiency gains need to be quantified to give a clear picture to the 3PL warehouse service providers on the benefits of implementing automated processes.

6.1.2. Recommendation Two: Additional factors to be considered by 3PL warehouse service providers prior deploying automated processes

Considerations of 3PL warehouse service providers in deploying automated processes should not be limited to efficiency gains and benefits but should consider about other multiple factors ranging from knowledge gaps, change management, high capital investment and resistance from employees (chapter 4.2 – qualitative study analysis).

Type of warehouses operated by different service providers vary based on the warehouse configurations. For an example some service providers provide service for

a single client whereas some warehouses are multi-user facilities. In addition, though the primary warehouse activities are consistent, secondary activities depend based on the type of cargo handled; whether it's FMCG, apparel, project cargo or perishables. Hence, it is important to be aware on configurations prior deploying automated processes. Also it is important to initially identify the bottlenecks in the service rather than blindly deploying technology as it is proven to generate efficiency gains.

Moreover, it was determined from the in-depth interviews that level of internet connectivity and availability of Wi-Fi-connectivity too are deciding factors on the use of automated processes in the Sri Lankan context.

6.2. Recommendations for further research

6.2.1. Recommendation One: Extend the study in to other automated processes

Automated processes is a vast concept which comprise of multiple sub factors and not limiting to the four elements; WMS, RFID, AGS and UAVs discussed under the study. It was further pointed out during the in-depth interviews.

At present, a significant importance is given to technological developments such as Internet of Things (IoT), fork lift telematics; wireless fleet management and automated storage and retrieval system (AS/RS) at global level.

Number of studies which elaborate on the use of automated processes in the Sri Lankan context is very minimal, similarly the author too has pin pointed only on four aspects. However for future research the scope could be increased by considering the newest technologies outlined above.

6.2.2. Recommendation two: Research on barriers for successful implementation of automated processes in Sri Lankan 3PL warehouses

It was reflected during the in-depth interviews that there are many challenges associated with implementation of automated processes. Change management which poses difficulties in changing the mindsets of people in adopting technology, lack of support from the political environment and language barriers were highlighted during the interview sessions. In addition, knowledge gaps and gaps in education which creates the resistance for technology adaption were emphasized.

Author has not dug in to barriers in implementing automated processes in detail, however the scope could be extended to explore on the barriers as well in future research.

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Appendix 1 – Sri Lankan warehousing industry

Sri Lanka's strategic location among the main marine and air navigation routes have contributed for the country to be considered as a significant destination for the logistics sector development. Transport and warehousing are two main elements of logistics and Colombo port which is the main marine transport point of the country has been ranked among the top 50 container ports during the past 5 years.

Logistics industry contributes to 2.5% of the national GDP while it has created direct employment opportunities for over 40,000 people. Sri Lanka is aiming at becoming the multimodal logistics hub by providing integrated services such as warehousing through development of physical infrastructure, telecommunication and information technology.

Other than Sri Lanka's vision towards becoming the logistics hub, few other factors have contributed for the increase in demand for warehousing. Growth in e-commerce business is one factor, which was USD 40 Million in 2018 and is expected to grow up to USD 400 Million in 2022, according to the ministry of industry and commerce. In addition, large segment of the Sri Lankan population are internet users and online shoppers.

Growth of the apparel, tea, FMCG, textile and Pharmaceutical industries could also be considered as reasons for the growth of demand for warehousing, In addition, internal and external connectivity with the improvement of transport infrastructure could be outlined as a driver of warehousing demand.

There is a 7.41 million square feet of warehousing space in Sri Lanka. Out of the warehouses 86% are 'B' grade and 14% are 'A' grade. Besides, demand for cold storage space has increased with more perishable goods entering in to the market. There are 4 main warehousing corridors identified in Sri Lanka; Colombo, Wattala-Peliyagoda, Ja-ela-Katunayake and Ratmalana.

Appendix 2 – Questionnaire

The influence of automated processes on warehouse efficiency; a study on 3PL warehouses in Sri Lanka

Dear Respondent,

I am Chamindri Sooriyabandara, a student of Next Campus (affiliated by Birmingham City University of UK). I am carrying out a study to determine the influence of automated processes implementation on warehouse efficiency as a partial fulfilment for the requirements of MSc in Logistics and Supply Chain Management.

The questionnaire will require on average 10 minutes of your precious time and participation in this questionnaire is voluntary. There will be no compensation nor any known risks associated with the questionnaire and data gathered shall be confidential and shall only be used for academic purposes.

Thank You for the support extended.

Chamindri Sooriyabandara
chamindrin@gmail.com

1. Experienced service from a 3PL warehousing service provider

a. Have experience	
b. Currently experiencing	
c. No experience	
d. Looking forward to experience	

2. Industry you are currently employed under

a. Logistics		f. FMCG	
b. Manufacturing		g. electronics and white goods	
c. Apparel		h. Automobile	
d. Pharmaceutical		i. Stationery and Printing	
e. Telecommunication		j. Other	

3. Place the most suitable answer in the box regarding the use of **automated processes** by your 3PL warehousing service provider.

1. Highly agree 2. Agree 3. Neither agree nor disagree 4. Disagree 5. Highly disagree

Statement	1	2	3	4	5
3PL service provider has deployed automated processes to improve warehouse processes.					
3PL service provider has a state of the art warehouse.					

A warehouse management system (WMS) is deployed for inventory management.					
RFID technology has been deployed in the warehouse to improve operational processes.					
Has deployed automated guided vehicles (AGVS) for cargo carrying and picking within the warehouse.					
Has deployed drones for picking cargo at top rack locations in the warehouse.					

4. Place the most suitable answer in the box regarding **efficiency related elements of 3PL warehousing** service provider's service.

1. Highly agree 2. Agree 3. Neither agree nor disagree 4. Disagree 5. Highly disagree

Statement	1	2	3	4	5
3PL service provider ensures timely conduct of unloading and loading of goods.					
Timely acknowledge the client on receipt of goods to the warehouse.					
Manages inventory accurately and ensures correct inventory recording.					
Carry out any value additional activities such as labelling, sorting and sticker pasting efficiently.					
Provides the warehouse service at a considerably affordable rate.					
Faces difficulties and delays in manually handling cargo at inbound and outbound.					
Experiences delays in locating cargo from locations in which cargo is stored.					
Experienced discrepancies in the physical inventory and inventory records.					
3PL service provider has taken adequate measures to minimize any health and safety related issues within the warehouse.					
Have visibility to the inventory at storage, cargo received at the warehouse and cargo dispatched from the warehouse.					
Inventory reports are generated manually.					
Receive system generated daily inventory reports.					
Difficulties faced due to errors in cargo picking for dispatch.					
Has adequate space to accommodate cargo.					
Achieves fulfilment deadlines.					
Have sufficient labor deployed to make operations efficient.					
Overtime costs are high for operations carried out beyond stipulated working hours.					

5. Do you agree with the statement that ‘your 3PL warehousing service provider has adequately invested on automated processes and technological norms for improving efficiency’?

Highly agree	
Agree	
Neither agree nor disagree	
Disagree	
Highly disagree	

6. Do you agree with the statement that ‘deploying technology and automation could be beneficial for the customer’?

Highly agree	
Agree	
Neither agree nor disagree	
Disagree	
Highly disagree	

7. What benefits do you think could be achieved by the customer if the 3PL warehouse service provider deploy more automated processes?

Adequate space availability through space optimization	
Reduce errors associated with manual handling	
Cost efficiency shall be passed to the customer	
Orders could be picked efficiently	
Better inventory visibility	
All of the above	

8. Place the most suitable answer in the box regarding deployment of automated process to improve warehouse efficiency.

1. Highly agree 2. Agree 3. Neither agree nor disagree 4. Disagree 5. Highly disagree

Statement	1	2	3	4	5
Deployment of a warehouse management system would optimize warehouse space.					
Deployment of a warehouse management system would minimize manual handling and would lead to less number of errors.					
Deployment of a warehouse management system would improve cost efficiency.					
Deployment of a warehouse management system would improve order picking efficiency.					
Deployment of a warehouse management system would enhance inventory visibility.					
Deployment of RFID technology would optimize warehouse space.					

Deployment of RFID technology would minimize manual handling and would lead to less number of errors.					
Deployment of RFID technology would improve cost efficiency.					
Deployment of RFID technology would improve order picking efficiency.					
Deployment of RFID technology would enhance inventory visibility.					
Deployment of Automated Guided Vehicles would optimize warehouse space.					
Deployment of Automated Guided Vehicles would minimize manual handling and would lead to less number of errors.					
Deployment of Automated Guided Vehicles would improve cost efficiency.					
Deployment of Automated Guided Vehicles would improve order picking efficiency.					
Deployment of Automated Guided Vehicles would enhance inventory visibility.					
Deployment of Unmanned Aerial Vehicles (UAVs)/drones would optimize warehouse space.					
Deployment of Unmanned Aerial Vehicles (UAVs)/drones would minimize manual handling and would lead to less number of errors.					
Deployment of Unmanned Aerial Vehicles (UAVs)/drones would improve cost efficiency.					
Deployment of Unmanned Aerial Vehicles (UAVs)/drones would improve order picking efficiency.					
Deployment of Unmanned Aerial Vehicles (UAVs)/drones would enhance inventory visibility.					

9. Do you agree with the statement that ‘automated processes positively impact warehouse efficiency’?

Highly agree	
Agree	
Neither agree nor disagree	
Disagree	
Highly disagree	

Appendix 3 –Discussion guide

Interviews were conducted using the discussion guide pre-prepared by the author using the literature and derived conceptual framework.

Area of Discussion	Response Summary
About the warehouse industry of Sri Lanka and its core players	
Challenges in 3PL conventional warehousing	
Means of overcoming barriers in conventional warehousing	
About use of RFID in warehousing	
About use of UAVs in warehousing	
About use of AGVs in warehousing	
About use of WMSs in warehousing	
Ways in which automated process effect warehouse operations	
Benefits of using automated processes in warehousing	
Challenges of using automated processes in warehousing	

Appendix 4 – Dissertation supervision log

MASTERS DISSERTATION - SUPERVISON LOG

This log in an integral part of your dissertation journey. This log will need to be maintained as a live document through your research and be submitted along with the final dissertation submission.

Important Information – General:

- It is recommended that you have six (06) meetings with your supervisor.
- Four (04) meetings are mandatory.
- All meetings must be completed 1 week prior to the final submission deadline and be spread over your 12-week period.
- If the student fails to complete at least 2 meetings with the supervisor within the first 6 weeks of the research period, NEXT Campus will make arrangements to move you to the following Cohort.
- Meeting requests must be made at least 96 hours prior to when you require the same if you have not agreed on the dates at the first meeting - Meeting times needs to be mutually convenient. Supervisors are not required to fit into your schedule.
- Feedback documents need to be shared with the Supervisor 24 hours prior to the meeting. Supervisors reserve the right to reschedule the meeting if the document is not provided for reading 24 hours before.
- Once feedback is given on a section, it is the student's responsibility to incorporate the changes. The supervisor will not look at the changes again.
- A meeting cancelled by the student within 24 hours of the scheduled time will be considered a missed meeting and be counted as 1 of 6.

Important Information – Student:

- The dissertation is student led; i.e the student must get in touch with the supervisor.
- Maintaining the log is the student's responsibility. You must ensure that your supervisor completes the log and sends it you and NEXT within 24 hours of the meeting.
- You are advised to work with your supervisor and not approach different tutors. This can cause unnecessary confusion.
- The supervisor's responsibility is to provide feedback to the work you have done, not do the research for you.

Important Information – General:

- The meeting log needs to be completed in detail and emailed to the student and research@next.lk within 24 hours of the supervision meeting.
- Should you face any difficulty please get in touch with Ms. Nilakshi Senadhira on 0777 974 854 or nilakshi@next.lk

Name of student:	**21103938 / Chamindri Sooriyabandara**
Course:	MSC LSCM/PM
Cohort:	16
Research Title:	**The influence of automated processes implementation on warehouse efficiency; a study on 3PL warehouses in Sri Lanka**
Supervisor:	Jayamal Jayaweera

Meeting 1 - Mandatory	
Recommended Time Frame: Week 1- 2	Date of Meeting: 31st July 2021
Guidance on areas of discussion: • Agree on timeline, meetings date and ways of working. • Review approved proposal and any recommendations provided therein • Overall discussion and understanding of research project.	

Matters Discussed

- 1st Meeting
- Refine the data supporting the business problem by showing the targets against the actual performance (Example: Figure 1 – NRI ranking should have the expected target.)
- Re-word the research question to be more neutral and open. (Example: What impact do automated processes have on warehouse efficiency?)
- Objective 3 appears to be a bit out of scope of the academic research as this is not an implementation project. Consider focusing on identifying the elements that contribute towards warehouse efficiency, some of which then can be shown to be candidates for automation.
- Move the conceptual framework to the end of the literature review as this should reflect the summary of the review. Consider specifying the elements / dimensions of the concepts on the conceptual framework.
- Include a table that shows the specific elements / areas of the concepts explained / discussed by the writers identified in the literature review. (Example was shown at

Action / Research to be undertaken before next meeting

- Complete Chapters 1 & 2
- Proceed to the methodology section.
- Discuss the relevant philosophy applicable to the research supported with justifications.
- Discuss the data gathering strategies.
- Identify the population and the sampling method used to select the sample. Need to justify the sampling method used.
- Explain how quantitative and qualitative data will be gathered.
- Explain the tools and techniques that will be used to analyse data.

Student:  **Supervisor** 

Meeting 2 - Mandatory	
Recommended Time Frame: Week 4	Date of Meeting: 29th August 2021
Guidance on areas of discussion: • Provide Feedback on Literature review • Provide Feedback on conceptual framework • Discuss Methodology Section • Discuss Survey / Questionnaire	

Comments on Progress since last meeting

- Literature review and methodology section completed.
- Questionnaire submitted for review and sign-off

Matters Discussed

- Need to complete the methodology section with special focus on research philosophy, population and the sampling method for data collection
- Data analysis has to be done based on the conceptual framework.

Action / Research to be undertaken before next meeting

- Complete the rough cut analysis and submit for review.

Signed by Student and Supervisor to verify that the above is a true record of the tutorial.

Student:  **Supervisor** 

Meeting 3 - Mandatory	
Recommended Time Frame: Week 6	Date of Meeting: 12th September 2021
Guidance on areas of discussion: • Provide Feedback on Methodology • Provide Feedback on questionnaire design / interview guide	

Comments on Progress since last meeting

- Methodology section completed
- Data gathering commenced.

Matters Discussed

- Analysis of the data should be from the perspective of the conceptual framework.
- The objective should be to prove the relationship between the concepts.
- Both the quantitative and the qualitative analysis should follow this principle.
- In the discussion of findings substantiate the discussion with excerpts of literature that supports it.
- Conclusion should state how the research objectives have been met.
- Recommendations should state what you recommend for future research based on important areas that could have fallen out of scope for this project. In addition need to state what you recommend for the organization and/or for the industry.

Action / Research to be undertaken before next meeting

- Complete the above and get ready for the viva presentation.

Signed by Student and Supervisor to verify that the above is a true record of the tutorial.

Student: **Supervisor**

Meeting 4 - Mandatory	
Recommended Time Frame: Week 9	Date of Meeting: 9th October 2021
Guidance on areas of discussion: • Review and discuss findings and presentation of the same	

Comments on Progress since last meeting

- Report completed

Matters Discussed

- Conclusions could be substantiated with in-text citations to literary sources.
- Study limitation cannot be included in the recommendations section.
- Include relevant resources along with the dissertation supervision log in the appendix section.
- Sign the relevant sections in the dissertation supervision log.

Action / Research to be undertaken before next meeting

- Proceed with submitting the report.

Signed by Student and Supervisor to verify that the above is a true record of the tutorial.

Student: **Supervisor**