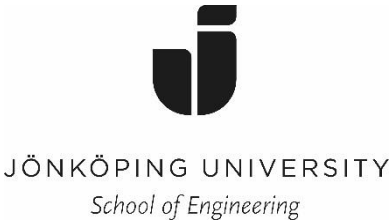

Challenges while moving towards Warehouse Automation

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The authors take full responsibility for the opinions, conclusions, and findings presented.

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Abstract

Currently, customers are pushing companies by demanding high quality, customized products, reduced lead time, and reliable delivery. To provide such high customer satisfaction, companies have to rely on third-party logistics and warehouse operations. The variety of products, combined with shorter delivery times makes warehouse operations even more complex. To manage these complexities, warehouses are turning to "automation technologies" that provide a competitive edge in the market by lowering costs and improving productivity in all operations, throughout the shop floor. This project aimed to explore how warehouses can implement automation successfully by analysing the challenges that arise with the automation approach. The project will be limited to the planning phase of the automation approach. Based on the aim, two research questions were defined. The first one concerns identifying the challenges that arise when a warehouse is becoming automated, while the second one concerns, finding solutions that mitigate these challenges. To fulfill the purpose, a single case study was conducted in the warehouse of a logistic company in Jönköping. The case study method consisted of interviews and observations as primary data collection techniques. In total thirteen challenges were identified in the literature, out of which ten were found at the case company. The identified challenges were classified into the organisational, technological, and people factors. In order to mitigate the challenges, suggestions were provided to the case company. The thesis concludes that even though automation is a good strategy for improving production activities, it comes with several challenges within organisational, technological, and people dimensions. Moreover, the study will be useful, for researchers and practitioners working in warehouse automation to identify and solve challenges while automating the facility

Keywords: Automation, Warehouses, Automation challenges, Implementation barriers.

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1 Introduction

This chapter introduces the thesis by providing the background, which then leads to a problem description. After this, the purpose and research questions are defined, followed by a delimitation of the research.

1.1 Background

In today's globalized industrial market, production and logistics management play a vital role in fulfilling customer demands (Winkelhaus & Grosse, 2020). The main reason for this is considered as, the emergence of business-to-consumer operations. Many companies try to gain market share, by providing consumers the opportunity to order at any hour and have them delivered as quickly as possible. As a result, the times available for processing and delivering products have shortened. Opportunities to cancel an order, change the delivery address, increasing product variety adds more complexity to the operation. Therefore, to be competitive in this environment requires investing more time and resources to improve their logistics network (Christopher, 2005).

An important link in a logistic network is warehouses, where goods are stored prior to their transportation to subsequent links within the network of the supply chain (Waheed, 2008). A warehouse is a facility that stores products from different suppliers for further distribution, either directly to customers or another local warehouse (Hamberg & Verriet, 2012). In simple terms, warehouses activities can be defined as a collection of activities that help to deliver the products at the right time to the right location. The working of the warehouse remained the same until the advent of the Just In Time (JIT) philosophy, where the bigger orders of the same product are broken down into small orders of a variety of products (Custodio & Machado, 2020).

Warehouses contribute to 20 percent of the total logistics cost (Baker & Halim, 2007). To reduce the cost incurred at warehouses, it is important to have a suitable material handling system (Kučera, 2017). Material handling can be defined as all those functions such as acquisition, handling, control, and movement of materials within the warehouse (Alghalayini, 2020). The JIT, along with the increase of e-commerce platforms, mass customization, omnichannel distribution (Custodio & Machado, 2020), further intensified the competition among companies, requiring shorter time-to-market. Hence there is a great need for automation in warehouses to achieve better performance that matches the present market scenario (Petković, 2017).

The term automation has been defined by Groover (1996), as a technology that does involve minimum human intervention in a process or procedure and uses the power, program, and control system to execute the instructions to carry out the procedures. Since 1990, more automated solutions have been implemented in the area of logistics.

Automation possibilities have been widely utilized in activities such as transport handling, storage, packaging. In general, they are utilized in tasks where the intelligence of the system does not play a significant role (Echelmeyer, 2008). Automation of item picking, and sorting is getting more important as the cost of labour increases over time. Concerns such as availability of human operators, their training requirement, error frequency, quality and accident issues, ergonomic factors bespeak the need for automation. In addition to these, most warehouse activities are performed during the night and are considered uninspiring work, this also points to the need for automation (Hamberg & Verriet, 2012). Also, there is influence from online e-commerce giants such as Amazon on third party logistics to go for automation (Pearson, 2017).

Automation in warehouses is expected to rise in the future (Aldewereld, 2011). Hence this thesis is directed towards 'warehouse automation', which is defined as the direct control of handling equipment, initiating movement, and storing inventory without the need for operators or drivers (Rowley, 2000). Consequently, warehouse automation includes equipment such as automated storage and retrieval systems, automated guided vehicles, and conveyorized sortation system (Baker & Halim, 2007).

Even though warehouse automation is discussed in the past, there exist challenges in adopting automation (Baker & Halim, 2007). A 'challenge' is something that needs great mental or physical effort to be done successfully (Walter, 2008). This study will try to explore challenges that exist while adopting warehouse automation and later investigate this in a case company. This study will be useful for (1) researchers, to increase their knowledge on challenges related to warehouse automation and develop dedicated solutions; (2) warehouse practitioners in third party logistics (3PL) companies for the planning automation projects, and (3) policymakers, to guide policies to overcome challenges in warehouse automation.

1.2 Problem description

Companies need to improve their performance over time to provide customer satisfaction. Increasing e-commerce business and responsiveness in deliveries put more demands on modern production firms. This has raised the importance of 3PL logistic firms in the supply chain and their performance. A 3PL offers to deliver products from various suppliers to end customers (B2C) and from suppliers to other industries (B2B) (Bowersox et al., 1999). 3PL and its distribution center can be treated as the backbone of logistics operations. The efficacy of the whole supply chain process is determined based on customer satisfaction (Bowersox et al., 1999). Various dimensions of performance measurement of a distribution center are quality, delivery time, service, price, and flexibility. Delivering quality goods at cheaper service rates and on time can increase customer satisfaction and capacity for being quick helps firms to win over competition (Alsmadi, 2011).

Warehouses consist of many non-value-adding activities during material handling. Studies by Giannikas et al. (2017) report that for improving responsiveness in warehouse activities, improvements in material handling are required. The best way for optimizing the activities in the logistic production area is by adopting suitable material handling systems supported with automation. Thus various non-value-adding operations can be reduced and the role of the warehouse can be shifted to a value-adding service (Sainathuni et al., 2014). Automated warehouses offer more efficient working, require less effort, and offer reliable results compared to manual handling systems (Kučera, 2017). Thus by streamlining material flow with help of automation, companies can increase productivity and delivery performance (Bansal et al., 2021).

Even though automation brings a lot of benefits such as reducing labour cost, improved productivity, and others as discussed earlier, implementing it does not always live up to expectations and instead creates more disruption or disturbances, which puts automation decisions in a grey area among managers (Susman, 1989). In some situations, assessments that support the automation decision are based on unstructured and informal interpretations, rather than facts (Fasth, 2008).

In order to investigate the challenges from an empirical standpoint, a single case study was done. The case company was purposively selected based on being in their initial stages for automation and they need more knowledge on the challenges that they might face while moving forward in warehouse automation. Hence, through this work, the challenges that the company may face while adopting automation will be studied and thus will provide strategies to mitigate these challenges. This would be helpful for decision-making in warehouse automation.

1.3 Purpose and Research questions

In accordance with the background and problem description stated, the purpose of this study is:

“To increase the understanding of challenges in warehouse automation”.

This is done by, identifying and examine these challenges first, that can hinder the possibility of automation at the case company. In the second part, possible solutions to these challenges would be addressed (see Figure 1).

The purpose of the study will be fulfilled by answering the following two research questions:

RQ1. What are the challenges faced by logistics companies in moving towards warehouse automation?

The first research question is intended to explore the challenges within moving towards warehouse automation. The challenges are investigated by keeping organisational, technological, and people perspectives. These three categories were chosen to ensure that every challenge area is covered.

RQ2. How can these challenges be mitigated by logistics companies in moving towards warehouse automation?

In view of the identified challenges from RQ2, this research question's objective is to provide suggestions on how to mitigate these challenges in automating the process (Figure 1).

Figure 1: The phases of the study

1.4 Scope and delimitations

The focus of this thesis is on the challenges while adopting automation and thus the unit of analysis of the study is the automation of internal material handling and will not analyse any external value-chain activities. Since the topic is vast, the project does not consider any activities like purchasing processes, sales, distribution, among others.

The research will not attempt to identify or determine the most suitable form or level of automation; instead, it will examine the challenges while moving towards automation and suggest ways to tackle these challenges.

2 Theoretical Background

This chapter presents the relevant theoretical background for the thesis on topics, logistic systems, and automation. Hence this chapter goes through areas such as logistics systems, the role of third-party logistics (3PL), warehouse automation, levels of automation, and challenges in warehouse automation. The Figure 2 given below, presents the outline of the theoretical background used in this thesis.

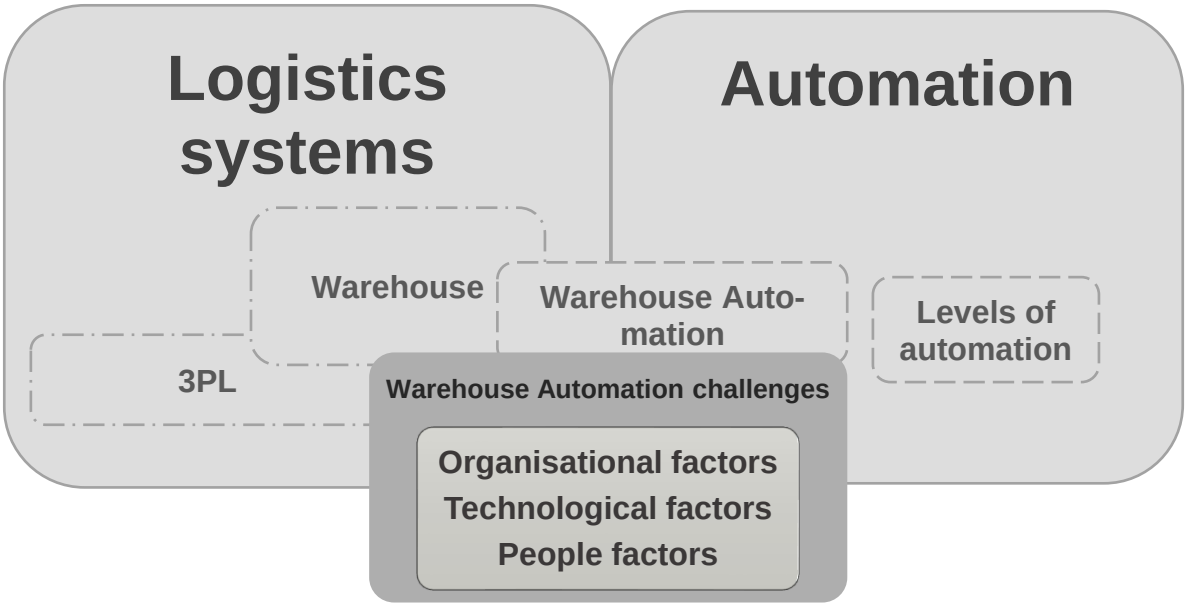

Figure 2: Outline of the theoretical background

2.1 Logistics systems

Logistics have been defined in a variety of ways by different authors. It is the planning, execution, control, and storage of products and services for bridging the dimensions of time and space within a system. The European Committee for standardization CEN defines logistics as the planning, execution, and management of the movement of people or products, as well as supporting activities connected to such movement, within a system designed to achieve certain goals (Gleissner & Femerling, 2014). Logistics is also defined as designing, implementing, and controlling an efficient, effective flow and storage of goods and services from the point of external origin to the company, as well as from the company to the site of consumption, in order to meet customer requirements (Winkelhaus & Grosse, 2020).

Tasks associated with logistics can be graphically represented by the so-called seven R's as shown in Figure 3.

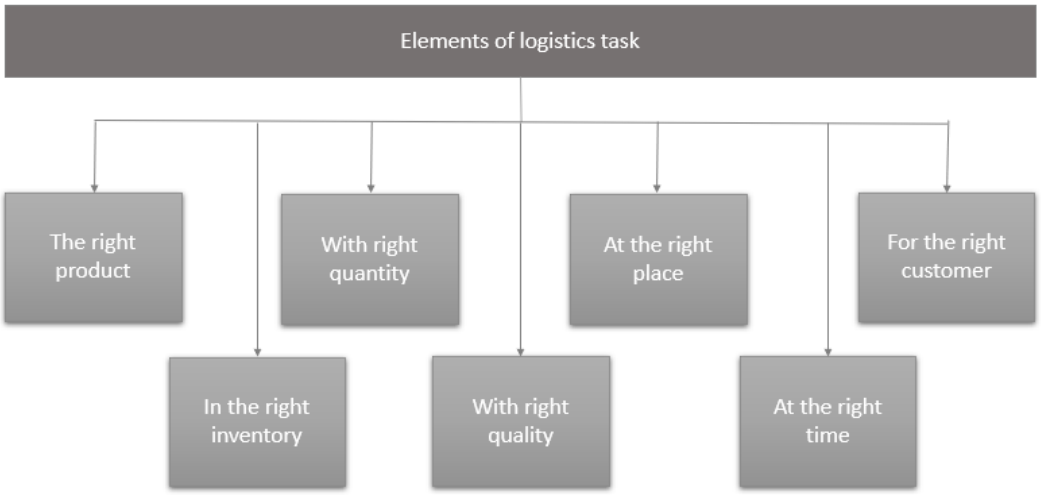

Figure 3: The 7R's of Logistics (Gleissner & Femerling, 2014)

Over the past decades, logistics moved from serving a simpler, unidimensional operational support function to being a networked, multidimensional process that spans all value-added steps. Thus, it aims to optimize holistic and complex operational and economic activities.

Depending upon the functions, elements in logistics can be divided into three which are: procurement logistics, production logistics, and distribution logistics. Procurement logistics deals with the organization and the physical process involved in the transport and supply of the input factors for the corporate process. This part of logistics aims to ensure the economic supply of the material or commodities which needed to be processed. Production logistics is associated mainly with manufacturing organisations. This form of logistics deals with the activities such as planning and controlling, the internal processes that relate to the material flow, storage, and internal transport. Also, it plays a significant role in bridging procurement and distributional logistics. Distribution logistics focus on coordination of all process that ensures the supply of the goods to the recipient or the point of sale for consumption by the end-user (Gleissner & Femerling, 2014).

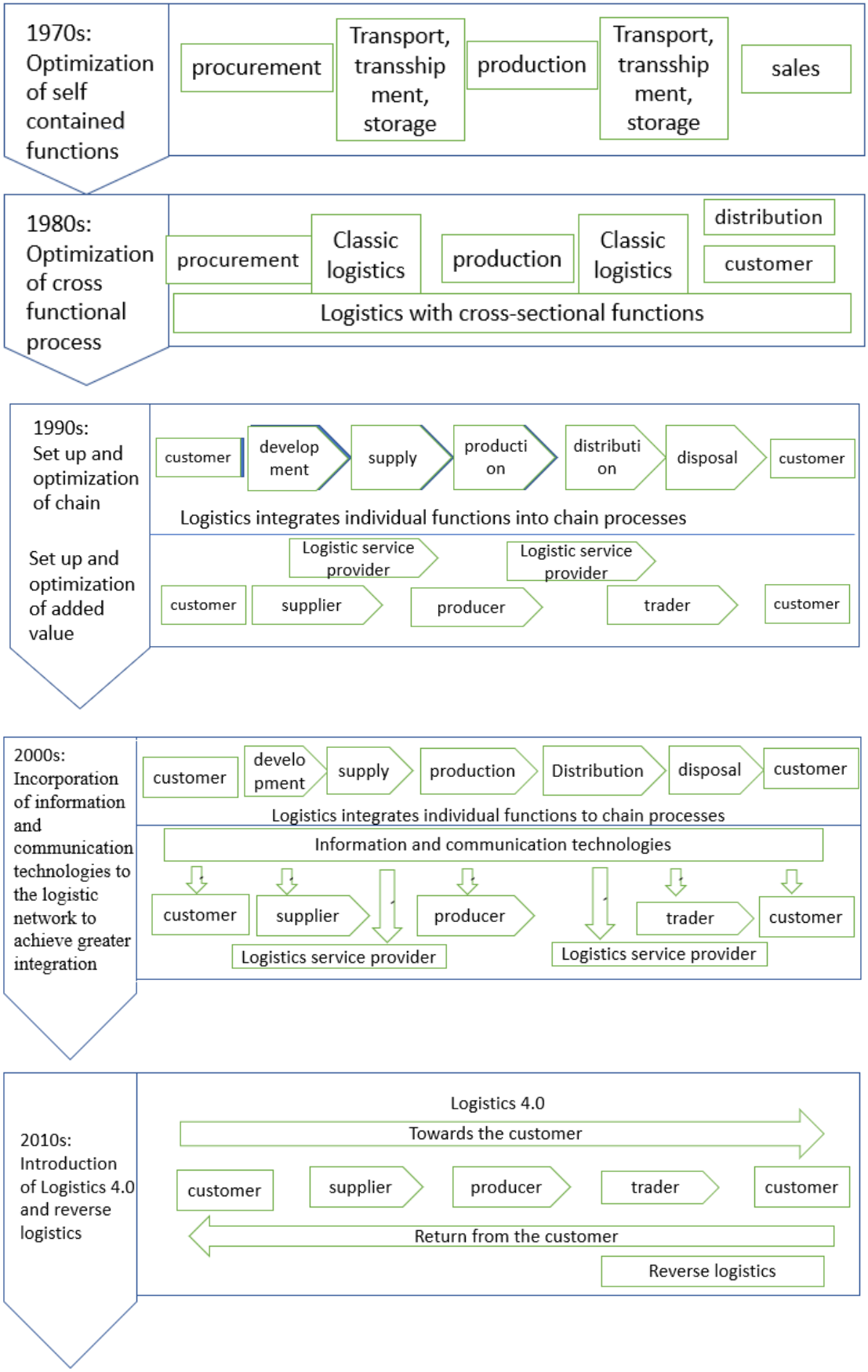

Figure 4: The evolution of logistics over the years (adapted from Gleissner & Femerling, 2014; Glistau & Elke, 2018)

The above Figure 4 also denotes the changes in the field of logistics. It begins from the original, rather simplistic view of transporting, handling, warehousing with its importance on the physical aspect of the logistical task and moves on to the current management-oriented view of the integrated value chain. While moving towards the 2000s, lean and agile strategies started to develop, which necessitated the development of a resilient supply chain, that can respond and recover disturbance with minimum cost as possible (Pawar et al., 2015). Greater levels of integration were achieved between procurement, production, and distribution logistics with the help of the effective use of information and communication technologies. Since 2010, there has been more awareness in the field of logistics to reduce the carbon footprint (Pawar et al., 2015). In addition, the adoption of lean principles demanded the reuse of products, which developed new logistical challenges.

Hence these days logistics and supply chain operations are no longer limited to the time it takes for a product to reach a customer; they now include both the 'to the customer' and 'return from the customer' cycles (Salema et al., 2006). Reverse logistics is the term used to describe the later cycle. Return from the customer may include the products to be refurbished or recycled (Salema et al., 2006). Logistics 4.0 is a result of the application of industry 4.0 in the field of logistics. Logistics 4.0 transforms traditional logistics solutions by introducing new enabling technologies such as cyber-physical systems, which enables the networking and automation of storage system transportation as well as decentralized software control. Industry 4.0 technologies can help to achieve specific sustainability targets in the process involved. In logistics 4.0, digitalization, virtualization, and networking of data and information play an important part in integration (Glistau & Elke, 2018). The application of bar code, RFID, electronic data interchange devices, automated guided vehicles (AGV), augmented reality, big data analysis, has increased in recent years (Glistau & Elke, 2018).

2.2 Maturity model for Logistics 4.0

Currently, businesses are focusing their business model elements on sustainability to ensure long-term market stability and performance. As a result, businesses are redesigning their operations to meet their desired sustainability goals. Industry 4.0 technologies can successfully assist in achieving desired sustainability targets in logistics processes, as well as improving overall company performance (Winkelhaus & Grosse, 2020).

In order to implement logistics 4.0, the company must first assess its current status. In addition, new methodologies and tools have been developed to provide direction and support in aligning business objectives and goals with industry 4.0 (Winkelhaus & Grosse, 2020). A maturity model is a method for determining the best paths to take when implementing industry 4.0 in the logistics process. A maturity model, as the name implies, is a structure or a framework that identifies the maturity or development state of a field of study (Santos & Martinho, 2019). This method can be used to measure,

compare and determine a path from an immature process to a better or mature process (Facchini et al., 2019). The maturity levels are divided into five categories, with the first level indicating that no logistics 4.0 capabilities exist and the fifth level indicating that logistics 4.0 has been fully implemented and integrated. This model is built on the three dimensions of logistics 4.0, which are (1) management, which includes investments and innovation management, (2) material flow, and (3) information flow (Facchini et al., 2019).

The below

Figure ***5*** shows the five maturity levels for evaluating the maturity of companies in adopting logistics 4.0.

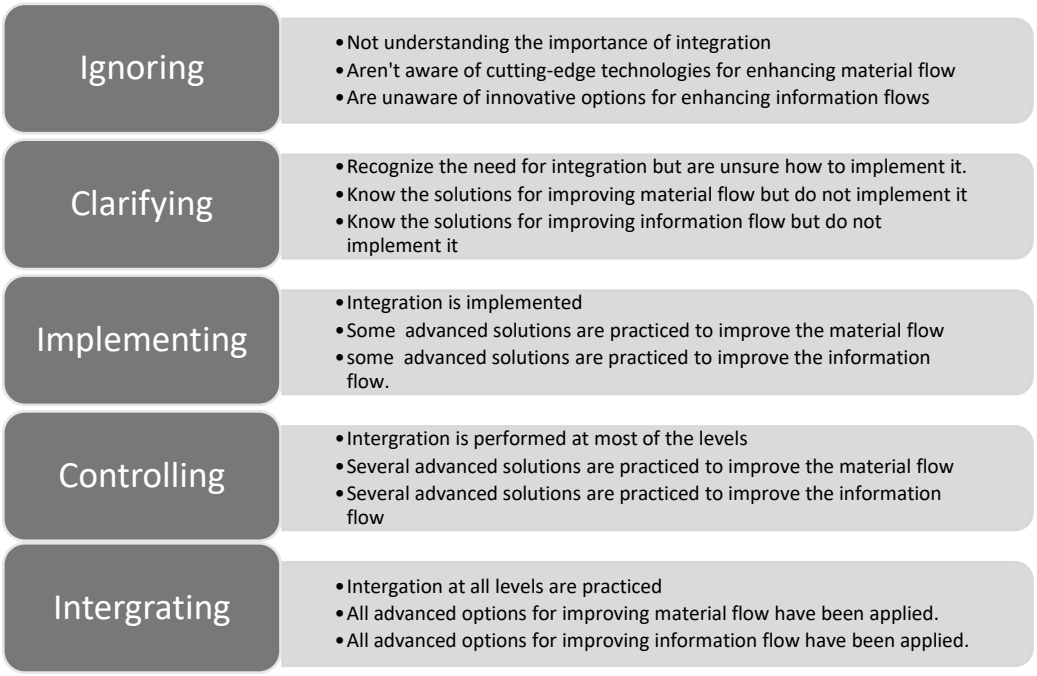

Figure 5: Maturity model for logistics 4.0 (adapted from Facchini et al., 2019)

2.3 Role of third-party logistics (3PL)

The global market environment is now changing, and growing competition is compelling companies to search for better business opportunities. Hence, companies outsource their non-core activities to external providers so that they can concentrate on their core competencies (Gudehus & Kotzab, 2012). It is a strategy that aims at increasing profits by reducing the cost of operations while ensuring consumers with the best service.

One of the common practices is third-party logistics (3PL), where companies outsource their logistics activities to third-party logistics suppliers, as a good way for companies to achieve high service performance and also helps in reducing cost. 3PL is defined as

an external contractor who, on behalf of a supplier, handles, monitors, and delivers logistics operations. Thus, companies can save expenses from investing in resources that can be done by 3PL (Hertz & Alfredsson, 2003).

3PL sectors have the cost-saving advantage as they integrate businesses from different companies such as various pickups, deliveries, and render services to their clients by using their assets (Kotzab et al., 2005). In addition, 3PL will offer the best service to please clients as they are experienced and well established in the logistics field. Another advantage of 3PL is that by reducing expenses, a firm or company will be able to reduce the price of its product or services for its customers, which will in turn offer customer satisfaction. In simple logic, it will have a positive influence on the profit margin of a company.

In the eighties of the last century, 3PL was launched, where conventional services such as transport and warehousing were provided, and since then its development has been rapid and currently contributes to the performance of the supply chain (Maloni & Carter, 2006). Today, 3PL acts as an orchestrator, simplifying the distribution channel and integrating better information systems to facilitate best practices in the supply chain.

2.4 Warehouse automation

Automation is a factor that alters constantly with time, hence it is challenging to define automation in a general sense (Parasuraman & Riley, 1997). According to Groover (2002), automation can be seen as a form of technology that enables processes or procedures without the need for human assistance. The definition correlates the link between automation and mechanization by saying that mechanization is the substitute of machines for physical human labour, thereby stating that automation can be seen as a way of incorporating machines into a framework of a self-governing system (Groover, 2002). Warehouse automation is defined as one with all the strategic and anticipated warehouse processes are performed using suitable technical means. A process is an activity within a system where material, energy, or information is reformed, transported, or stored (Hompel & Schmidt, 2006). In a warehouse, these processes can be material movement, sortation, order picking, unloading, and loading.

Automation can be categorized between fully manual and fully automatic systems (Frohm et al., 2003). This categorization was further classified into three broad levels: manual handling (where work is performed entirely manually), mechanical handling (manual work is done along with machines), and, ultimately automatic handling (where entire work is automated with no manual work) (Gattorna, 1991). In general, the classification can be conceived of as differentiation between manual, mechanical handling, and automatic handling depending on the degree of human intervention (Bellgran & Säfsten, 2010).

Warehouse automation can be regarded as a competitive method for increasing work performance. Over the years several authors have discussed the motives for introducing warehouse automation, as seen in Figure 6 below.

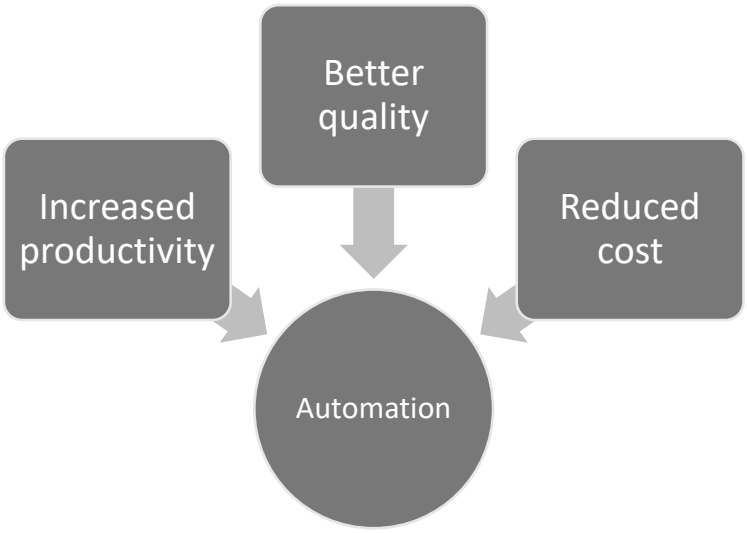

Figure 6: Motivations of warehouse automation

According to Sainathuni et. (2014), higher operational costs can be minimized with the introduction of automation, which will also benefit humans by assisting them and resulting in a better working environment (Kučera, 2017). Automation can increase working efficiency and productivity, resulting in better delivery results (Bansal et al., 2021). With all of the above benefits, some authors state that by automating warehouses, companies can gain a competitive advantage. Some of the common factors as discussed by most of the authors for an organization to automate are:

Increased productivity: By adapting to automation systems, companies will be able to have better productivity by having lesser process times. Automation intends to reduce the lead times and work breakdown time enabling better overall productivity. Ultimately the delivery performance of warehouses could be improved.

Better quality: Here, quality can be seen in two ways, the quality of the products as well as the quality of work. The increase in demand among the customers has compelled companies to increase or standardize the product quality. By adopting automation technologies; machines can be better at detecting errors or defects in products (Ariss et al., 2000) and thereby eliminate capital in reworks (Zairi, 1993). Also, human errors can be avoided with the upcoming of intelligent automated systems (Breton & Bossé, 2003). Hence companies can ensure the quality of the products with automation and humans can be saved from harsh, unhealthy, or dangerous tasks. The automated system can work along with the humans in reducing the operator's workload (Breton & Bossé,

2003). Companies can ensure safer and better working conditions by introducing automation.

Reduced cost: Automation can be seen as an idea, which is of long-term perspective were once implemented it takes time in achieving the balance. When coming to the cost factor, at the initial stages of implementation, automation will have a large investment cost. Once the automation system has been planned and implemented well, in the long run, automation can reduce the operation costs at companies (Frohm et al., 2006).

2.4.1 Levels of automation

The level of automation within manufacturing can be defined as ”*The allocation of physical and cognitive tasks between human and technology, described as a continuum ranging from totally manual to totally automatic*” (Frohm, 2008). Automation in manufacturing cannot be defined as “all or nothing”, instead, it should be treated as a “continuum of automation levels”. According to Frohm (2008), there are 7 levels of automation. The first or the lowest level (LoA 1) represents a system being performed fully by manual handling while the highest level (LoA) represents the fully automatic system. Table 1 below details different levels of automation.

Table 1: Levels of automation

LoA	Mechanical and equipment
1	Totally manual – Totally manual work, no tools are used, only the user's muscle power
2	Static hand tool – Manual work with the support of static tools. E.g packaging tape dispenser
3	flexible hand tool – Manual work with the support of flexible tool. E.g pallet jack
4	Automated hand tool – Manual work with the support of automated tool.
5	Static machine/ workstation – Automatic work by the machine that is designed for a specific task.
6	Flexible machine/ workstation – Automatic work by the machine that can be reconfigured for different tasks.
7	Totally automatic – Totally automatic work, the machine solves all deviations or problems that occur by itself. E.g Autonomous systems.

The lower level of automation usually results in higher flexibility (Windmark et al., 2012). This is suitable for companies producing a greater mixture of products, by reducing the setup time. While the higher degree of automation is more suitable for companies with less variety and offer higher productivity (Frohm, 2008). Levels 5 & 6 are

considered as “semi-automatic” and all the levels till LoA 4 are considered as “Manual handling”. Most of the manufacturing systems consist of both humans and automation in connection. Thus these systems belong in between manual and full automation

2.5 Classification of challenges

When deploying new technologies, the business will confront a slew of difficulties. Researchers point out that, efficient technology selection and implementation necessitates a thorough awareness of many difficulties (Sambasivarao & Deshmukh, 1995). Later these difficulties were divided into two categories: tangible and intangible. The tangible factors are connected to cost benefits while the intangible factors are the indirect or direct factors that are generally not quantifiable. This includes people, social, technological, and strategic issues (Sambasivarao & Deshmukh, 1995). Strategic issues are regarded as a subset of organisational factors and henceforth the term organisational factors will be used. Thus, in this thesis, people, organisational and technological factors while moving towards automation are considered relevant to be studied. These challenges are presented in Table 2.

2.5.1 Organisational factors

Organisational factors denote how work is formally and informally organized. Hence this factor covers areas such as job definitions, responsibilities, and power, hierarchical positions, policies, business goals, and strategies. Organisational culture is also part of this factor (Karltun et al., 2017). To make innovative projects successful, decisions taken during the project should be contingent upon a host of organizational characteristics. This includes organizational structure, top management attitude, etc. Top management attitude towards these projects is a crucial determinant in its success. Even the perception of a lack of support can be just as detrimental to a project’s implementation as a genuine lack of support. Moreover, top management should be broad-minded to take short-term risks for long terms benefits. Support of top management should be visible in ensuring the integrity of the team, top-down planning, and while allocating other necessary resources (Co et al., 1998).

2.5.2 Technological factors

This can be divided into two parts. The first one is the primary technical system comprised of production equipment committed for production, which can be defined in different ways concerning technical limitations, problems, reliability, and availability. In complex technical systems, the system will be considered as a network of linked autonomous parts which to a large extend separately controlled and managed. The second one is the secondary technical system which is formed by the administration and procedures of the company and does not involve value-adding operations (Breivold & Sandstrom, 2015). Thus, the secondary technical system consists of information systems, hardware, and software.

2.5.3 People factors

The introduction of automation is likely to influence the job of shop floor employees in the warehouse. Job tasks, the physical layout of the warehouse, type of communication, amount of information to process, among others, could change with the introduction of automation. Hence in people factor, areas such as individual skills, expertise, background, motivation, weakness, relation to other colleagues, among others, are considered for the study. People considered can be operators, supervisors, mechanics, or bystanders (Scholtz 2003). The performance of the people depends on their designated role in the system. Approximately 50% of automated related advanced technology implemented in the USA are found to be less successful in terms of reliability, quality, flexibility, and responsiveness. The main reason for this is improper attention given to human aspects while implementing these technologies (Chung, 1996).

2.6 Categorisation of warehouse automation challenges

When reviewing the literature on the automation challenges, it was observed that different authors list various challenges, irrespective of classification. Therefore, a holistic classification is necessary. The Table 2 below points to the various challenges that industries have encountered so far as they move toward automation. The challenges identified from the literature were classified into people, organisational and technological areas based on the origin of the challenge.

Table 2: Organizational, Technological & People challenges of automation.

Sl no	**Challenge**		**Sources**	**Description**
1	Commitment from top management	Organisational	Co et al., 1998; Kumar et al., 2020	This challenge refers to the management's role in supporting different projects in terms of resources.
2	Evaluation and economic justification strategy	Organisational	Afanasyev et al., 2019; Beatty & Gordon, 1988	This challenge is related to issues with different methods, the company uses to calculate economic returns of projects.

3	Assessment of critical success factors	Organisational	Hasan et al., 2008; Ramamurthy & King, 1992	This challenge is related to difficulty in assessing critical success factors for automation.
4	Initial justification of the need for change	Organisational	Potdar et al., 2017; Ramamurthy & King, 1992	This challenge addresses the difficulty to justify the need for automation.
5	Strategic focus and planning	Organisational	Ramamurthy & King, 1992	This challenge addresses company's ability to be strategically aware of implementing new technologies.
6	Implementation and human resource strategic issues	Organisational	Cirillo et al., 2021;Ramamurthy & King, 1992	This challenge is related to difficulties in organisational changes with the introduction of automation.
7	Data and service security	Technological	Afanasyev et al., 2019	This challenge refers to the new data security concerns that can arise with the coming of automation.
8	New technology introduction and training	Technological	Afolabi & Oyebisi, 2007	This challenge is related to difficulties arising from the introduction of new

				technologies due to different reasons.
9	Flexibility	Technological	Wadhwa, 2015	This addresses the robustness of the machines with the varying product lifecycles and market environment.
10	Reliability	Technological	Chavaillaz et al., 2016	This challenge is about the level of trust, safety, and availability of systems.
11	Worker resistance to organisational changes for automation	People	Kumar et al., 2020; Morris & Barnacle, 1989	This challenge addresses worker's reluctance to changes due to automation.
12	Change in the skill of workers	People	Frohm et al., 2003	This challenge addresses the changes in worker's skills required, to meet the requirements of the job.
13	Communication challenge for operators	People	Cirillo et al 2021; Pietro & Schremser, 1987	This challenge addresses change in communication patterns due to the introduction of automation.

3 Method and implementation

This chapter presents the research method used along with the design of the study. To give a clear idea regarding how research questions would be answered, various steps of implementation are detailed.

3.1 Research Philosophy

Research philosophy is a system of beliefs and assumptions which form a foundation for knowledge development (Saunders et al., 2009). These assumptions and beliefs play a crucial factor throughout the thesis, from shaping research questions to forming the results of the study (Crotty, 1998).

There are three types of research philosophies for conducting research, which are positivism, interpretivism, and critical theory (Young, 2001). Positivism philosophy is a type of research where a study is conducted on an existing theory or knowledge (Uduma & Sylva 2015). states that the positivist approach uses a quantitative way of performing with a deductive style of reasoning to test a particular hypothesis. While interpretivism, as the name suggests, is of an explanatory nature as human beings interpret a phenomenon differently, interpretivism produces a vibrant and detailed interpretation of a phenomenon (Saunders, 2016). Interpretivist uses a qualitative way of approach with an inductive style of reasoning to generate a hypothesis (Williamson, 2004). The critical theory is a type of study based on social action, politics, and science (Howell, 2016). For critical theory, the object of study and the subject of study as highly interlinked, and the researcher is part of the object of inquiry (Ponterotto, 2005). In critical theory, the critics play a purposeful and central role in the study.

After analysing the company circumstances through interviews and observations, the researchers formulated the purpose and research questions through the interpretation of the texts and data that is collected and socially constructed, hence an interpretivism approach is used throughout this thesis work. The researchers believe that by considering the viewpoints of people who are completely different from themselves, the diverse challenges within the warehouses can be well formulated and analysed (Glesne & Peshke, 1992).

3.2 Research Approach

The research approach is the type of reasoning style, used by the researchers in analysing the data. The research approach shows how an idea is empirically perceived or interpreted (Thomas, 2017). The research approach has been categorized into two - deductive and inductive reasoning. The deductive method is related to quantitative analysis and deals with logical testing based on a theory. While inductive reasoning is linked to qualitative analysis, it deals with the development of the theory (Williamson, 2004).

Here the researchers started their approach with a literature search. The literature review offered an up-to-date status of the area of study and provided information to perform the research at the case company. To get a depth of knowledge about the problem at the case company, data from interviews, observations and notes would be analysed with data from the literature search. Hence an inductive approach of research is carried throughout the study. An inductive strategy is "a type of reasoning that starts with specific instances and ends with general statements or principles" (Williamson, 2004). The inductive method was more fitting since this study would contribute to theory or by adding to previous theory in relation to the pre-study on automation.

The below Figure 7 depicts the research approach of this study, which shows the plan by which the study is to be carried out. The first step is the pre-study where the researchers formulate the purpose and RQs. Then a systematic literature study will be done based on keywords that can give the researchers an in-depth knowledge of the area of research which is “warehouse automation”. Then examines the current production systems with the help of data from interviews and observations. In the later stages’ challenges identified from the literature search will be compared with the case company warehouse and hence challenges will be finalized along with solutions. The results will be documented as the final report.

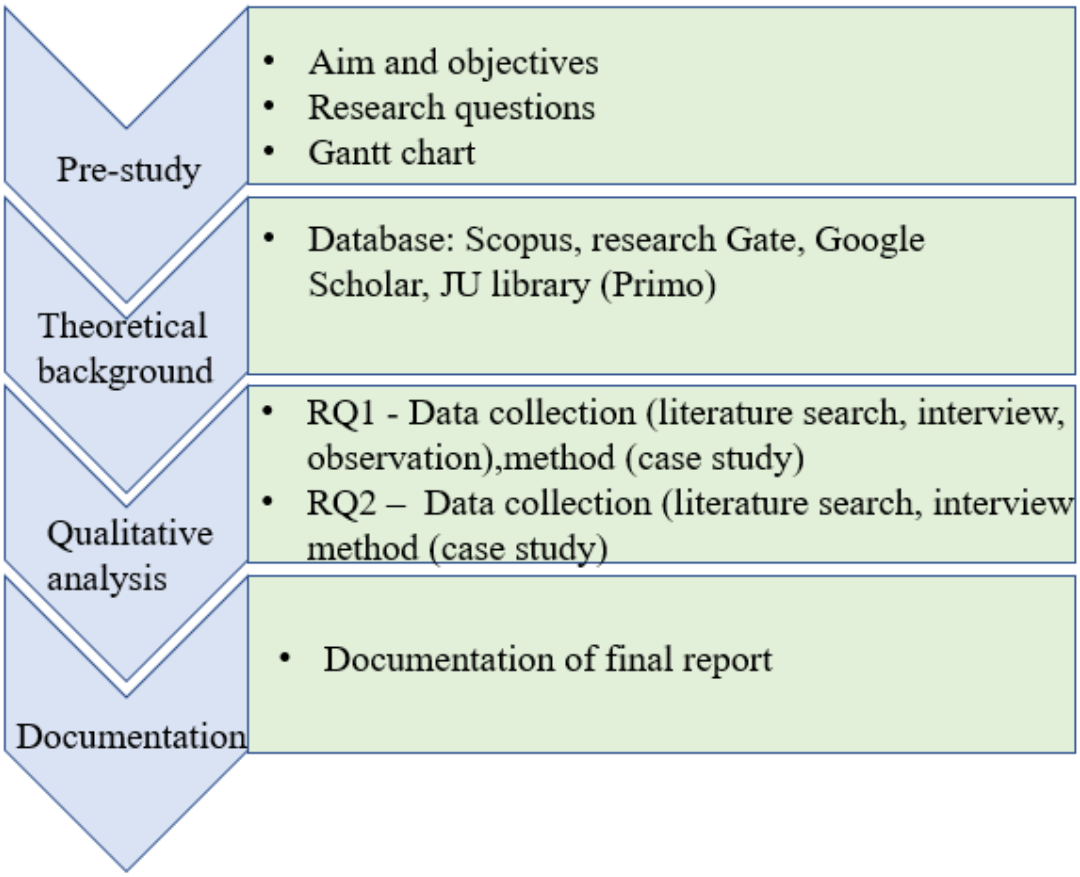

Figure 7: Research approach of the study

3.3 Single case study

A case study design was chosen for this study, as it can be seen from the purpose of the study that this thesis is exploratory in nature. The study focuses on the challenges of warehouse automation and how companies can deal with these challenges. The case study is appropriate for studies when little is known and a deeper understanding is required regarding a specific topic (Eisenhardt & Graebner 2007). A case study can also be used in solving complicated situations with the help of previous research findings (Zainal, 2007). To conduct a case study, researchers use different methods to collect data in order to produce materials appropriate. (Yin, 2014) have identified six major sources in collecting data which are direct observation, interviews, documents, archival records, physical artifacts, and participant observation. In this work, researchers would be using interviews and observation as a source of data.

According to Williamson (2004), case study is classified into two types: single case study-this type of case study is used in studying a specific situation or specific company and multiple case study-this study uses multiple cases or companies to study a specific theory or principle. For this study, the analysis is done on a single case company and hence the research method is a single case study, which helps the researchers to have a deeper understanding of the exploring subject. The case study focuses on the automation of warehouse production systems, to improve productivity along with a better working environment. Here the unit of analysis of the study of this research study is the warehouse production department.

3.3.1 Data collection

Generally, there are two types of data used in research: primary data and secondary data. Primary data is clearly described as data that is obtained for the first time for a particular study directly from the key sources by interview, observation, survey, and other means. The primary data for this study was gathered by observation and interviews. Secondary data, on the other hand, is information that already exists in the form of books, newspapers, censuses, and other sources which are readily accessible to researchers. This thesis collects secondary data through the literature review.

Observation

Observation can be considered as one of the important methods of primary data collection. Observations can be made either by looking at a process, taking pictures, or taking notes as it takes place (Williamson, 2004). In addition, if more observers are involved; more accurate would be the results from an observation (Yin, 2014). In this study, both authors were involved in the observations. The authors used a non-participant observation method for the analysis, in which both the authors were passively engaged with the work environment (Kumar, 2011). This method helped the authors fully understand the

current situation of the warehouse's operations, environment, and management-employee interactions. Important observations were noted. One downside of this technique is that if an individual or group learns that they are being watched, they try to alter their behaviors and that may yield incorrect data. Hence the employees were not aware in certain instances of the exact time the researchers would be in the section so that the employees would behave and act the same way they normally do.

Interview

An interview is done for collecting qualitative information data from the individuals or in groups which can provide a deeper understanding of the investigated area (Patton, 1987). For this study, the interview helped the authors in gathering information on the various ways by which different projects are planned and executed within the company. One of the key advantages of this primary data collection method is the flexibility where the author can choose the format and questions to ask the respondent. According to Williamson (2004), interviews are categorised into: structured, semi-structured, and unstructured interviews. Structured interviews are more of a rigid type of interview where predetermined or standard questions are asked in the same order. As a result, there are not a lot of chances to investigate and discuss subjects further (Saunders et al., 2009). Unstructured interviews often progress in the way a regular discussion does, but it involves the study subject under consideration (Saunders et al., 2009). A semi-structured interview is a mix of both structured and unstructured interviews, where it does maintain some structure, but depending on the flow of conversation additional information can be asked (Saunders et al., 2009).

For this research, to obtain a wide variety of details, the researchers used semi-structured interviews, in which the interview would be performed based on the ideas obtained from the literature search, and hence the questions would be more open-ended. The key goal of the interview in this case is to give the interviewee a lot of leeway in answering the questions (Bryman & Bell 2003). The interviews are meant to serve two purposes: firstly, an interview would be instrumental to get a general understanding regarding the approach of the case companies towards automation and other projects management aspects such as budgets, resource allocation, employee participation. Secondly, an interview would be useful to get information regarding the nature of challenges discovered within the company. In order to have a better understanding of the nature of the challenges, the researchers wanted to get diverse perspectives on the study area, so interviews were conducted with people across varying designations (see Table 3).

Table 3: Interview details

No	Designation	Number of interviews	Duration
1	Production Manager	1	30 min
2	Project Manager	3	50 min
3	Team Leader	2	30 min
4	Operator 1	3	20 min
5	Operator 2	3	20 min

Literature review

Literature aims to provide a foundation for the topic of research. The authors search for empirical research data and critical analysis studies to see if a scientific study applies to the problem area (Forsberg, 2016). The literature review aims to educate the reader about a topic and to form the basis for another study (Cronin et al., 2008).

For this thesis, the literature review is done to gain knowledge around the subject of automation challenges. The authors used string search with Boolean operators to conduct their literature search, which included the terms "Automation," "Warehouse," and "challenges." The keywords with their synonyms were used resulting in a higher quality of review process. Table 4 below shows an example of a string search used for the thesis.

Table 4 : Strategy for literature search

Database	Search string	Delimitation			Results
		Search field	Document type	Language	
Scopus	((warehous* OR "distribution centre") AND (automat* OR "advanced manufacturing" OR iot OR "internet of things" OR "autonomous robot" OR "cobot" OR "big data" OR "virtual reality" OR	Peer-reviewed journals	Articles	English	756

	"augmented reality" OR "exoskeleton") AND (challeng* OR barrier* OR problem*))				
	Total no. of initial search results				756

The authors used the Boolean operators during the literature search to obtain relevant information and irrelevant areas were filtered out.

Primary data was gathered from peer-reviewed research papers in the Scopus databases provided by Jönköping University. By sorting through the document and language filters, a total of 756 articles were discovered during the initial literature review process.

3.4 Data analysis

According to Patton (1987), the analysis of findings depends upon the type of data collected. For this study, a qualitative data collection method was used, with the researchers gathering information through observation, interviews, and a literature search.

To begin, a literature review was conducted using a string search based on different keywords to gain a comprehensive understanding of the subject. The articles found through the string search were further narrowed down through a screening process. The authors used an Excel sheet to conduct the screening process, which included importing articles from the Scopus database into an Excel sheet. Thereafter, the articles were further sorted by removing duplicates, filtering articles based on citations, and finally, the authors sorted the articles by reading the abstracts of each article found. Later terms "organization," "people," and "technological" were used to screen out most suitable articles. After reading the abstracts for all 756 publications, 704 were ruled out. Following that, the authors examined 52 publications, 21 of which are studies on warehouse automation challenges.

Interviews were conducted and recorded based on the information gathered from observation and literature search. The recording allowed the researchers to concentrate on the interview rather than taking notes, and it also aided in the later analysis of the findings. The collected data was then analyzed with theory to provide suggestions for mitigating those challenges. The case study differentiated various challenges of automation implementation into people, technological and organizational issues.

3.5 Research Quality

The quality of research is an important part of the study, and four terms, reliability, validity, triangulation, and research ethics, were defined to ensure that quality was fulfilled.

3.5.1 Reliability

Reliability can be defined as the consistency in the result when a study is repeated in the same context or under similar situations. The study's reliability is ensured by thoroughly describing the methodology procedures used during the research (Flick, 2018). Researchers believe that if the same methodology is used for a case study of similar situations, the same results will be obtained.

But there exist some threats for reliability since the method relies on qualitative data collection techniques such as observation and interview. Data collected from these methods could be biased depending on the interviewee's mood or due to the notion of being observed. To reduce the biasness of the interview, the researchers used multiple interviews with different people performing the same work task.

3.5.2 Validity

The validity of research can be seen as the extent to which the study has answered the research questions. Validity has been also defined by (Williamson, 2004) as the capacity of an instrument to measure what it is intended to measure or the accuracy of an instrument to measure the value. Validity for research has been mainly classified into two internal and external validity (Goodwin et al., 1999). Internal validity can be seen as the degree to which the results apply to a particular variable or situation. While external validity is the extent to which the results can be generalized to other situations or events.

For this study, internal validity was assured with the use of triangulation. With the method triangulation, the researchers made use of interviews and observation in cross-checking with the challenges found from the literature review. The data triangulation approach was done by performing interviews with different people at different levels. Also, the literature review was conducted by evaluating literature from various periods. This way of approach is in line with (Collis & Hussey, 2021) who stated that using a variety of methods and tools can aid in improving the quality of research. In terms of the study's external validity, most of the data were collected within the case company, so external validity is limited. Since this study is a case study, the results cannot generalized in other areas (Yin, 2014), however, the result of this study can be used by similar logistics firms.

3.5.3 Triangulation

Triangulation means the use of multiple research methods or sources or researchers to study a certain phenomenon (Collis & Hussey, 2021). The process of triangulation can help in strengthening the result found by incorporating several viewpoints and methods. The purpose of triangulation in a study is to boost the credibility and validity of the research by explaining different aspects of the phenomenon of interest (Ashatu, 2015).

There are many different approaches to triangulation, and classifies triangulation in four forms (Denzin, 2009):

- Data triangulation: Data is gathered from a variety of sources, including time, space, and people, to form a single body of information. Triangulation can be applied to a variety of areas within a study and can help to reduce the risk of fallacious interpretations.
- Method triangulation: When researching a situation or phenomenon, more than one method or data collection technique is used for conducting a study. This method can be used to reduce the flaws and biases that come with any single method.
- Theoretical triangulation: It is the application of multiple theories to the interpretation of a situation or phenomenon. The application of this method allows you to examine a situation from various angles and with a different set of questions in mind.
- Investigator triangulation: When more than one investigator is involved in the analysis of the data collected during a study. As the investigators confirm findings across investigators without prior discussion or collaboration, the approach can help improve the credibility of a study.

For this thesis, the researchers utilize methodological and data triangulation approaches are used to enrich the study. The methodological approach as seen from Figure 8 is performed by making use of the observation, interviews, and literature review to answer the set of research questions formulated. The data triangulation approach has been performed by collecting data from different sources at different times. Interviews are done with the operators as well as with the company representatives to further strengthen the result of the study. Literature reviews are conducted from different data sources and the timeline of articles varies throughout this study, allowing for a better understanding of the research area.

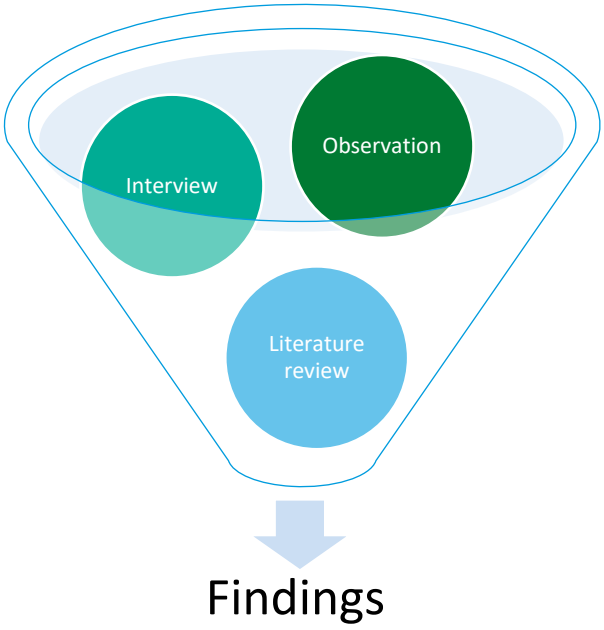

Figure 8: Methodological triangulation approach

3.5.4 Research ethics and morality

Research ethics can be seen as doing what is morally right at different stages of the research process (Hedrick et al., 1993). For the thesis, a code of conduct was well followed by the researchers with the case company. Starting with protecting anonymity and confidentiality, we have used proxies for the case company name along with the names of interviewees. The recorded interviews are stored in teams platform with access only to the researchers of this thesis. The risk of harm is minimized by having consent from the participants when designing this thesis work.

4 Findings and Analysis

This chapter details the data that have been gathered during the thesis period using different data collection methods such as interviews and observation. The chapter is divided into three parts, the first of which includes a review of the case company and its current state, followed by challenges that have been identified and solutions for these challenges.

4.1 Case company description

To investigate the challenges during warehouse automation, the authors decided to do it as a case study in a warehouse facility of a 3PL logistic firm. The specified warehouse is located at Jönköping in Sweden. The warehouse facility is mainly used as a cross-docking facility for logistic movement of goods for small and large businesses such as Ikea, Samsung, JSYK, Brofab, Ellos, System Bolaget, and so on throughout the Nordic region. The case company holds the functions of a 3PL and is responsible for handling goods from various suppliers. Products that are being handled, varies from E-commerce to medicinal drugs. E-commerce products are of mainly two types, one being called "White goods" and the second one being home delivery goods (HD goods). White goods include fridge, oven, induction stove, while HD goods include furniture, TV, AC coolers. Medicinal drug sorting, HD sorting, White goods sorting are done at specific areas of the warehouse. These production activities consume nearly 40% of the total available floor space. The functions of the warehouse are depicted as following Figure 9.

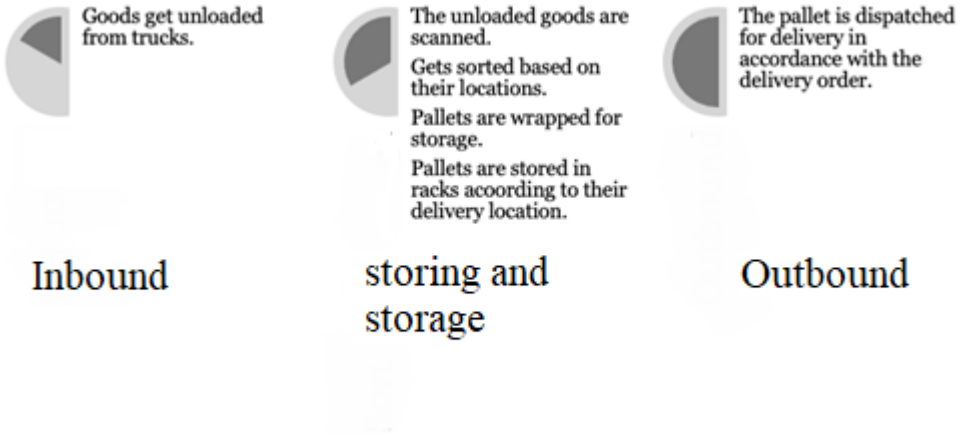

Figure 9: The function of the warehouse

The company uses barcode technology to register the arrival of the product. A certain part of the warehouse is utilized as a storage location with the help of racks. In these racks, goods are stored which are delivered upon customer order. A large part of the sorting of goods is done using manual labour. Due to this company faces many challenges such as prolonged production lead time, material damages, and thus higher op-

erating costs and risk. In addition to the above-mentioned challenges, ergonomic concerns, load variation issues, lower productivity, the company is considering automation possibilities.

Currently, the company has different levels of automation in various processes. Movement of goods such as unloading, loading is done with the help of pallet trucks. Hence this process can be considered under LoA 3. Very few automated devices such as plastic wrapping machines, pallet and clamping trucks, plastic compressing machine were used in the production activities. All other activities such as palletizing/de-palletizing, sorting goods, inventory handling, labeling, scanning, are done manually and this process fits under LoA 1.

The company considers automation as a potential means to further optimize manual sub-process with assistive technology. The company identified different forms of automation such as conveyor sorting, cart-based picking, pick to light system, and automated storage and retrieval systems as part of the production system in near future. As a result, the company can be deemed to be at the defining stage of the maturity levels, where it is aware of advanced solutions and is looking for the need for integration. Also, the company believes that through automation, job quality of terminal worker can be improved since most of the work done in the warehouse are hard physical work.

4.2 Challenges in moving towards warehouse automation

During the data collection, the authors tried to check the existence of different challenges which were identified from the literature in the case company. Some challenges were identified from the interview and observations.

4.2.1 Organizational challenges

Six organizational challenges were identified in the literature of which three were identified at the case company, and these are:

Challenges in critical success factors and evaluation criteria

Most of the automation projects require huge investment and results in organisational changes. The effectiveness of these changes is difficult to quantify and thus exists as a challenge. From the interview with the production manager, it was understood that the company had recently faced a similar situation. According to him “the *company faces issues while scheduling trucks for different departments during some occasions. During black Fridays and other similar business occasions company forecast fails to meet the accurate number of trucks needed due to multiple issues. So, it won’t be a surprise that it would be difficult to figure out critical success factors for automation project”.*

Challenges in evaluation and economic justification strategy

So far, when evaluating the economic aspects of new projects, the case company uses traditional justification methods such as rate of return, payback period. for all previous

projects aimed at changing the way of working, these methods were given priority or only needed since it does not bring any major organisational changes. But traditional methods of evaluation and justification, that are based on direct labour cost savings would not be sufficient when considering the economic benefits of automation since automation has a significant impact on overall efficiency, effectiveness, and competitiveness.

Implementation and human resource strategy issues

One of the major challenge companies faces while moving towards automation is likely to be the identification of the type of organizational changes they need to adopt. Since automation brings changes in skills of employees, position or title of employee's changes. This challenge could exist but was not confirmed in the interview. However, upon observation, it was found that human resource allocation has been an issue at the case company during the change in strategy and this was observed from the shift leader's interview in which he expressed difficulty to start a new shift by reorganizing the existing team when a new customer was added.

The remaining three organisational challenges were found in the literature review, however, these did not seem to exist in the case company. These challenges were:

Top management commitment

From the interview with the production manager, it was clear that the warehouse works with a classic organisation structure as shown in Figure 10, with 4 main departments as production, purchase, sales, and finance. The production department handles all production activities including process improvements, quality assurance, manpower planning, truck scheduling, and other supporting functions. The purchase department is responsible for deciding and prioritizing the purchase orders for the warehouse's functioning. The sales team handles marketing and thus customer interactions. The finance department like the name says covers the financial aspects of the warehouse working. Therefore, due to the dedicated roles, the top management commitment is expected to be high in warehouse automation projects. But During the interview with the project manager mentioned that "while *carrying out projects, organisation had experienced difficulties due to lack of technical expertise in the project fields and that's one of the reasons why the company is slow in adopting RFID technology in their production warehouses. Because of these observations company is considering hiring new people in technical areas for new projects"*.

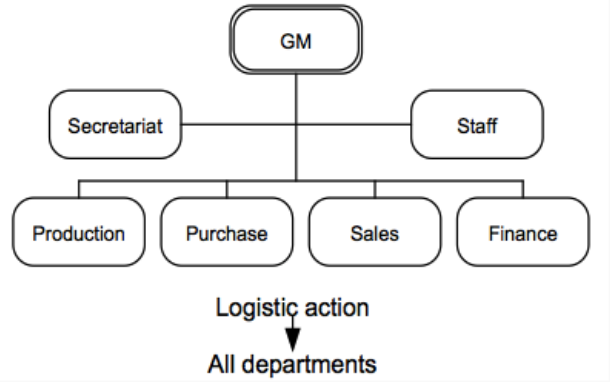

Figure 10: Organizational structure in case company

Strategic focus and planning

The ability of an organisation to be aware of technological advances and thereby reorganize internal performance shortcomings through an effective control system is a deciding factor to incorporate new technologies, thus a challenge while going for automation. The introduction of automation can bring major organisational change affecting the functional roles and established power linkages of the organisation. This challenge could exist but was not confirmed in the interviews.

Initial justification of the need for change

Certain organizations reward their managers according to his/her department's contribution to profit. The majority of investment decisions are made based on the projections of increased productivity. In such organisations, managers tend to hesitate to make investments since automation takes time for the return of investment. This could arise as a potential challenge while moving toward automation (Beatty & Gordon, 1988). In the case of company, investment decisions are made considering the potential benefit of the technology, and not on managers' contributions to profit. This challenge does not exist at the case company.

4.2.2 Technical challenges

In total, four technical challenges were identified in the literature, of which all four were identified at the case company.

New technology introduction and Training

Automation is associated with the digitalisation of working systems; it is intended to move work from humans to machines; however, humans are still required to control the platform and optimize its use. When implementing the new technologies, there will exist a gap in knowledge on operating or in control, this can cause a fear of incompetence to handle the new technology among employees. This was mentioned by one of the operators, during the interview. According to him "*when the company introduced a*

new type of clamping trucks, it took nearly 4 weeks to get control of basic functions, because its control systems were entirely different from the traditional one. Also, when new PDA was introduced, it took some time for operators to get used with it". The operator's fear while adopting new technology was clear from that interview. As a result, when organization adopts automation, this can pose a challenge since many system component operations are unfamiliar to employees.

The case company currently has training plans and schedules that suit current production methods. Some of these training are common or some are customized. Recently case company had developed QR based SOP available at each workstation. These pieces of training are focused mainly on truck driving, Gate operations, locking and unlocking of trucks to gates, Use of PDA (personal digital assistant), wrapping machines, compressing machines, ergonomic practices. But these training plans are not sufficient while adopting automation and thus designing new training plans would exist as a challenge.

Data and service security

Since automated systems consist of computers, PLC, sensors, and other monitoring devices, systems are susceptible to disruption, due to attack or information theft/loss. Along with the development and use of more digital technologies, the case company believes that they might become more and more vulnerable to external attacks such as cyber threats. During the interview, the project manager had reported that over the span of 2 years company had some network breaching issues causing their network system to crash. This has resulted in slowing down the company's operation. Further on the Manager revealed that making a system completely automated can be challenging as a cyber threat or the reliability of the system is in question.

Flexibility of system

Automation can be a cost-effective way of dealing with operations, but one of the main challenges that can arise with automation is the flexibility of the system. Flexibility or a flexible system can be defined as the ability of the system to adapt to new or changing environments (Weber, 2004). While interviewing the production manager he quoted that "*one of the reasons the facility hasn't been automated is because of its versatility concerns. We have been adding new customers to our system, of product varying size from 20*20 cm to 100*200 cm. When we discussed designing a system that would operate optimally for this product range, with automation companies, their response was that it is a difficult job. Also, sometimes trucks arrive late, in these situations capacity of the system would exist as a challenge in terms of flexibility and thus hinders operations within the warehouse*".

Reliability of systems

At the case company, system reliability is a major concern when implementing automation. System reliability is primarily related to the level of trust, safety, and availability of systems. During the interviews, one of the most common issues raised by the operators was about their safety and level of trust in the machines. Automation brings complexity into the picture and unpredictable operating conditions can possess a threat to the operators. According to the team leader, *"if an operator has a high level of trust in automation, but the machine or device sends a false alarm, the operator's level of trust in automation decreases."* He further stated that some of the common anxiety raised regarding automation implementation by his fellow co-workers are due to the accidents reported while operating automated compressing and wrapping machine. Another issue related to reliability was system availability. It was observed that all processes are currently done manually with a low level of automation, so any failure in any operation will not affect the production system because the rest of the operations can still be carried out. This observation was supported by one of the team leader's answers during the interview, who stated that by having a fully automated system, the system's availability can be called into question because any failure in the system can bring the entire production to a halt.

4.2.3 People challenges

In total, three people-related challenges are identified in the literature review, of which, all exist in the case company.

Resistance of workers to the organization changes caused by automation.

The introduction of automation can bring organisational changes. When automation units such as conveyors, wrapping machine were introduced in the case company, resistance from workers belonging to respective departments were observed. At times, when the system fails and reports an error, employees get frustrated and blame the change instead of attempts to identify the root cause of the error and learn from it. Also, it was observed that the workers in this automation unit initially expressed reluctance to adopt the new system due to issues of trust and lack of knowledge in how to operate. Hence, this is a challenge when case company moves towards automation.

Implementation of automation demands changes in the work skill of workers.

One of the primary advantages of automation is that it relieves the operator of physically demanding tasks; however, it frequently leads to new and complex tasks. During interviews with various people ranging from managers to operators, it was found that a new challenge that can arise with automation is a change in operators' work skills. With the introduction of automation, the operator's job description evolves from manual labour to a problem-solver or a decision-maker. The observation provided additional proof because it was discovered that the current system is manual driven, and the operators have not dealt with many digital systems; thus, with the advent of automation, operators

may have to learn how to handle digital devices such as computers, PLC, sensors, scanners, and other mechanical, electrical, and hydraulic components. Hence operators must be more skilled than those who use conventional equipment, for these systems to function properly and to be maintained.

Communication challenges for human operators

The introduction of automation demands changes in communication preferences from the operators. Earlier operators may need to communicate mostly with colleagues within the shop floor or team leaders but now they may need to interact more with support personnel from other departments. In automated plants, the pace of production, bigger physical distance between workstations, more concentration requirements, make direct communication more difficult, increasing the mental demands of the job. In automated systems, operators have more supervisory responsibilities than manual operation and thus require supervisory skills.

In a nutshell, automation would result in more data to process, increased person-machine communication, and increased intragroup and intergroup communication. Also, automation will demand more informal than formal communication (Pietro & Schremser, 1987). This challenge was observed relevant for workers moving from manual to conveyor-based production systems at the case company. Below Table 5 summarizes challenges identified in the case company.

Table *5*: Summary of challenges identified in the data collection.

No	**Challenges**		**Literature**	**Interview**	**Observation**
1	Commitment from top management	Organisational	√		
2	critical success factors and evaluation criteria		√	√	
3	Assessment of critical success factors		√	√	
4	Initial justification of the need for change		√		
5	Strategic focus and planning		√		

6	Implementation and human resource strategic issues		√		√
7	New technology introduction and training	Technological	√	√	
8	Flexibility requirement due to varying product lifecycles and market environment		√	√	
9	Data and service security		√	√	
10	Reliability of systems		√	√	
11	Worker resistance to organisational changes for automation	People	√		√
12	Change in skills of workers		√	√	√
13	Communication challenge for operators		√		√

4.3 Mitigation of challenges in moving towards warehouse automation

To mitigate the challenges faced while moving towards warehouse automation, several strategies were proposed based on the literature review

4.3.1 Mitigation of organizational challenges

In total, four mitigation strategies are proposed to deal with the organisational challenges.

Awareness and long-term planning

The perceived lack of support for the automation initiative is as debilitating as the actual lack of support. Automation introduction can bring organisational changes. Top management commitment is so critical in any major organizational change. Top management risk behaving levels or unwillingness to undertake activities involving uncertainty, affect the success rate of automation implementation. Also, the lack of understanding of the manual process variability can hinder the smooth transition towards automation (Charalambous et al., 2015). Hence top management should be aware of these circumstances and strategic and long-term decisions for automation should be

taken with a broad-minded vision. It was evident that the company need more specialists in the field of automation and digitalisation such as automation specialists, software specialists, data scientists, and industrial engineers to support automation functions during implementation and normal operation phases. This was confirmed by the project manager during his interview.

Establish success factors and evaluation criteria

Despite its conceptual significance, assessing organizational effectiveness has proven to be a challenging and intractable problem in both theory and practice. Because of the diversity, size, and complexity of the organisation as well as its pursuit of multiple objectives, this is a complicated problem, particularly in the case company. This is a serious concern given their efforts to automate the handling of a wide range of products. Also, the case company considers the automation projects as one requiring huge investment and is aware that it may result in major organization changes. Hence the needs of automation should be evaluated on its effectiveness and thus establish measurement criteria for monitoring its success parameters.

Use of decision-support tools

Since automation benefits are long-term and contain intangible factors, traditional economic evaluation methods cannot be used for economic justification. Hence to solve this challenge, the case company can adopt techniques such as Analytical hierarchy process (AHP). AHP- Promethee methods of decision making could be helpful for the case company to establish priorities and check consistency thus leading to effective decision makings regarding the levels of automation required. Intangible benefits such as reduced lead time to market, better customer satisfaction, flexibility should be considered and measured during the planning stages of automation. For this to accomplish may case company requires personals with experience to perform these tasks.

Formalize implementation plan and human resource strategy

To successfully introduce automation, the company must create a detailed master plan and follow it step by step. The milestones should be tracked by the core team. Since the automation project is expected to last a long time, the plan developed should allow for technical and physical expansion (Co et al., 1998). More mental and monitoring skills are needed during the early stages of automation projects. While planning the implementation phase case company needs to formalize the plans for training, developing new job titles, skill development, and other aspects such as motivation, participation, reward schemes. This would enable the case company to prepare its workforce to adapt easily to the new working environment.

4.3.2 Mitigation of Technological challenges

The interviews and observations at the case company revealed a combination of data security, flexibility, system reliability, and new technology and training as some of the

technological challenges that can arise with warehouse system automation. In total, four mitigation strategies are proposed for the technological challenges.

Develop IT security systems

One of the issues that can arise with automation is a lack of data security of the systems. This challenge can be controlled from the beginning of the planning phase, where the system requirements and objectives can be thoroughly studied and should implement the system based on current and long-term strategic objectives. The system should be scalable enough to add new devices and networks without jeopardizing the performance of existing devices, networks, and data transmission.

The digital system should also be well monitored and secured after they are implemented to protect against external data threats. It is critical to provide security mechanisms to increase the level of data protection and message communication between devices because data or service unavailability can have a significant impact on customer business. Insecure communication, weak system authentication, a lack of data encryption, and poor configurations are some of the factors that contribute to external data threats (Afanasyev et al., 2019). The following are some possible countermeasures that could be followed by the case company (Iaiani et al., 2021):

- Network segmentation and flow restriction: The IT system will be segmented into smaller multiple smaller networks, with the goal of controlling the flow of traffic in the system. Furthermore, network segmentation can prevent unauthorized network traffic or attacks from reaching areas of the network to which we would prefer to prevent access, and also make network traffic monitoring much simpler.
- System updates and audits: IT teams should conduct regular audits to protect against malicious code and system errors. By delivering the necessary updates, system performance can be improved by resolving bugs. Monitoring event logs securely and preserving audit trails can aid in system improvement.
- Password-based authentication: To add a layer of security, authenticating users into each server or system should be done via password authentication. They can also establish password strength standards, which can be enforced under internationally recognized and proven password guidelines.

Thus, data security issues can be resolved by implementing a proper system in accordance with the requirements. By proper monitoring and control of IT systems, external attacks can be prevented.

Improve flexibility of systems

According to the project manager, one of the major challenges that can arise when automating is the system's flexibility. The growing competition among companies and ever-shortening product lifecycles has made a huge impact on warehouse management

in handling a huge variant of products. As a result, when implementing an automated system, companies should design the system to be adaptable to changing market conditions. For this case company, there lies no solid solution as the market condition, since the customer goods dimensions are unpredictable. According to Rigelsford (1999), the flexibility of a system is highly dependent on product variants and production volumes; therefore, for a warehouse, this can never be generalised and an optimum solution is difficult to suggest at this stage.

One idea which case company can follow when automating is to design a system based on market analysis and forecasting. For example, a system can be designed to handle higher production flows and bulk goods than the current requirement, allowing the warehouse to handle new orders as they might arise in the future. Another suggestion which warehouse can incorporate is the fact that a hybrid system could be designed incorporating machines with humans which can cope up with product variations and changes in production orders. Overall, the production department must have the human and technological functions working together to withstand any potential market changes (Bellgran & Säfsten, 2010).

Provide external training on introducing new technology

An automated system should have a sufficient level of trust mechanism so that the interconnected devices and users of the system will have the confidence that the information and services being exchanged can be relied upon (Breivold & Sandstrom, 2015).

Risk assessment should be done. Machine limits should be determined, potential hazards should enlighten and how to handle them should be trained. If the Risk factor identified with the working of the machine is higher than the tolerance range, then risk reduction techniques should be considered. Solutions such as safeguarding, interlocking guard, presence sensing devices, lockout, and Tagout (LOTO), could be considered depending upon the choice of automation. Also, the involvement of workers in risk assessment should be encouraged to increase the level of trust (Yuvin & Real, 2006).

In reality, organization own training was often insufficient to either improve expertise or to gain employees' trust in their abilities to accomplish the job satisfactorily. In such cases, an external agent or consultant training should be preferred.

Improve reliability of systems

Some of the solutions that the case company can consider, in achieving better reliability of system are:

Improved system design: The system should be designed in an appropriate way by using suitable models and methods, which can be used in analysing the Root Mean Square Error (RMSE) of systems (Sanz, 2010). Also, during the design phase, case company

collaboration is recommended since the system to be designed is highly unique for its case, it would be helpful if the system complexity is reduced by simplifying the system design thus helping the operators to learn and trust the machine.

Training: Besides the technical measures to have a much higher level of confidence and safety, training should be provided to all staff members. The operators can have an accurate set of procedures for different environments by providing training on the process and safety. Based on the interviews, we believe that external training from consultants would be much better for the case company, as there is a lack of automation knowledge and people at the case company to train the operators.

Maintenance: The availability of the machine depends on how well the machine is maintained. The availability is measured using mean time between failure (MTBF), mean time to repair (MTTR), and probability to fail on demand (PFD). MTBF is a statistical representation of the likelihood of a component device or system to fail while MTTR is the average time to repair a system (Barabady & Kumar, 2007). PFD is a statistical measurement of how likely a process, system, or device will be operating and ready to serve a function for which it is responsible. Thus, with the introduction of automation, it is necessary to have a low MTTR to ensure a smooth operation of production. According to our observations, the case company currently has strategies and maintenance plans in place for zero or manual automation systems. As a result, we recommend that the case company consider expanding its resources and planning future maintenance requirements under the newly adopted automated system.

4.3.3 Mitigation of people challenges

People play important role in implementing automation. To ensure collaboration, support, and build confidence among people, warehouse automation systems should have a design focused on human-centered instead of technology-centered. Such a design can also address the needs of workers to compensate for unexpected or unanticipated situations. This opinion was observed from one of the shop floor employee's statements on wrapping machine malfunction. In his words "*whenever wrapping machine gives out error signals it's hard to understand since it just gives out only codes without any explanation. It would have been better if it provided some clues regarding the state*". Moreover, the technology alone cannot increase a company's efficiency on its own, as it requires management and employees' support.

The challenge of workers' resistance to change can be resolved by addressing its root cause. The main factor contributing to this is the fear of change either due to lack of confidence or knowledge. The team leader during the interview mentioned that "when *new personnel digital assistant is introduced, operators expressed their reluctance due to lack of confidence. They demanded some training regarding its function*. Hence the

company acknowledges that the challenge, resistance to change, from employees can be resolved through workforce training, proper communication, and information/knowledge sharing. In the topic of automation technology, education and continuous training are essential for success. A long-term educational and training program should be designed and implemented in order to improve employee skills. Additionally, the educational opportunities provide workers the opportunity to develop expertise and confidence. In addition to these, a Suitable reward system can be developed to motivate employees to learn and adapt to new automation technologies (Kumar et al., 2020).

5 Discussion

This chapter discusses the methods and findings. This section starts with a discussion of methods used to conduct this thesis, which will be followed by the discussion of results achieved.

5.1 Discussion of methods

The purpose of this thesis was to examine the challenges that a logistic company may face in its automation approach. This thesis identifies the challenges and proposes solutions to overcome most of the challenges that warehouses might face with the implementation of automation. The thesis approach is aided by Figure 1 which shows the different phases of this study. The research questions of the thesis are presented below:

RQ1. "What are the challenges faced by logistics companies in moving towards warehouse automation?" – The objective of this RQ 1 is in identifying the challenges that can arise with the approach of automation.

RQ2. "How can these challenges be mitigated by logistics companies in moving towards warehouse automation?" – The objective of RQ2 is to propose solutions in overcoming the challenges found.

To investigate the challenges that could occur during its automation approach, the researchers first had to investigate the case company's current situation with respect to the kind of automation currently being used, the operator's knowledge of machines, and the ease of adapting to upcoming changes. Second, the researchers categorized the challenges into people, technological and organizational factors. Later for these intangible challenges' solutions were proposed to assist the case company to overcome the difficulty.

For this study, an inductive approach was used, with the researchers conducting a literature review on warehouse automation implementation and its implications for warehouses. The literature review assisted the researchers in gaining a broad understanding of the challenges, which later aided in identifying the case company's various challenges. The authors benefited from a detailed literature search in terms of warehousing, warehouse operations, material handling decisions, and so on. This helped us analyze the situation and come up with possible solutions during our observation and interview. Since this study was exploratory and the researchers wanted to include different viewpoints and perspectives, the use of a single case study was a suitable method for this thesis. The researchers used primary data collection methods. The researchers considered that the use of interviews and observation helped them in improving the validity of the findings. This strategy of triangulation or combining methods aided us in boosting in improving the credibility of the research and helped in verifying the results of the study.

Interviews and observations were conducted in order to identify the challenges at the case company. The researchers conducted semi-structured interviews with interviewees given a set of questions in advance. Their responses provided a much more comprehensive picture of the challenges. triangulation method helped the researchers in strengthening the results of the case study. The interviews were also recorded with permission allowing the researchers to go back and listen to the recordings to confirm the findings in detail.

Field notes and observations were also taken in order to analyse the challenges at the case company. The visits enabled the researchers to observe the current state of work in its natural setting. The observation method was limited to few visits to the case company due to the ongoing Covid-19 pandemic.

The limitation of this research is that since the scope of the study is limited to the production area of the case company and as the research was done within a single case company, the generalizability of the result is low. The focus of this researcher was to have high internal validity and internal reliability of the study. However, the challenges and mitigation strategies presented in this research could be utilized in similar logistic warehouses that are planning towards warehouse automation.

5.2 Discussion of findings

Through a literature review, challenges for warehouse automation were summarised. Later this was classified into three main categories, people, technological and organisational factors. Interviews and observation were useful to identify the potential existence of the challenges in the case company business environment. Some of the challenges were not identified from the data collection methods.

5.2.1 RQ1: What are the challenges faced by the logistics companies while moving towards warehouse automation?

The main purpose of this research question was to identify the existence of different challenges in the case company. Moreover, this research question had a purpose to look into the nature in which particular challenge remains within the case company. The case study did not present any new challenges beyond those already identified through the literature review. The researchers believe that this is because the company is in the clarifying stage of adopting the automation and when the company advances to the next levels of maturity, more and different challenges may arise (Facchini et al., 2019). Even though the case company had made a lot of progress with advancements in logistics, it still contains room for betterment by adopting new technologies such as automated guided vehicles (AGV), augmented reality, big data analysis in its operations (Glistau & Elke, 2018).

Thirteen challenges were identified for the case company while they move towards automation. Out of which ten challenges were acknowledged either by interview participants or observed at the case company. Evaluation and economic justification strategy, assessment of critical success factor, new technology introduction and training, flexibility requirement, data, and service security, reliability of the system, change in the skill of workers were the challenges noted from the interview. Four challenges were noticed from observation. They were worker's resistance to organisational changes, change in work skills of workers, communication challenge for workers and implementation, and human resource strategic issues.

5.2.2 RQ2: How can these challenges be mitigated by logistics companies in moving towards warehouse automation?

During the research, the focus was mainly on challenges. In the context of the case company, authors perceive that mitigating the following challenges will take more time to get resolved: evaluation and economic justification strategy for automation, assessment for critical success factor, strategic focus and planning, new technology introduction and training, and workers resistance to organisational changes. All other challenges could be mitigated more easily. Solution identified were discussed with the case company and there are being considered while they move forward with the project.

Assessment of critical success factors would be difficult to handle since automation needs many organisational changes. It would be challenging for the company to precisely assess the critical success factor because of its diversity, size complexity of the organisation, and pursuit of multiple goals (Ramamurthy & King, 1992). Moreover, deciding the level of automation needed would be a challenging task to fulfill. Since automation produces several intangible benefits, evaluation and economic justification strategy would be a hurdle for the organisation. The organisation may have to seek an expert opinion as well adopt a risk-taking behaviour to face this challenge. Strategic focus and planning is another challenge that authors perceive to be difficult to deal with, by the case company. This is because a variety of external and internal factors influences the development of organisational strategies. These factors may include their attitude towards profitability versus market share, as well as external environmental constraints such as economic, social, and political uncertainty. In addition to these, organisational changes that happen due to the introduction of automation make this a difficult challenge to deal with (Ramamurthy & King, 1992).

New technology and training is a challenge that the company would face when they adopt new technology. Automation training and education take far longer than expected and most organisation are unable to absorb such many changes in a short period. As a result, it necessitates a high level of integration. This puts more pressure on diverse

organisational functional elements to collaborate (Co et al., 1998). Moreover depending upon the level of automation adopted suitable risk assessment needed to be carried out. A team consisting of operators, safety engineers, maintenance staff, and representatives from management should be involved in the risk assessment. This would guide the organisation to formulate the necessary actions in form of training, adding new safety feature that ensures the smooth and safe introduction of new technology in the facility (Yuvin & Real, 2006). Employee opposition to organisational change will also be a difficult challenge to overcome as automation will serve as a direct replacement for workers at certain levels. As a consequence, there will develop dynamic interaction between the adoption of technology artifacts and expertise, skills, and power relationship among employees within the company which can affect the efforts to reduce employee opposition to organisational change (Cirillo et al., 2021).

Usage of organisational, technological, and people classification helped to check whether each area gets equal importance. During the thesis work, it was realized that the field of logistics is lacking comprehensive study in some challenges, that they may face while moving towards automation. Technological and people challenges seem to be addressed more frequently and organisational challenges appear to get less attention. Especially the challenges like top management commitment, success factor evaluation, and assessment criteria need to be studied more. Moreover, some of these challenges are common to any new technology introduction, hence investing more effort in this would be beneficial.

5.2.3 Contribution to academia, industry, and society

This thesis contributes to academia in several ways. This thesis addresses the topic of warehouse automation, which is interesting to academics from both the logistics and automation domains. Through this thesis, the challenges for warehouse automation were identified and compiled. There exist limited studies that have clearly outlined the challenges of warehouse automation, despite the popularity of the topic of warehouse automation. Furthermore, the challenges were classified based on holistic categories, such as organisational, technological and people. There are limited studies that have categorized challenges, and therefore, future studies could use the same categorization. Furthermore, in this study, the maturity level of the case company was reflected upon. For example, the challenges found in case company correspond to the ‘clarifying’ stage of the maturity model. Therefore, this study investigated the challenges from a specific stage of the maturity model. This could allow academics to investigate challenges pertaining to other stages of the maturity model. Next, this study also provides suggestions by which these challenges could be mitigated. Therefore, academics can use this study to develop decision support tools for handling the challenges of warehouse automation.

This thesis also contributes to the industry in several ways. Firstly, the thesis would be useful for managers to identify the challenges while moving towards warehouse automation. Managers would be able to foresee the challenges that occur in the 'clarifying' phase of the maturity model. Next, this would allow managers to make decisions regarding which logistics processes should be automated based on the categorization of challenge. This thesis also provides a set of solutions to mitigate the challenges. Based on this, managers would be able to systematically design and deploy systems that would mitigate the different challenges. This in turn would help the managers in preparing for future automation. Other managerial activities could also include informing the organization in order to allocate resources to mitigate the challenges.

This thesis also contributes to the society. Automation, in general, is associated with net loss of jobs within society. However, warehouse automation would rather transform jobs within the society. Warehouse automation should involve people in a collaborative manner. Employees within logistics companies need education and training to deal with challenges of warehouse automation. Therefore, universities also need to develop training/courses keeping in mind the future needs of warehouse automation. The thesis points to the various people-related issues that may arise in new technology introduction in a warehouse context. Policymakers and governments need to understand the warehouse automation challenges and draft policies accordingly. Moreover, the thesis briefly explains how the 'people' factor works in the automation project and would be useful to bring in safe automation.

6 Conclusions and future research

Due to fierce market competition, logistics firms are required to improve their efficiency to be successful. This has prompted businesses, particularly 3PL and warehouses to introduce and implement new automation systems in their facilities. This study investigated the challenges that logistics companies face while moving towards warehouse automation. Furthermore, this study proposes strategies that can mitigate the identified challenges. As the case company moves towards automation, they may face a variety of challenges. In total thirteen challenges were identified in the literature. The case study conducted showed the presence of ten of these challenges belonging to the organisational, technological, and people factors. Finally, mitigation strategies were suggested to deal with these challenges.

For future research, it would be interesting to study multiple warehouses that allow to generalise the findings. The findings of this thesis work are focused on a single case study in Sweden. Furthermore, future research can also focus on the implementation process of warehouse automation as more problems could arise during the implementation phase.

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8 Appendix

8.1 Some of the interview questions developed for the purpose of data collection:

1. Who all are the current customers of the case company and what type of product are being handled.?
2. How many employees are working in the facility.?
3. Why all automation technologies company consider for future.?
4. How far company has progressed in them.?
5. Is there any new technical title created with in the organisation for pacing the development of these projects.?
6. How company does economic evaluation on these projects.?
7. Which all factors company consider as critical for automation?
8. Did introduction of any new technological devices or systems caused any issues for normal working.?
9. Did company face any data related issues so far.?
10. Due to the varied product size range, do you think flexibility of the system as a major concern.?
11. When organisational changes were brought in, did company faced any challenges from the operators.?
12. What were the challenges operators faced when new conveyor was introduced.?