JÖNKÖPING UNIVERSITY
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Implementation of Technology in Warehouse Operations

A case study on internal logistics in warehouses from a sustainable perspective

PAPER WITHIN *Warehouse Operations*
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Abstract

Purpose – The purpose of this report is to see how business-to-business (B2B) suppliers from a sustainable perspective can take advantage of new technology and how it can impact the way firms manage their warehouse´s internal logistics. Based on the purpose, two research questions have been formulated.

1. *How does increased technology usage transform how warehouse operations are managed in small and medium-sized enterprise?*
2. *How will the implementation of new technology affect efficiency in warehouse operations from a sustainability perspective?*

Method – The method adopted in this research paper is a single-case study together with the data collection techniques interviews, observations, document analysis, and literature review. In addition, the data quality has been evaluated by studying the validity and reliability of the collected data.

Discussion and Analysis – The development of technology in the last decades has facilitated how supply chains are managed and have shown improvements regarding efficiency rates in warehouse operations. Technology has enabled processes that earlier were handled manually to now become more automatic and by using the technology in the right way, firms will be able to take advantage of all the possible benefits. Nevertheless, it is increasingly important to evaluate new investment with help of the triple bottom line i.e., people, planet, and profit, to meet the rapidly growing demands regarding sustainability.

Conclusion – Technology can both increase overall efficiency and transform how warehouse operations are managed in a small and medium-sized enterprise for the better from a sustainable perspective.

Keywords

Warehouse operations, technology, sustainability, internal logistics and triple bottom line.

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1 Introduction

In the following chapter, a short introduction will be given to the topic and will be followed with the problem description. Thereafter, the purpose will be presented together with the research questions and delimitations. Lastly, the outline for the thesis will be described.

1.1 Background

During the last century, the automotive industry has been going through a large change where technology and innovation have played an important role. The number of companies founded are continuing to grow as there is an increasing demand among end customers. Furthermore, due to globalization, it has become easier to establish firms in international markets and more people are given the right prerequisites to start a business (Talay & Cavusgil, 2009).

The competition among suppliers has never been higher which has led to the world´s leading companies can set higher demands on their suppliers. To stay strong against competitors it is important for both parties to have a sustainable relationship, especially if the firm wants to keep its product quality and overall flexibility high (Kwak et al., 2010). It can also become very expensive for the supplier if the demands are not met. Costs that need to be considered are premium freights, express purchases, fees connected to the client’s production like delays or stops etc. The reasons why these situations occur vary, but it is usually connected to their own production e.g., delayed shipments, issues with the in-house production or internal logistics, or incorrect deliveries to customers.

These situations have one thing in common, they are all a part of or have a connection to the warehouse operations including internal logistics and inventory management. Nevertheless, as most departments, the warehouse operations have been affected by the industrial revolutions in various ways. The third industrial revolution (Industry 3.0) was first seen around the 1960s. It is known for the implementation of information and communication technology (ICT) which is usually used to automate processes (Dalenogare et al., 2018). However, it does not end there as technical development has continued at a rapid pace. Internet of things (IoT) and Cyber-Physical System (CPS) has been discovered to be very helpful for industries as it has made it possible to link different areas within the supply chain, which is known as the fourth industrial revolution (Industry 4.0) (Qin et al., 2016). Industry 4.0 as a subject is commonly discussed both within academia and in the industry as it is anticipated to play an important role for manufacturing firms in the future (Qin et al., 2016).

With the increased digitalization it is predicted that the interaction between humans and machines will shift. This follows up to that in the end it is the machines that should be adapted to humans and not the other way around (Ma et al., 2019). Since

Industry 4.0 still will involve some human interaction, it is important to continue to give employees the correct resources and provide pedagogical training for their job (Zakoldaev et al., 2019). In practice, this means that when focusing on the warehouse operations the transition will involve leaving most of the human interaction behind and instead focus on the automation of processes where the aim is a more adaptable deployment (Kattepur, 2019).

1.2 Problem Description

In the early era of warehouse management, warehouses were operating fully manually but alongside the industrial revolutions, they have become increasingly automated. For a firm to adapt to the new industrial era, it is vital that its investments are profitable in a realistic time-period and enhances efficiency. Furthermore, the objective of investing in new technology is to improve operational performance and thereby create competitive advantages over their competitors. However, several resources are needed to be taken into consideration and become investigated before a technology investment is made and implemented in the warehouse operation. These resources are financial, infrastructure, education, and training (Bianchi & Labory, 2018). Hence, it has been shown that it is not only the technology itself that can be portrayed as complex but also the whole investing process of it.

If you place warehousing out of the supply chain context it does not add any value to a firm, since all activities in a warehouse increase cost (Škerlič et al., 2017). There is also a high risk of errors occuring, where the order picking process stands for more than 60% of the warehouse´s operational costs (Berg & Zijm, 1999; Straudt et al., 2015). To reach a higher level of efficiency, productivity, and quality, a firm could advance its current systems by implementing new technological solutions. However, introducing new technological solutions in a warehouse also creates questions like; whether the investment is adding any value, better quality, and decreases the number of errors (Škerlič et al., 2017).

Nevertheless, if a firm chooses not to invest in new technology in its warehouse operations it can work as long as the firm is operating on a smaller scale or if the firm does not generate any increases in sales. To continue to handle the warehouse manually when the firm is growing can be a challenge. Therefore, the warehouse needs to be in line with the technical development of the whole company in order to achieve a sustainable, agile, and adaptable supply chain that is operating smoothly from a holistic perspective.

1.3 Purpose and Research Questions

The purpose of this report is to see how business-to-business (B2B) suppliers from a sustainable perspective can take advantage of new technology and how it can impact the way firms manage internal logistics in their warehouse.

Based on the purpose, the authors have formulated the following two research questions (RQ).

RQ 1. *How does increased technology usage transform how warehouse operations are managed in a small and medium sized enterprise?*

RQ 2. *How will the implementation of new technology affect efficiency in warehouse operations from a sustainability perspective?*

1.4 Delimitations

This research paper is limited to the internal- and inbound logistic flows and operations in warehouses connected to small and medium sized enterprise (SME). Hence, it does not cover how increased technology usage throughout all the nodes in the supply chain can affect the efficiency of a firm. Factors that can have an impact on the efficiency of a warehouse operation that have been excluded are warehouse lay-out, warehouse location, and the handling process of loading and unloading. This paper also excludes large-sized enterprises and firms who are doing business to customers (B2C).

1.5 Outline

The bachelor thesis begins with an introduction, where the reader is given a background to the topic followed by problem description, research questions, and delimitations. In chapter two the theoretical framework is presented, which includes the topics of technology, warehouse operations, efficiency, and sustainability. Chapter three presents the methods used for the collection of data. Chapter four is presenting the empirical study performed at the case company. Continually, chapter five presents the analysis of the two research questions. The sixth chapter is the discussion and conclusion, which provides the reader with a summary of the thesis which fulfils the purpose. The two final chapters contain the references used in the chapters connected to research and some appendices to complement the study.

2 Theoretical Framework

In this chapter the relevant theories will be presented according to the intended research questions. The theories are related to warehouse operations, technology, efficiency, and sustainability.

2.1 Connections between Theory and Research Questions

In the following chapter, theories will be presented. As seen below, it is showed how the different theories are linked to the specific research question.

RQ 1. *How does increased technology usage transform how warehouse operations are managed in a small and medium sized enterprise?*

Key subjects connected to RQ 1 are technology and warehouse operations.

RQ 2. *How will the implementation of new technology affect efficiency in warehouse operations from a sustainability perspective?*

Key subjects connected to RQ 2 are technology, warehouse operations, efficiency, and sustainability.

In the report, theories regarding technology and warehouse operations will be used for both research questions to give the reader a clear picture of the current state. Technology and warehouse operations will play an important role when analyzing and discussing both the research questions.

When discussing efficiency, it is important to start by defining the subject in order to make it clear for the reader. The definition will be used to see how the implementation of technology will affect efficiency in warehouse operations. This will then be used to answer RQ 2.

Efficiency can be seen from different perspectives and the authors have chosen to study it from the sub-headlines *The Eight Wastes* and *Key Performance Indicators*. Additionally, the result for RQ 2 will be viewed from a sustainable perspective. Moreover, the findings in the report will be discussed from a triple bottom line perspective where the social, economic, and environmental aspects are taken into consideration.

2.2 Warehousing and Warehouse Management

Warehousing has become one of the most critical activities in a supply chain (Accorsi et al., 2014; Faber et al., 2002). A warehouse's main function is to receive items, store them, and then retrieve and ship them off on the customer´s request (Accorsi et al., 2014). Warehousing can be described as a holistic system where warehouse management, warehouse administration, and storage of goods are the warehouse organization. The administration controls the stock, the number of orders, and employees whereas management focuses on the warehouse process e.g., order picking and material flow (Martin, 2018). The following sections will present more about warehouses, warehouse operations, and warehouse management system (WMS).

2.2.1 Warehouses

Warehouses are no longer only a place for storage but rather a place where value-adding activities take place as some warehouses are starting to assemble and packing products in the warehouse (De Koster et al., 2017). There are three different kinds of warehouses from a value-adding perspective. A procurement warehouse supplies the production with the material, a production warehouse act as a buffer within the production stages, and a distribution warehouse store the final products (Martin, 2018). But warehouses can also be divided after their functions. A unit warehouse only stores logistical units (load units) whereas, in an order-picking warehouse, products are picked and packed to fulfil the customer´s request. The first can easily be automated compared to the second option that usually requires a lot of personnel, but it can be automated if certain conditions are met. Both versions´ layout is flexible but the unit warehouse can manage both pallets, crates, and containers (Martin, 2018).

When it comes to how to store the products in the warehouse, firms can either use fixed storage site allocation or free storage site selection (Martin, 2018). Fixed store site allocation means that each item has its specific storage location in the warehouse. The advantage of this system is that it is easy to organize the space as the storage location number equals the item number. On the other side, the system needs the warehouse to match the largest storage volume and each product needs its own space which could be seen as a disadvantage. Firms whose products are of small quantities in low volume e.g., spare part warehouses or when using FIFO (first in first out) usually prefer fixed storage site allocation (Martin, 2018).

If a company instead chooses free storage site selection, the disadvantages from the fixed system can be avoided as all products can be located in any free storage space. An advantage with this system is that the utilization of the storage space is much higher (close to 100%) but it requires more effort to structure a database to keep track of the items, their location, and the free space. This system can be used both in order picking warehouse and unit warehouses. To make it work each storage space needs its label connected to a WMS, either a manual or IT-supported system (Martin, 2018).

2.2.2 Warehouse Operations and Warehouse Management System

The requirements of warehouse operations have during the years expanded and customer needs are becoming more important e.g., order precision (right order at the right time and at the right quantity) (Accorsi et al., 2014). Along with the requirements, different costs need to be considered in the warehousing process, which are inventory cost, personnel cost, the operation cost of resources, building costs, and other costs (Martin, 2018). Improvements regarding warehouse operations can be achieved by implementing WMS or other information technology (IT). But with changes come new challenges. Gu et al. (2007) predict that lean production or just in time (JIT) can come to challenge warehouse operations as they require higher standards.

Warehouse operations can be managed in different ways but today the most common way is to use a WMS (Baruffaldi et al., 2019). WMS can be defined as a "*software used for support and optimization of warehouse processes and management*" (Martin, 2018). It both provide, stores, and report information (Faber et al., 2002). The employees in the logistic department use WMS to keep track of the warehouse transactions. The transactions are then used to sustain an accurate inventory, but it also helps in the process to increase the warehouse efficiency (Shiau & Lee, 2009) and warehouse performance (Baruffaldi et al, 2019).

According to Baruffaldi et al. (2019) and Shiau and Lee (2009), WMS contains "*four processes: receiving, storage, order picking, and shipping*" (Shiau & Lee, 2009) which can be seen in Figure 1. These processes can also be referred to as warehouse activities (Berg & Zijm, 1999). Nevertheless, Banaszewska et al. (2012), Forslund and Jonsson (2010), and Markovits-Somogyi et al. (2011) (as shown in Staudt et al., 2015) says that there is another process that needs to be included, the delivery process. They mean that the delivery process is a warehouse responsibility, therefore it should also be counted as an activity (Staudt et al., 2015). However, not all researchers do consider all five activities but most of them include the order picking process which is appropriate as it is one of the most expensive activities in a warehouse (Accorsi et al., 2014; Staudt et al, 2015) and one of the warehouse's core function (Shiau & Lee, 2009). The order picking process stands for more than 60% of the warehouse´s operational costs (Berg & Zijm, 1999; Straudt et al., 2015) and a reason why it is so expensive is that it requires a lot of labor with manual systems and a lot of investments in automated systems (De Koster et al., 2007). However, not everyone agrees, Accorsi et al., (2014) says that it is the storage process that is the most important warehouse activity since the received items must be put away for storage.

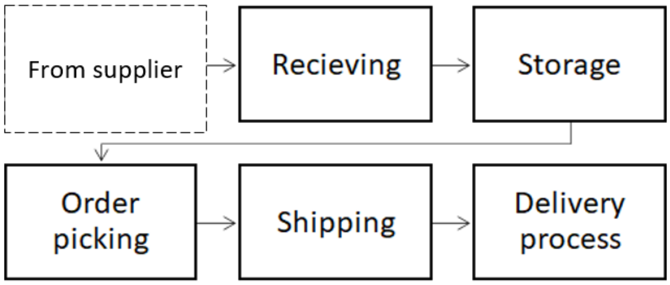

Figure 1. The five warehouse processes.

The two factors of warehouse management that can be seen as key drivers are task complexity (the range of product and volume produced) and market dynamics (how fast the external environment change). Task complexity is considered to be the stronger driver of the two (Faber et al., 2013). Faber et al. (2013) found out that task complexity can decide what kind of WMS a firm should use as "*the more complex a warehouse task is, the more specific is the functionality of the information system*" (Faber et al., 2013). They also point out that there are several advantages that firms could benefit from if they started to use WMS e.g., better productivity and use of space. However, choosing the wrong type of WMS might lead to disadvantages when it comes to competitiveness and costs (Faber et al., 2002).

Since warehouses usually integrate with other business functions throughout the supply chain e.g., buyers, production, and sales, the WMS must communicate with those functions´ information systems (Faber et al., 2002). This can be solved by using an enterprise resource planning (ERP) system.

2.3 Technology

The industrial sector has become more and more sophisticated and complex. Furthermore, the technology development for a company has become vital to enable improvements of efficiency, productivity, and competitiveness (Siddharthan & Narayanan, 2016). Technology can be defined as "*Systematic knowledge and action, usually of industrial processes, but applicable to any recurrent activity closely related to science and engineering and viewed as providing the means of doing something desirable. Technology may be embodied in a physical reality (see Hardware) or in a method, technique, collection of techniques, or know-how, that is, the capacity to use technology (see Software).*" (Heller, 2012).

The connection between technological innovation and industrial development is not a new phenomenon (Siddharthan & Narayanan, 2016) and began already back in 1760 when the first industrial revolution started (Vinitha et al., 2020). Continually, this section will present the history of the industrial revolution, the impact of technology investment in warehousing, and different kind of warehouse technologies.

2.3.1 History - The Industrial Revolutions

The industrial revolutions started in the mid-18th century and the industrial growth has continued ever since. It has been one of the most critical parts of the development towards the modern era (Vinitha et al., 2020) and has shown a major impact on societies around the world (Marks, 2015). Further, the revolution could be presented as four phases with different advancements, which will be presented in the following sections.

The First Industrial Revolution
By the 19th century, the world population had reached 950 million, two and a half times as many as by the 14th century. To support the increase in population and to meet the demand for goods, a change needed to happen in terms of people's relation to the availability of land and their effectiveness in the work (Marks, 2015). The first industrial revolution known as Industry 1.0, began around 1760 (Vinitha et al., 2020) and reflects the transition from the agricultural society to the industrial society. It has enabled humans to escape the limitations of the old regime and to build entirely new economies and ways of organizing life based on stored sources of energy, especially coal and oil (Marks, 2015).

The revolution made it possible for industries to go from hand production methods to machines, and the use of steam power was for industries the greatest discovery for increased efficiency (Vinitha et al., 2020). Furthermore, it also marks the first technological paradigm shift where continuous technological change started to drive the modern era of rapid economic growth (Snooks, 1994).

The Second Industrial Revolution
The technological revolution, also called the second industrial revolution or Industry 2.0, is marked between 1870 and 1914 (Bragg & Nargund-Joshi, 2017) and developed both the industry and technology in sectors like automobile, iron, chemical and machine tools, etc. (Vinitha et al., 2020). With the assistance of the advances of machine tools, the primary focus of the revolution was the manufacturing mass production (Vinitha et al., 2020).

Continually, the development within standardization and industrialization that happened during this time had its roots in the evolution of computers and telecommunications (Friedman, 1993). New technologies adopted were e.g., telephones, gas, electrical power, railroad networks, and the internal combustion engine (Vinitha et al., 2020). The railway expansion enabled people and ideas to become more mobile and organizations to connect with new customers segments. Hence, the world during this time witnessed a new wave of globalization and people became both richer and more urban (Friedman, 1993).

The Third Industrial Revolution

The rise of the third industrial revolution, Industry 3.0, took place in the 1970s (Vinitha, et.al., 2020) through both partial automation and fully automation industries by using computer technology, electronics, and telecommunications. The partial automation when human and machine interfaces could also be called the technologies of computer numeric control (CNC) and functions with the control of special software (Zakoldaev et al., 2020). Moreover, industries are starting to automate the entire production process without the interface of humans, which has contributed to great growth in the engineering field (Vinitha, et al., 2020).

The advantages of automation are increased efficiency and reliability of the industrial system, and can be applied in areas like facility operations, manufacturing, and transportation. Nevertheless, the implementation of new technology has significantly impacted unemployment rates since the automation process replaces labor (Vinitha, et al., 2020).

The Fourth Industrial Revolution

The fourth industrial revolution, Industry 4.0, is known to link manufacturing systems with information and communication technologies (ICT) (Dalenogare et al., 2018) and it started in the 21st century (Vinitha, et al., 2020). The internet of things (IoT) and cyber-physical system (CPS) are examples of ICT which makes it possible to connect different parts of the supply chain or production on a new level (Qin et al., 2016).

Additionally, the vision of Industry 4.0 can be divided into four groups, which are the factory, business, products, and customers. Where all the four groups will be affected by the new technology (Qin et al., 2016). The concept of smart factories comes from firms that successfully implemented Industry 4.0 in their factories (Fernández-Caramés et al., 2019). However, it does not only affect the machines or technology but also the role of the employees. As the processes will become more complex, the employees will require more technical support like tablets or smartphones (Lodgaard & Dransfeld, 2020).

2.3.2 Technology Investments in Warehousing

Warehouse operations are not itself adding any value to a business when taken out of the supply chain context since all activities in a warehouse increase cost. Further, the high cost of the risk of the occurrence of errors in the warehousing process also needs to be considered. To increase efficiency, productivity, and quality of work, a firm could upgrade its current systems by implementing technological solutions, which consequently could reduce the risk of errors (Škerlič et al., 2017). Over the past decades, advances in technology have favored the emergence throughout the modern supply chains (Fawcett, 2011) and it has had the power to transform both industries and organizations. However, before deciding on a new investment it is vital for a manager to understand the effect that technology can have on all variables of the firm (Dehing et al., 2005).

The benefits of introducing technology in warehouses are e.g., improved control, reduced operational costs, fewer work-related accidents, the possibility of coordinating flows of products to avoid bottlenecks, savings in energy and manpower, better use of space, and fewer manual handling operations (Škerlič et al., 2017). Contrarily, according to Reason (1997) "*the warehousing process is changing, because the increased use of automation results in fewer manual handling operations, but at the same time, it increases data processing. These changes in warehousing operations mean that there are fewer errors in terms of the movement of goods, but they also give rise to a series of different types of errors that are associated with the increased use of technology*" (as shown in Škerlič et al., 2017).

Even if the objective of technology investments is to ameliorate operational performance and relationship with customers and suppliers, a lot of firms have not been able to capture the benefits. Since the focal point has been the technology itself rather than how it should be used to transform the performance of the operation for the better (Dehing et al., 2005; Fawcett, 2011). Škerlič et al. (2017) also highlight that firms who neglect the positive impact of effective use of technology in their warehouse process often observe it more unmanageable to adjust to the need of more modern customers in the supply chain.

Another matter is the failure of management to understand the long-run advantages of new technology investments (Dehing et al., 2005). Technology investment can both be expensive and of high risk, and it is important to not forget to consider the resources connected to financial, infrastructure, education, and training (Bianchi & Labory, 2018). Moreover, this kind of investments often consists of a large initial cost, which is then followed by smaller annual expenses for depreciation, maintenance, and support. Nevertheless, management will over time see decreases in the firm's competitive advantage by just consider short-term profits and looking at the cost of the new technology (Dehing et al., 2005).

2.3.3 Warehouse Technology

Introducing warehouse technology into an organization´s processes has dramatically changed how the jobs are conducted at warehouses around the globe. The majority of the work that earlier was handled manually are now handled fully automated with help of the WMS and other modern warehousing solutions. The results of the study performed by Škerlič et al. (2017) shows that errors quite easily occur during warehouse operations and that more than half of all the errors happen during the process of inventory control and the picking process. Consequently, to ensure both the quality and safety of work this places warehousing among the activities that should have a high number of technical systems (Škerlič et al., 2017).

When talking about automation in warehouses it refers to ICT devices and material handling solutions. The main purpose of them both "*is to control the movement and storage of the products, together with the benefit of enhanced security and quicker handling" (Škerlič et al., 2017).*

Warehouse ICT systems can be categorized as:

- Barcode
- Radio-frequency identification (RFID)
- Voice picking technology (PbV)
- Light picking technology (PbL)
- Warehouse management system (WMS)

And the handling equipment can be categorized as:

- Hand pallet truck
- Reach forklift truck
- Electric forklift truck
- Motorized pallet truck
- Gas forklift truck
- Hybrid forklift truck
- Stacker crane
- Horizontal carouse
- Vertical carousel
- Automated guided vehicle (AGV)
- Automated Storage and Retrieval Systems (AS/RS)

Continually, this research paper will focus on the three most commonly used functions of warehouse systems.

Barcode
Barcode is the most frequently used technology amongst warehouse systems, and it has been implemented for over 40 years. The technology is safe to use and has been showing low result rates of mistakes. The barcode uses conventional identification methods and includes interrogators (readers or scanners) and transponders (tags) (Škerlič et al., 2017).

Warehouse Management System

Warehouse management system (WMS) has become an essential approach for warehousing (Škerlič et al., 2017). It provides, gathers, and stores information on objects, processes, and resources, by then recording the transactions and transferring them to the enterprise resource planning (ERP) system of the company (Baruffaldi et al., 2019). Furthermore, it is designed to lower costs through effective warehouse processes, and compared to manual handling systems it provides more reliable and efficient results and less effort (Škerlič et al., 2017).

Radio-Frequency Identification

Radio-frequency identification (RFID) can easily be explained as the contemporary successor to the barcode. In supply chain management it is considered to be the next step since it has the ability to enhance operational efficiency by tracking and tracing goods, sharing real-time information, and can enable total visibility throughout the supply chain. The system includes interrogators (readers or scanners) and transponders (tags). When the tags are attached to its object it is possible to communicate via radio signals. However, compared to barcodes the benefit with RFID is the possibility to read multiple tags at the same time, the ability to read tags without the line near, and the possibility to change and store information on the tag (Škerlič et al., 2017).

2.4 Efficiency

Efficiency can be defined "*as the ratio of the useful work performed by a machine or in a process to the total energy expended"* (Ocampo, 2019). In order to enhance efficiency in a warehouse operation the strategy of identifying waste and eliminate it is advantageous. Thus, the next section will define the eight different kinds of wastes that can appear in an organization. Moreover, to be able to see if the implementation of new technology affects efficiency in warehouse operations key performance indicators (KPIs) can be analyzed.

2.4.1 The Eight Wastes

The philosophy of eliminating waste, or muda, have for a long time been one of the automotive manufacturer Toyota´s major focus (Liker, 2004), as well as in the philosophy of just-in-time (JIT) (Ocampo, 2019). Waste could be identified as everything that does not add any value to both the external end customer and the internal customer at the next steps in the production process. Before redesigning a business process where it has been a focus on a waste-free one-piece flow system, many businesses consist of 90 percent waste and 10 percent value-added work (Liker, 2004).

Toyota did early define the eight different kinds of waste, which are (1) overproduction, (2) waiting time, (3) unnecessary transport, (4) over-processing, (5) excess inventory, (6) unnecessary movement, (7) defects and (8) unused employee creativity. Hence, by eliminating waste an organization can become more efficient and create a higher level of customer satisfaction (Liker, 2004).

2.4.2 Key Performance Indicators

"*Key performance indicators focus on the aspects of organizational performance that are the most critical for the current and future success of the organization*" (Parmenter, 2020). KPIs are used to analyze the current performance of a company. There is an ongoing discussion on how KPIs should be used, only as a comparison tool for the company itself or to compare with other firms. When choosing KPIs it is important to consider their characteristics e.g., accountability, easily understood, suitable, relevant, and consistent (Graham et al., 2015). The selection of KPIs is based on the organization and they are focusing on the company´s operations (Parmenter, 2020).

Key Performance Indicators in Warehousing

For a warehouse to improve its performance, it is essential to conduct warehouse performance measurements and identify its KPIs. The performance measurement is used to calculate the effectiveness and efficiency of action. When studying traditional logistics both quantitative and qualitative measures should be included (Kusrini et al., 2018). In a research paper, Kusrini et al. (2018) studied which KPIs are the most important ones within the five warehouse activities. Their result showed that the "*most important KPI for receiving is productivity (receive per man-hour), KPI for put away is cycle time (put away cycle time), KPI for storage is utilization (% location and cube occupied), KPI for order picking is cycle time (order picking cycle time) and KPI for shipping is productivity (order prepared for shipment per man-hour)*" (Kusrini et al., 2018).

Key Performance Indicators for Investments

Return on investment (ROI) "*represent an actual value developed by comparing program cost to benefits*" (Phillips, 2003). According to Phillips (2003), there are different ways of how to calculate ROI, but it is common to either use the ROI formula or the benefits/cost ratio (BCR). The BCR is calculated by dividing "*program benefits*" (annual economic benefits) with "*program costs*" (Phillips, 2003).

$$BCR = \frac{Program\ Benefits}{Program\ Costs}$$

If BCR equals one, benefits and costs are the same but if BCR equals three (written 3:1) then three dollars will return for each dollar spent. Phillips (2003) points out that it is important to remember that BCR only is appropriate to use when calculating the return on investments regarding training investments. When calculating the return on investments for a plant or equipment, it is better to use the ROI formula. Then the "*net program benefits*" (program benefits – program cost) is divided by the "*program cost*".

$$ROI\ (\%) = \frac{Net\ Program\ Benefits}{Program\ Costs}$$

The answer is shown in percentage and e.g., 198% indicates that the return on investment will almost be two dollars per dollar spent. (Phillips, 2003).

2.5 Sustainability

In 1987, the World Commission on Environment and Development defined sustainability as *"meeting the needs of the present without compromising the ability of future generations to meet their own needs".* Nonetheless, it is first in the recent decade that it has become a global paradigm where sustainability has become one of organizations´ main area of development (Grant et. al. 2017). From a strategic point of view, taking the lead in adapting towards more sustainable alternatives can be a strong competitive advantage, and will likewise promote long-term environmental security and egalitarian living standards (García-Arca, 2016).

Sustainable supply chain management has been defined by Carter and Roger (2008) as *"the strategic, transparent integration and achievement of an organization's social, environmental, and economic goals in the systemic coordination of key inter-organizational business processes for improving the long-term economic performance of the individual company and its supply chains"* (Carter & Roger, 2008). The definition is based upon the triple bottom line (TBL), which will be introduced in the following paragraph.

2.5.1 The Triple Bottom Line

The triple bottom line (TBL), which is shown in Figure 2, presents how an organization could approach sustainability by the three elements people, planet, and profit. The model is frequently represented by a Venn diagram, which is called Elkington´s model of the triple bottom line (Grant et. al. 2017). It urges firms to not only have a focus on maximizing the economical profit for its shareholder but also take responsibility for all stakeholders from an economic, environmental, and social perspective. Finding a balance between the three perspectives will help firms to grow in a more balanced, well-rounded way and move towards a sustainable future (Grant et. al. 2017).

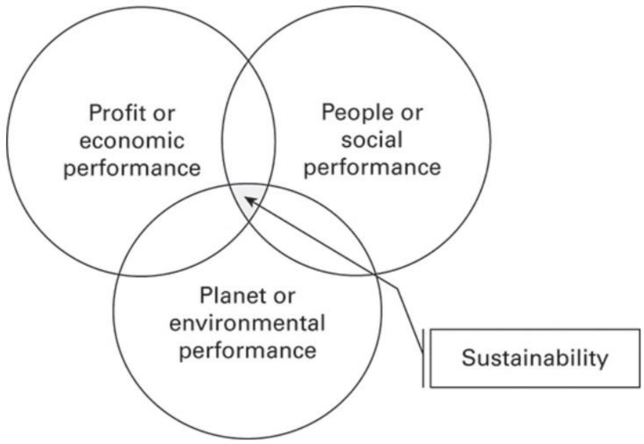

Figure 2. Triple Bottom Line. (Grant et. al., 2017).

3 Method

In this chapter the method used to answer the research questions will be described and analyzed. The research quality will also be discussed to further indicate the validity and reliability of the research project.

3.1 Research Design

The research design chosen for the project is a case study, which in this case can be defined as descriptive since it focuses in-depth on a particular situation (Edgar & Manz, 2017). A case study can be defined as *"an empirical enquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident"* (Yin, 1994) (as seen in Williamson, 2002). Moreover, multiple sources of evidence can be used when performing a case study and the research approach and strategy can be both qualitative and quantitative data collection methods, or a combination of them both (Aaltio & Heilmann, 2009; Williamson, 2002). The data collection techniques used in this research are interviews, observations, document analysis, and literature review. The advantage of using several kinds of methods is that it enables triangulation, which increases validity (Aaltio & Heilmann, 2009), this will be further explained and discussed in *3.4. Data Quality*.

The approach of a case study is both rather holistic and inductive, which means that it begins from an entity and often moving from a more general standpoint to a specific one. It can also be considered ideographic since it is trying to examine individual cases in their unique situation (Aaltio & Heilmann, 2009). Williamson (2002) further explains that a case study methodology is appropriate to use when the process of understanding the context of a situation is of great importance. Therefore, the authors have chosen the research design of a case study. Four other motives that also have been taken into consideration in the choice of research design are that (1) a case study is preferable to use when the case is dynamic, (2) when the research still is at an early stage (Williamson, 2002), (3) its ability to provide a viewpoint of an insider during the research process, and (4) the flexibility it gives to use different methods which help to gain a more holistic picture of the situation (Aaltio & Heilmann, 2009).

The choice of case study as research design has also been considered from an ethically perspective since it facilitates closing the gap between academic research and work-life (Aaltio & Heilmann, 2009). Nevertheless, a challenge that may limit the validity of the findings in a case study is the process of data collection and data analysis are subject to the authors´ background and characteristics. Hence, it also relies on the authors´ interpretations and rendering of documents, literature, events, and interview material (Williamson, 2002). Furthermore, this research project is for the collection of data based on a single case study which was performed at Kongsberg Automotive (KA) in Ljungsarp. The choice of a single case study was made because it is appropriate to use when a research is exploratory, and it allows the authors to perform the research in-depth which contributes with a deeper understanding of the subject (Williamson, 2002).

KA is an automotive manufacturer founded in 1987 in Kongsberg, Norway, with headquarters in Zurich, Switzerland. In 2008, KA Group acquired the plant in Ljungsarp, who earlier was owned by Teleflex Automotive (Kongsberg Automotive, 2021). Anyhow, the study performed is limited to the plant in Ljungsarp and can therefore be considered as an SME. The plant produces steering columns for the off-road segment. The local design and process engineering team has developed and implemented a complete modular steering column program in the production, which supplies automotive companies all around the world, e.g., Volvo, CAT, and John Deere (Kongsberg Automotive, 2021). Currently, the warehouse obtains around 1600 different articles and over the years the company has grown, and the number of purchase items has increased. As a result, greater sales have been generated.

Nevertheless, the production site has not grown and currently KA works on the same premises as they have done for years, and the warehouse is till operated manually. For a firm to adapt to the new industrial revolution and to its market, it is vital that its investments are profitable in a realistic time-period. Hence, the authors have chosen to conduct a case study at KA in Ljungsarp. This to see how they, as a major supplier in the automotive industry, can benefit from an investment in updated warehouse operation technology.

3.2 Data Collection

In this section the methods used for data collection in the research will be presented.

3.2.1 Interview

Interviews were conducted to gain a larger understanding of the processes in the warehouse as well as the current state of the warehouse. The authors chose to use semi-structured interviews. In semi-structured interviews, some questions or topics can be prepared before the interview but there is no more structure than that (Thomas, 2017). Thomas (2017) writes that semi-structured interviews are the most common outlined interview technique used among researchers as the structure keeps the interviewer on track but still is kind of flexible. He also points out that it is smart to take notes during the interview and if required, a recorder can be used.

Before each interview, the authors discussed and decided which subjects to include in the interview and wrote down some questions to ask, see Appendix 1. At the beginning of each interview, the interviewers asked the interviewee to describe their role at the company. The aim was to get to know the employee a little more to ask appropriate questions connected to their position.

In this report, the interviewees were picked after their relevance to the project. It was important for the authors to select employees from different departments and levels of hierarchy to gain as much information as possible. In total, eleven interviews were conducted with employees from various departments connect. The authors chose to take notes separately during the interviews as Thomas (2017) recommended and the interviews took between 15 to 60 minutes. The lengths of the interviews depended on both how the interviewees answered the questions and how much information they wanted to share. The interviews were conducted in person at the company either in a conference room or at the production site.

3.2.2 Observation

Observation is a useful method that gives the direct opportunity for understanding people's behavior and what happens in a setting (Rozsahegyi, 2019; Williamson, 2002). It can be a highly illuminating data source that provides both persuasive and valuable findings for the research. Nevertheless, this is only applicable if the observation is designed, conducted, and reflected with considerations taken to methodological, moral, and ethical issues (Rozsahegyi, 2019). Furthermore, the four main styles of observations are ad libitum, behavior, focal, and scan (Williamson, 2002). In this research, the authors used scan, which can be defined as "*'Scan' involves quickly scanning a whole group or an individual at regular intervals and then recording the information"* (Williamson, 2002) and behavior defined as "*'Behavior' involves choosing a particular behavior and recording who does it, and when it is displayed*" (Williamson, 2002).

Observation can also be categorized into participant or non-participant and structured or non-structured (Rozsahegyi, 2019). Participant observation includes active involvement and interaction with the observed context by the researcher and non-participant stresses the opposite. The authors had the opportunity the conduct both approaches during the four weeks interval they were present at the case company. Structured observation, also called systematic observation, is similar to structured interviews or surveys and needs preparation and planning regarding pre-determined categories. On the other hand, unstructured observation, also called naturalistic observation, is when the data is collected and recorded as they happen. Rozsahegyi (2019) indicates that a semi-structured approach is often the most advantageous alternative, which was the chosen approach in this case. The quantitative data was collected with structured observations and qualitative data was collected with unstructured observations, like taking field notes.

3.2.3 Document Analysis

Since a lot of information was received through documents from the case company, document analysis was performed. Document analysis can be beneficial to use when a larger understanding of a subject is wanted e.g., by reading documents from the case company (Williamson, 2002). It is important to read the documents carefully and then think about them to understand what they say (Thomas, 2017).

3.2.4 Literature Review

The literature review was performed to present previous theories and studies that are connected to the subject of the research. It was also done to assist the authors with a greater understanding of the subjects connected to the research questions in their context. The process involves *"identifying, locating, synthesising, and analysing the conceptual literature, as well as completed research reports, articles, conference papers, books, theses, and other materials about the specific problem or problems of a research topic"* (Williamson, 2002).

3.3 Data Analysis

In this section each method stated under *3.2. Data Collection* will further be explained from the perspective how the data was analyzed.

3.3.1 Interview

The information collected during the interviews was analyzed by the authors in different ways. After each interview, the authors discussed the information received and analyzed and compared the notes to draw relevant conclusions. In some cases, the authors had to ask some follow-up questions to some interviewees at a later state e.g., when new information came up. The answers and collected information were also compared between the interviews to see if the information matched.

3.3.2 Observation

The data collected from the observations were analyzed on an unconscious basis as the authors performed the observations. Nevertheless, the data were also analyzed on a conscious basis which took form as discussions between the authors, where the notes taken during the observations were compared, known as immediate notetaking, before they together took notes with the method of delayed notetaking (Williamson, 2002). There was no recording done during the observations. However, some pictures were taken, which is shown in Figure 3. The photos were also analyzed as part of the discussions connected to the notes.

3.3.3 Document Analysis

The documents received from the case company were analyzed by the authors. Starting by carefully reading the document followed by a discussion between the authors to make sure both authors understand the information and interpret it in the same way. Thereafter, the relevant documents were saved and used in e.g., the current state analysis and the material flow charts.

3.3.4 Literature Review

The chosen literature in the literature review have been found in books and articles. The articles were sourced from ProQuest, Scopus and Primo, which are all databases with a broad area of scientific publications. The presented articles have also assessed the relevance with a systematic approach with the criteria that they were all scientific publications, peer-reviewed, and, when relevant and applicable, the ones most recently updated (Thomas, 2017). Moreover, as guidelines for the search words, keywords and synonyms to the keywords, from both the research questions have been used.

3.4 Data Quality

Reliability and validity are commonly used to evaluate the quality of data presented in reports. Thomas (2017) states that *"reliability is about consistency and dependability of data-gathering procedure"* (Thomas, 2017). The result from the research instrument used in the study needs to be the same when it is repeated which is the reason why many experiments are repeated several times.

Validity *"refers to the extent to which a research instrument measures what it is designed to measure"* (Williamson, 2002). In other words, validity focused on the accuracy of e.g., an experiment. There are according to Williamson (2002) three types of validity are internal, external, and construct validity. Internal validity means that it is the independent variable that has impacted the result and not an unknown factor, also known as the cause-and-effect relationship. External validity implies that the findings are generalizable. Construct validity shows the extent to which something measures what it is supposed to measure (Williamson, 2002).

Triangulation can be used as a research strategy to increase or test the validity of a report. Triangulation refers to *"the use of two or more methods or techniques to investigate the same research question"* (Williamson, 2002). There are two types of triangulations that are frequently used among researchers, source- and method triangulation. Source triangulation is used to cross-checking for consistency e.g., by interviewing people from different levels of hierarchy. Method triangulation also checks for consistency but by using different methods to collect the data. It can either be quantitative or qualitative or a combination of the two (Williamson, 2002).

In this report, both source and method triangulation has been used by the authors. The source triangulation is used in the interviews when employees from different levels of hierarchy are interviewed. Similar, method triangulation was applied as several different methodological instruments were used in the research paper. These were interviews, observations, document analysis, and literature review.

To increase the quality of data collected in the interviews, the authors chose to interview employees from several different departments and levels of hierarchy (source triangulation). The departments included were production planning, material planning, finance, customer support, quality, logistics, and floor operators. When it comes to levels of hierarchy, managers on different levels were interviewed as well as team leaders and employees/operators with no managerial responsibility. By including a broad selection of employees, different views of the processes and issues were discovered, and it made it possible to hear different sides of the story.

4 Empirical Study

In this chapter, the authors will present the findings from the case study. It includes a current state analysis of the case company´s warehouse system together with a current performance analysis. Additionally, a solution to improve the efficiency of the warehouse is presented and analyzed.

4.1 Current State

To be able to judge if an investment in a warehouse system will enhance a firm´s efficiency it is important to evaluate the current state. Hence, this chapter will firstly state KA´s current state of their processes. Secondly, the cost of the current performance will be considered. Thirdly, this cost will be compared with the performance cost for the new warehouse system. The net benefits of the new investment will then be divided by the total cost of the investment to investigate the ROI. Furthermore, all results from the calculations have been rounded.

4.1.1 Current Processes

After conducting the interviews and observations at the case company, the authors have been able to map the warehouse activities. The first task was to define which type of warehouse system KA uses. Currently, the warehouse system in use is called the “Index Card Model”, which is built up of physical paper cards, see Figure 3. The Index Card Model system works as follows:

1. Goods are received and two cards are printed.
2. One card is attached to the pallet.
3. The pallet is placed on any free pallet space and the pallet space number is noted on the second card as seen in the upper right corner in Figure 3.
4. The second card with the pallet number is then placed in the index card file belonging to the workstation where the material is used, also seen in Figure 3.

Figure 3. An example of a card from the Index Card Model.

After mapping the activities, an analysis of the incoming material was carried out, which resulted in Figure 4, a flowchart of incoming material. The color of each step indicates how critical each step is, where green is not critical, yellow is slightly critical, and red is critical.

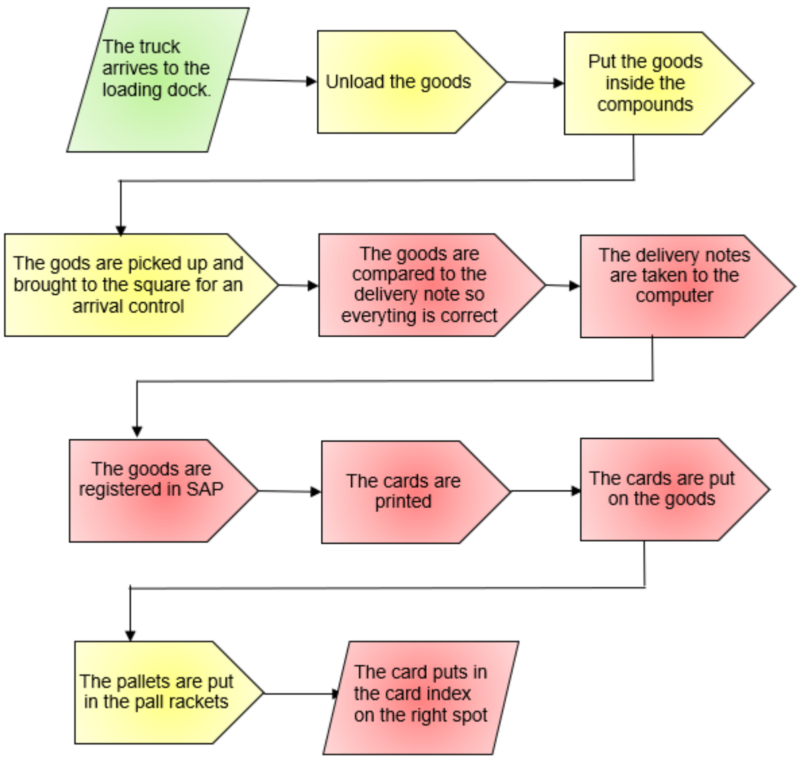

Figure 4. Flowchart for incoming material.

The process starts when the truck arrives at the loading dock and unloads the goods. When the goods have been unloaded and placed in the square for incoming goods, the delivery notes are picked up from the pallets. The delivery notes are then compared with the received goods to check if everything is correct and if some deliveries require an extra quality control. Thereafter, the goods are registered in KA´s ERP system (SAP). In connection with registering the goods in SAP, the two cards are printed out (for the index card file). When a card has been placed on the pallet, a forklift moves it and places it in any free space in the pallet racks. In connection with the placement in the pallet rack, the shelf number is noted on the second card that was printed, as seen in Figure 3. Continually, the second card is inserted in a specific index card file close to the workstation where it is being used.

When the overall warehouse process was identified, the authors moved on to study the specific process of the internal logistics within the production area. The result can be seen in Figure 5, a flowchart for in-house material orders. Similar to Figure 4, the color of each step indicates how critical each step is, where green is not critical, yellow is slightly critical, and red is critical.

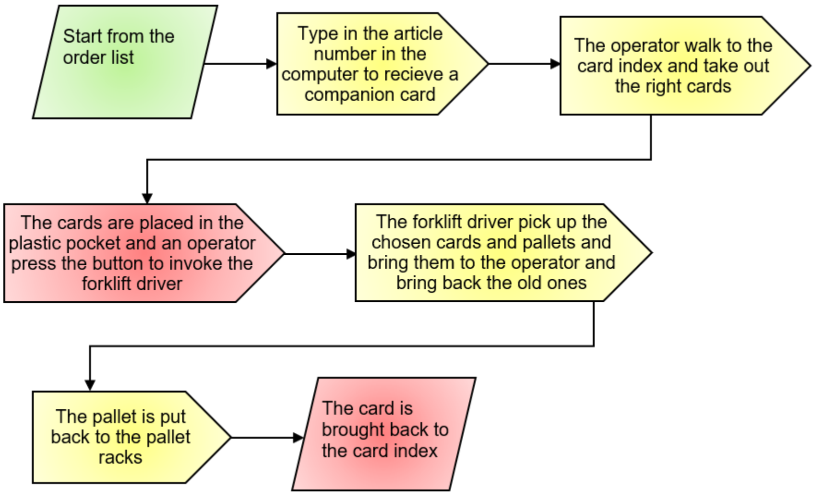

Figure 5. Flowchart for inhouse material orders.

As is described in Figure 5, the operator starts by checking the order list to know which product to assemble or produce. The article number from the list is typed into the computer and a companion card is received. The operator walks to the index card file and takes out the right cards. The cards are then placed in the plastic pocket in a specific area and the operator pushes a button to invoke the forklift driver. The forklift driver picks up the chosen pallets and brings them to the operator. When delivered, the driver brings the finished pallets back. Those pallets are then put back in the pallet racks and the cards are brought back to the index card file.

The index card model has worked well for KA until a few years ago when the inflows of the material significantly increased. Today, the company has a recipient of goods, but the employee does not usually have enough time to maintain the index card files. This has resulted in that employees do not know where the material is located. Consequently, a lot of time is spent looking for pallets with unnecessary production stops as a result. Sometimes materials are not found even though it according to SAP should be somewhere in the warehouse. This leads to extra purchases to enable continuous production, which contributes to unnecessary costs like premium freights and capital tied up.

Continuously, the authors have discovered that KA has no written standards on how to manage the warehouse system. Several of the interviewees mentioned that there is a lack of knowledge among new employees regarding how the system works. When new employees start, they are not given any written instructions, instead, other employees would pass on instructions orally based on their own experience.

Furthermore, several employees described during the interviews how much time they spent looking for material, where one said up to four hours per day. The authors thought this was interesting, so they asked all employees involved to keep track of the time spent looking for material during two specific weeks in February. The result and exact numbers will be presented in *4.2. Current Performance*. The result showed that the employees spend a lot of time looking for material but not as many hours as described during the interviews. If this is a coincidence or not is impossible to know for sure but it shows the importance of using source triangulation.

4.1.2 Current Performance

To calculate how the current performance is affected by the index card model, the formula for the extra expenses the firm has every month as a consequence of the system will first be presented. Second, the relevant data will be presented. Third, the data and formula will be used to calculate the total extra cost every month that the firm needs to pay due to the index card model.

The formula that has been considered for the extra expenses the firm has every month because of the index card model is the following.

$$TC = X + Y + Z \quad (1)$$

In Formula 1, TC is the total cost per month (1), X is the cost for the extra time spent on looking for material per month (2), Y is the cost for premium freights per month, and Z is the additional warehouse handling cost.

$$X = (C * H) + S \quad (2)$$

In Formula 2, C is the hourly net cost for an employee for the company and H the amount of hours per month searching for material, and S is the net cost per month to have an extra staff employed searching for material. Therefore, the final formula (3) for the extra expenses the firm has every month as a consequence of the index card model is the following.

$$TC = \left((C * H) + S\right) + Y + Z \quad (3)$$

In Table 1, the data collected will be presented to be able to calculate the average cost per month.

Table 1. Variables of Formula 3.

Variables		
C	Net Cost of Employee	240 SEK/h
H	Material Searching (Average/Month)	57 h
S	Net Cost of Extra Staff	39 000 SEK/month
Y	Premium Freights (Average/Month)	180 000 SEK
Z	Additional warehouse handling cost	0 SEK or to be determined.

** See Appendix 2 for calculation.*
***See Appendix 3 for non-rounded numbers.*

The average total cost of the extra expense the firm has as a consequence of the index card model and the processes around it is 233000 SEK/month + Z, (the calculation is demonstrated below).

$$\left((240 * 57) + 39\,000\right) + 180\,000 + Z = 233\,000\ SEK + Z$$

To investigate the production efficiency rate, the reality of the production will be compared with the company´s target goal for the production (4).

$$Efficiency = \frac{Reality}{Goal} \quad (4)$$

Kusrini et al. (2018) stated that productivity is one of the most important KPI for receiving in warehousing. Therefore, KA´s production efficiency was calculated. Currently, they have a monthly capacity to produce a certain number of products. For January and February, the goal was to produce 16000 units if working at full capacity. This implies that the recourses necessary were in place during that period, e.g., the right number of employees and the required supply. However, as seen in Table 2., the case company only managed to produce 12137 units. This means that they worked with an efficiency rate of 76 % in January and February.

Table 2. Production Efficiency Rate.

	Goal	Reality	Efficiency
January & February	16 000	12 137	76 %

*See Appendix 3 for non-rounded numbers.

4.2 Solution Proposal

According to the knowledge that the authors received when collecting data for the case study, the advice to KA would be to not invest more money in their existing warehouse system. They could have employed more personnel to continue to handle the index card model, but it would not be beneficial in the long term. Their costs related to issues with the current system are too high and bring an average monthly cost of 233000 SEK. There are many variables included in that number as mentioned above whereas some of them can be limited or reduced by introducing new technology.

4.2.1 Solution Proposal Process

The proposed solution for KA would be to invest in a new warehouse system together with scanners and computers for the forklifts. Škerlič et al. (2017) report that most of the errors that occur in warehouses are connected to the processes performed by humans. Hence, using more technology could decrease the number of errors and increase the overall quality and safety of the warehouse´s workers. Škerlič et al. (2017) also present that by using a WMS and barcodes, the warehouse´s processes will become more effective and result in fewer mistakes. In addition, barcodes have been used for more than 40 years, which indicates that the system is reliable.

The new system would make it possible for KA to scan both the pallets and the racks to see the pallets' location in the software system. This software is an additional software in SAP called *Warehouse Management System* (SAP´s WMS). This would facilitate their daily work as they would not have to spend as much money or resources on handling the issues that arise with the current system. For example, today the forklift driver´s workload is very high but using the suggested technology should decrease the workload since the time spent executing different activities is decreasing. The new system would make it easier for the forklift drivers to carry out their daily work since they e.g., will see the pallet´s location in the computer in the forklift instead of having to look for the location in the index card file. Additionally, by facilitating the forklift drivers´ work, the operators would not have to help them look for pallets and instead, they can focus on assembling products, which also would increase the production efficiency rate.

Furthermore, the new system will impact Figure 4 since several steps are removed and changed. As seen in Figure 6, the middle steps will either disappear or become slightly critical instead of critical and the last two steps will change from critical and slightly critical to not critical.

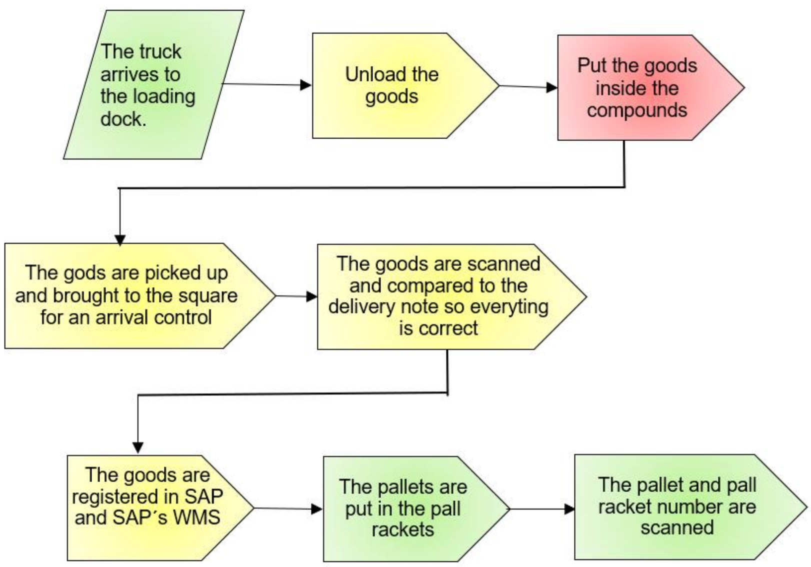

Figure 6. Flowchart for incoming material after the new investment.

Similarly, Figure 5 will also be affected by the new system but since the processes are changing, the flow chart presented in Figure 5 will no longer be accurate. Instead in the new processes, the operators will order material by using SAP´s WMS. When an order is placed, the forklift drivers will see the request on the computer in forklifts as well as the location of the pallet. Thereafter, the driver will collect the requested order by scanning the correct pallet´s barcode and deliver it to the worker who requested it.

4.2.2 Solution Proposal Investment

If KA decides to use more technology, they need to purchase the right equipment. The authors have after investigated the market and come up with the solution that the right equipment for KA in Ljungsarp could be SAP´s WMS, two computers for the forklifts, and five scanners. However, different costs need to be involved when calculating how much this investment would cost e.g., financial, infrastructure, education, and training (Bianchi & Labory, 2018). To make it clear, the total cost has been divided into two parts, the initial cost, and the maintenance cost. The initial cost (I) can be calculated with the following formula (5):

$$I = A + B + D + E + F \quad (5)$$

where A is the cost for installing SAP´s WMS. Faber et al. (2002) point out that it is important to use the right WMS to increase efficiency. Therefore, it is recommended for KA in Ljungsarp to use SAP´s WMS since it links and facilitates the communication between different business units as both SAP and SAP´s WMS already are implemented throughout KA Group. B is the total cost for two computers and two scanners for the forklifts, D is the cost for another three scanners, E is the costs for the internal implementation team, and F is the implementations (including costs related to infrastructure) and training cost.

The maintenance (M) cost could be calculated with the following formula (6).

$$M = Y + Z \quad (6)$$

where Y is the premium freight cost, and Z is the additional warehouse handling cost.

The overall expenses related to the implementation of the new warehouse system will therefore be the initial cost plus the maintenance cost. Table 3 shows the different variables.

Table 3. Variables of Formula 5 and 6.

Variables		
A	The Cost for Installing SAP´s WMS	Internal cost, yet to be determined.
B	Total Cost for Two Computers and Two Scanners	61 000 SEK
D	Total Cost for Three Scanners	24 000 SEK
E	Total Cost for the Implementation Team	5 000 SEK
F	Implementation and Training Cost	15 000 SEK
Y	Premium Freights (Average/Month)	50 000 SEK
Z	Additional Warehouse Handling Cost	0 SEK or to be determined.

**See Appendix 3 for non-rounded numbers.*

The variables that have been valued are the ones for which the authors received an offer, or the number was known or estimated by KA. Since KA Group owns SAP´s WMS, variable A will be an internal cost and the exact number is yet to be determined by the organization. Z is 0 SEK or to be determined because it varies from month to month. If no extra material is ordered, the additional warehouse handling cost will be zero. This means that the initial investment (5) for KA would be the costs for the scanners (five in total), the computers for the forklifts, the implementation team, and the implementation and training.

$$A + 61\,000 + 24\,000 + 5\,000 + 15\,000 = 105\,000\ SEK\ (+A)$$

The investment cost would then be 105000 SEK plus A, where A is the cost for installing SAP´s WMS. However, as mentioned earlier, KA Group already owns this system, and it will therefore be an internal cost.

The premium freights will be difficult to exclude completely with the new system. The premium freights are also sometimes used to deliver products to KA´s customers if they are late with the delivery. The business controller at KA will continue to set aside 50000 SEK each month which means that the maintenance cost (6) will be 50000 SEK plus Z. The variable Z is as mentioned earlier the cost for additional warehouse handling, and it will be kept as a variable since it varies from month to month. If KA needs to order extra material because they e.g., cannot find a pallet, it means that they will have two pallets of the same article inside the warehouse. As a result, they now must find space for two pallets instead of one which requires extra warehouse handling. Furthermore, capital will be tied up in the lost pallet, but eventually, when they find it, they will be able to use it. However, during the months when KA does not need to use any premium freights or handling any additional material in the warehouse, the maintenance cost will be close to zero.

4.2.3 Annual Cost and Key Performance Indicators of Solution Proposal

To be able to judge if an investment in a new warehouse system will enhance KA´s efficiency in their operations the cost of the current performance will be compared with the cost presented in chapter *4.2. Solution Proposal*.

Table 4 shows that the current system cost for KA annually is 2796000 SEK (+Z), after multiplying the monthly cost of 233000 SEK with 12 months. Meanwhile, the estimated annual cost of the solution proposed is 600000 SEK (+ Z), after multiplying the monthly cost of 50000 SEK with 12 months. This gives a difference of 2196000 SEK, which also could be called the annual benefit.

$$(2\ 796\ 000 + Z) - (600\ 000 + Z) = 2\ 196\ 000\ SEK$$

When calculating the annual benefit, the Z variables eliminate each other. In this case, the authors have after careful consideration decided that it is realistic to keep the premium freight (Y) even though it most likely will become less frequent with the new investment. KA will also not have the need to receive goods as quickly as they cannot be found in the warehouse. Nevertheless, the additional warehouse handling cost (Z) when it comes to ordering extra material will probably also become less with the new investment. Z is less dependent on the frequency of the need for premium freights since the warehouse handling cost related to material order varies both in quantity and price. Nevertheless, the annual benefit could also be expressed as a yearly cost decrease of 75-80%, which has been calculated by dividing the annual benefit by the cost of the current system.

To further prove numerically that KA should consider implementing the new investment, the net benefit will be divided by the total cost of the investment to investigate the ROI (7). As earlier mentioned, Philips (2003) claims that when calculating the return on investments for a plant or equipment, it is best to use the ROI formula. The ROI will be investigated on an annual basis and will continually help to decide whether or not the investment is considered efficient. To calculate the net investment benefit of the new investment, the new investment cost is subtracted from the benefit of the new investment (investment benefits – investment cost).

$$ROI\ (\%) = \frac{Net\ Investment\ Benefit}{Investment\ Cost} \quad (7)$$

$$\frac{2\ 196\ 000 - 105\ 000}{105\ 000} = \frac{2\ 091\ 000}{105\ 000} \approx 20 = 2\ 000\ \%$$

The ROI can be evaluated in terms of how many dollars are returned from each dollar spent, shown as x:1 (Phillips, 2003). The calculated ROI is 2000%, given that KA will pay off the investment during the first year and that the average Z will be the same with the new investment. In this case, this could be considered as a very good ROI since it means that KA will receive 20 SEK back per one SEK spent, 20:1. The investment will thereby be earned within 19 days (365 days / 20 ≈ 19 days).

Nevertheless, the result could be considered optimistic since there are some costs that are to be determined but since the ROI is high, there is still room for some additional costs.

Table 4. Annual cost and KPIs.

Annual Costs and KPIs	
Annual Cost of Current Performance	2 796 000 SEK (+Z)
Annual Cost of Solution Proposal	600 000 SEK (+Z)
Annual Benefit	2 196 000 SEK
Annual Benefit in Percentage	75-80 %
Total Initial Investment Cost	105 000 SEK
Net Investment Benefit	2 091 000 SEK
ROI	2 000 %
Payback Period	19 days

5 Analysis

In this chapter the authors will analyze each research questions separately.

5.1 Research Question 1

RQ1. How does increased technology usage transform how warehouse operations are managed in a small and medium sized enterprise?

Increased technology usage can in many ways change the way warehouse operations are managed and especially how it is handled. Technology makes it possible to move away from manually handling most of the processes in the warehouse to manage more with automation. New ways of working will affect the warehouse and by using a WMS, companies can increase their warehouse efficiency (Shiau & Lee, 2009). Nevertheless, it is important to pick a system that is a good match for the firm´s specific operations since using the wrong WMS could lead to competitiveness disadvantages (Faber et al., 2002).

After studying the case company, one recommendation to them was to use SAP´s WMS because it will facilitate the transaction since it comes from the same source. Furthermore, using a system that the employees are familiar with should mean that they should not need as much training as if they started to use another system i.e., the training cost is lower. Using an ERP system requires less effort and at the same time gives more reliable results (Škerlič et al., 2017). Additionally, SAP is one of the most popular ERP systems in the world, and using it, will simplify the process of adapting to Industry 4.0 in the future. As mentioned earlier, Industry 4.0 link the manufacturing systems by using different kinds of ICTs which makes it easier for the supply chain to communicate in a new way (Dalenogare et al., 2018).

Technology can also affect the five different warehouse activities which were shown in Figure 1. Each activity and the processes around it can be supported and improved with technology. The process of registering incoming and outgoing goods can be carried out with scanners instead of doing it manually which would facilitate the task. Overall, technical equipment will make it possible to handle the activities more effectively and at the same time increase the quality as the errors are reduced. The case company KA is a good example where technical equipment will facilitate processes in their warehouse. Figure 3 shows KA´s current index card model system where it can be noted that employees apply handwriting to note the goods´ location. This is both time-consuming and can create a quality problem due to a stressful environment, but it could easily be avoided with the help of technology.

If companies want to start using more technology, it usually means that some type of investment is needed. Technology can be expensive, so the management must understand the long-term advantages of the investment. There is usually a larger initial cost and some lower annual costs like maintenance (Dehing et al., 2005).

Bianchi and Labory (2018) point out that resources regarding training and education are also very important to include in these investments. For a firm to capture the benefits, it must know how to use the technology rather than focusing on the technology itself (Dehing et al., 2005; Fawcett, 2011). Hence, proper education of the new technology together with training is vital for the employees to successfully be able to use the new technology. It is especially important if a firm wants to take a big step from not using technology at all to use it in multiple processes. The case company KA can be seen as an example since their present warehouse system involves using paper cards manually. When KA wants to adopt more technology, training will be essential for their employees if the management wants to give them the right prerequisites to become successful. Since KA´s plant has very few employees it should be quite easy to carry out the training.

Large changes require support why another factor that companies need to be aware of is their employees´ feelings toward the implementation. Regarding the case company, their employees were all very positive toward using more technology like new warehouse equipment. Without this support, it would have been harder for the managers to try to implement anything. The firm is no more than its employees and it is important to have them onboard before implementing any greater changes.

Overall, implementing more technology in warehouses could transform how warehouse operations are managed in SMEs for the better. Implementing the right WMS is very important since it enables the different parts of the company and supply chain to communicate. Using a WMS will decrease the number of errors and at the same time increase the warehouse´s efficiency. Technology opens for new possibilities and if used the right way, it can facilitate the daily tasks within a warehouse.

5.2 Research Question 2

RQ 2. How will the implementation of new technology affect efficiency in warehouses operations from a sustainability perspective?

In the last decades, the development and innovation of technology have facilitated how supply chains are managed (Fawcett, 2011). The research done by Škerlič et al. (2017), has shown that the efficiency and productivity rates have been improved both from a time and economical perspective. However, as Dehing et al. (2005) present, the management team needs to understand the effect technology could have on the firm's both internal and external variables. Additionally, sustainability has rapidly become one of firms´ top priority where every decision should be based on the concept of the TBL. Thus, when it comes to warehouse operations and investments in technology, e.g., barcode, WMS, and RFID, it is indeed vital that before implementation the investment should be considered from the three aspects of environmental, social, and economic.

The two trends of technology and sustainability have shown a force towards a positive acceleration to each other. Technology has made it possible to firms to create transparency throughout the whole supply chain, including warehouses. With help of achieved transparency, a firm could simply locate areas of development connected to sustainability. Furthermore, technology has from the beginning of the industrial revolution driven the development in societies and the economy (Marks, 2015; Vinitha et al., 2020). Even if the revolutions have contributed to the increased amount of greenhouse gases, it will come to play a major role when it comes to finding new solutions to fight the challenges of climate change. Consequently, the increasing demand for organizations to find solutions that improve the quality of life for employees and decrease the impact on the environment have forced new waves of innovation.

For the management of warehouses, the major focus should be to find investments that avoid the trade-offs between the parameters of social, environmental, and economic. Instead, satisfy the firm from all three perspectives by creating a win-win situation. This will help them achieve a more efficient operation both holistically and in the long term. Continually, the three perspectives of sustainability will be evaluated in terms of how technology affects efficiency.

From an *environmental* perspective, warehouse operations could reduce their impact on the environment with help of new technology. In the case study, KA will with help of barcodes and SAP´s WMS be able to decline their need for premium freights since the accuracy level of inventory in the warehouse will keep a higher quality. Hence, this will result in fewer unplanned transports which will result in lower levels of CO_2 emissions for the company. Moreover, advanced technology could enable improved waste management, e.g., less chemical usage, resource reduction, and excess inventory. Thereby, also become more efficient from the perspective that it helps to optimize areas connected to the eight wastes (Liker, 2004).

From a *social* viewpoint, integrating technology in the warehouse processes have changed how the employees conduct their work task. The tasks that earlier have been handled manually are now handled fully automated with help of the WMS and other modern warehousing solutions. Lodgaard and Dransfeld, (2020) point out that this also has impacted the role of the employees and that they in the modern era of technology and automatization requires a whole new skill set. In some aspect, this shift has contributed to happier, less stressful, and healthier employees since some tasks now are easier and more efficient to perform. However, if the training is not carried out comprehensively this could endorse a feeling of frustration amongst employees and instead increase stress levels. Anyhow, the implementation of technology and automation of processes in warehouses have had an impact on unemployment rates since it many times replaces labor (Vinitha, et al., 2020). Even if this is not applicable in every case, like at the case company, this can also contribute to both scarcity and stress among employees.

The *economic* advantage of technology is that firms will be awarded benefits like reduced operational costs and avoidance of bottlenecks (Škerlič et al., 2017) as well as better warehouse performance (Baruffaldi et al, 2019). Another benefit of using technical solutions, like WMS, are that the risk that errors connected to movements of goods are reduced (Škerlič et al., 2017). In theory, if the overall performance is increased, the capacity might increase as well, which could result in larger revenue. For the case company, this could mean that their customers would become more satisfied since KA would be able to decrease the risk of late deliveries due to production- or logistic errors. Nevertheless, Reason (1993) argues in Škerlič et al. (2017) that using technology also has some risks. Technology can make processes more complex which could result in that the employees will need extra technical support in their new roles, which could result in that the expenses exceed the planned budget (Lodgaard & Dransfeld, 2020).

Finally, the implementation of new technology will come with the risk that firms might not always be able to claim all the expected benefits from a short-term perspective (Dehing et al., 2005). Nevertheless, when looking from a more holistic and long-term perspective, it is possible to see how the implementation of technology has a key impact on the management and development of a company. Not only the aspect of efficiency and economical profit but also from an environmental and social perspective.

6 Discussion and Conclusion

In this chapter the discussion of findings and contributions will be presented. Additionally, a discussion of method and empirical study will be given. Finally, a conclusion is stated to summarize the findings together with suggested future research.

6.1 Discussion of Findings and Contributions

The purpose of this report was to see how B2B suppliers can take advantage of new technology and how it can impact the way firms manage their warehouse´s internal logistics. After conducting this study, the findings imply that implementing more technology in warehouse operations will have a large impact on the way they are handled. Technology makes it possible for processes to become more automated with less involvement from humans. It is shown several times during the last decades how technology influences the overall processes by e.g., facilitate how supply chains are managed, increase efficiency in warehouse operations, and reduce the risk of errors. However, to gain all the benefits from using technology, it requires that it is used the right way.

Siddharthan and Narayanan (2016) showed that technology development is vital for firms to facilitate improvements in efficiency, productivity, and competitiveness. It is well-known that technological innovation and industrial development are linked, and Industry 2.0 opened for the first globalization when the railway expanded. Similarly, Industry 4.0 created a path for another globalization since technology made it possible for people to work and interact with other people on far distances by using different types of technical solutions. When studying the previous industrial revolutions, it is clear that the time between each period is becoming smaller which implies that the next industrial revolution is on the horizon. This means that the organizations that are "stuck" in e.g., Industry 3.0, are advised to start welcoming more advanced technology soon. Companies must embrace the transition to Industry 4.0 before the gap becomes too big as the next industrial revolution arrives. A study conducted by Škerlič et al. (2017) indicates that up to 60% of firms do not use any of the available modern warehouse solutions. The authors do not think this is surprising since the step can be quite large for some companies and prevent them from adapting towards implementing more technology. However, with the right timing and enough resources and training, it should be manageable for firms to go through with the implementation, especially if they take a small step at a time.

Nevertheless, it is important to remember that a successful technology implementation must include a commitment from all employees, clear goals, and focus on the user. There is a risk that unforeseen events might happen and that hidden costs occur, which consequently can increase both the cost and time spent on the implementation. There could also be drawbacks if the employees do not adjust well to the technology, which is more common if they are not provided with the right training. As a result, the firm will not receive the positive effects and the stress level among employees will increase. Therefore, the plant will become less efficient both from a time and economical point of view.

Other benefits of using new technology are that it makes it possible for firms to lower their warehouse operation´s negative impact on the environment e.g., CO2 emissions can be reduced, and wastes removed with advanced technology. Overall, technology is necessary to be able to tackle the increasing threat of climate change. The demand regarding sustainability is growing fast and more and more people are starting to view sustainability from a triple bottom line perspective. This means that firms need to include a people, planet, and profit perspective when evaluating how large impact their investments have in order to manage and fulfill the new demands. Everyone, both individuals and companies, must act and a good start can be to use the tools and equipment available in the market.

With this thesis, the authors have added value to the warehouse operations research field in different ways. The result shows that technology investments within warehouse operations can facilitate the shift towards modern solutions and automation. It can also be seen that the shift can impact the operations for the better by increasing efficiency, as well as the social and environmental factors. Furthermore, the authors point out how important it is with proper training and to view technology investments from a long-term perspective to be able to gain all the benefits.

6.2 Discussion of Method

The choice of method has been a mix between case study, interviews, observations, document analysis, and literature review. By choosing to use multiple methods, it has made it possible for the authors to perform triangulation which has strengthen the validity of the research. The usage of triangulation especially brought value in the case study since the perception when interviewing employees did not always match the results with the collected data. A good example was the situation regarding how much time the employees spent looking for material in the warehouse where the perception and reality did not match. Reliability has been increased since the research has been conducted by two authors. Hence, the data have been interpreted from two different perspectives throughout the research.

However, to further develop the method in terms of both validity and reliability the author could have chosen to perform a multiple-case study. The authors could then have had the possibility to explore and analyze the topic deeper and compare the current single-case study to another case conducted e.g., at a company that has come a bit further in the technology development. Thus, the authors could have explored more how the new company would have coped with their current integration with technology in their warehouse and how they are planning to adapt to technology connected to Industry 4.0. Nevertheless, this area of development has been limited due to the limited time frame.

6.3 Discussion of Empirical Study

KA is a great example where the implementation of technology in terms of a new WMS, scanners, and forklift computers will impact their overall processes for the better. The company will not only be able to reduce their yearly cost by 78,5% but also become more time efficient. The new investment will reduce the time spent looking for material for the production, and in line with the eight wastes, it will reduce the waiting time, unnecessary transport, excess inventory, and unnecessary movements (Liker, 2004). Škerlič et al. (2017) have also proven that if the right technology investment is implemented it will help to improve a firm's overall efficiency. Nevertheless, Dehing et al. (2005) say that it is important to not just focus on the short-term economic costs but rather see the advantages that come from a long-term perspective. Hence, the authors will continually discuss the solution proposal from a triple bottom line perspective.

The calculated ROI for the investment of KA is 2000 % and it will therefore only take 19 days to pay off the investment. This made the authors question why the investment has not been done earlier since there are clear benefits with it. However, in the interviews, the authors were told that KA has been thinking of investing in a new system for many years. They have been in contact with suppliers of solutions several times but never gone through with it. Alternatively, KA has also been thinking of hiring more personnel to cope with the current index card model system. Nevertheless, the absence of an efficient ERP system has previously made it less valuable to introduce the warehouse technology which is now in pipeline. There have also been major changes in the management team in recent years. So, with that in mind, it is easier to understand why KA still uses the index card model as their warehouse system.

Nonetheless, since KA implemented SAP last year it enhances the possibility to start using SAP´s WMS and go on with the implementation of SAP´s WMS, scanners, and forklift computers. Furthermore, in the interviews conducted, the employees have also expressed a high willingness to adapt to a new system because they are frustrated that the current system does not work. This will overall facilitate the implementation of the new system. SAP´s WMS should therefore not require as much training as if it would have been another WMS software. Thus, the authors recommend KA invest in the new system which means that they will not have to hire more personnel.

It has earlier in this research paper been presented that KA´s production efficiency rate during January and February in 2021, was 76 %. Even if the collected data from the interviews showed that the index card model was not the only factor that affects the production efficiency rate, it will most likely become improved with the new investment. Moreover, the warehouse workers will with help of the new investment be able to become more efficient and to carry out the work they are supposed to do. As a result, the employees in the production will most likely not need to go and pick up material in the warehouse areas by themselves anymore. Similarly, the employees who are looking for material (57h/week) will be able to focus more on their main tasks with fewer disruptions. Therefore, it will also not be necessary to have one employee looking for material full-time. Hence, the investment will help the whole plant to become more efficient and KA will have the possibility to relocate the resource to another department or function where the need for help is higher.

Additionally, by becoming more time efficient the need for working overtime in production will decrease. This will create more time for the employees to rest and create a less stressful environment, which overall will result in healthier and happier employees. Another aspect connected to the social perspective is that the new implementation of technology can create a scarcity amongst the personnel that the technology will take over their work and they will lose their job (Vinitha et al., 2020). However, this will not become the case at KA where the new technology instead will expectantly increase the overall quality of life for the employees.

The new investment will also bring environmental benefits. When the need for premium freights declines as the index card model is replaced, it will result in fewer incoming transports which means less CO2 emissions. Therefore, it is shown that the investment not only would benefit KA from a financial perspective but also from a social and environmental perspective i.e., the triple-bottom-line. Finally, there are many benefits connected to increased technology usage and the advantages are far more than the disadvantages from a long-term perspective. Hence, KA has a lot to gain from investing in technology and a new system for their warehouse.

6.4 Conclusions

By implementing and integrating more technology in warehouse operations, it could transform how the operations are managed in SMEs for the better. However, when budgeting for technology investments, firms need to see it from a long-term perspective to fully be able to take advantage of all the benefits. Overall, technology unlocks new possibilities for SMEs and if adopted in the right way, it can increase efficiency and facilitate the daily tasks within a warehouse from a sustainable perspective.

6.4.1 Further research

For future research, it would be interesting to limit the study to how warehouses will adapt to the technology connected to Industry 4.0. and upcoming revolutions, and further investigate the sustainable value of it. In addition, it would be compelling to perform research on how the implementing process of technology in warehouses might be different between an SME and a large enterprise.

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8 Appendices

Appendix A

Interview Guide

A. Background.

B. Position and function of position.

C. The index card model.

- The process of it
- How it works
- The interviewee’s thoughts about it
- Pros and cons, etc.

D. Suggestions for improvements for the picking process.

E. Willingness to adapt to a new system.

F. Further comments.

Appendix B

Calculations – Case Study

Table A. Cost of Employee.

Cost of Employee (C) (SEK/h)	
Hourly Cost	240

Table B. Material Searching.

Material Searching (H) (h)				
	Team A	Team B	Team C	Total
Week 7	5,83	5	5	15,83
Week 8	3,08	1,92	5	10
Average/Week	4,455	3,46	5	12,915
Average/Month	19,602	15,224	22	56,826

Table C. Cost of Extra Staff.

Cost of Extra Staff (S) (SEK/month)	
Average Monthly Net Cost	39 000

Table D. Premium Freight.

Premium Freights (Y) (SEK)	
January	173 000
February	187 000
Average/Month	180 000

Appendix C

Non-rounded values

Table E. Variables of Formula 3.

Variables		
C	Net Cost of Employee	240 SEK/h
H	Material Searching (Average/Month)	56,826 h
S	Net Cost of Extra Staff	39 000 SEK/month
Y	Premium Freights (Average/Month)	180 000 SEK
Z	Additional Warehouse Handling Cost	-

Table F. Production Efficiency Rate.

	Goal	Reality	Efficiency
January & February	16 000	12 137	75,9%

Table G. Variables of Formula 5 and 6.

Variables		
A	The Cost for Installing SAP´s WMS	-
B	Total Cost for Two Computers and Two Scanners	61 320 SEK
D	Total Cost for Three Scanners	23 700 SEK
E	Total Cost for the Implementation Team	15 000 SEK
F	Implementation and Training Cost	5 000 SEK
Y	Premium Freights (Average/Month)	50 000 SEK
Z	Additional Warehouse Handling Cost	-