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Process and technological innovations in logistics and supply chain management of a first-tier supplier in the automotive industry

Diploma Thesis

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Candidate:	**Olena Koshelieva, M.A.**
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Thesis title: **Process and technological innovations in logistics and supply chain management of a first-tier supplier in the automotive industry.**

Aim: The thesis describes the basic concepts of Supply Chain Management principles and wholeness systems thinking. The aim of the thesis is to analyze the current situation in automotive, to suggest ways to improve and apply the missing tools, to suggest how to increase efficiency, and evaluate the potential benefits of their use.

Content areas:

1. Definition of the basic concepts of Supply Chain Management and Wholeness System Thinking.
2. Analysis of existing Supply Chain principles in automotive and identification of last innovations in the industry.
3. Compare different logistics innovations and evaluate the expected benefits from their implementation.

Length of thesis: 55 – 65 pages

Recommended literature:

1. HOLMAN, David; PEŠTA, Zdeněk; DOLEJŠOVÁ, Venuše; LENORT, Radim; WICHER, Pavel; STAŠ, David. Competitiveness of Sustainable Logistics Management in the 21st Century Requires Innovation of Effectiveness, Not Only Efficiency. In: *CLC 2018: Carpathian Logistics Congress.* Czech Republic: Tanger, 2018, p. 475–481. ISBN 978-80-87294-88-8.
2. IVANOV, Dmitry; TSIPOULANIDIS, Alexander; SCHÖNBERGER, Jörn. *Global Supply Chain and Operations Management: A Decision-Oriented Introduction to the Creation of Value.* Cham: Springer, 2019. 578 p. ISBN 978-3-030-06830-1.
3. HOLMAN, David; WICHER, Pavel; LENORT, Radim; DOLEJŠOVÁ, Venuše. Sustainable Supply Chain Management Requires Wholeness System Thinking . [online]. 2018. Accessible from: https://www.mdpi.com/2071-1050/10/12/4392.

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Contents

List of abbreviations and symbols

SCM	Supply Chain Management
SC	Supply Chain
JIT	Just in time
MRP	Materials Requirements Planning
OEM	Original Equipment Manufacturer
CVS	Clear Vision System
ICTs	Information and Communication Technologies
RFID	Radio frequency identification
IoT	Internet of Things
AI	Artificial intelligence
WMS	Warehouse Management Systems
EoL	End of Line

Introduction

In today's dynamic and competitive business landscape, companies are navigating the intricate maze of Supply Chain Management (SCM) to not only survive but thrive. The automotive industry has undergone a remarkable metamorphosis in its logistical and supply chain practices over the last decade. This evolution is spurred by the imperative to meet the escalating demands of customers who crave swift and dependable product deliveries, all while striving to slash costs and enhance product quality.

Over this transformative decade, the automotive industry has bid farewell to conventional SCM methods like Just-in-Time and lean manufacturing. In their place, we've witnessed a technological revolution that has reshaped how supply chain management operates in the automotive sector. Automation and digitalization have become the driving forces behind a profound shift in logistics practices. Through the savvy use of these technologies, companies can not only optimize their operations but also gain improved visibility and traceability, trim lead times, and elevate overall efficiency.

As the automotive industry moves into the future, it is crucial for companies to cooperate with emerging technologies to remain competitive and adapt to rapidly changing market demands. Innovative technologies can automate processes, optimize supply chains, and enable real-time decision-making. Therefore, it is essential for companies to embrace the integration of new technologies and develop robust strategies to adapt to these changes.

The aim of the work is to analyse the current state of the chosen company, to identify weaknesses in the internal logistics processes, to suggest ways to improve and apply the missing tools, to define areas where it is possible to upgrade the workstation while implementation of technological innovation solutions. The study aims to identify the key theories and concepts and to develop a theoretical framework that can guide the research process, to suggest how to increase efficiency, and evaluate the potential benefits of their use.

1 Supply Chain Management

As the 21st century begins, the approach of quality has changed from just manufacturing or processes to customer satisfaction, risk management and minimizing defects/wastes. Customer satisfaction is not only limited to product quality and product demand, but also includes product delivery lead time, fulfilment of customer specific requirements, risk management etc.

Additionally, in the era of globalization, the competition among organizations has increased. So, to remain in the market the organizations have to improve their operational efficiency, innovation and have to overcome all the challenges. All these could be achieved with smooth process flow from suppliers of raw material to end user. Thus, SCM appears as an important tool which allows the development of a link between the market, the distribution network, the production process and procurement activities, offering to customers a service of excellence at a low cost. SCM as defined by the Council of Supply Chain Management Professionals (CSCMP): "Supply Chain Management encompasses the planning and management of all activities involved in sourcing and procurement, conversion, and all logistics management activities. Importantly, it also includes coordination and collaboration with channel partners, which can be suppliers, intermediaries, third-party service providers, and customers" (CSCMP, 2023, p.187).

New innovations in the supply chain industry can help companies provide superior service through collaborative systems. SCM works by integrating procurement, suppliers, manufacturing facilities, distributors, retailers, and customers throughout the production, buying, and sales cycles. Since the supply chain is affected by various factors such as environmental conditions and fuel prices, it requires active management. If a company is knowledgeable about these factors, it can effectively manage them.

A supply chain (SC) “describes a linkage of supply-related activities across multiple functions and organizations” (Nakano, 2020, p.3). By efficiently managing the SC, a company can tightly control its production, inventory, distribution, vendor, and sales records. SCM enables the management of expenses at each step and facilitates prompt delivery of products to customers.

1.1 Definition and importance of SCM in current logistics processes

Global and political dynamics, along with unpredictable weather and natural occurrences, have historically shaped supply chains. However, a constant in the realm of supply chain management is the inevitability of change.

The organisation and monitoring of assignments associated with the transfer of goods and services from suppliers to customers characterize SCM. “The supply chain structure is always influenced by the specific conditions in which it was created and has been operating. The basic model of the structure is referred to as "linear" and is mostly used for theoretical study, since at each stage it contains only a single subject” (Lenort et. al., 2017, p.8). This process encompasses the harmonious integration of suppliers, manufacturers, distributors, and retailers, aiming for a streamlined approach that not only fulfils customer requirements but also secures a competitive edge. Figure 1 shows the structure of SCM as vector illustration.

Source: (Vecteezy, 2023)

Figure 1 SCM icon - vector illustration

SCM is the process of managing the flow of goods and services from the point of origin to the point of consumption. It involves a range of activities, such as planning and forecasting, sourcing and procurement, production, storage and inventory management, and logistics and distribution. These activities are interdependent and require coordination and collaboration among various stakeholders, including suppliers, manufacturers, distributors, and customers.

Efficient and resilient supply chain management tools and practices are an essential component to your company’s survival – and success. Some of the core SCM processes include:

Supply chain planning involves forecasting product demand and coordinating the various elements of the supply chain to meet it. This process includes not only demand forecasting and planning, but also supply planning, material requirement planning (MRP), production planning, sales and operations planning (S&OP), etc.

Product Lifecycle Management (PLM) is a holistic approach to control a product throughout its lifecycle - from conception, engineering, design to manufacturing, maintenance, disposal or recycling. PLM software systems play a critical role in integrating these processes, enabling enterprise-wide collaboration, and serving as a centralised repository of information about each product throughout its lifecycle.

Procurement, on the other hand, is the process of purchasing materials, goods and services to fulfil business requirements, with a focus on ensuring quality, fair price and value. One of the important challenges facing procurement and sourcing teams is accurately forecasting order quantities, as both shortages and surpluses can negatively impact the business. SCM systems that utilise machine learning and predictive analytics offer valuable tools to take the guesswork out of procurement and sourcing processes.

Logistics management involves the transport and storage of goods throughout the supply chain, from raw materials and manufacturing to the delivery of finished goods to shops or customers. This process includes product maintenance, returns and disposal. The main business functions associated with logistics management include inbound and outbound transport management, fleet management, warehouse management, inventory control and customer service.

Manufacturing execution management monitors, tracks, documents, and controls the process of manufacturing goods. It keeps production and processes as lean as possible – while maintaining (and improving) quality, sustainability, and customer satisfaction. The system uses data gathered from AI and Industrial IoT-powered systems to streamline and automate manufacturing processes. Companies can use on-demand 3D printing to eliminate shortages and surplus, and smart machines to deliver mass customization economically. Benefits include improved quality control, increased uptime, reduced inventory, a paperless shop floor, and improved product tracking and genealogy. These systems also help to ensure that the latest compliance and regulatory practices are in place.

Efficient supply chain management is indispensable in today's global economy, serving as a linchpin for business success. This intricate process involves overseeing the seamless flow of goods from origin to consumption, influencing procurement, logistics, and distribution.

A key advantage lies in cost reduction. Streamlining procurement and sourcing lowers raw material expenses, while optimizing logistics and distribution cuts transportation and inventory costs, directly enhancing profitability. Efficiency is equally crucial, as rapid and seamless movement of goods through the supply chain improves response times and reduces lead times. Balancing efficiency and cost-effectiveness is a continuous challenge for supply chain managers, requiring a creative and individualized approach.

The pinnacle advantage is heightened customer service. Timely and intact product delivery builds trust and loyalty, setting the stage for increased sales and positive responses. Maintaining consistency and quality distinguishes businesses, fostering a robust brand reputation. Prioritizing supply chain management becomes a strategic imperative, offering companies lower costs, increased efficiency, and enhanced customer loyalty, thereby ensuring long-term viability in the competitive business landscape" (MITYUSHENKOV, 2023).

1.2 Wholeness System Thinking, SCM principles and Lean Principles

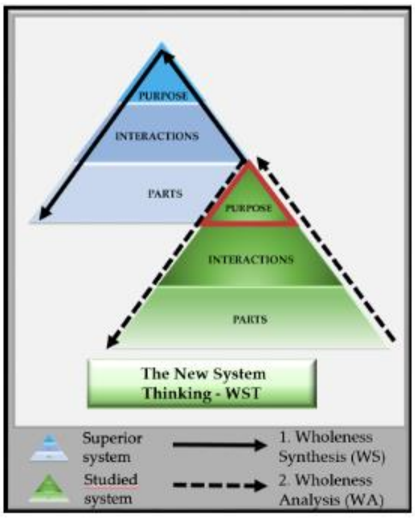
Nowadays, sustainable logistics management has become increasingly important as businesses strive to reduce their environmental impact while maintaining profitability. To achieve sustainable logistics, a Wholeness Systems Thinking (WST) approach is necessary, which involves taking a holistic view of the entire supply chain and considering the interdependence of all its parts. One critical component of sustainable logistics management is SCM, which involves managing the flow of goods and services from the point of origin to the point of consumption.

To implement and make supply chain management more effective and efficient organisation needs to adapt and following vital paraments in the structure of different department of their management:

Wholeness System Thinking (WST)

Before describing the WST, we should firstly identify System Thinking (ST).

System Thinking consist of three parts, elements, interaction, and purpose. Systems thinking can help to connect each element together, analysis each function of elements through their interactions, so that they can achieve the system's purpose. Wholeness System Thinking is equal to wholeness analysis plus wholeness synthesis (WS). “WS defines the superior system expectations, which are represented by new customer orders. WA systematically implements these expectations into the performance of the logistics system elements (warehousing, production, and distribution) requiring the optimal consumption of resources” (Holman et. al., 2018, p.13). Figure 2 graphically shows WTS structure.



Source: (Holman et. al., 2018)

Figure 2 Wholeness Synthesis and Wholeness Analysis

The Wholeness System Thinking approach identifies the new role of a system’s purpose, deriving the performance of the selected system’s parts and interactions. The purpose of the whole system is synthesised from the superior system (representing the external environment) perspective through WS, it creates limits for the performance of studied system parts and interactions; the purpose is analysed by WA into the performance of the system’s parts and interactions.

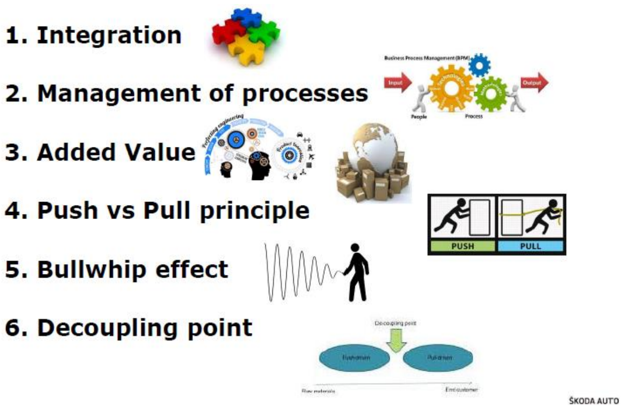
“The system purpose is the system element responsible for the performance of system parts and interactions, considering the important role of the external environment. WS synthesises the system purpose from the superior system perspective. The performance of a system’s purpose is derived from the superior system and is defined in three steps:

- Identifying the superior system,
- Understanding the superior system,
- Identifying the purpose of the studied system in the superior system" (Holman et. al., 2018, p.8).

Systems thinking consists of analysis and synthesis. Analysis focuses on structure. It reveals how things work. Synthesis focuses on function which reveals why things operate as they do. It does not mean that synthesis is more valuable than analysis. It means that they are complementary. Analysis investigates the system; synthesis looks outward to consider the systems environment. Both views assessing the system's understanding and development have the same importance.

Supply Chain Principles

SC Principles serve as the guiding framework that organizations adhere to in orchestrating the intricate web of processes involved in the movement of goods and services. These principles form the bedrock for optimizing efficiency, reducing costs, and enhancing overall competitiveness within the dynamic landscape of supply chain operations. Before delving into a detailed exploration of these principles, it is essential to establish their foundational significance in shaping resilient and effective supply chain strategies. Figure 3 presented a short description the six fundamental Supply Chain Principles.



Source: (Holman, 2021)

Figure 3 Six Fundamental Supply Chain Principles

Supply chain integration is a large-scale business strategy that brings as many links of the chain as possible into a closer working relationship with each other. The goal is to improve response time, production time, and reduce costs and waste. There are two types of integration, vertical and horizontal:

- Vertical integration that refers to any moves that include different levels of the chain. It could involve merging or buying out a link ahead of or before your organization, or possibly developing your own capabilities for handling the entire supply chain, front to back. “A vertical process is usually business planning and budgeting, and allocation of the scarce resources of funds and talent” (Nakano, 2020, p.24).
- “Horizontal process is designed around workflow, for example, new product development or the entry of a customer order” (Nakano, 2020, p.24). Horizontal integration that could include merging with or purchasing firms that supply similar products. This type of relationship could support the firm gain many more customers and give them greater control over the price and supply of central processing units.

The second SCM principle is related to process management. Process management includes synchronizing processes with the strategic goals of the organization, developing and implementing process architecture, creating systems to measure processes according to organizational goals, and training and organizing managers to effectively manage processes.

In the automotive industry, JIT technology is a practical example. JIT is a process management strategy in which components and materials are delivered to the assembly line just-in-time. “A JIT supply chain brings a myriad of advantages to firms including reduced costs, lowered inventory, improved product quality, shortened lead time, increased responsiveness, boosted customer satisfaction, and superior competitive advantages” (Heizer et al., 2016). Toyota, an innovator in JIT manufacturing, ties this approach to its strategic goal of minimizing inventory holding costs while ensuring production efficiency. Another example - many automotive companies utilize Six Sigma methodology for quality management. By aligning processes to quality standards using Six Sigma methodology, defect rates are reduced, and customer satisfaction is increased, thus achieving strategic goals related to product quality.

The Added Value to the Supply Chain for Competitive Advantage focuses on delivering value to customers rather than simply functioning as a cost centre within the company. It illustrates the activities that create value for an organization, with significant weight given to supply chain functions. Within the value chain, each internal activity identified in the diagram adds value to the final product or service by converting inputs into outputs.

A further point is the **Push vs. Pull Principle:**

- Push supply chain strategy means that decisions about when products are manufactured and shipped is determined by anticipated customer demand. “Push processes implemented in a push system are implemented before the expected demand od customers based on the demand forecast” (Lenort et. al., 2017, p.11). The benefit of push supply chain strategy is that it gives all the involved parties (like manufacturers, shippers, and retailers) plenty of time to plan for things like raw material needs and expenses.
- Pull principle is driven by actual consumer demand. “Processes performed in the pull system are performed on already accepted orders. At the time when the processes are carried out, customer demand are known” (Lenort et. al., 2017, p.11). One benefit of pull supply chain strategy is the ability to carry little inventory, to invest inventory dollars only when you know you have a buyer. Another is being able to charge a premium for custom merchandise.

The bullwhip effect in supply chain management refers to the amplification of demand fluctuations as they move up the supply chain. “The best illustration of the bullwhip effect is the well-known "beer game". In the game, participants play the roles of customers, retailers, wholesalers, and suppliers of a popular brand of beer. The participants cannot communicate with each other and must make order decisions based only on orders from the next downstream player” (Hau et. al. 1997, p.93). For example, in the automotive industry, variations in customer preferences at the dealership level may lead to exaggerated orders at the manufacturing plant. The distortion continues upstream, causing suppliers to react to perceived demand surges that may not accurately reflect actual consumer needs. This ripple effect results in increased costs, excess inventory, and inefficiencies throughout the supply chain.

Decoupling points in a supply chain network are areas that break down the production line to lean manufacturing system (Push system) and agile manufacturing system (Pull system). A supply network can be decomposed into two parts, the upstream and downstream sectors. The upstream section includes manufacturing operations from the beginning of the production process to decoupling points and downstream is from break point until the end of production lines. "To identify decoupling points, three important aspects should be considered:

1. Minimization of the production cost.
2. Minimization of the delivery time to customers
3. Maximization of the customer satisfaction.

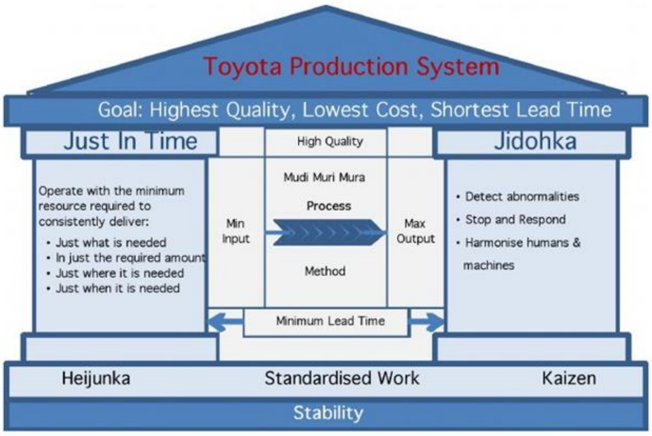
So, we faced with a multi-criteria decision problem that includes minimization of the production costs and product delivery time to customers as well as customer consistency maximization" (Ebrahimiarjestan et. al., 2017, p.355).

Lean Principles

LEAN logistics stands as a strategic method in the realm of logistics and supply chain management, striving to curtail inefficiencies and cut down on unnecessary resources. Originating in the 1950’s with Taichi Ohno, the Toyota Production System (TPS) has evolved into a holistic philosophy, emphasizing efficiency, waste reduction, and continuous improvement. TPS principles include just-in-time production and the pursuit of perfection through eliminating non-value-adding activities.

In the early 1990s, "Lean Thinking" by James Womack, Daniel Jones, and Daniel Ross popularized TPS internationally. Lean thinking focuses on delivering value, eliminating waste, and fostering continuous improvement. Embracing Lean principles enhances processes, customer satisfaction, and adaptability in dynamic business environments. "The lean approach promotes the need among organizations to continuously understand and differentiate between value-adding activities and non-value-adding activities from the customer’s perspective in the processes of creating and delivering a product or services, and to constantly remove those activities that are perceived as non-value-adding" (Smith et. al., 2015, p.2).

“Toyota visualized its values, principal way of working and the most important tools in the Toyota house of quality, the roof of the house expresses the goals of the organization (best quality -lowest cost-shortest lead time-best safely- high morale). The foundation of the house addresses the principles, followed by number conditions that are always needed. Here you can find standardized work and visual management. There are two pillars. The first pillar is called Jidoka and is about building in quality thaw second pillar is called JIT and inclines several logistical principles and tools. In the centre of the house, you will find the continuous effort of improving the organization” (Kulkarni, 2016). Figure 4 presented Toyota Production System House more detailed.



Source: (World of Agile, 2016)

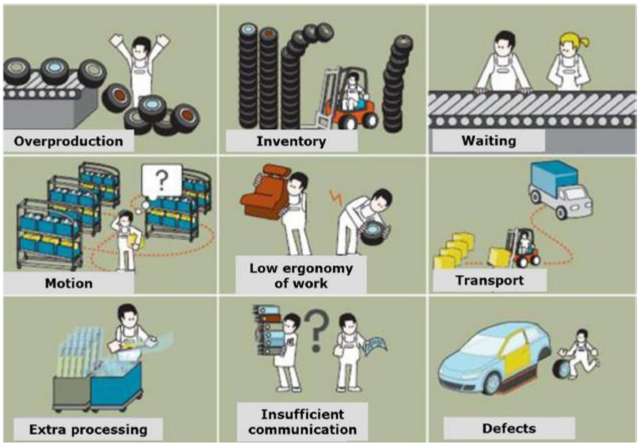
Figure 4 Toyota Production System House

The fundamental tenets of LEAN logistics revolve around pinpointing and eradicating wasteful practices within the supply chain. Such wasteful practices encompass surplus inventory, idle waiting times, overproduction, defects, superfluous processing, and needless motion. Through the systematic reduction of waste in these domains, LEAN logistics endeavours to enhance productivity and slash operational costs. One of the key benefits of LEAN logistics in the automotive industry is improved efficiency in the manufacturing process. By reducing waste and improving production processes, manufacturers can produce vehicles more quickly and at a lower cost. This can help automotive companies remain competitive in an increasingly crowded marketplace (Smith et. al., 2015). LEAN logistics can also help automotive companies to improve customer satisfaction by reducing lead times and improving delivery times.

However, there are also several challenges associated with implementing LEAN logistics in the automotive industry. One of the main challenges is changing the culture of the organization to embrace the LEAN philosophy. This can be difficult, particularly in larger organizations where there may be resistance to change.

Another challenge is the need for skilled employees who can implement and manage LEAN logistics systems. This can require significant investment in training and development and may also require the recruitment of new staff with specific skills and expertise.

The basic idea behind a lean manufacturing system, which has been practiced for many years in Japan, are waste elimination, cost reduction and employee empowerment. The Japanese philosophy of doing business is totally different than that of the US. The traditional belief in the west is that the only way to make profit is to add it to the manufacturing cost in order to come up with a desired selling price (Ono et. al., 1988). Figure 5 describes the most common types of waste in automotive.



Source: (Holman, 2021)

Figure 5 Types of waste in automotive

Creating a pull system: Allow demand to pull goods or services – to do only what is requested by the end point (customer) or the next step during a process. Value is pulled through a process rather than being created in batches or as capacity constraints allow. This minimizes overproduction, stocks and ultimately working capital. Inventory is considered one of the biggest wastes in any production system. The goal of a pull-based system is to limit inventory and work in process items while ensuring that the requisite materials and information are available for a smooth but efficient flow of work.

Setting up one piece flow: Enable value to flow – the addition of value needs to be uninterrupted through the processes across the value stream. Focusing on the ideal, the addition of value of one single piece at a time enables us to optimally affiliate process steps across the business while eliminating wasteful activities. After removing wastes from the value stream, the following action is to ensure that the flow of the remaining steps run smoothly without interruptions or delays.

Working in takt: Work in a rhythm according to the pace of customer demand - takt is the German term for timing. This pace is how fast you need to manufacture a product or offer a service to fill your customer orders. It provides the heartbeat of a Lean system that allows us to balance work content and achieve a continuous flow through the business. It also allows us to adjust the rhythm and respond flexibly to changes in the marketplace (Lean Compass, 2022).

Striving for zero defects: Stop and fix when something goes wrong - defects are easily identifiable at or remarkably close to the point at which they arise. By addressing the root cause of the defect immediately and neither accepting nor passing on defects, subsequent defects and problems are avoided, and overall product or service quality is improved.

1.3 Logistical components of the Supply Chain

Supply chain logistics is a crucial and complex task for businesses. The basic components ensure goods move smoothly from manufacturers to distributors or consumers. These components, including transportation, warehousing, inventory management, and order fulfilment, serve as the backbone of operations. Effectively managing these components is vital to meet customer needs, cut costs, and stay competitive globally. Here are the five main components of logistics management:

Storage, Warehousing, and Materials Handling:

These components play a pivotal role in ensuring the secure and efficient storage of products while facilitating their seamless movement from one point to another.

Beyond mere physical placement, effective storage involves maintaining optimal conditions like temperature and humidity to safeguard the quality of goods. Warehousing goes beyond being a storage space; it involves strategic organization and layout planning for maximal capacity utilization and convenient access to stored items.

Packaging and standardisation:

These two components are important parts of the supply chain. Packaging refers to the materials and structures used to protect and hold products during storage and transport. These can be boxes, bags and other materials designed to protect products from damage and contamination. Standardisation, on the other hand, means grouping products into larger units for more efficient storage and transport. This also allows efficient stacking capability during a transport (1+2, 1+5, etc.), especially overseas. For this purpose, pallets, shrink wrap and other materials can be used to combine products into larger units to optimise space utilisation and reduce the number of individual handling operations.

Inventory:

The impact of inventory management in the automotive industry goes beyond simply knowing the quantity of inventory on hand. Maintaining excessive inventory can lead to issues such as discounting and the accumulation of obsolete stock, while also tying up valuable cash that could be utilized elsewhere in the business. On the other hand, insufficient inventory levels can result in lost sales and dissatisfied customers due to stock-outs. Striking the right balance between holding too much inventory and not having enough can be challenging, especially when relying on outdated methods like spreadsheets or manual processes. And, implementing an inventory management system in the automotive industry provides suppliers with enhanced visibility of items across all channels (Blog IoT, 2021).

Transport:

Transportation is another critical component of the supply chain. It involves the movement of products from one location to another, whether it be within a facility or across the world. Transport includes the use of trucks, trains, planes, and ships to move products, as well as the management of logistics processes to ensure timely delivery and minimize transport costs. Effective transportation management involves route optimization, carrier selection, and coordination to ensure timely delivery while minimizing costs. Real-time tracking and tracing capabilities provide visibility of shipments, enabling proactive problem-solving (RUSHTON et. al., 2015).

Information and Control:

Information and control involve the use of data and technology to manage and optimize logistics processes. This includes the use of software to track inventory levels, manage transport logistics, and monitor the flow of products through the supply chain. The element of information and control is needed by all the elements to act as triggers to various operational procedures. We have mentioned the information needed for inventory. Order levels help decide what orders need to be picked and packed in warehouses and enable the planning and organisation of transport. Information and control's role is to help design information systems that can control operational procedures. They are also key in the forecasting of demand and inventory as already mentioned (RUSHTON et. al., 2015).

1.4 Key challenges in SCM for a first-tier supplier in automotive

The automotive industry faces a variety of significant supply chain management challenges. These include complex logistics networks, rising customer expectations, regulatory compliance, integration of advanced technologies and the need for skilled labour. The complexity of automotive supply chains comes from the global nature of the industry as suppliers and manufacturers are located in different regions of the world. This leads to difficulties in transport coordination, inventory management, and quality control.

Challenges in Supplying Semiconductor Chips from Taiwan

At present, the automotive industry is facing an extremely critical issue regarding the supply of semiconductor microchips from Taiwan. The shortage of these microchips, especially those used in automobiles, has been a serious problem in recent years. "The risks for disruption in the semiconductor supply chain are significant. That is true whether the source of the disruption is a natural disaster like an earthquake or typhoon, a global shock to the trading system like the COVID-19 pandemic, a disruption caused by political considerations such as a blockade or armed conflict, or by other factors" (Project 2049, 2023, p.1). As a result, many automakers have been forced to slow down or even stop production completely due to shortages of critical components. This situation highlighted the importance of implementing a robust supply chain management system that can quickly adapt to changing conditions and ensure uninterrupted supply of components.

Impact of the COVID-19

The automotive industry has been significantly affected by the COVID-19 pandemic, “around 51.7% of respondents from the auto sector said disruptions to supply chains were “very significant” - the highest proportion across the six industries” (Yen Nee Lee, 2021).

The scarcity of parts, notably microchips, has hindered the completion of vehicle assembly for many automotive manufacturers. Consequently, automotive OEM supply chains have redirected their attention from long-term planning to immediate needs. To deal with pandemic-induced supply chain challenges, it is crucial to monitor real-time supply issues, maintain open communication with parts suppliers, and streamline access to supply data. Moreover, engaging third-party logistics providers can assist automotive companies in resolving supply chain issues and minimizing the impact of disruptions.

Importance of Monitoring Processes in Real-Time

It is of utmost importance to closely monitor the supply chain in real-time to ensure its seamless and efficient functioning. By continuously observing and evaluating the different stages and activities involved, companies can quickly identify and address any potential issues that may occur, such as blockages or delays. Additionally, real-time monitoring provides a deeper understanding of the complexities within the supply chain, enabling businesses to pinpoint areas that could be enhanced and optimize their overall operations accordingly. For instance:

- Tracking Inventory Levels: A company can use real-time monitoring to keep a close eye on inventory levels at various warehouses and distribution centers. Programs to use: ERP software like SAP, Oracle, Microsoft Dynamics.
- Supplier Performance Monitoring: Real-time monitoring can help assess the performance of suppliers. For example, if a key supplier's shipments are delayed in quality, the company can immediately take action, such as sourcing alternative suppliers or negotiating better terms. Programs to use:

SCM software, such as SAP, JDA Software, Kinaxis, and Blue Yonder (formerly JDA), focuses specifically on supply chain optimization, visibility, and planning.

- Transportation Tracking: Real-time GPS and logistics data can provide insights into the location and status of goods in transit. If a shipment is delayed due to traffic, weather, or other issues, companies can re-route or expedite deliveries to minimize disruptions.
- Demand Forecasting: Companies can use real-time data from point-of-sale systems, e-commerce platforms (mostly for aftermarket / service parts), and other sources to forecast demand accurately. SAP offers a range of tools and functionalities to support demand forecasting including statistical models, predictive analytics, and machine learning algorithms.

Improving Supply Chain Processes through Automation

The integration of automation within the supply chain landscape can yield remarkable benefits, including heightened operational efficiency and cost savings. Through the automation of critical functions such as order processing, inventory control, and transportation management, enterprises can significantly reduce error rates and bolster data precision. This, in essence, equips them with the ability to make informed decisions and respond promptly to the ever-evolving market dynamics. Furthermore, automation plays a pivotal role in the identification of vulnerabilities within the supply chain, thereby providing organizations with the tools needed to implement corrective actions swiftly. This, in turn, leads to a reduction in lead times for component deliveries and a more streamlined and agile supply chain. For instance, implementation of End of Line (EoL).

The implementation of an EoL system in the automotive industry provides numerous benefits. EoL systems enhance quality control, minimizing defects and potential recalls. They generate valuable data for informed decision-making and improve traceability, reducing recall costs. EoL systems streamline production, leading to cost savings and increased output. Ultimately, they boost customer satisfaction, ensure compliance with industry standards, and contribute to brand reputation in the highly competitive automotive market. Implementation of such a system may require a high investment in equipment, but the effect and impact on improving process efficiency is worth it.

Lack of Visibility

Visibility is a key challenge for automotive supply chains, as well as for other industries. “Automotive supply chains’ top challenge is visibility. In fact, the concern is even higher for automotive; compare to 70% in all other industries, the automotive industry has concern rate of 81%. Even though 84 percent of automotive executives have implemented real-time supply chain information transparency in the enterprise, only 13 percent have done extensively. Additionally, less than 30 percent of automotive companies view their collaborative practices as very effective at customer inventory planning and arrangement programs“ (Malaviya, 2018). Any oversight in the manufacturing process can result in problems such as inventory shortages and delays. By implementing these measures, automotive manufacturers can improve visibility, optimize component management, and ensure consistent production processes. For instance, whic implementing tracking systems using RFID or barcodes, utilizing cloud-based data sharing platforms, leveraging digital twin technology.

Overstocked Inventories

Effective inventory management holds great importance in automotive manufacturing as excessive stockpiles of unused raw materials can result in missed revenue opportunities. To address the problem of surplus inventories, automotive firms may engage third-party logistics (3PL) providers utilizing software to monitor quantifiable data, offering insights into product demand. Employing a just-in-time (JIT) production approach also aids in curbing overstock situations and facilitates more informed daily inventory decisions. Automotive manufacturers can implement a Vendor-Managed Inventory system, where suppliers monitor inventory levels and replenish materials as needed. This strategy reduces overstocking, minimizes carrying costs, and optimizes production.

Sustainability

In recent years, European automotive manufacturers, including notable companies like Škoda Auto and Volkswagen (VW), have placed an increasingly strong focus on sustainability within the industry. Since 2015, these manufacturers have embarked on a journey to adopt more environmentally responsible practices in vehicle manufacturing. For instance, Škoda Auto has actively worked to reduce its carbon footprint by implementing energy-efficient processes and materials in their production. "ŠKODA AUTO is increasingly turning to renewable energy to manufacture vehicles, and in doing so is significantly reducing CO2 emissions in production. This means that all three Czech plants will be operating with net-zero carbon emissions by 2030" (ŠKODA STRATEGY 2030, 2022), while "the Volkswagen Group is implementing a comprehensive decarbonization program, which includes the whole life cycle of the vehicles and is characterized by a clear hierarchy of measures: The top priority is measures with which CO2 emissions can be avoided or reduced" (Association Climate Review 2023, 2023, p.4). This shift towards sustainability is not merely a matter of expectation; it's driven by stringent regulations that mandate that manufacturers and their third-party collaborators embrace eco-friendly construction processes.

Quality Control Issues

Challenges in the automotive industry demand meticulous attention to detail during the assembling process. Given the increasing complexity of modern vehicles, manufacturers must implement robust quality control measures. Internal audits, carried out by cross-functional teams and advanced technologies, scrutinize every aspect of the manufacturing process, from component precision to final assembly. Additionally, external audits initiated by customers, conducted by independent quality assessors offer an objective evaluation, ensuring adherence to industry standards and regulations. These combined efforts not only prevent errors but also proactively identify areas for improvement, ultimately safeguarding against quality issues that can lead to costly recalls, revenue loss, material waste, and potential damage to the company's hard-earned reputation.

2 Process and technological innovations in SCM

Technological advancements have completely transformed the way businesses function in the era. The supply chain management sector, responsible, for overseeing the coordination and administration of goods and services from production to consumption has also embraced this revolution. Integrating technology into supply chain management has resulted in enhancements in efficiency, transparency and cost effectiveness making it an indispensable component of business operations.

Peter Drucker, otherwise known as the "Father of Innovation" or the "Father of Modern Management", defined the term innovation in his book in 1985, but in a very ageless way, as "a specific tool of entrepreneurs, a means of using change as an opportunity to introduce a new product or service. It can be taught as a discipline, it can be learned, it can be practically applied. Entrepreneurs must deliberately seek out sources of innovation, change and signs of change, indicating opportunities for successful innovation. And they must know and apply the principles of successful innovation" (Drucker, 1985, p. 17)

The incorporation of technology into supply chain management has revolutionized practices by rendering them adaptable, agile, and responsive to ever changing market dynamics. In the past managing supply chains involved processes that were time consuming and often entailed intermediaries and paper-based documentation. However, with the emergence of information and communication technologies (ICTs) digital supply chains have emerged that are streamlined, transparent and data focused.

Innovations such, as radio identification (RFID), the fully automated End of Line (EoL) solutions, robotics, and automation, e-kanban, the Internet of Things (IoT) and artificial intelligence (AI) are some examples of advancements that have significantly reshaped the landscape of supply chain management.

However, improving operational processes does not always mean investing in technology. The path to operational excellence does not always require significant investment in advanced technology. Despite the popular belief that progress is synonymous with the integration of advanced hardware and software, one idea is that significant improvements can be made by looking at existing processes from the inside out. This chapter will also provide theoretical information on how a firm can significantly help to optimize its processes without multi-million-dollar investments, just by implementing process changes in production, organizations can find areas for improvement that can lead to increased efficiency of the entire supply chain. Innovations can be critical in achieving business success and companies should apply both approaches to maintain a high level of competitiveness in today's rapidly changing business environment (Veber et al., 2016).

2.1 Brief history and current state of logistics in automotive industry

The automotive industry is a network that consists of manufacturers, suppliers, logistics providers and customers. It is a field that undergoes constant changes and advancements. In the industry the logistics function plays a role, in ensuring timely and efficient delivery of goods and services from suppliers to manufacturers as well as from manufacturers to customers. The evolution of logistics in this industry has been influenced by factors such as economic growth, technological advancements and shifts in customer expectations (Morana, 2013).

20-30 years ago, SCM in the sector primarily relied on manual processes involving paper-based documentation, phone calls and faxes. Inventory management was also predominantly manual leading to inefficiencies and delays. The adoption of technologies like Enterprise Resource Planning (ERP) systems was just beginning to gain momentum within the industry. However, time data collection and analysis capabilities were limited at that time while communication among stakeholders, in the supply chain often faced challenges.

Today digital technologies have completely revolutionized the logistics aspect of the industry. One of the advancements is the implementation of RFID technology, which allows for real time tracking of goods and services (below this topic will be described more detailed). Thanks to this technology, logistics providers can now monitor inventory levels track shipment statuses and ensure delivery. Another exciting innovation is the integration of vehicles for transportation purposes which holds potential for improving delivery times and reducing costs.

Furthermore, data analytics and artificial intelligence (AI) have played a role in transforming logistics. Logistics providers can analyse amounts of real time data empowering them to make informed decisions and optimize their supply chain processes. The application of AI in logistics is gaining popularity as it enables the optimization of delivery routes, accurate demand prediction and identification of disruptions, in the supply chain.

The logistics function of the industry has become more integrated than in the past. Collaboration and communication among supply chain stakeholders has increased. The use of technology has also improved the speed, accuracy and efficiency of logistics operations. However, the industry still has obstacles to overcome, such as supply chain disruptions, inventory management challenges, and maintaining sustainability. (Hugos, 2018).

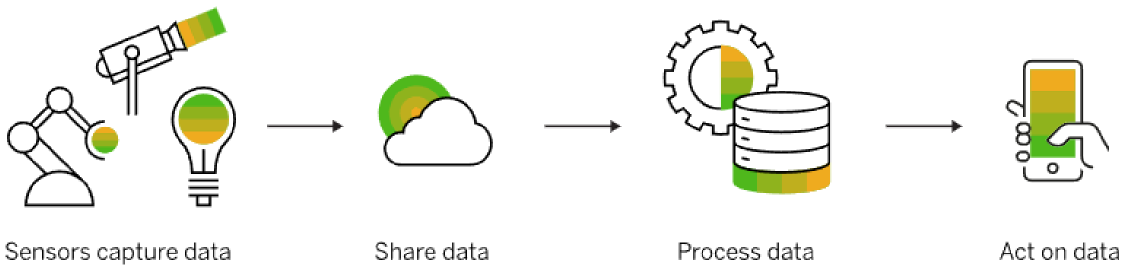
The advancements, in logistics within the industry over the twenty to thirty years demonstrate how technology has brought about significant changes. Moving forward we can expect efficiency, cost effectiveness and a strong emphasis, on sustainability. These factors will ensure that the automotive sector continues to lead in terms of practices.

2.2 Emerging trends and technological innovations in SCM

The supply chain is an essential aspect of modern-day businesses, and the integration of technology has revolutionized the industry. As such, the use of technology in the supply chain has become critical to enhancing efficiency, reducing costs, and improving customer service. Supply chain management, as a dynamic field, is undergoing a profound transformation due to rapid technological advancements. Emerging trends in supply chain management, like Robotics (AGV unit loads), Automation (Fully Automated End of Line Solutions), e-Kanban Solutions, RFID for Labelling and Inventory Tracking, and the Internet of Things (IoT).

Internet of Things

Physical devices are connected to the Internet of Things (IoT) which enables the monitoring and transfer of data without intervention. In logistics the utilization of enhances efficiency, in managing inventory by providing visibility throughout the supply chain. The application of IoT has brought about changes in supply chain management (SCM). By using sensors, we can even predict equipment maintenance needs and proactively order replacement parts. There are four key stages in this process, described at figure 6:



Source: (SAP.com, 2022)

Figure 6 Internet of things

The Internet of Things (IoT) plays a role in enhancing supply chain visibility and its potential growth of the company. With IoT organizations have real time monitoring capabilities for inventory management automated stock replenishment and streamlined delivery tracking. Car manufacturers and their suppliers can now easily share real time information through a system thanks, to sensors, data collection devices, networks, and user-friendly software. This valuable data enables route planning, proactive maintenance to prevent breakdowns and enhanced safety measures. Cooperation and coordination with suppliers via cloud services service providers is also essential, intermediaries and other partners affecting the logistics chain and the creation of value to the customer (Drake, 2011).

Robotics AGV

By incorporating robots into logistics, supply chain operations will be faster and more accurate, and human error will be reduced. Robots outperform human employees in terms of uptime and productivity. Unlike humans, robots do not replace them; instead, they work in tandem with people to improve productivity. Automation of robotic processes helps supply chain managers find and improve inefficiencies across the network. Using artificial intelligence, it makes possible for managers to operate a seamless operation round-the-clock. SCM automation encompasses not just activities but also manual chores. Drones are increasingly being utilised for the delivery of lightweight items in transportation. For instance, Automatic Guided Vehicle (AGVs).

Automatic Guided Vehicle (AGVs), see figure 7 - are self-propelled trolleys that are fully capable of performing handling operations with material, without human operators. Nowadays, it is one of the most developing branches of internal logistics, both in large manufacturing enterprises as well as in various storage units.

Source: (TECH design, 2021)

Figure 7 Unit load carrier

“An automated guided vehicle is a programmable mobile vehicle. The automated guided vehicle is used in industrial application to move material around a manufacturing facility. The AGV are capable of transportation task fully automated at low expanses. AGV have to make the system automatic by doing the decision on the path selection. This is done through different method frequency selected mode, path selected mode and vision based mode etc. The central processing system of AGV is issue the steering command and speed command. For the pre defined manufacturing environment the map is saved in the AGV memory and control by stationary control unit of warehouse (Vancea and Orha, 2019, p.43).

A general AGV system essentially consists of vehicle periperheral on site component as well as stationary control system. The main components of AGV system are:

- Vehicle,
- Guidence Path System,
- Floor Control And Traffic Management System.

The faultless interaction of these components ensuring the efficiency of working plant. AGV will guarantee a safe performance of that care of personal as well as the load and surrounding (Das, 2016, p.30).

Automation is becoming more popular as businesses try to meet the competing needs of omnichannel supply chains and the requirement for flexibility and agility (KANNA NAMADEVAN, 2023, p.19-20).

Implementation of EoL (End of Line) fully automated solution

Manufacturers are actively exploring approaches to improve the efficiency and timeliness of their end of line production. EOL solutions specifically refer to the processes and technologies used at the stage of manufacturing production. This stage represents the step, where various items, like boxes, bags, bottles and reels are handled using machinery.

The main goal of EOL solutions is to ensure that the final product meets high quality standards before it is sent out to customers. The way these solutions are implemented can vary depending on the industry and characteristics of the manufactured goods. Classical EoL system is shown at the figure 8.

There are challenges associated with packaging including:

- Delays in responding to changes in market demand affecting production.
- Difficulties for planners in accessing and reviewing data inputs due to processes and complex data ecosystems.
- Prioritizing profitability by aiming for responses to changes in supply or demand.
- Reliance on labour for delivery leading to a risk of error.
- Increased cost pressures due to quality issues caused by products.

Source: (The packaging observer, 2022)

Figure 8 EoL solution illustration

There is a risk of experiencing quality problems due to issues such as underweight, items or missing items. These problems could lead to compliance issues damage to our brand reputation and difficulties, in retaining customers.

Let's s define end-of-line automation to understand how it works:

Scanning the Package: Checking for foreign materials, such as metal, bone, glass, or any other contamination, is crucial for end-of-line operations. While this may be done manually, X-ray equipment is rapidly being utilized to identify abnormalities and automatically send afflicted items to discard bins.

Weighing the Package: Checking the packaging weight is also crucial for business efficiency, security, and compliance. With automated systems, it has become more accessible. When products of varied sizes and weights are carried over a single weigh-conveyor, modular grading systems may assure correct weighing.

Labelling the Package: The accuracy of labelling examination and pack verification is critical. High-speed vision inspection devices with pinpoint precision are now available Label positioning, expiry dates, and batch numbers are also double-checked.

Case Packing and Palletizing: After the product has been examined, it must be collated and packaged into cases in most situations. Products can be piled, sorted, loaded, elevated, and sealed using entirely or semi-robotic case packaging systems.

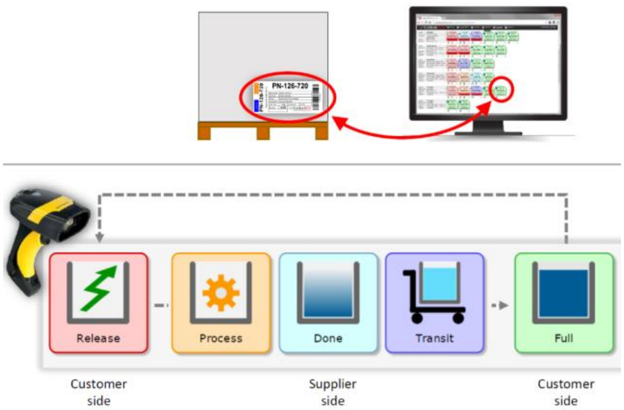
End-of-Line automation, including robotic case packing, can help businesses overcome challenges such as slow production rates, bottlenecks, and loss of productivity.

The goal is to boost output while reducing expenses, and the article encourages businesses to explore EOL automation solutions for their packaging processes.

Warehouse Automation

Automation of inventory movement into, within, and out of warehouses to consumers with little human intervention is known as warehouse automation. By automating repetitive physical tasks and manual data input and analysis as part of a business' operations, the company saves time and money.

Humans are still involved in warehouse automation systems that span everything from unloading trucks to completing orders. For instance, the implementation of E-Kanban systems with RFID for warehouse automation optimizes inventory management, reduces errors, and enhances efficiency through real-time visibility and automated replenishment processes. Kanban card usually contains information such as "order" description, part/item number and name, quantity to be processed, type, packaging, supplier, time, and date of not only order but also delivery (Gros, 2016). This integration represents a modern and agile approach to warehouse operations, ensuring organizations maintain optimal stock levels while minimizing operational costs, visualisation of e-kanban system is shown at Figure 9.



Source: (EMIG E-Kanban, 2020)

Figure 9 E-Kanban

E-Kanban replaces the traditional physical cards with a digital system. Each item or bin in the warehouse is assigned a unique digital identifier, and the system monitors inventory levels in real-time. RFID tags are affixed to items, containers, or pallets. These tags contain unique identification information. RFID readers strategically placed throughout the warehouse automatically capture data from these tags, enabling seamless and accurate tracking. As inventory levels fluctuate, RFID readers capture the changes in real-time. When an item reaches a predefined reorder point, the E-Kanban system generates an automatic replenishment signal.

Warehouse automation has many advantages. One of the first advantages warehouse managers notice when they begin automating their operations is a decrease in the number of human mistakes.

Utilization of Warehouse management system

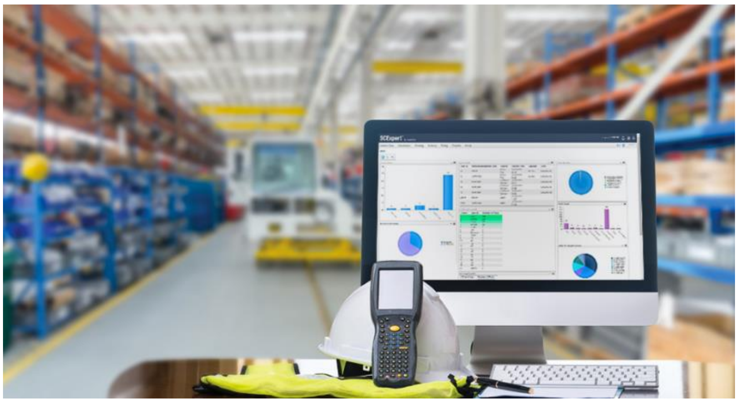
Warehouse Management Systems (WMS) play a role, in boosting and optimizing the efficiency of warehouse operations. The main aim of a WMS is to manage the movement and storage of goods within a warehouse starting from their arrival until they are dispatched.

WMS provides the following features for the company such as:

- Real time Tracking: WMS offers real time visibility into the whereabouts and status of inventory items. This feature empowers warehouse managers to make informed decisions. Promptly respond to changes in demand or unforeseen circumstances.
- Order Fulfilment: WMS simplifies the process of order fulfilment ensuring precise and timely picking packing and shipping of products. This results in enhanced customer satisfaction and reduced errors in order processing.
- Inventory Management: WMS aids in maintaining inventory levels by automating inventory tracking minimizing stockouts and preventing overstock situations. This leads to cost savings while preventing disruptions in supply chain operations.
- Data Accuracy: WMS relies on accurate data capture through technologies like barcode scanning and RFID. This minimizes manual errors, improves data accuracy. Forms a foundation, for decision making.

- Efficient Space Utilization: WMS helps maximize the utilization of warehouse space by optimizing storage configurations minimizing wasted space and ensuring use of resources.
- Warehouse Management Systems (WMS) can integrate smoothly with enterprise systems, like Enterprise Resource Planning (ERP) and transportation management systems. This integration fosters a well-coordinated supply chain ecosystem (CHRISTOPHER, 2005).

Visualisation of the WMS are shown at Figure10.



Source: (Ware IQ, 2023)

Figure 10 Warehouse Management Systems

Anyhow, the above-mentioned technologies require some form of investment. However, it is not always the case that a company needs to improve the technology. Sometimes, it is worthwhile to pay more attention to and analyze the basic processes in production, internal or external logistics to identify obvious illogical technological solutions that, if reversed, would work more efficiently.

Embracing Efficiency without Immediate Investment in Technology

In situations where immediate technological investments not feasible these strategies offer a path to efficiency. Analyzing and mapping processes lay the foundation for identifying areas of improvement while streamlining workflow ensures that changes happen naturally. This commitment to optimizing processes without an upgrade in technology is more than just a cost saving measure; it's a strategic investment in the company’s ability to adapt and withstand challenges. By empowering employees to participate in the optimization process organizations can achieve long lasting improvements in their logistics and production workflows (CHRISTOPHER, 2005).

To sum up strategic process optimization through process mapping, analysis and workflow streamlining provides guidance for companies dealing with hurdles. It enables them to navigate complexities, boost efficiency and adjust to changing circumstances - all without a need for significant technological investments.

2.3 Benefits and challenges of implementing innovations

The incorporation of advancements in supply chain management (SCM) and logistics has brought about significant transformations in the industry. By leveraging technology businesses can optimize their operations, improve efficiency, and enhance customer service. However, implementing these innovations comes with its own set of challenges. In this article we will explore six advantages and three obstacles that arise when integrating innovation into SCM and logistics. Evident advantages of them:

- Enhanced Efficiency: Technological breakthroughs have allowed businesses to automate various processes resulting in improved efficiency. For example, automating order processing and fulfillment has reduced the time required for these tasks. As a result, businesses can handle orders efficiently while reducing lead times and increasing customer satisfaction.
- Enhanced Data Management: SCM and logistics generate amounts of data that can be overwhelming to handle effectively. Technological innovations have provided businesses with data management capabilities enabling real time tracking, analysis and reporting of supply chain operations.
- Improved Customer Service: The integration of technology into SCM and logistics has significantly elevated the standard of customer service. For example, the ability to track orders in time allows businesses to give customers accurate delivery times, which in turn reduces the chances of missed or delayed deliveries.
- Cost Reduction: The integration of advancements in supply chain management (SCM) and logistics has led to significant cost reductions. For instance, automating processes like order processing and inventory

management has decreased labor expenses. Moreover, real time tracking of shipments has minimized instances of lost or misplaced deliveries.

- Enhanced Collaboration: The incorporation of technology in SCM and logistics has improved collaboration among stakeholders within the supply chain. Real time tracking of orders and shipments enables businesses to share data with suppliers, carriers and customers fostering collaboration and communication throughout the supply chain network.
- Sustainability Improvements: Technological innovations have empowered businesses to implement practices in their supply chain operations. For instance, adopting vehicles and drones for deliveries helps reduce carbon emissions (Vancea and Orha, 2019).

And it’s challenges:

- Costs of Implementation: Implementing innovations within SCM and logistics can be expensive. Businesses are required to invest in infrastructure well as hardware and software solutions necessary for incorporating these technologies. The upfront expenses can pose a significant hurdle for certain businesses trying to enter the market.
- Challenges in Integration: Incorporating technology into supply chain management and logistics can be tricky especially when dealing with systems. The process of integrating these systems may lead to discrepancies and errors in data causing delays and operational mistakes in the supply chain.
- Security Concerns: The integration of technology in supply chain management and logistics has increased the vulnerability to cyber-attacks. Businesses need to establish cybersecurity measures to safeguard their data and prevent the possibility of data breaches, which can result in substantial financial losses.

3 Analysis of the current state of studied company

Chapter 3 introduces in detail the company under study - a Czech division, a production company, a first-tier supplier for automotive OEMs, their current situation and it’s weaknesses. In addition, the relevant theoretical knowledge presented in the first and second chapters is used for suggestions for optimizing the processes in the company in this chapter (approach of wholeness system thinking, EoL solution for a production automation, the implementation of E-Kanban systems with RFID for warehouse automation for a returnable and one-way packaging.

A brief introduction of what chapter 3 is about: first, an introduction to company XY, its main processes in logistics (focusing on the changes in the company over the last 2 years), which is the object of analysis, is given. Then, based on the SWOT analysis, 3 weak topics for optimization were identified, such as: technological implementation of the EoL fully automated solution, optimisation proposal for a warehouse space optimization and process optimization of the using returnable and one-way packaging.

3.1 Introduction to the company under study

To complete this thesis and achieve the goals of this study, a chosen company for some reason did not wish to disclose its name. The reason for this is the company's fear of disclosing confidential information about its internal processes, so it is referred to in this thesis as company XY.

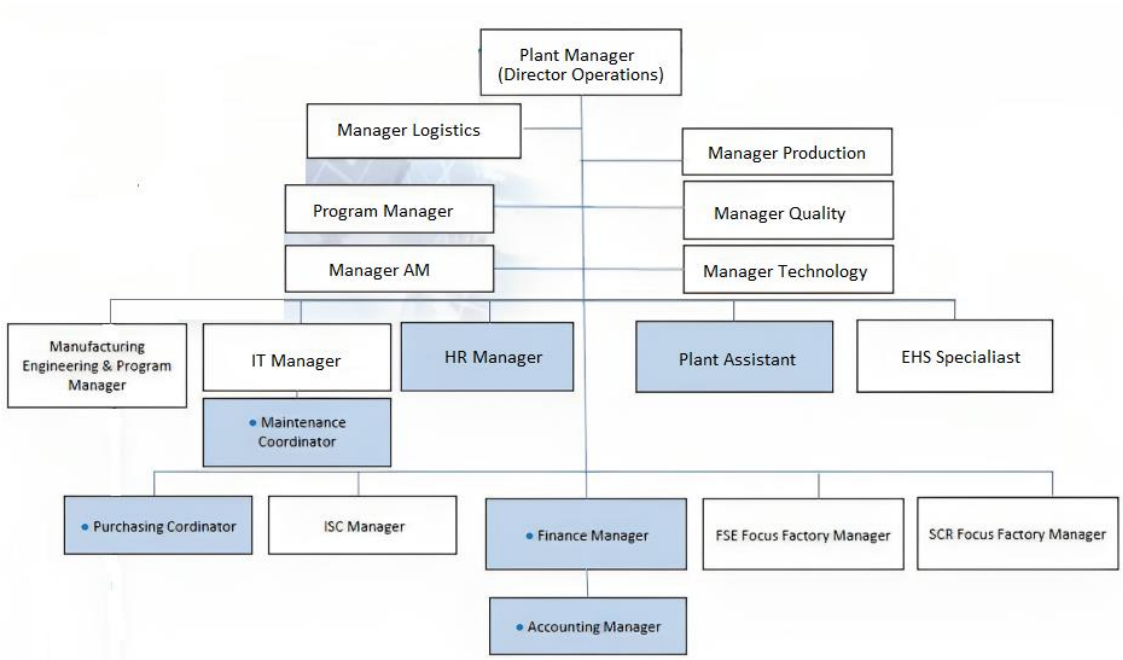
Company XY - part of the global Industrial Group founded in the United States of America. With a growing worldwide presence, the industrial group and its division, company XY, is within a top 100 global supplier to the automotive industry. As a first-tier automotive supplier with more than 30 plants in 13 countries, designs, develops and manufactures traditional and hybrid fuel systems, advanced cleaning solutions for assisted and autonomous driving, engine camshafts and plastic industrial packaging solutions. A leader in the design and manufacture of automotive plastic fuel systems, company XY is pioneering solutions for the era of new mobility by expanding its portfolio to offer thermoplastic composite and composite-metal hybrid battery enclosures and underbody protection. Table 1 shows the worldwide presence of divisions and number of facilities.

Table 1 Worldwide presence of industrial group and its division

Europe	
Belgium	1
Czech Republic	2
Germany	5
Romania	2
Spain	1
United Kingdom	2
North / South America	
Canada	1
Mexico	2
United States of America	6
Brazil	1
Asia	
China	7
India	1
Japan	2

Source: (Company XY presentation, 2023)

Regarding the company under studying, which was chosen for an analyze in this thesis located in middle-north part of Czech Republic supplies since year 2011 wide range of parts for clear vision systems for key automotive OEMs within the Europe, China and America (South and North). Plant size is approximately 4000 m2, currently company using a two external warehouses. Number of employees – 500. Annual turnover in 2022 – 31,5 million USD. Company exporting finished goods semifinished goods and spare parts to around EU, Asia, Africa, North and South America, to more than 30 countries. Company XY is a division, primarily focusing on the design, development, and manufacturing of advanced automotive clear vision systems. The organizational structure serves as the framework that defines how tasks, responsibilities, and authority are distributed within a company. See Figure 11 for the detailed organization structure of company XY.



Source: (Company XY presentation, 2023)

Figure 11 Company's organisational structure

Facilities description, machine park consists of more than 20 units of blow molding and injection molding machine. Technological processes contain blow molding, injection molding, hotplate welding, final assembly, extrusion & over molding, hose cutting, hose assembly and jets assembly. These systems encompass a wide range of components and technologies associated with a vehicle's visibility, including:

Blow-Molded Washer Bottles: a company specializes in manufacturing blow-molded washer bottles, which are essential components of a vehicle's washer system., resistance to leakage, and compatibility with various cleaning solutions.

Filler Necks: The company also produces filler necks that complement the washer bottles. These components facilitate the easy and safe refilling of the washer fluid, ensuring efficient maintenance of the clear vision system.

Injection-Molded Washer Bottles & Filler Necks: Injection-Molded Washer Bottles: In addition to blow-molded washer bottles, the company manufactures injection-molded washer bottles.

Filler Necks: Just as with blow-molded washer bottles, the company produces filler necks designed for injection-molded washer bottles. These filler necks are engineered for compatibility and ease of use, aligning with the washer system's overall reliability.

Hose Assemblinh: company XY designs and manufactures hose assemblies that form a critical part of the clear vision system. These assemblies enable the transfer of washer fluid from the washer bottle to the nozzles or jets on the windshield.

Heated Jets: Heated jets are an advanced component designed to improve visibility in cold weather conditions. These specialized nozzles dispense washer fluid onto the windshield.

The primary business of studied company XY is revolves around the production and advancement of automotive clear vision systems and related components. These components play a critical role in enhancing the safety, comfort, and performance of vehicles, aligning with the broader automotive industry's emphasis on innovation and safety.

The company's main customers in the automotive sector range from large component manufacturers to multi-level suppliers and various global automotive brands. In addition, they serve tier one suppliers who supply OEMs with complete systems or major components, enabling them to offer complete automotive solutions. The company also serves tier two and tier three suppliers who specialize in small or specialized components required for vehicle assembly. Additionally, the company extends its activities to the automotive aftermarket by supplying parts and accessories used for vehicle maintenance and repair, thereby facilitating maintenance by owners and repair shops. Figure 12 shows the key customers of company XY.

Source: (Company XY presentation, 2023)

Figure 12 Company's key partners

3.2 Overview of the current state, its weaknesses and challenges

During the whole 2022 company XY has been involved in the process of transfer. One of its divisions in UK was decided to close by September 2022, and all equipment, facilities, stock, components, semi-finished parts, and the entire liability in front of the customers were to be redistributed between three plants - in the Czech Republic and two other plants in EU. One year was not enough for a smooth and seamless transition, at some point many tasks piled up and outside help was needed. New part numbers (more than 2000 new SKUs) were gradually arriving on the company's balance, which had to be restarted in a short period of time, as well as continued production and shipments to customers already from the Czech Republic.

Delays in the supply of components for such a major OEM due to internal changes in the corporate structure cannot be tolerated. Any shutdown of a production line at a car manufacturer is fraught with serious penalties for the supplying company.

A brief interview with the company representative was followed by internal discussions that highlighted several concerns and weaknesses in the organization. The dialogue has spotlighted the spatial constraints arising from the relocation of production facilities, the quality assurance challenges associated with the rapid start of deliveries from the new plant, and the financial strain caused by rising costs, schedule slippage and the constant pressure of additional warehousing and transportation costs. In addition, the company's reliance on second-tier suppliers, potential disruptions with UK component suppliers following the move, and an increased workload for employees creating a risk of errors were also identified. These findings identified critical areas requiring strategic attention and improvement to enhance the company's overall operational sustainability and efficiency.

Company’s XY weaknesses and challenges:

Space Constraints: The immediate growth in workstations and needs for goods storing leaded to a lack of physical space, potentially impacting workflow efficiency and employee comfort, and as a result - Extra cost for a two external warehouses (4500m2 + 2000m2) and continuous demand for a goods movement (2 drivers, 8 hours each driver 5 days a week)

Quality Issues: The occurrence of quality issues and customer claims suggests potential challenges in maintaining the same level of product quality after the transfer. This had an impact on customer satisfaction (ranking), and as a result Customer Relations Management: Continued pressure on production lines and potential quality issues strained relationships with a key customer. High risk of losing a long-term contract.

Financial Strain: The combination of space constraints, training needs, scheduling issues, and quality concerns contributed to financial strain and especially Transportation Expenditures for taxi: Continued high transportation expenditures for special transport (up to 10 000 EUR for air freight for one shipment) in the initial months after relocation strained the company's budget and financial stability.

Relocation Impact on UK Component Suppliers: Relocating facilities may pose challenges in maintaining relationships with UK-based component suppliers or Czech Republic. Needs to find a new supplier in EU or Czech Republic. And as a result, Penalties for Non-Delivery of Parts: The imposition of penalties for non-delivery of parts, leading to stoppages in the production line, represents a significant threat that could adversely affect Company's XY operational and financial performance.

To gain a comprehensive view of company's XY operational environment, the SWOT methodology was selected for analysis. SWOT, an abbreviation, for Strengths, Weaknesses, Opportunities and Threats offers an approach to examining both external aspects of an organization in detail. This methodology enables an examination of the company's strengths, potential weaknesses, external opportunities, and upcoming threats within its operating environment.

The significance of applying SWOT analysis in this research thesis lies in its capacity to identify areas that require attention and optimal solutions to address them within a timeframe. By identifying and categorizing the company's strengths, weaknesses, opportunities and threats this analysis acts as a roadmap for acting. It does not provide an overview of the company's state but also pinpoints areas that can be enhanced.

3.3 SWOT analysis

Recognizing the importance of comprehensive research, the idea of using a structured methodology for a more in-depth analysis appeared. The decision to undertake a SWOT analysis was dictated by the need to systematically assess the company's internal strengths and weaknesses, as well as external opportunities and threats. This methodological approach is designed to provide a holistic understanding of the current state of the company, facilitating informed decision-making and strategic planning. The SWOT analysis will examine the intricacies of the company's global footprint, financial stability, production capacity, supplier relationships, and operational efficiency. By utilizing this analytical framework, XY aims to not only address the problems identified, but also uncover hidden opportunities for growth and improvement. Table 2 shows the key factors was found which using SWOT analysis of company XY.

Table 2 SWOT analysis of company XY

STRENGTHS:	**WEAKNESSES:**
➢ Global Presence: Company XY has a presence in multiple EU countries. ➢ Part of the global Industrial Group – financial support during crisis periods. ➢ Established global automotive TIER1 supplier with extensive experience in development and integration, ➢ Increasing the size of production through equipment transfers and new projects. ➢ Long-term contracts with big market players OEM.	➢ Space Constraints: due to facility transfer, ➢ Quality Issues: repetitive claims due to mislabeling, ➢ Financial Strain: Increased expenditure due to various challenges (special transport due to backlogs, claims, additional warehouse and transportation costs. ➢ UK component suppliers after the relocation, ➢ Increased employee workload - potentially high error risks (mislabeling, discrepancy, etc.)

OPPORTUNITIES:	THREATS:
➢ Gaining new businesses – long term contracts, ➢ Increasing market share, ➢ Automation of the processes, ➢ Supply Chain Optimization: Streamline supply chain processes and explore alternative suppliers to mitigate disruptions. ➢ Investment into goods/processes development, ➢ Efficiency in Warehousing: Optimize warehouse space utilization and minimize external warehousing costs.	➢ Rapid technological progress, ➢ Customer Relations Management: Potential Impact: Risk of losing long-term contracts due to continuous claims, ➢ Penalty for non-delivery parts (stop on the production line, ➢ Law regulation (for product or material usage) ➢ Lack of Holistic Systems Thinking

Source: (own contribution, 2023)

STRENGTHS

Company XY has been identified as possessing strengths that constitute key attributes providing it with a competitive advantage in the automotive industry. The company holds a strong market position, ranking among the top 100 global automotive industry first-chain suppliers. Additionally, being part of a large industrial group ensures financial stability and support during times of crisis. Moreover, XY is independently involved in strategically expanding its production, with a particular focus on innovative developments in the field of CVS. This strategic approach grants the company independence and greater influence on the outcome of development projects. Facility transfer in 2022 led to temporary disruptions in the company's usual processes, it significantly contributed to the company's expansion. This expansion included securing new long-term projects, launching new equipment, a complete overhaul of the production scheme, expanding the company's physical footprint (in square meters), and increasing the number of employees. Globally, these changes are expected to positively impact the company's financial efficiency in the future. Strong strategic partnership relations with major auto manufacturers (OEM) up to 10-year, ongoing projects and those in the pipeline is a clear competitive advantage.

WEAKNESSES

The most relevant and glaring weakness identified during the analysis is the insufficient space for the proper organization of process flows. The impact on various stages, including the component warehouse, semi-finished parts, and finished product storage, has been significant, leading to process failures and subsequent challenges in quality assurance. The current factory premises, with an area of 4000 m2, are deemed critically small. While some critical issues were promptly addressed in the short term (taking two external warehouses in rent, 4500 m2 and 2000 m2, in 10km and 15km away from the plant, additionally with daily usage of 2 external drivers for 8 hours shift each created a cost for rent a 61 EUR per m2), their resolution did not translate into a positive impact on long-term financial results. Financial difficulties further compound to challenges. The company is grappling with escalating costs due to various issues, including schedule slippage necessitating special transport and claims. Ongoing financial strain persists due to additional warehousing and transport costs. Another vulnerability lies in XY's dependence on timely component deliveries from UK. Historically, production facilities were not situated in the Czech Republic, leading to a concentration of most component suppliers from UK. In the short term, this dependency poses a potential risk to the company's operations. Moreover, the significant surge in production and its scale has increased the workload of employees, thereby elevating the risk of machine errors, such as mislabeling and discrepancies.

Nowadays, company XY don’t have a stable process of packaging order, and it’s also connected to the planning of the production. Due to large volatility at production planning, company overconsuming the returnable packaging provided by customer, so it has created a few issues – overstock, needs to use later a one-way packaging for free, with no compensation and wasting of manpower for repackaging.

OPPORTUNITIES:

The main opportunity for growth and development of the company now is the elimination of weaknesses in the form of solving the issue with a high cost of 1 m2 of rented external warehouse, until the amount of claims for goods not sent on time, for payment of transport will not create an unnecessary financial expenditure. Further, if we find a solution within the area, the main opportunity for the company is to get new long-term contracts. In addition, the analysis revealed the lack of automation of some processes, for example, in the production and labelling of finished goods, which subsequently leads to complaints from the customer for incorrectly delivered material. To avoid human errors, it makes sense to introduce automation in the processes that minimize the mislabeling of finished products (for example, by implementation of EoL system. An important possibility for the company is also the optimization of the SCM, raw material deliveries, ordering process for returnable and non-returnable packaging (which also affects the need for storage space in the warehouse).

THREATS:

One of the possible threats to the company was identified as rapid technological progress in the automotive market, possible changes in trends with a change in the vector of development. Also, on the side of communication with the customer on quality issues, there is a risk of losing the high ranking as a responsible supplier, which may affect the prolongation of long-term contracts. The risk of stopping the customer's production line, with penalties of 1 minute – could be up to 50,000 EUR, in case of failure to deliver on time can lead the company to millions of dollars in losses. And threats from regulatory changes (for product or material use). It was also revealed that the company underestimated the impact from the transfer, to keep a stable and smooth operations. The company's approach to the supply chain appears to focus on individual components rather than viewing it as a cohesive system. Enhancing the understanding of the fundamental aspects, such as planning production, determining packaging material quantities, and prioritizing initial material production, would contribute positively. Addressing questions about post-use fees for disposable packaging in case of delayed returnable packaging delivery and optimizing invoice amounts for returnable packaging can safeguard the company's financial interests in well-managed processes.

3.4 Problem definition: case 1 - Lack of footprint space

As was mentioned in chapter 3.2, during 2022 company XY has been involved in the process of transfer, when one of the company’s divisions in UK was closed on September 2022, and most of equipment, facilities, stock, components, semi-finished parts, and the majority liability was relocated to Czech Republic. One year was not enough for a smooth and seamless transfer, due to facilities and machine park with more than 20 units of workstations. For the beginning 2022, plant size is approximately 5,000 m2. Figure 13 shown current layout material flow, where:

1 - receipt of material,

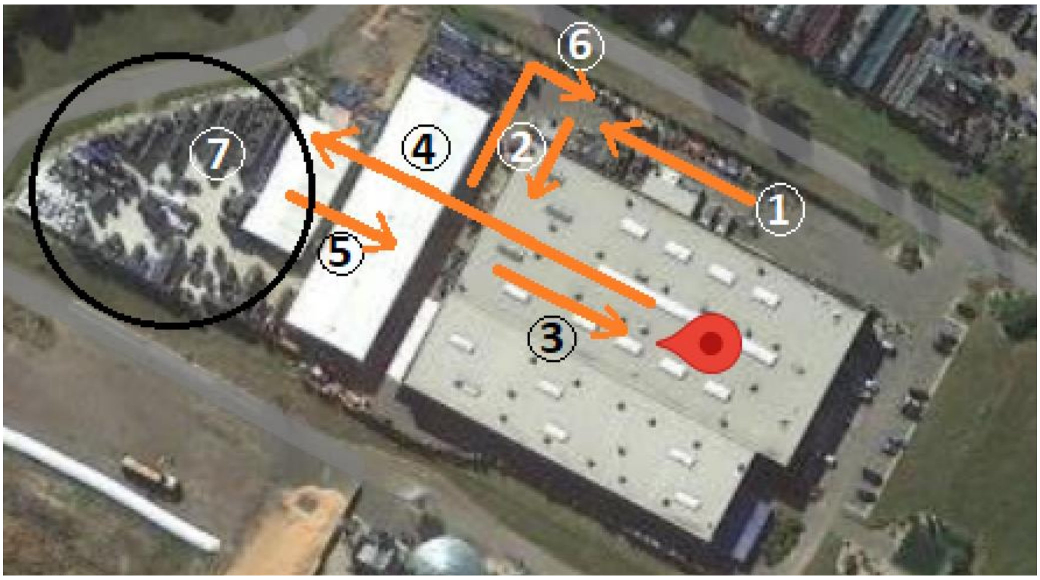
2 - placement of material in the warehouse,

3 - material flow to production,

4 - flow of finished/semi-finished goods to the warehouse,

5 - transfer of material for preparation before shipment,

6 - material dispatch.



Source: (Company XY, 2023)

Figure 13 Current layout of material flow

Figure 13 also shows the area (No. 7), which was put into operation from February 2022 as an additional outdoor storage space, as a preparatory stage for the transfer of equipment and the need for additional storage space (before that the plant area was 4,000 m2), the company was able to find an opportunity with the landlord of the plant and get another 1,000 m2 for use. On that territory there were also installed two tents with area of 450 m2 and 300 m2 (included in the obtained 1,000 m2) for closed storage of finished and semi-finished products. Monthly rental costs are shown in the costing in Appendix 1.

Previously, the territory behind the plant was not used, so it has taken 3 months to expand the space, install the necessary utilities, strengthen the floor (pouring asphalt). According to the agreement, the financial costs were borne by the landlord. After commissioning, pallets were moved to this place, which could be stored without temperature control. Figure 14 shows footprint space before and after commissioning.

Source: (Company XY, 2022)

Figure 14 Commissioning of additional area

At the time of the highest tension from moving the equipment and its parallel operation, in September 2022, it became obvious that the previous actions taken to increase the space were not enough. The correct organization of the space was disturbed, the flow of material between the warehouses was disrupted, manufactured products and semi-products were lost and due to the inability to place the material correctly, to make a specific regal, to enter the movement data in the SAP, an urgent decision was made to put into operation an external warehouse. Taking into account the lack of high offer on the market, the most optimal in terms of location, size and cost, within a month, in October 2022 was launched an external warehouse No.1 in 10 km away from the plant.

Technical parameters of warehouse No. 1:

Total area: 4,750 m2, cost for 1m 2 – 5,50 EUR, of which 30%, 1,450 m2 - unutilized, as it occupies technical communication, aisles for the passage of the forklift truck, and narrow corridors. The warehouse is divided into two areas, 2,375 m2 each: the first with the ability to store material in pallets with density 1+1, the second - with density 1+3. The new warehouse's ability to stock – 2,200 pallets.

In addition, the rent cost of the warehouse includes the cost of staff labor, forklift truck, garbage disposal, utility bills, etc. In Appendix 2 shows the calculation for the new warehouse area.

Also, considering the distance of the warehouse from the factory, there is a demand for two truck drivers. On the Appendix 2 the costs for one of the drivers for 2022 and 2023 are shown, in the calculation the sum of coefficient 1.5 is considered, because not all 100% of the time in the shift they worked for the transportation of material from/to the external warehouse. Driver No.2 on average receives the same wage for his services as driver No.1, so the data for the second driver can be considered similar.

Also, after the successful commissioning of the external warehouse, the management of the company decided to hire external warehouse No.2, from November 2022, with a cost per m2 – 3,00 EUR, to store there the material to be sold as spare parts for aftermarket. The frequency of shipment of the material placed in this warehouse is rare, and the volume occupied in external warehouse No. 1, with a cost per 1 m2 - 5,50 - is not profitable.

Technical parameters of warehouse No. 2:

Total area: 2,000 m2, cost for 1m2 – 3,00 EUR. Stack ability to store material in pallets - 1+1. The warehouse No.2 ability to stock – 2,200 pallets.

In Appendix 2 shows the calculation for the warehouse No.2. Please consider the monthly rent for the warehouse of 6,806 EUR as an equal payment for 2,000 m2. The remaining amounts included in the calculation in 2023 are related to the additional goods and services not related to the warehouse rent.

Based on the above-mentioned information that XY Company faced last year, as well as on the SWOT analysis that highlighted this space challenge, this problem has been taken into consideration, and it is this problem with the extra high cost for storage space and transportation that will be considered, and optimization will be proposed in the next chapter.

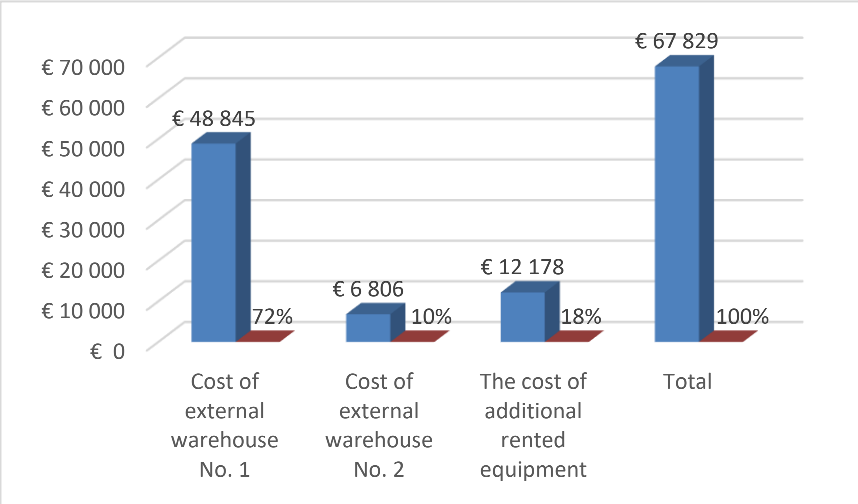
In addition, the final calculation with the current costs of storage space is presented:

Cost of external warehouse No. 1 - 48,845 EUR,

Cost of external warehouse No. 2 – 6,806 EUR, The cost of additional rented equipment for warehousing at the plant – 12,178 EUR.

Total monthly costs for the company's warehousing needs: 67,859 EUR.

Figure 15 shows the visualization the presented data before the optimization:



Source: (own contribution, 2023)

Figure 15 Presented data before optimization

As we can see, the cost of external warehouse No. 1 consumes 48,845 EUR per month, what is 72% overall from the monthly expenditures for a warehousing. Based on the results, a problem has been identified that requires improvement soon. It is obvious that payment for the service of warehouse No. 1 is very high. Chapter 4.1 will suggest solutions to reduce these costs.

3.5 Problem definition: case 2 - Process of HU backflushing & label printing while offline production

As was described in chapter 3.3, the SWOT analysis highlighted another stage in production that needs optimization and process improvement, and it is related to repetitive claims for mislabeled materials at one of the washing tank production workstations. The company uses pre-printed labels for offline production to prepare the finished product at this workstation. However, the current process is error-prone, particularly mislabeling, which occurs when operators have to pick up labels from the team's shift office during product preparation. Offline production can pose challenges related to data accuracy, real-time visibility, and the ability to respond promptly to changes in the production environment. It may also lead to situations, as described in your previous scenario, where operators face difficulties in accessing pre-printed labels or other necessary information in real-time, leading to errors and inefficiencies. This manual involvement not only creates the potential for errors, but also results in a significant loss of time. The consequences of mislabeling lead to repeated complaints from customers, highlighting the need for workflow optimization and automation.

That's why implementing automation is critical. Implementing automation and integrating offline production processes with SAP systems can help address these challenges by providing real-time data synchronization, improving accuracy, and ensuring better control over production activities. This integration is often crucial for maintaining consistency, traceability, and efficiency in manufacturing operations.

Today the process of production and preparation of washing tanks at the workstation is as described below:

1. The semi-finished parts arrive at the workstation,
2. Following the technological assembly process, the washing tank is assembled manually,
3. Manual labeling of the sticker with barcode on each washing tank (label contains data and time of production),
4. Packing the washing tanks according to the packing instruction, 6 pieces per packaging unit,
5. Operator leaves the workstation for: going to the team shift leader's office to pick up the production label / to the team leader who has a scanner / to solve a problem with a scanning poka-yoke error (in case of unsuccessful HU backflushing to SAP),
6. After the production label is placed and fixed on a packaging unit, and the poka-yoke is successfully done, the pallets with the material are transferred to the warehouse for further storage.

As we can see from the process analysis, it is at step 5, when the operator leaves the workstation in search of what is needed to complete the finished product registration process, that the potential mislabeling error occurs, as well as the loss of searching time.

By implementing the new system, which will help to achieve the traceability at the workstation, there are two main problems to be solved:

- Automatic HU creation for production Backflush of finished or semi-finished products as soon as the packing unit is complete.
- Automatic printing of respective HU labels.

After negotiation and analyzing the data received from other company divisions with a similar production group, several proposals with different investment costs for implementation were received. The most optimal for the company at the moment was the solution with the lowest investment cost, namely the implementation of EoL. The EoL is not only a technical solution or a simple application transaction, but also process used in other sister's plant. More details about the cost and description of the technical process will be described in chapter 4.2.

4 Improvements suggestions: implementation of new processes

Chapter 4 will present proposals and steps, which based on the analysis of the situation can help the company to optimize the cost of storage space, to accelerate the flow of material from the reception, warehouse to the use of production, as well as to optimize the costs that the company carries due to disruptions in the supply of returnable packaging, to improve the process of communication with the supplier of disposable cardboard, thereby reducing the stock in the warehouse on the territory of the company XY.

Before making proposals and suggestions, negotiations were also held with representatives of the company from other divisions, and their experience in solving additional problems was taken over in this thesis.

4.1 Process optimisation: case 1 - Warehouse space optimization

Based on the experience of preparing for the transfer, the big advantage of the landlord was that he is open to negotiations, and if it is possible, to expand the territory for his client.

Since the beginning of 2023 - the negotiation process with the landlord was started. After that, it was successfully agreed to allocate to the needs of the company XY an area in front of the factory, in 10 meters away from the production facility, with a size of 30x42 m (1,260 m2), which at that time was not used.

Considering the experience of temporary solution, the installation of a tent was not considered for the following reasons: high humidity, leaking from the roof, cold, no electricity (without the possibility of moving employees and connecting machinery), this time it was decided to build a full-sized construction and communications.

Taking into account the analysis of costs for two external warehouses, rental of equipment for the installation of tents, high wages for drivers, loss of time for the transportation of material, taking into account the availability for planning and use of the area near the plant, it was decided to develop a project with the construction of a maximum capacity warehouse to store 2,200 pallets (which would completely end the cooperation with warehouse No. 1, the costs of which reach 49,000 EUR.

A contractor who specializes in the construction of warehouses has been engaged in the negotiations and is ready to offer a complete package of services (from the design of the project to the purchase of all other equipment - regals and forklift.

Annex 4 shows the project plan.

The cost of the construction of this object is not disclosed and was fully taken on the side of the landlord (with the subsequent lease).

Technical characteristics of the project:

Total area: 1,260 m2 in 10m away from the plant facilities, cost for 1m2 – 4,99 EUR. – 5 years fix, termination – 6-month, inflation not considered. Ability to store pallets with density 1+6. The total warehouse's ability to stock – 2,200 pallets. Time - 10 month for project implementation. Figure 16 shows the visualization for a new warehouse.

Source: (Company XY, 2023)

Figure 16 Visualization of new warehouse project

Figure 17 shows the new layout material flow, where:

1 - receipt of material,

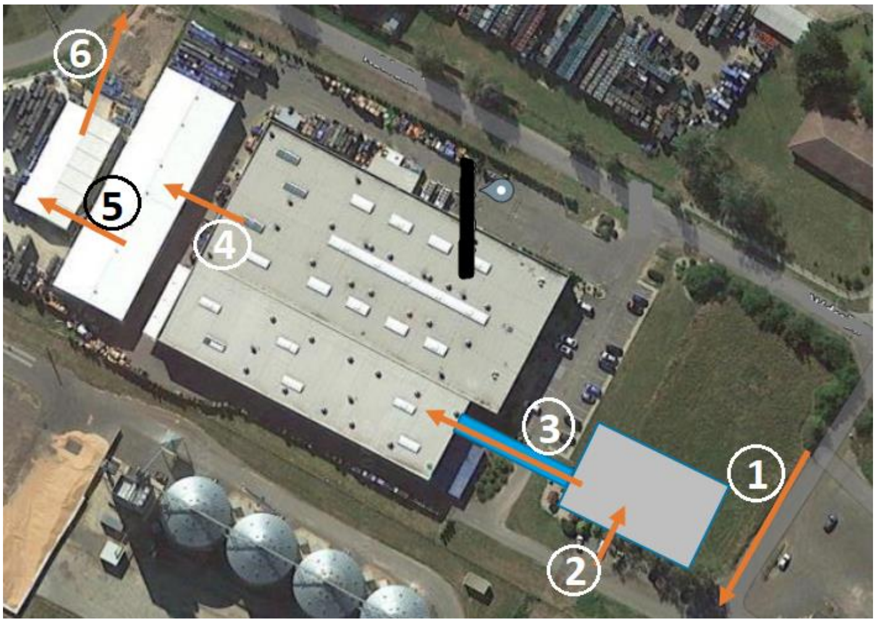
2 - placement of material in the warehouse,

3 - material flow to production,

4 - flow of finished/semi-finished goods to the warehouse,

5 - transfer of material for preparation before shipment,

6 - material dispatch (new exit for loaded truck created).



Source: (Company XY, 2023)

Figure 17 New layout of material flow

The final calculation with the costs for suggested warehouse is presented:

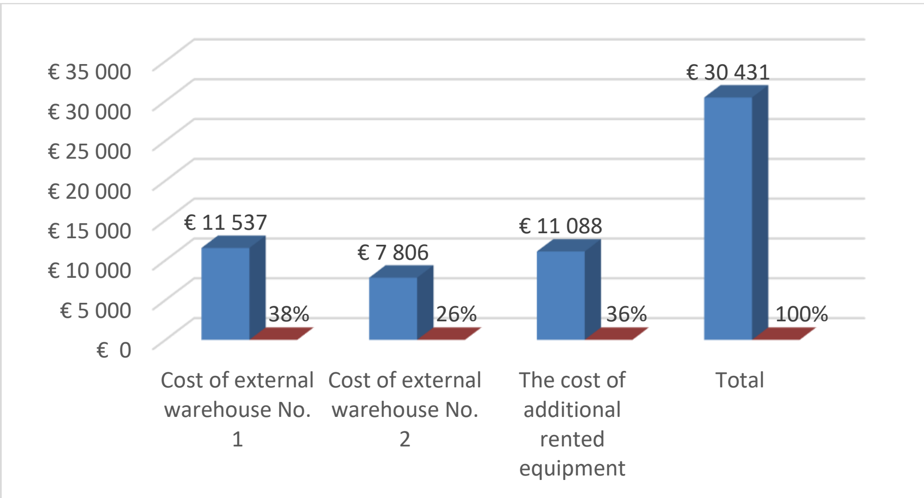
Cost of new own warehouse – 11,537 EUR,

Cost of external warehouse No. 2 – 7,806 EUR,

The cost of additional rented equipment for warehousing at the plant – 11,088 EUR.

Total monthly costs for the company's warehousing needs: 30,431 EUR.

Figure 18 shows the visualization the presented data after the optimization:



Source: (own contribution, 2023)

Figure 18 Presented data after optimization

As we can see, the new cost of the newly built external warehouse No. 1 (next to the production facilities of the company XY) will consume 11,537 EUR per month, what is 38% overall from the monthly expenditures for a warehousing. Based on chapters 3.4 and 4.1, evaluation of suggested improvements and identification of the benefits from it will be presented in chapter 5.1.

4.2 Technological optimisation: case 2 - Process optimization while implementing EOL – for HU backflushing & label printing

The theoretical part about an EOL system is described in more detail in chapter 2.2. These systems are different and offer the user a solution to a different problem. The company does not have a goal to reduce the number of employees and replace them with machinery, but because of certain financial difficulties the installation of a fully functional EOL system is very expensive for the company at this time.

However, one of the company's divisions has shared a solution that has been put into operation with minimal cost.

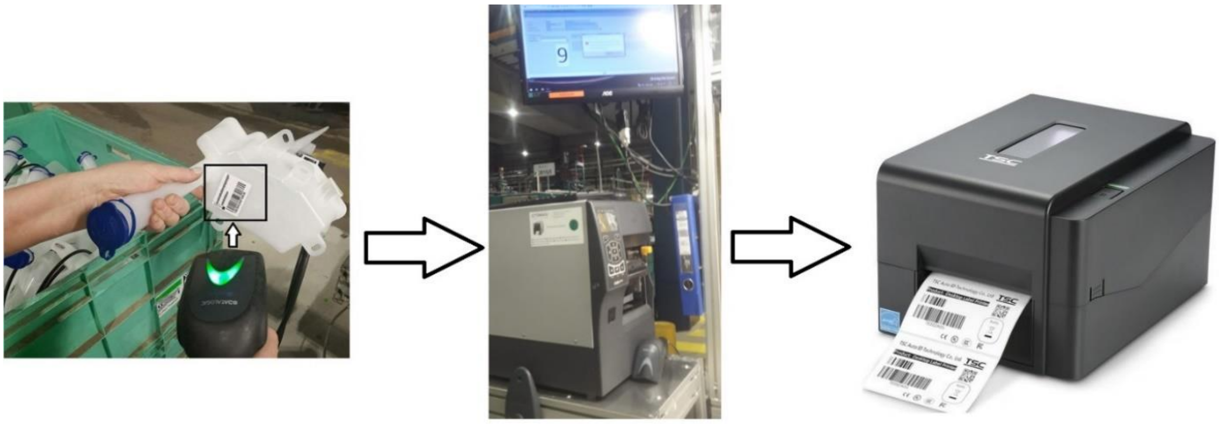
The solution is described below:

Additional equipment is installed near the workstation, the main of which is a new user in the SAP system (under whose login all the work on material production will take place, all now it will be fully online production with the availability of relevant real-time data).

Also, the following additional equipment should be installed at the workstation:

- PC (incl. monitor, keyboard, mouse)
- hand scanner,
- thermo printer.

A visualization of the new process can be shown in Figure 19:

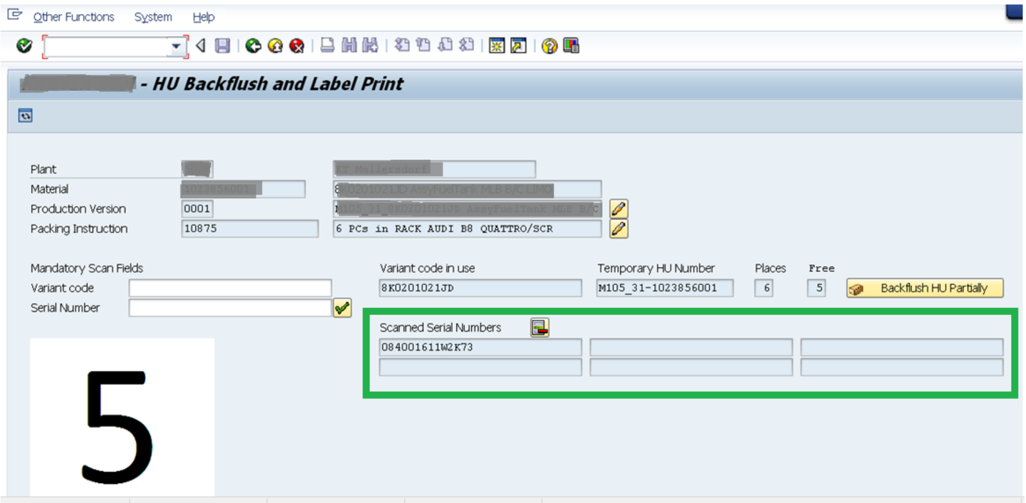


Source: (Company XY, 2023)

Figure 19 Visualization of the new backflushing process

After the implementation of EoL system, production, and preparation of washing tanks at the workstation is as described below:

1. At the beginning of each shift, team shift leader helps to the switch on the PC and enter the required transaction at the software (each shift – individual access),
2. The semi-finished parts arrive at the workstation,
3. Following the technological assembly process, the washing tank is assembled manually,
4. Manual labeling of the sticker with barcode on each washing tank, and then to scan it immediately before to put the finished and scan wash tank into the packaging unit,
5. At the monitor in front of the operator, he can see the data in real-time, and to see which HU (small stickers with barcode was already scanned and placed into the packaging unit. Figure 20 shows the data visible at the screen,



Source: (Company XY, 2023)

Figure 20 Input screen

6. Packing the washing tanks according to the packing instruction, 6 pieces per packaging unit,

7. After scanning the last 6-th barcode on the wash tank, the system automatically backflushing the HU for a single packaging unit as a finished product and prints a production label. The figure 21 shows the production label printed as "online production",

Source: (Company XY, 2023)

Figure 21 Automatically printed production label

8. After the production label is placed and fixed on a packaging unit, and the poka - yoke is successfully done (for a production validation of the produced parts), the pallets with the material are transferred to the warehouse for further storage.

The calculation for that solution implementation is shown at Appendix 5.

Table 3 shows the one-time cost for equipment purchasing, which is equal to 580 EUR.

Table 3 One time cost for EoL inplementation

Item	Cost
LCD	€ 125
Printer	€ 330
USB scanner	€ 125
Total one time investment:	**€ 580**

And, at the table 4 shows the runtime costs, for a monthly basis is costs for a company XY 167 EUR.

Table 4 Run time cost for EoL inplementation

Item	Cost
PC rental, licenses, patching	€ 63
SAP user license	€ 104
Monthly cost:	**€ 167**

Considering the average cost of penalties from the customer for mislabeling material in the average 300-400 EUR for one single claim (practicality, up to 2 claims per month), as well as the loss of time to solve operational problems arising with production label backflushing, the monthly cost of maintenance of the implemented system is insignificant, taking into account the obtained results and increasing the efficiency of the workstation on productivity per shift.

Based on chapters 3.5 and 4.2, a more detailed evaluation of suggested improvements and identification of the benefits from it will be presented in chapter 5.2.

5 Evaluation of suggested improvements

Based on the previous chapters, taking into consideration the given results, in this chapter will be described a final evaluation of suggested improvements for a company XY.

5.1 Case 1 - Warehouse space optimization

Based on this proposal, as well as the costing of the new warehouse, when considering all the costs of construction and commissioning of the new warehouse, which in many respects wins in comparison with the current situation, the main indicators were considered when agreeing on this project, summarized benefits of main and additional services are shown at the Table 5.

Table 5 Summarized evaluation from the suggested improvements (overall)

	Cost before	**Cost after**	**Optimization, %**	**Optimization, Eur**
Cost of external warehouse No. 1 (inc. shutt. serv.)	€ 46,875	€ 11,537	-75,4%	€ 35,338
Cost of external warehouse No. 2 (inc. shutt. serv.)	€ 8,806	€ 7,806	-11,4%	€ 1,000
The cost of additional rented equipment	€ 12,178	€ 11,088	-9,0%	€ 1,090
Total	**€ 67,859**	**€ 30,431**	**-55,2%**	**€ 37,428**
Using of overall warehousing area, **m2**	11,670	6,592	-43,5%	5,078
Stuttle service (number of drivers)	2	1	-50,0%	-
Shuttle service (overall for 2 drivers):	€ 13,336	€ 1,000	-92,5%	€ 12,336
among them cost for a shuttle for warehouse #1	€ 11,336	€ 0	-100,0%	€ 11,336
among them cost for a shuttle for warehouse #2	€ 2,000	€ 1,000	-50,0%	€ 1,000

Besides, the main benefits can be identified the following:

- closeness to the factory - eliminating the need for 1 driver, reducing the cost from 13,336 EUR to 1,000 EUR) – **92,5%** of optimization,
- The entire cost of the investment project: development, engineering, implementation, contractor costs for 10 months of construction, equipment (2 modern forklifts) - all at the expense of the landlord’s side,

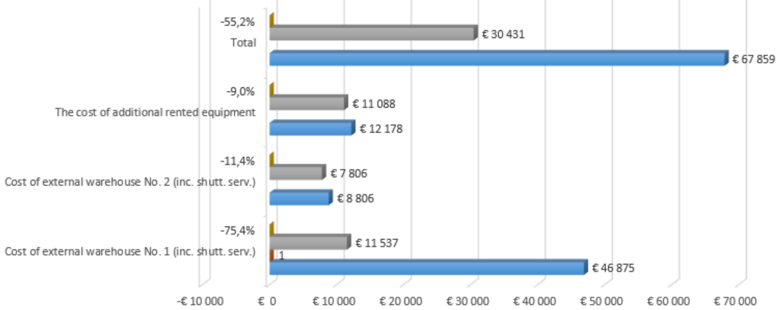
- Transition from external warehouse №1 to own warehouse near the plant, reducing the cost from 46,875 EUR to 11,537 EUR) – **75,4%** of optimization after the suggested solution,
- Total reduction of warehouse costs, including external warehouses, transportation services and services for rented tents, from 67,859 EUR to 30,431 EUR per month – **55,2%** of optimization,
- reduction of the number of rented footprint space with the same efficiency, to keep in the main warehouse 2,200 pallets (from 11,670 m2 to 6,592 m2) – 43,5% of optimization,
- cost per 1m2 - 4,99 EUR compared to the old price of 5,50 EUR, with reduction of rented footprint area from 4,750 m2 to 1,260 m2,
- a fully electrified space - the possibility of working part of the logistics department - ccreating a more comfortable working area for expedition department employees,
- optimization of material flow from the moment of receipt to the moment of shipment.

Total monthly costs for warehousing before optimization: 67,859 EUR.

Total monthly costs after suggested optimization: 30,431 EUR**.**

Saving from this case implementation: 37,428 EUR, decrease of the monthly expenditures of 55,2 %

More specifically, a graph showing visually the changes in the value of the 3 main warehouses is shown at Figure 22.



Source: (own contribution, 2023)

Figure 22 Evaluation of improvments, case 1

5.2 Case 2 - Process optimization while implementing EOL – for HU backflushing & label printing

Based on this proposal of implementation for EoL system for backflushing and label printing right at the workstation where the goods are assembling, taking info account the annual cost 2000 EUR for using this system (at Annex 5 shown the annual cost), it can be said that a monthly cost in 167 EUR costs the company twice as much as one potential complaint from a customer (300-400 EUR on average). And if possible, fines for stopping the production line at the customer's place of assembly, where the cost of 1 minute of downtime is 50,000 EUR, the monthly maintenance costs of this solution of 167 EUR per month (and 2000 EUR per year) can be considered a perfect achievement. Table 6 shows the calculation with runtime cost, what is optimistic scenario.

Table 6 Cost for EoL implementation

Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Total per year**
2023									€ 747	€ 167	€ 167	€ 167	**€ 1,247**
2024	€ 167	€ 167	€ 167	€ 167	€ 167	€ 167	€ 167	€ 167	€ 167	€ 167	€ 167	€ 167	**€ 2,000**
2025	€ 167	€ 167	€ 167	€ 167	€ 167	€ 167	€ 167	€ 167	€ 167	€ 167	€ 167	€ 167	**€ 2,000**

Anyway, let's check the two possible pessimistic scenarios if there is no implementation of EoL. Scenario 1, see table 7 - odd month - two complaints, even month - 1 complaint. The average cost of one complaint is 300 EUR.

Table 7 Scenario 1

Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Total per year**
2024	€ 600	€ 300	€ 600	€ 300	€ 600	€ 300	€ 600	€ 300	€ 600	€ 300	€ 600	€ 300	**€ 5,400**
2025	€ 600	€ 300	€ 600	€ 300	€ 600	€ 300	€ 600	€ 300	€ 600	€ 300	€ 600	€ 300	**€ 5,400**

Scenario 2, see table 8 - odd month – one complaint, even month - 0 complaint, but once a year - stopping the production line at the customer's place of assembly for 2 minutes. The fine cost of a stop for a 1 minute – 50,000 EUR.

Table 8 Scenario 2

Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Total per year**
2024	€ 300	€ 0	€ 300	€ 0	€ 300	**€ 100,000**	€ 300	€ 0	€ 300	€ 0	€ 300	€ 0	**€ 101,800**
2025	€ 300	€ 0	€ 300	€ 0	€ 300	€ 0	€ 300	€ 0	€ 300	**€ 100,000**	€ 300	€ 0	**€ 101,800**

As we can see, the three possible scenarios are possible to become a reality, once the operators will mismatch the production labels, due to leaving the workstation. Table 9 shows the comparison of three scenarios.

Table 9 Comparison of a few scenarios

Type	**Optimistic scenario**	**Pessimistic scenario #1**	**Pessimistic scenario #2**
Year	Total per year	Total per year	Total per year
2024	€ 2,000	€ 5,400	€ 101,800
2025	€ 2,000	€ 5,400	€ 101,800

From the final evaluation its better in exclude the Pessimistic scenario #2 as it is too extreme. Table 10 show the evaluation of the optimistic scenario after the suggested improvements of EoL system, and the pessimistic scenario #1, as a as the situation if no improvements are made.

Table 10 Summarized evaluation from the suggested improvements

Type	**Optimistic scenario**	**Pessimistic scenario #1**	**Optimization in %**	**Optimization in eur.**
Year	**Total per year**	**Total per year**	**Total per year**	**Total per year**
2024	€ 2,000	€ 5,400	-63%	€ 3,400
2025	€ 2,000	€ 5,400	-63%	€ 3,400

The main benefits from such a solution can be identified the following:

Total annual costs for a regular claim for a mislabeling of a final goods (mismatch delivery to a customer) before optimization: **5,400 EUR /year.**

Total annual costs after suggested optimization (for a run time cost for a EoL): 2,000 EUR /year**.**

Saving from this case implementation: 3,400 EUR /year, decrease of the annual expenditures of 63 %.

Besides, additional benefits can be identified the following:

- Traceability Improvement: Automation facilitates enhanced traceability throughout the production process, ensuring accurate recording and tracking of materials and products.
- Time Savings: Automation reduces the time spent on label retrieval, allowing operators to focus on productive tasks, thus increasing overall efficiency.
- Error Minimization: Poka-yoke scanning and automation contribute to a significant reduction in mislabelling, leading to fewer customer claims and improved product quality.
- Cost-Efficiency: By reducing labour costs and minimizing errors, the proposed automation aims to contribute to the overall cost-efficiency of the production process.
- Enhanced Customer Satisfaction: A more reliable and efficient production process is expected to result in higher customer satisfaction and a reduction in customer claims.

As a result, implementing automation in the HU backflushing and label printing process at company XY offering a comprehensive solution to enhance efficiency, reduce errors, and improve overall productivity.

Conclusion

The main purpose of the thesis is to analyse the current state of the company XY, to identify weaknesses and to suggest ways to improve where it is possible, and to upgrade the processes while implementation of process or technological solutions.
In todays paced business world it is crucial for companies to stay ahead by incorporating both advancements and process innovations. By embracing these changes company can boost their efficiency and quickly adapt to the ever-changing market conditions. By adopting innovations companies do not establish themselves as industry frontrunners but also equip themselves with the flexibility to meet customer demands effectively. This ensures their long-term success. Competitiveness in a challenging market environment.
The study aims to identify the key theories and concepts and to develop a theoretical framework that can guide the research process, to suggest how to increase efficiency, and evaluate the potential benefits of their use.
In this thesis, in the first chapter, it has been possible to collect relevant theoretical knowledge in the field of logistics and supply chain management in the automotive industry, to identify its components and the key challenges that first-tier suppliers currently face.
In the second chapter the main trends in technological innovations in logistics were collected, new tools that help companies to improve their performance in the supply chain were described. In the third chapter of this thesis was described the selected company for the study, its specifics of work, the current state, the method of SWOT analysis were identified weaknesses of the company, as well as areas that require immediate intervention and their improvement - these are two cases - lack of storage space as well as the implementation of the EOL system. In the fourth chapter on the basis of deep consideration of the situation, taking into account the received theoretical knowledge were given measures to improve and optimize the provisions, which in the fifth chapter showed very positive results at minimal cost to the company.
Just following trends and innovations can help the company not to get into a crisis, to improve existing processes, to get rid of unnecessary destructive costs, and to use the free up finances in the future for business development and increasing profits in the future.

Bibliography

6 Benefits of Inventory Management for Automotive Supply Chains [online], 2021. 2021-04-08 [cit. 2023-11-12]. Dostupné z: https://www.itconvergence.com/blog/6-benefits-of-inventory-management-for-automotive-supply-chains/

Association Climate Review 2023. 2023, 2023-05-02. [online]. Dostupné z: https://www.volkswagen-group.com/en/reporting-15808. [cit. 2023-11-11].

CSCMP Supply Chain Management Definitions and Glossary of Terms [online]. Copyright © 2022 Council of Supply Chain Management Professionals [11.11.2023]. Dostupné z: https://cscmp.org/CSCMP/Educate/SCM_Definitions_and_Glossary_of_Terms.aspx

DRAKE, Matt. Global Supply Chain Management. Business Expert Press, 2011. ISBN 978-1-60649-276-5.

DRUCKER, Peter. Innovation and Entrepreneurship. 1. vyd. Oxford: Elsevier Ltd., 1985. ISBN 978-0-7506-8508-5.

EBRAHIMIARJESTAN, Mina and WANG, Guoxin, 2017. Determining decoupling points in a supply chain networks using NSGA II algorithm. Online. Journal of Industrial Engineering and Management. 2017-05-15, roč. 10, č. 2, s. 352-372. Available at: https://doi.org/10.3926/jiem.2158.

GROS, Ivan. Velká kniha logistiky. Praha: Vysoká škola chemicko-technologická v Praze, 2016. ISBN 978-80-7080-952-5.

HEIZER, Jay; RENDER, Barry and MUNSON, Chuck, 2016. Operations Management: Sustainability and Supply Chain Management, Student Value Edition. 12th Edition. PEARSON. ISBN ISBN 0915299-14-3.

HOLMAN, David, Pavel WICHER, Radim LENORT, Venuše DOLEJŠOVÁ, David STAŠ a Ioana GIURGIU. Sustainable Logistics Management in the 21st Century Requires Wholeness Systems Thinking. Sustainability [online]. 2018, 10(12) [cit. 2023-05-09]. ISSN 2071-1050. Dostupné z: doi:10.3390/su10124392

HUGOS, M. H. Essentials of supply chain management 4th Edition. New Jersey: John Wiley & Sons, Inc., Hoboken, 2018. ISBN 978-11-1946-110-4

CHRISTOPHER, Martin. Logictics and Supply Chain Management: Creating Value-added Networks. London: Pearson Education, 2005. ISBN: 0-273-63049-0.

KOSHELIEVA, Olena, Seminar work "Identification of SCM and LEAN principles in Supply chain of ZARA company", April 2022, ŠAVŠ.

KULKARNI, Amit. Toyota Production System [online]. 25.01.2016 [cit. 2023-11-12]. Dostupné z: https://worldofagile.com/blog/toyota-production-system/

KUMAR DAS, Suman, 2016, Design and methodology of Automated Guided Vehicle-A Review. IOSR Journal of Mechanical and Civil Engineering. 2016. Vol. 03, no. 03, p. 29–35. DOI 10.9790/1684-15010030329-35.

Lean Compass [online]. Neunkirchen: Lean Compass, 2022 [2023-11-20]. Dostupné z: https://lean-compass.com/takt-principle/.

LEE, Hau L.; PADMANABHAN, V. and WHANG, Seungjin, 2015. The bullwhip effect in supply chains. Online. IEEE Engineering Management Review. Roč. 43, č. 2, s. 93. Available at: https://doi.org/10.1109/EMR.2015.7123235.

LENORT, Radim, Andrzej BUJAK, Ingo GESTRING, et al. *Sustainable solutions for supply chain management*. [Passau]: rw&w Science & New Media, 2017. ISBN 978-3-946915-17-1.

MALAVIYA, Jay. Smart Solution for Supply Chain Challenges in Automotive Industry. 2018, 2018-07-16. Dostupné z: https://medium.com/@jaymalaviya/smart-solution-for-supply-chain-challenges-in-automotive-industry-2d7e99dbbbe9. [cit. 2023-11-11].

MITYUSHENKOV, Alexey. The Importance of Supply Chain in modern economy [online]. 2023, 27.03.2023 [cit. 2023-11-12]. Dostupné z: https://www.linkedin.com/pulse/importance-supply-chain-modern-economy-alexey-mityushenkov

MORANA, Joëlle. Sustainable Supply Chain Management. John Wiley & Sons, Incorporated, 2013. ISBN 978-1-84821-526-9.

NAKANO, Mikihisa. *Supply Chain Management: Strategy and Organization.* Singapore: Springer Nature Singapore, 2020. ISBN 978-981-13-8478-3.

ONO, Taiichi a BODEK, Norman. Toyota Production System: beyond Large-Scale Production. Boca Raton: CRC Press, 1988. ISBN 0915299-14-3.

Project 2049, Institute and US-Taiwan Business Council. "United States, Taiwan, and Semiconductors: A Critical Supply Chain Partnership". January 2024. www.us-taiwan.org/wp-content/uploads/2023/06/2023.06.21-Final-Semiconductor-Report.pdf

RUSHTON, Alan, Phil CROUCHER a Peter BAKER, 2014. The handbook of logistics and distribution management. 5th ed. London: Chartered Institute of Logistics and Transport. ISBN 978-0-7494-6627-5.

SMITH A, Thangarajoo Y, 2015. Lean Thinking: An Overview. Industrial Engineering and Management [online]. 04(02) [cit. 2023-11-12]. ISSN 21690316. Dostupné z: doi:10.4172/2169-0316.1000159

Survey finds auto industry hit hardest by supply chain disruptions during Covid pandemic , 2021, https://www.cnbc.com/2021/08/25/auto-industry-supply-chains-hit-hardest-during-covid-pandemic-survey.html

Sustainability at the heart of the NEXT LEVEL – ŠKODA STRATEGY 2030. Sustainability at the heart of the NEXT LEVEL – ŠKODA STRATEGY 2030 [online]. 2022, 2022-09-21 [cit. 2022-11-11]. Dostupné z: https://www.skoda.co.uk/news/details/skoda-presents-roadmap-for-sustainable-mobility

VANCEA, A. P. and ORHA, I., 2019, A survey in the design and control of Automated Guided Vehicle Systems. Carpathian Journal of Electronic and Computer Engineering. 2019. Vol. 12, no. 2p. 41–49. DOI 10.2478/cjece-2019-0016.

VEBER, Jaromír. Management inovací. Praha: Management Press, 2016. ISBN 978-80-7261-423-3.

KANNA NAMADEVAN, Yuvanesh, 2023. Use of Unit Load AGVs for Picking Cart Handling. Diploma Thesis. Mlada Boleslav: Škoda Auto Vysoká škola o.p.s.

List of figures and tables

List of figures

List of tables

List of appendices

Appendix 1 Current cost for warehousing before optimization

External warehouse cost = 47.328 EUR (thereof Warehouse cost = 35.539 EUR) (base for calculation)

Total cost						
Item	**Space**	**Meas. unit**	**Price**	**cost**	**Total Cost**	**Comment**
Warehouse space	4750	m2	5,50	€/m2/month	€ 26 125	Inside used area for 2200 pallets
Outside area	40	m2	1,10	€/m2/month	€ 44	Empties + scrap
Outside area	150	m2	1,10	€/m2/month	€ 165	Unloading / loading area
Energy					€ 2 106	Gas + electricity
Cleaning services					€ 98	Cleaning 2 x week, 1,5 hour
Waste disposal					€ 32	Monthly 1x1100L plastic, 1x1100L general waste + transport
Handling forklift cost					€ 3 205	Hourly rate 310 czk + 50 czk FTL
Log. Operator + handler					€ 3 764	Hourly rate 290 czk
Shuttle service (overall for 2 drivers)		coef. 1,5			€ 13 336	was used for a services from warehouse #1, and 15% for a services from warehouse #2.
Cost for a shuttle for warehouse #1					€ 11 336	
Cost for a shuttle for warehouse #2					€ 2 000	
Total cost for service	4940				**€ 48 875**	
Ext. warehouse #2	2000	m2	3,0	€/m2/month	**€ 6 806**	For a service parts (low running) + 806 eur (energy, waste disp., etc)

Cost of other logistics areas within plant = **12.178 EUR**

Supplier	Description	Specification	Space, m2	Cost, €	Cost/month
Company ABC	Large tent	20x60m	1280	5,30	€ 6 784
Company ABC	Outside area for WIP	concrete space	2700	1,10	€ 2 970
Company XYZ	Small tent 1	50x30x4m	450		€ 1 390
Company XYZ	Small tent 2	15x20x4m	300		€ 1 034
Total m2			4730	**Total cost for service**	**€ 12 178**

Grand Total cost = 67.859 EUR

Appendix 2 Cost for warehouse №1 and №2 (inc. transport services)

External warehouse No. 1, eur

Year	1	2	3	4	5	6	7	8	9	10	11	12	Average	Total per year
2022	x	x	x	x	x	x	€ 12 597	€ 12 597	€ 12 597	€ 12 597	€ 12 597	€ 12 597	**€ 12 597**	€ 75 582
2023	€ 44 578	€ 43 002	€ 41 547	€ 33 778	€ 32 803	€ 27 027	€ 25 717	€ 25 773	€ 25 512	x	x	x	**€ 33 304**	€ 299 737

Driver No. 1 - transport services, czk

Year	1	2	3	4	5	6	7	8	9	10	11	12	Average, czk:	Average, eur:	Total per year
2022	91 960 CZK	95 590 CZK	115 555 CZK	78 650 CZK	125 840 CZK	107 690 CZK	99 825 CZK	262 570 CZK	320 650 CZK	323 675 CZK	333 355 CZK	213 565 CZK	180 744 CZK	**€ 7 531**	€ 90 372
2023	359 975 CZK	256 520 CZK	243 790 CZK	208 337 CZK	218 356 CZK	197 496 CZK	164 487 CZK	181 475 CZK	187 792 CZK	164 487 CZK	164 487 CZK	x	213 382 CZK	**€ 8 891**	€ 97 800

External warehouse No. 2, eur

Year	1	2	3	4	5	6	7	8	9	10	11	12	Average, czk:	Average, eur:	Total per year
2022	x	x	x	x	x	x	x	x	x	x	163 350 CZK	163 350 CZK	163 350 CZK	**€ 6 806**	€ 13 613
2023	167 222 CZK	197 774 CZK	481 615 CZK	397 400 CZK	426 222 CZK	405 011 CZK	417 280 CZK	406 693 CZK	404 043 CZK	x	x	x	367 029 CZK	**€ 15 293**	€ 137 636

Appendix 3 New cost for warehousing after optimization

New warehouse cost = 19 343 EUR (included external warehouse #2 for service parts 2000m2)

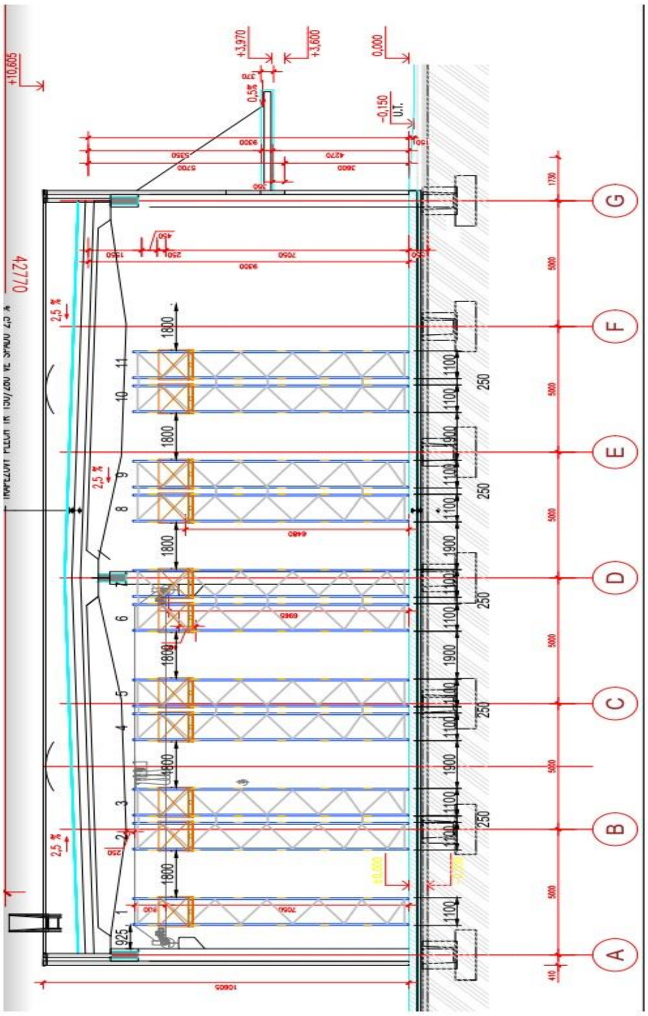
Supplier	Description	Specification	m2	cost	Invoice/month
New Warehouse	Warehouse for components	Narrow aisle warehouse	1260	4,99	€ 6 287
New Warehouse	Outside area around warehouse	Concrete space	450	1,15	€ 518
New Warehouse	Connecting tunnel	supply parts to production	152	1,95	€ 296
	2 x containers	receiving / entrance	6x6 / 3x3		€ 385
	EPS				€ 211
	Narrow aisle stacker	1+1		lease	€ 3 840
Ext. warehouse #2	For a service parts (low running)		2000	3	€ 6 806
Shuttle service	1 driver, 2 days/week	125 eur/trip, 8 trips/month	8	€ 125	€ 1 000
		Total monthly fee			€ 19 343

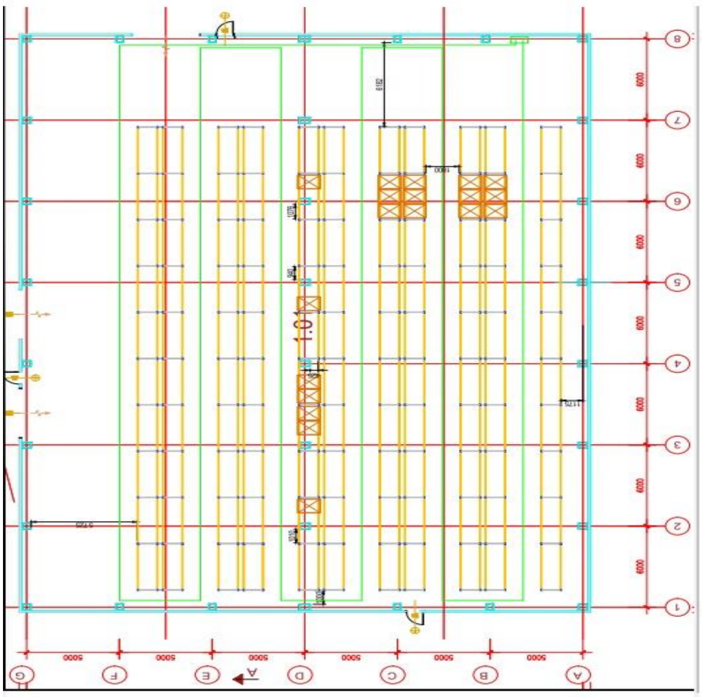
Cost of other logistics areas within plant = **11. 118 €** (reduced 1 small tent from plant area)

Supplier	Description	Specification	Space, m2	Cost, €	Cost/month
Company ABC	Large tent	20x60m	1280	5,30	€ 6 784
Company ABC	Outside area for WIP	concrete space	3000	1,10	€ 3 300
Company XYZ	Small tent 1	15x20x4m	450		€ 1 034
Total, m2			4730	Total cost for service	€ 11 118

Grand Total cost = 30 461 EUR

Appendix 4 Drawing of the new warehouse project





Appendix 5 EoL implementetion cost

EOL station one time costs:

Item	Cost
LCD	€ 125
Printer	€ 330
USB scanner	€ 125
Total one time investment:	**€ 580**

Runtime costs

Item	Cost
PC rental, licenses, patching	€ 63
SAP user license	€ 104
Monthly cost:	**€ 167**

	1	2	3	4	5	6	7	8	9	10	11	12	**Total per year**
2023									€ 747	€ 167	€ 167	€ 167	**€ 1 247**
2024	€ 167	€ 167	€ 167	€ 167	€ 167	€ 167	€ 167	€ 167	€ 167	€ 167	€ 167	€ 167	**€ 2 000**
2025	€ 167	€ 167	€ 167	€ 167	€ 167	€ 167	€ 167	€ 167	€ 167	€ 167	€ 167	€ 167	**€ 2 000**

ANNOTATION

AUTHOR	**M.A. Olena Koshelieva**		
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SUPERVISOR	**Ing. David Holman, Ph.D**		
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SUMMARY	**The aim of the work is to analyse the current state of the chosen company, to identify weaknesses in the internal logistics processes, to suggest ways to improve and apply the missing tools, to define areas where it is possible to upgrade the workstation while implementation of technological innovation solutions.** **The study aims to identify the key theories and concepts and to develop a theoretical framework that can guide the research process, to suggest how to increase efficiency, and evaluate the potential benefits of their use.**
KEY WORDS	**SCM, Logistics in automotive, Process inovations, technological innovations, warehouse space optimization, End of Line.**