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Sustainability of warehouse process by SWP model with orientation on cost reduction and growth performance

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Abstract: Warehouse management is based on improving productivity while reducing costs, improving quality, lead times, workforce availability, health, safety, and environmental effects. The warehousing costs create key factors for the efficiency of the warehouse process, too, in the food industry. The main goal of the research was to optimize costs in the warehouse process of the food company and improve the efficiency of the warehouse process. We stated the hypotheses oriented towards improving the quality of the warehouse process, which can decrease warehousing costs and increase the warehouse process's efficiency. The results of the research confirmed the hypothesis. Hypothesis H1: Improving the quality of the warehouse process decreases warehousing costs. This hypothesis was confirmed because warehousing costs decreased by 8341€ in the year 2025 and by 1070€ in the year 2024. H2: Improving the quality of the warehouse process influences the efficiency of the process. Ineffective processes - meat, fruit, vegetables, pallet warehouses became effective processes. The corrective measures brought benefits such as financial sources, efficiency, the layout of the warehouse, the JIT system, and cost reduction to the warehouse process in the food company. The suggestion of corrective measures can be used as a SWP model for smart warehouse processes in food companies.

1 Introduction

The sustainability of the supply logistics process is based on 5 pillars, such as costs, time, quality, price, and suppliers. Those pillars are key factors for growth performance and improvement of the supply process. In the frame of research, we deal with stocks in the selected firm. The storage stocks create company assets and represent liquid resources that can be converted quickly to financial resources. Liquidity is one pillar of business sustainability. The cash form represents the liquidity of the company and the source for buying new storage stocks. This is the reason for warehouse process management. It is necessary to monitor and optimize the stocks. Monitoring of stocks relates to the digitization and visualization of the logistics chain. Digitalization of the logistics chain plays an important role in monitoring the value of the stocks in warehouses, and visualization is the framework of the Industry 4.0 approach for mapping the state of stocks in the warehouse in amounts. The main goal of the research was to optimize stocks of the reason to bind financial resources and cost optimization in the warehouse process of the food company. We stated two hypotheses: Hypothesis H1: Improving the quality of the warehouse process decreases warehousing costs. Hypothesis H2: Improving the quality of the warehouse process influences the efficiency of the process. Based on the determination of corrective measures, we plan to change the supply process in the food company and reduce storage costs. The main instrument for improving warehouse processes is automation, including the use of robots and modern technologies such as conveyor belts for material handling. That approach is creating conditions for improvement and optimization.

2 Literature review

Warehouse management is based on improving productivity in all logistic processes connected with supply. Baruffaldi, G. et al. (2020) state that reducing costs, improving quality, lead times from customers, workforce availability, health and safety, and effects on the environment are priority factors for effective logistic processes and the basis for logistic sustainability [1]. Logistics sustainability focuses on efficient flows from the supplier to the customer, and it depends on internal logistics, transport time and costs [2]. Mensah et al. (2021) said that the logistic sustainability is standing on the priority green logistics management practices are a significant driver of organizational performance, such as environmental sustainability, social sustainability, and business performance [3]. Nantee et al. (2021) said that logistics sustainability focuses on automated warehousing systems. on the economic, environmental, and social dimensions of sustainability performance of those systems [4]. Larson et al. (2021) said that logistics sustainability is connected with logistics performance. Logistics performance is a driver of economic activity and success; it is also a

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contributor to environmental degradation in the form of harmful emissions [5]. Jayarathna et. al. (2023) said that logistics sustainability depends on transforming toward a circular economy is a viable strategy for achieving sustainable logistics systems [6]. Fernando et. al. (2023) said that logistics sustainability is connected with a circular economy-based reverse logistics that emphasises the effect of reverse logistics on sustainable resource commitment and financial performance [7]. Gupta et. al. (2022) said that logistics sustainability of the circular economy is oriented on service quality that influences the performance of supply chains [8]. Kádárová, J. et al. (2015) state that the supply and warehouse process is important to know. Reaction to the risks and investigating the conditions of crises of deficit of stocks is the basis for effective supply and warehouse management [9]. There are three basic flows (Figure 1) in the supply-customer chain, material, information, and financial, which ensures logistical sustainability [10]. Automation and digitization are the driving forces of the Industrial Revolution 4.0. which relates to the increased need for modern warehouses. To cope with huge product flows, modern innovations (such as IoT) should be used more extensively to manage these processes. The Internet of Things (IoT) is a technology designed to process large amounts of data with maximum efficiency in real time [11]. The base of each logistic process in the industry companies is the economic principle. Economic categories such as material costs, production costs, transportation costs, warehousing costs, and operational costs are important for the supply and warehouse process and their optimization. In this area, an important place stands for cost controlling [12].

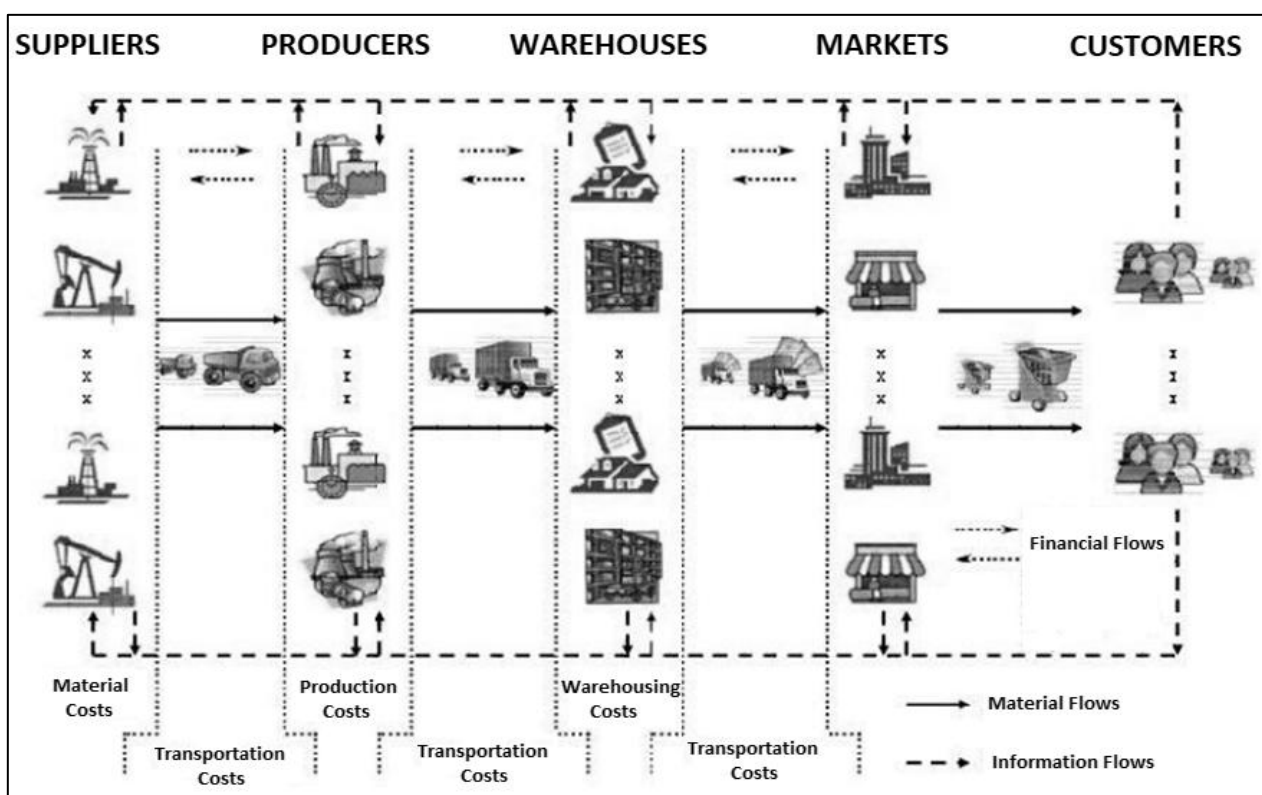


Figure 1 Basic logistic flows [4]

Potkány, M. et al. (2024) commented on the barriers to the implementation of business controlling in practice and the advantages of the collection of data and their processing [13]. Kádárová et al. (2015) commented on the BSC approach, which creates a customer and internal process perspective through the warehouse process. This approach is important for the performance strategy and progress of the supply process [9]. Kumar, S. et al. (2021) created a multi-warehouse inventory model that creates the base for the improvement of the warehouse process. The performance of stocks and other indicators for the performance of the warehouse process create the base for improvement and economic growth of the process by indicators such as efficiency [14]. The business sustainability presented by Mosteanu et al. (2020) means that all management tasks heavily depend on successful integration between the supply chain and logistics [15]. The theme of the future is the integration of sustainable supply chain management and logistics applications in the logistics chain. Van Geest et al. (2020) commented that smart warehousing aims to design the reference architecture. The intelligence model was presented using feature diagrams that show the common and variant features of smart warehouses [16].

Maheshwari, P. et al. (2023) presented that warehouses are a vital link in the supply chain and the pillars of Industry 4.0. The main pillars of Industry 4.0 are optimization, digitalization, automatization, and customization. It is the goal idea for create an instrument for the proactive and modern warehouse process [17]. A warehouse is a place where multiple

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activities are carried out, depending on the warehouse function. Saderova et al. (2021) present that the warehouse process holds an irreplaceable position in the supply chain. Their methodology for designing the warehouse system is based on five phases: Identification, Process design, System analysis, Synthesis of the logistical system, and Process evaluation. This methodology is a suitable tool for decision-making in the field of selection and design of the warehouse system for various areas [18]. Marasová, D. et al. (2018) overviewed warehouse optimization orientated to the technical structure of the warehouse, standard operational and organizational frame of warehousing, coordinating and controlling systems for warehouse operations, and typical operations in the warehouse [19]. Van Geest et al. (2021) commented that smart warehouses aim to increase the overall service quality, productivity, and efficiency of the warehouse while minimizing costs and failures. It was identified that the key subdomains where smart warehouse technology has been adopted are receiving the order, storing and shelving management, order picking, and order shipping [20]. Prasetyawan et al (2020) obtained that the spatial and temporal optimization for smart warehouses relates to fast turnover. With the development of commerce, the same day is provided delivery [21]. Millstein, M.A. et al. (2022) state that the market is implementing unmanned smart warehouses to improve logistics efficiency and cost reduction in the warehouse [22]. Pinto et al (2020) solved the problem with the warehouse locations for goods distribution. They found that the minimum distance is cost-efficient, and a short time is the optimal time [23].

Marziali, M. et al. (2021) presented the new storage assignment policy. They reduced transport time for order picking by benchmarking, toward the implementation of corrective and preventive solutions [24]. Živičnjak et al. (2022) said that warehouse management is becoming an increasingly important task and responsibility for employers whose goal is to maximize the profitability of the whole business which is orientated to economic indicators and performance key indicators [25]. Verma, A. et al. (2023) presented that the warehouse process can use target costing calculation for material stocks based on demand. This effective form decreases the costs of stocks [26]. Csikósová et.al. (2021) commented that financial performance is part of the evaluation of companies' results, and it contains indicators of the warehouse process. The important indicators are the number of stocks, the price of stocks, the time of delivery, quality of stocks [12]. Khan, M. G. et al. (2022) created the multi-warehouse model. This model was oriented on total cost, total investment, and total delivery time. This model enables retailers to obtain more profit by maintaining a multi-warehouse model with fewer inventory holding costs [27]. Kordos et al. (2020) said a large share of operating costs related to product storage relates to the preparation of the expedition. Based on many studies, it has been established that about 60% of warehouse operation costs are the costs of picking up goods when completing orders. They confirmed that minimizing the order picking times reduces the costs in storage [28].

Sert et al. (2020) commented on the complexity of providing timely and cost-effective distribution of finished goods to customers makes effective operational coordination difficult. The effectiveness of the logistic processes is crucial for customer service and sustainable business [29]. For logistics planning are important the external factors. The most significant is the growing number of customers, varied geographical locations, the uncertainty of orders, and extreme competitive pressure to reduce inventory costs. Millstein et al. (2022) said a new form of distribution - Omni-channel distribution integrates stores and warehouses to fulfil online and store demand. Results document increasing benefits from optimizing the number, locations, and capacities of omnichannel warehouses as the demand increases. The results showed that the profit of different omnichannel designs is shown to depend strongly on the product category and the percentage of demand that is online [22]. Marasová et al. (2018) said that quality is becoming the key decision-making factor for customers when choosing from several products, services, etc. Competitive pressures on the market lead to increasing the quality of the transport services connected with the warehouse process [19]. Transport services possess specific features, as compared to tangible products (goods collection and delivery, claims, means of transport availability, transportation time, and service reliability). In the frame of optimization of the supply and warehouse process are important strategic innovations and use of the quantitative mathematic models of the operational research and managerial methods. Pinto, J. et al. (2020) commented that cost controlling is a road for cost optimization and smart warehouse processes [23]. The main part of managing organizations of all sizes and types because modern information technologies allow access to many data and give managers the possibility to quickly respond to changes in the business environment.

3 Methodology

The research was carried out in a food company in Slovakia in Europe, the purpose of which was to streamline the warehouse process, focused on cost optimization and stocks. The main goal was to create a new innovative model for logistic sustainability for various types of industry and services. The research was carried out from the year 2023 to the year 2025. At this time, the warehouse process was monitored. We suggested corrective measures for the warehouse process in the food company in the year 2023 that were realized in the supply process in the selected company in the following years, 2024, 2025. The suggested corrective measures were a change of warehouse layout, higher turnover of food stocks, a change of transport routes to the customer, a JIT system, reducing damaged stock (waste), stock transfer system. Monitoring of the warehouse process creates the base for the analysis of the coefficient of efficiency.

In the frame of the research were specified two hypotheses:

Hypothesis H1: Improving the quality of the warehouse process decreases warehousing costs.

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Hypothesis H2: Improving the quality of the warehouse process influences the efficiency of the process.

The data collection was realized by the accounting system named SAP – for financial accounting with the module of warehouse process and inventory in the food company at account number "501" in financial accounting. The costs for the year 2023 are processed in Table 1. All those costs are accepted by law. The high costs are in the meat warehouse, pallet warehouse and vegetable warehouse. Than we analysed all the types of warehouses.

Table 1 Warehousing costs in year 2023

Type of warehouse	2023
	Costs (€)
aluminum packaging	20 874
vegetable warehouse	50 450
meat warehouse	98 750
fruit warehouse	50 120
cans warehouse	20 590
cardboard warehouse	9 875
pallet warehouse	50 230
spice warehouse	40 560

Source: internal documents of SAP system

The main research algorithm focused on managerial methods applied in the analytical part of the study. These fundamental managerial techniques formed the basis for optimizing warehousing costs and provided insights into improving warehouse processes. Pareto analysis was employed in the economic domain. In the field of quality management, it is considered one of the most effective tools, illustrating that 20% of the causes are responsible for 80% of poor quality. This method enables the identification of key factors contributing to a problem, distinguishing them from less significant ones, and guiding efforts toward the most impactful areas for improvement.

Pareto analysis was realized in steps:

1. to rank the causes from the largest to the smallest value,
2. to determine the percentage of causes based on the formula (1),
3. to determine the cumulative structure of causes, based on the formula (2),
4. to prepare graph and Lorentz curve.

$$\text{Structure: } S (\%) = \frac{X_i}{\sum X_i} * 100(\%) \quad (1)$$

$$\text{Cumulative structure: } CS (\%) = \sum X_t + X_{t+1} \quad (2)$$

where: (S) structure, (CS) cumulative structure, (X) costs, (t) time.

Based on the Pareto analysis, categories were defined by ABC method based on the costs in the warehouse process through the ABC category classification (Table 2).

Table 2 Category of stocks by ABC method

Category of stocks	Cumulative structure (%)
A category	<80%
B category	<95%
C category	>95%

Source: Kádárová, J. et al., 2015

Category A includes costs that account for less than 80% of the cumulative structure. These costs are critical, as they significantly affect the quality of warehouse processes and inventory. It is essential to address and reduce these costs.

Category B covers costs that fall below 98% of the cumulative structure. These represent a smaller portion of expenses that can still be optimized.

Category C consists of costs exceeding 98% of the cumulative structure. These are negligible and do not pose a threat to inventory quality or warehouse operations.

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An important managerial method used in the research is the process efficiency method. The efficiency of the process was monitored using an efficiency indicator formula (3) and its threshold evaluation (Table 3), assessed after the implementation of corrective measures.

$$\text{Coefficient of effectiveness: } Ke = X_{(1)} / X_{(0)} \tag{3}$$

where: (X) costs, (t) time (1) real time, (0) previous time.

Based on the limit evaluation of the process efficiency, we can find out the efficiency of the process.

Table 3 Limited valuation of the selected process

Effective process	$Ke < 1$
Ineffective process	$Ke > 1$

The process coefficient (Ke) can be expressed in terms of any measurable economic parameters within the accounting system for a given process. The process coefficient can be expressed through the quantities of production, documentation, number of revisions performed, number of quality objectives met, results achieved in customer and employee satisfaction, number of projects completed within the agreed deadline, number of employees in the monitored period, number of employees meeting the level of education, number of confirmed purchase contracts, number of orders, meeting order deadlines, meeting the project period based on customer requirements, meeting financial indicators and quality indicators, number of complaints and rejections, etc. When calculating the coefficient process, we determine its efficiency, which considers the fulfillment of planned values and expresses deviations of actual values from planned values.

4 Results

In the current global market environment, the food company has decided to optimize its stocks and reduce warehousing costs. This logistics chain has eight warehouses (meat storage, fruit storage, vegetable storage, spice warehouse, storage of cans, aluminum packaging, cardboard warehouse, and pallet warehouse), which are essential parts of production and distribution. In the warehouses, some stocks tie up the company's financial resources, and on the other hand, these stocks can deteriorate, reducing the quality of stocks through continuous storage.

A large amount of stored inventory represents high storage costs for the food company, and overall, the company does not have enough liquid funds (cash) because they are tied up in inventory. The total value of stocks in warehouses represents 341 449 € in the year 2023. In the research, we analyzed warehouses according to the warehousing costs.

We used Pareto analysis (Table 4) for the determination of the critical type of warehousing costs. As part of the Pareto analysis, we determined the amount of the inventory in the individual warehouses in ascending order (from 98 750 € to 9 875 €). We determined indicators such as the structure and the cumulative structure by Formula (1) and Formula (2). Based on the structure indicator, we can conclude that the highest costs are in the meat warehouse, fruit warehouse, vegetable warehouse, and pallet warehouse. Those warehouses contain items with high-value - costs. Meat, fruit, and vegetable items are risk items from reason durability, freshness, and deterioration quickly. The reason for their optimization is the tie of financial sources, which is a problem for selected food companies in cash management. Cash is an important current asset for business. The cash balance is the most unproductive asset of an organization. However, it is important because it is used to pay liabilities.

Table 4 Pareto analysis of warehousing costs in year 2023

Costs (€) in the warehouses	2023	2023	2023
	Valuation (€)	Structure S (%)	Cumulative structure CS (%)
meat warehouse	98 750	29	29
fruit warehouse	50 120	15	44
vegetable warehouse	50 450	15	58
pallet warehouse	50 230	15	73
spice warehouse	40 560	12	85
cans warehouse	20 590	6	91
warehouse of aluminium packaging	20 874	6	97
cardboard warehouse	9 875	3	100

Source: own source

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We have determined the results of stock levels in individual warehouses based on the Lorenz curve in Pareto analysis (Figure 2), which states that 20% of stocks (items in warehouses) represent 80% of the costs of the warehouse process. This Lorenz curve specifies the critical type of inventory in the warehouses. The problem warehouses are on the rules 80/20 - meat, vegetable, fruit, and pallet warehouses.

This method is very easy for the classification of a critical type of inventory in the warehouses, and it provides possibilities for how to stop the warehouse problem for the enterprises. Pareto analysis have advantages such as Pareto analysis can be used to pinpoint the factors that are having an outsize impact on an organization, for better or worse, as a decision-making technique, Pareto analysis helps clarify the actions that could have the greatest positive impact, each problem or benefit is given a numerical score based on the level of impact on the company; the higher the score, the greater its impact. For this situation, it is important to suggest corrective measures. The corrective measures have to be oriented towards all the pages, such as technical, technological, social, political, economic, and ecological.

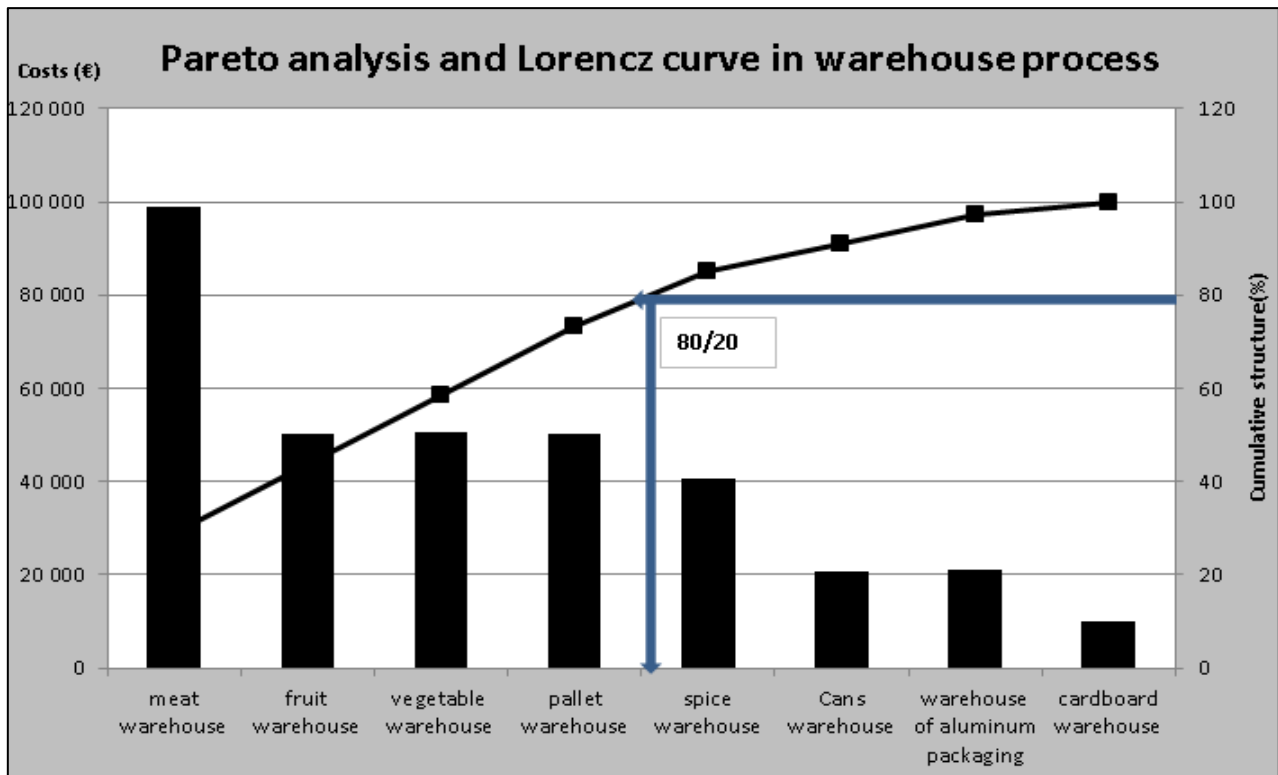


Figure 2 Pareto analysis of stocks
Source: own source

The category of warehouses (Table 5) that need to be addressed is represented by 4 warehouses: meat storage, fruit storage, vegetable storage, and pallet warehouses which make up funds tied up in stocks in the amount of 249 550 €.

Table 5 ABC category of warehouses items

Category	Structure (%)	Cost (€)	CS (%)	CS (%)
A	73%	249 550	<80%	73.77
B	18%	82 024	<95%	91
C	9%	9 875	>95%	97-100

Source: own source

Figure 3 represents ABC category for warehouses in the food company. The "A" category of stocks in the warehouse. In these warehouses it is needed to reduce the level of stocks, and determine the amount of insurance stocks, which will be used in the event of a stock deficit during sales. It is very important to determine the optimal number of stocks in the warehouse. In this part it is important to ensure the necessary quality of stocks and reduce waste due to the reduced quality of meat, fruit, and vegetables. The meat, fruit, and vegetable waste create high costs for food companies. The structure of this category represents 73% of the stocks.

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The second “B” category creates 18% of stocks in the warehouse. In the economy, it means 82 024 € costs of the stocks in the warehouse. That kind of stock introduces the spice warehouse and cans warehouse.

The third “C” category creates 9% of stocks in the warehouse. In the economy, it means 9 875 € costs of the stocks in the warehouse. That type of stock introduces the aluminum packing warehouse and cardboard warehouse. This warehouse creates the lowest costs in the warehouses of the food company.

The problem warehouses are on the rules Pareto analysis 80/20 - meat, vegetable, fruit, and pallet warehouses and too ABC category classification of the stocks shows the problem with meat, vegetable, fruit, and pallet warehouse and goods.

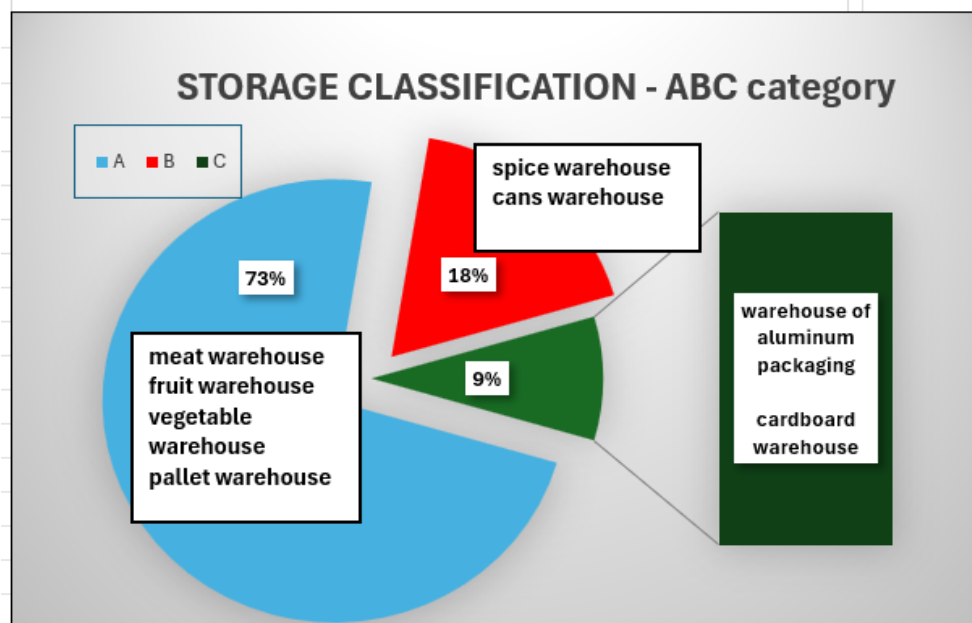


Figure 3 ABC classification of storage
Source: own source

In the results of the research in the year 2023, we suggested corrective measures for solving problems in the warehouses of the selected food company. Those corrective measures could improve the situation in the financial area by reducing costs, improving warehouse operations and systems, the layout of warehouses, and satisfy the customer's satisfaction. Based on these corrective measures, we expect a reduction in some types of costs in the warehouse management of the food company. The main categories of costs are operating costs, transport costs, warehousing costs, damage, stock costs, and labor costs. The results of research in 2023 in the warehouses of the food company recorded deficiencies. The analysis of the real state was provided by methods - Pareto analysis, and ABC classification. Those methods pointed to the critical warehouses and goods - meat, vegetables, fruit, and pallets.

Based on the implementation of corrective measurements in the warehouses, the food companies calculated the warehousing costs in the years 2024 and 2025 (Table 6). We monitor the improvement of the quality and efficiency of warehouse management in food companies in the sense of cost-oriented cost minimization: operating costs, transport costs, warehousing costs, costs of damage, stock costs, and labor costs.

Table 6 Costs after implementation of the corrective measures (501)

Type of warehouse	Costs 2024	Costs 2025	AD 2024/2023 (€)	AD1 2025/2024 (€)
meat warehouse	99 560	96 582	810	-2 978
fruit warehouse	50 230	48 596	110	-1 634
vegetable warehouse	51 269	50 250	819	-1 019
pallet warehouse	50 600	48 500	370	-2 100
spice warehouse	40 260	40 250	-300	-10
cans warehouse	20 100	19 860	-490	-240
aluminium packaging	19 800	19 500	-1 074	-300
cardboard warehouse	8 560	8 500	-1 315	-60

Source: own source

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Based on the collection of cost data from the SAP system for the years 2024 and 2025, we investigated the development of costs based on the implementation of corrective measures. We calculated the absolute difference and indicator of the difference in costs for two consecutive years. We calculated the coefficient of efficiency by formula 3 in Table 7. In the year 2024, costs were reduced in four warehouses, which were declared efficient warehouses in terms of efficiency. In the year 2025, inventory costs were reduced in all operating warehouses, and at the same time warehouses declared as inefficient were changed to efficient warehouses.

Table 7 Coefficient of efficiency in the warehouses

Type of warehouse	Ke/2022	Efficiency	Ke/2023	Efficiency
meat warehouse	1.01	Ke>1 Ineffective process	0.97	Ke<1 effective process
fruit warehouse	1.00	Ke>1 Ineffective process	0.97	Ke<1 effective process
vegetable warehouse	1.02	Ke>1 Ineffective process	0.98	Ke<1 effective process
pallet warehouse	1.05	Ke>1 Ineffective process	0.92	Ke<1 effective process
spice warehouse	0.99	Ke<1 effective process	0.99	Ke<1 effective process
cans warehouse	0.98	Ke<1 effective process	0.99	Ke<1 effective process
aluminium packaging	0.95	Ke<1 effective process	0.98	Ke<1 effective process
cardboard warehouse	0.87	Ke<1 effective process	0.99	Ke<1 effective process

Source: own source

We calculated the coefficient of efficiency by formula 3 for all types of warehouses in Table 7. In the year 2024, costs were reduced in four warehouses, which were declared efficient warehouses in terms of efficiency. The improvement was recorded in those warehouses: spice warehouse, cans warehouse, aluminum packaging, and cardboard warehouse. Those warehouses are introduced in Category B 18% and Category C 9% of all warehouses. Those categories are not critical on the economic base. All those warehouses were determined effective processes. In the year 2023, inventory costs were reduced in all operating warehouses, and at the same time warehouses declared as inefficient (meat warehouse, fruit warehouse, vegetable warehouse, pallet warehouse) were changed to efficient warehouses. The category of those warehouses is category “A”, and it is a critical category from an economic point of view.

5 Discussion

The basis for logistic sustainability we made by the Baruffaldi et.al. The foundation for logistic sustainability was based on the model developed by Baruffaldi et al. Baruffaldi, G. et al. state that reducing costs, improving quality, lead times from customers, workforce availability, health and safety, and effects on the environment are priority factors for effective logistic processes and the basis for logistic sustainability. Critical warehouses were identified through Pareto analysis, and the Lorenz curve was used to determine the threshold for these critical warehouses. Corrective measures were proposed to reduce costs that presented Pinto et.al., improve quality oriented on SMART warehouses by the suggestions of Van Geest et.al., shorten customer lead times in the paper presented by Burganova et.al., enhance workforce availability by the approach BSC presented in the paper by Kádárová et.al., ensure health and safety in warehouses that presented Marzialli et.al. orientated on critical problem and KPI indicators, and minimize environmental impact what was the main part of the paper by Khan et.al. with orientation on architecture and design such as smart warehouse management.

Corrective measures (Figure 4) serve as tools for enhancing quality and efficiency in warehouse management, with impacts across economic, environmental, technical, and social dimensions of the food company. In this research, we proposed several corrective actions for warehouse operations: Warehouse layout redesign based on the warehouse optimization model by Karásek (2013). Increased turnover of food stocks using IoT technology in warehouse management, as presented by Jarasuniene et al. (2023). Modification of transport routes to customers informed by the findings of Marasová et al. (2018) on transport quality. Implementation of a Just-In-Time (JIT) system, as part of a lean warehousing approach, described by Prasetyawan et al. (2020). Reduction of damaged stock waste through the multi-warehouse inventory model by Kumar et al. (2021). Stock transfer system optimization based on the warehouse location

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approach by Millstein et al. (2022). In this frame were recommended the use of robots and conveyor belts was recommended for inventory optimization. The food company considered renting equipment as part of its strategy to improve warehouse operations.

These corrective measures were implemented in 2024 within the warehouse processes of the food company. The results of these innovations led to measurable improvements in warehouse operations.

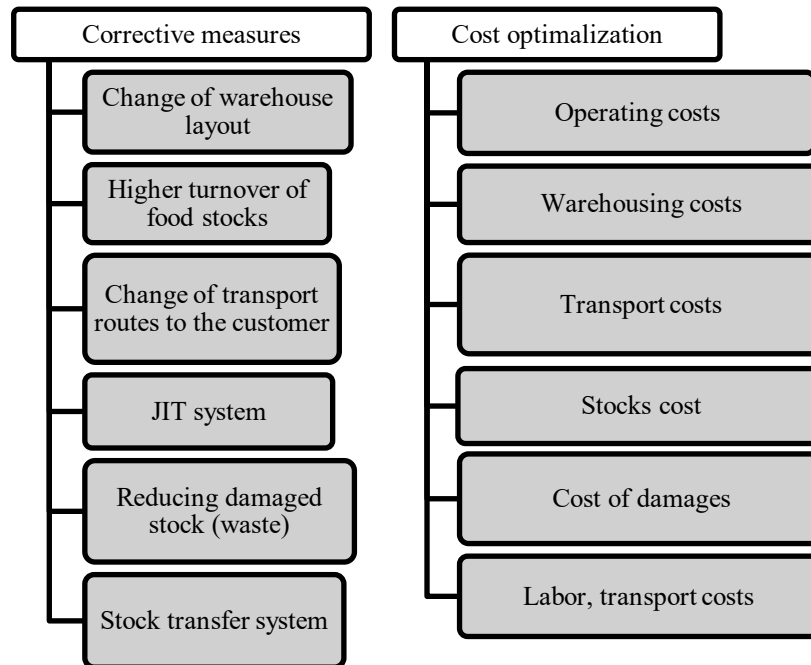


Figure 4 Corrective measures for warehouse process
Source: own source

Based on hypotheses H1: Improving the quality of the warehouse process decreases warehousing costs. This hypothesis was confirmed. A decrease in storage costs of 8341 was recorded in the year 2025 and 1070 in the year 2024. In all warehouses of the food, the company recorded the cost reduction. The implemented correction measures brought positive results for warehouse processes from an economic point of view. The second hypotheses H2: Improving the quality of the warehouse process influences the efficiency of the warehouse process. This hypothesis was confirmed. In the year 2024 there were 4 processes (meat warehouse, fruit warehouse, vegetable warehouse, pallet warehouse) ineffective. After implementing correction measurements those processes became effective. A decrease in efficiency from value 1,00 to value 0.92 was recorded in 4 critical warehouses (meat warehouse, fruit warehouse, vegetable warehouse, pallet warehouse) of the food company, which means increasing efficiency and those warehouse's process is effective. The results of the research in the food company are presented in the table (Table 8).

Table 8 Results for hypotheses

Category	2023	2024	2025	H1	H2
Costs (€)	341 449 €	340 379 €	332 038 €		
Cost reduction (€)	-	1070 €	8341 €	Confirmed H1	
(Ke) – coefficient of effectiveness	-	1.00-1.05 ineffective processes 0.87-0.99 effective processes	0.92-0.99 effective processes		Confirmed H2

Source: own source

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The results of the research of the selected food company are at a sufficient level of quality warehouse process. The hypotheses were confirmed. Suggesting corrective measures created the conditions for the SMART warehouses process by using machines such as robots, conveyor belts, IoT technologies, BSC approach, digital instruments, lean methods, and KPI indicators. We suggest a new model (SWP) for sustainable warehouse process based on the results of warehouse process optimization in the food company (Figure 5). We are based on the knowledge of other authors who presented benefits in warehouse processes. In the area of digitalization is needed to use the approach Zunic et. all. (2018) presented the warehouse management system. This WMS is one of the most important parts of the working process in food companies. The concept uses artificial intelligence algorithms to improve the standard warehouse management system by giving optimized solutions to users. The implemented concept optimizes stock planning, initial product placement, and the picking zone transfer process, as well as order picking, transport, and tracking processes. The optimized processes can make large time and cost savings and can create a more efficient environment [30].

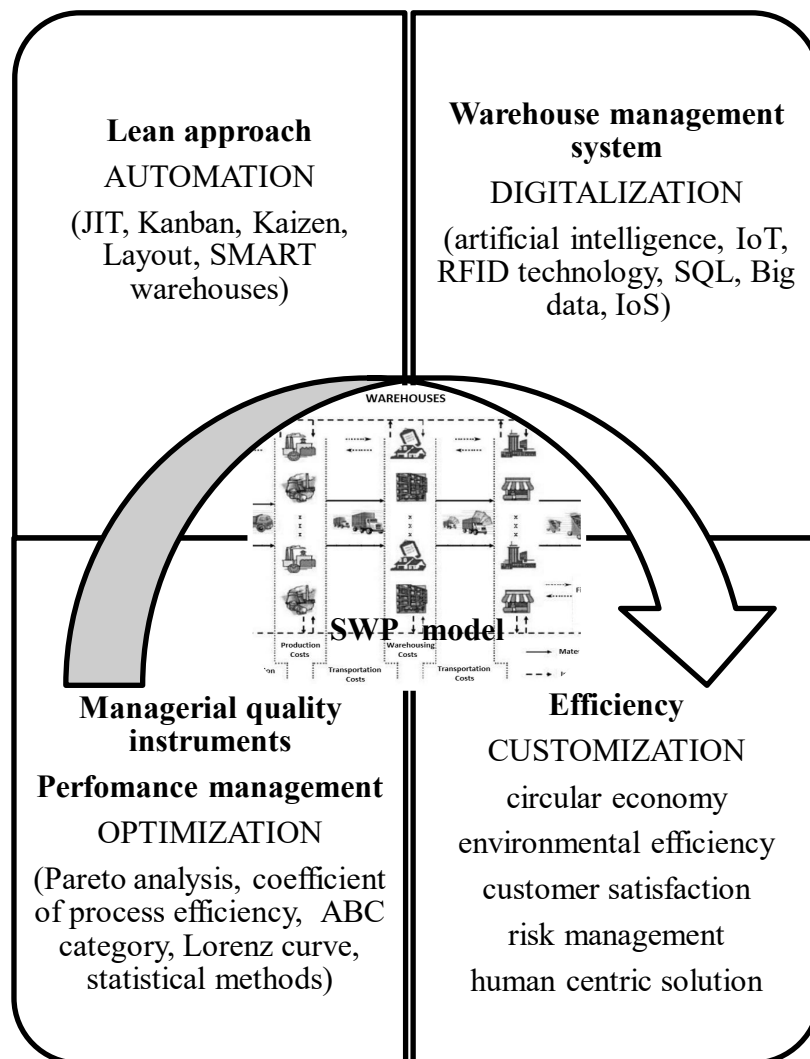


Figure 5 SWP model
Source: own source

The second area of the SWP model is important pillar of customization and efficiency. We go out of comment of Baruffaldi, G. et al. (2020) state that reducing costs, improving quality, lead times from customers, and workforce availability is the basis for logistic sustainability. The efficiency view is important, including economic, environmental, and social efficiency. Kádárová, J. et al. (2015) state that the warehouse process is important to know. Reaction to the risks and investigating the conditions of crises of deficit of stocks is the basis for effective supply and warehouse management.

The third area of the SWP model is important optimization, and this pillar creates part of performance management. Mensah et al. (2021) said that the logistic sustainability is standing on the priority green logistics management practices are a significant driver of organizational performance, such as environmental sustainability, social sustainability, and

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business performance. Nantee et al. (2021) said that logistics sustainability focuses on automated warehousing systems. on the economic, environmental, and social dimensions of the sustainability performance of those systems. Larson et al. (2021) said that logistics sustainability is connected with logistics performance. Logistics performance is a driver of economic activity and success; it is also a contributor to environmental degradation in the form of harmful emissions.

The fourth area of the SWP model is oriented on automation and lean logistics instruments. Logistics sustainability focuses on efficient flows from the supplier to the customer, and it depends on internal logistics, transport time, said Burganova et al. (2021). Jayarathna et al. (2023) said that logistics sustainability depends on transforming toward a circular economy is a viable strategy for achieving sustainable logistics systems. Fernando et al. (2023) said that logistics sustainability is connected with a circular economy-based reverse logistics that emphasises the effect of reverse logistics on sustainable resource commitment and financial performance. Gupta et al. (2022) said that logistics sustainability of the circular economy is oriented on service quality that influences the performance of supply chains. All of those comments presented the lean approach in logistic processes. Lean instruments create the base for connection with digitalization, optimization, and automation. The SWP model creates the pillar of logistic sustainability in various areas of industry and services. Affia et al. (2022) commented that the logistic sustainability is accomplished by the real-time visibility and traceability in warehousing could be accomplished by implementing the internet-of-things (IoT) technology that is part of the warehouse management system in the SWP model [31]. Simic et al. (2023) presented the new model based on the integration of the logarithmic percentage change-driven objective weighting (LOPCOW) method and the additive ratio assessment (ARAS) method in the food inventory sector. Industry 4.0 technologies embedded in the warehouse management system (WMS) are needed to improve the automation of material handling activities such as receiving, storing, picking, sorting, packaging, and delivering [32]. Zhou et al. (2024) presented an Intelligent Warehouse Management System (IWMS) that represents a technological leap forward in the realm of logistics and supply chain management. This sophisticated system integrates a suite of cutting-edge technologies, including artificial intelligence, machine learning, and the Internet of Things, to revolutionize the way warehouses operate [33].

6 Conclusions

The tool for warehouse process optimization is the approach as SMART warehousing by SWP model based on warehouse optimization, better customer service and customer satisfaction, lower costs, faster picking and shipping, tracking of assets and inventory for financial sources, and great accuracy in warehouse operations what was presented in our research of the food company. The main goal of the research was to optimize costs in the warehouse process of the food company. After the implementation of corrective measures (change of warehouse layout, higher turnover of food stocks, change of transport routes to the customer, JIT system, reducing damaged stock (waste), stock transfer system) in the warehouse process we obtained positive results for confirmation of the hypotheses.

Hypothesis H1: Improving the quality of the warehouse process decreases warehousing costs. This hypothesis was confirmed because warehousing costs were decreasing by 8 341€ in the year 2025 and 1 070€ in the year 2024.

Hypothesis H2: Improving the quality of the warehouse process influences the efficiency of the process. This hypothesis was confirmed because the coefficient of efficiency records changes from ineffective process to effective process. Warehouse processes were improved and brought benefits to the food company.

The first benefit was reducing costs, which means increasing financial sources in cash for paying the obligations and debts. The second benefit is effective warehouse processes that satisfy customers. The suggestion of corrective measures can be used as the model for smart warehouse processes in food companies such as an instrument for smart warehouse management. Tiwari (2023) presented that warehouses are crucial components of the logistics industry because their operational efficiency determines the operational efficiency of logistics. With the introduction of Industry 4.0 technologies, the warehouse's role has changed dramatically, the scope of warehouse operation has expanded, and the concept of smart warehouse, which denotes increased automation of traditional warehouse functions, has been introduced. Smart warehouses aim to improve overall service quality, productivity, and efficiency while lowering costs and failures [34]. Min (2023) said changes in the warehouse management have been further accelerated by rapid technological innovations resulting from the fourth industrial revolution (Industry 4.0). One of the most notable technological transformations was smart warehousing concepts. A smart warehouse will bring many managerial benefits, including warehousing cost efficiency, labor productivity, and agility in the era of the knowledge economy [35].

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