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Increasing Resilience of Warehouse in Logistic Supply Chain by Use of the Manhattan WMOS on the Example of the Chosen Enterprise

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Abstract:

Purpose: *The aim of the article was to investigate whether and to what extent the implementation of Manhattan Warehouse Management for Open Systems (WMOS) will positively affect the functioning of Aldi food industry warehouses.*
Design/Methodology/Approach: *The theoretical methods were used in the study - analysis and critical evaluation of source materials, which were of primary and secondary nature as well as practical ones, consisting in the participant observation of the authors in the functioning of the examined enterprise. Additionally, the performance indicators of a warehouse of the selected enterprise were examined. The object of the research was the food company Aldi. For the purposes of the article, the concept and method of operation of the WMOS Manhattan system in the studied enterprise were described, as well as internal data in the company were collected, thanks to which the indicators of warehouse operations efficiency were determined.*
Findings: *It can be noticed that the introduction of the Manhattan WMOS system was of the greatest importance for, outgoing deliveries (improvement by 12.4%), the improvement of completeness of order preparation, reducing the duration of selected tasks, the time from dock to warehouse for incoming deliveries decreased significantly, by as much as 6 minutes and finally the degree of inventory synchronization between the physical and the systemic condition reached as much as 98% correctness.*
Practical Implications: *The article points the changes and challenges in the functioning of organization within last years and indicates the need to consider change in style of management by introducing leadership based on values.*
Originality/Value: *The conducted research, has been shown that the correct implementation of the warehouse system brings measurable benefits for the reliable and safe functioning of the company's logistics chain.*

Keywords: *Management, logistic supply chain, resilience, warehouse.*
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Paper Type: *Case study.*

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1. Introduction

The main goal of logistics supply chain management is to create a uniform plan for the flow of products and information by the company (Christopher, 2016). The idea is that the process of strategic procurement, handling and storage of materials is carried out in a sustainable manner, so as to maximize current and future profitability through cost-effective order fulfilment (Monczka, Handfield, Giunipero and Patterson, 2016).

The key importance of the supply chain and the development of communication and information technology in the early 2000s is emphasized above all by companies that focus on the needs and wishes of customers (Cohen and Rousell, 2005).

Supply chain management is a chain management process as long as its links remain connected. The strength of the entire chain depends not only on the strength of a single links, but also on the connectivity between all its links (Witczyńska, 2019). Often, such a link in the logistics chain is a warehouse, and therefore its effective functioning is an essential element of the continuous and reliable functioning of the supply chain.

Nowadays, it is hard to imagine that this process would take place without IT systems. The task of these systems is to constantly support processes related to the operation of warehouses and provide real-time information for the managerial staff, which bases its decisions on the basis of accumulated information (Kluska, 2021).

The aim of the article was to investigate whether and to what extent the implementation of Manhattan Warehouse Management for Open Systems (WMOS) will positively affect the functioning of Aldi food industry warehouses and increase it resilience to turbulences in logistic supply system. The object of the research was the food company Aldi. The company operates in 12 countries and is a leading grocery chain in Germany.

Hailed by some as the largest retailer in Europe, the company has succeeded in defying virtually all supermarket standards, from legendary restraint to a "spartan atmosphere" in its stores (Figure 1). Aldi keeps operating costs low in many ways, such as by limiting the range of goods, using small spaces of consumer stores, bypassing expensive barcode scanners. Thanks to that Aldi's labor costs at about 4 percent of the store's sales, compared with 10-12 percent at most supermarkets.

2. Resilience of Logistic Supply System

Logistic supply chains have a significant impact on the operating costs of countries and enterprises. Based on the research, it was found that for individual European countries, the share of logistic costs in GDP is between 7 and 12% (Table 1).

***Figure 1.** The activities of the Aldi chain around the world*

***Source:** On the base of https://pl.wikipedia.org/wiki/Aldi.*

In the case of developing countries, the costs of logistics operations have a much larger share in the overall costs of GDP, for example in Indonesia it is as much as 22 percent compared to, for example, the Netherlands - approx. 7%. Research also indicates that in developed countries, the nature of logistics costs was previously recognized and care was taken to minimize them by creating more efficient logistics systems. This is evidenced by historical data on the costs of logistics functioning in currently developed countries, where, for example, about 30 years ago in Great Britain, logistics costs were between 18 and 20% (Ruston, Croucher and Baker, 2017).

***Table 1.** Logistics costs as a percentage of GDP in selected countries*

Kraj	**GDP 2020 (in bilion $)**	**Logistics (% of GDP)**	**2020 Cost of Logistics (in bilion $)**
Italy	1,884.9	9.0%	169.4
Netherlands	909.5	7.4%	67.5
Norway	362.0	8.9%	32.4
Poland	594.2	10.1%	60.3
Portugal	231.3	10.5%	44675,0
Romania	247.2	11.6%	44740,0
Spain	1,278.2	8.2%	105.0
Brunei	12.0	15.0%	44774,0
Kambodża	26.0	16.4%	44624,0
China	14,722.8	14.5%	2,134.8
Hong Kong	349.4	8.5%	44771,0

India	2,708.8	13.0%	351.8
Indonesia	1,059.6	22.0%	233.1

Source: *Based on https://www.3plogistics.com/3pl-market-info-resources/3pl-market-information/global-3pl-market-size-estimates/.*

A resilience supply chain is all about product availability. Many sources describe this as "delivering the right products to the right place, at the right time, to the right recipient, etc ...". Unfortunately, this statement does not fully reflect how much effort must be put into the logistics supply system, as well as the multitude of problems that may arise during the implementation of this process (Fernie and Sparks, 2019). It was visible in 2020, the unexpected COVID-19 pandemic broke out and changed the perception of supply chain security (Śliwczyński and Smal, 2022).

Therefore, to make products available, retailers need to skillfully manage their chain, know what is selling in their stores and on their websites, and anticipate and respond quickly to changes in demand. At the same time, they must be able to move products with less variability in demand in an efficient and cost-effective manner.

Supply chain management is therefore a means by which customer needs are met by coordinating the flows of materials and information that extend from the market, through the company and its operations, and then to suppliers (Christopher, 2016). Achieving such enterprise-wide integration, of course, requires a completely different approach to that normally found in a conventional organization. In today's turbulent environment, it is not possible for production and marketing to work independently of each other (Dani, 2015).

Therefore, in recent years, flexible production systems, new approaches to inventory and just-in-time methods have been implemented with the just-in-case concept and, perhaps most importantly, a sustained emphasis on total quality management (Blanchard, 2010). In this context, there has been increased recognition of the critical role of resilience supply chain plays in creating and maintaining a competitive advantage as part of an integrated logistics process.

3. Management of Warehouse Processes in a Selected Warehouse

Big companies, due to a wide range of activities, conduct their activities based on such basic operational modules as, sales and distribution, materials management, finance and accounting, warehouse management, human resources management, quality management, production planning. This is one of the reasons why they use ERP products in their daily operations, such as SAP S / 4HANA, WMOS Manhattan or Oracle Suite.

Such systems were created to support most of the business processes existing in enterprises. By effectively managing and using IT systems, an enterprise can create high-performance processes that run at lower costs, faster pace, greater accuracy, reduced assets and increased flexibility (Richard, 2011). This chapter presents the analysis carried out for the basic warehouse processes in a selected company.

Receiving, entering or handling goods is a key process in the warehouse (Hompel and Schmidt, 2007). This process is carried out in accordance with the requirements of suppliers and recipients, but in practice, during receipt, it is often too late to eliminate most of the problems that arise upon receipt. Before the goods are formally accepted, there are a number of steps:

- identifying palletized or non-palletized product deliveries;
- determination of the size (length, width, height) of the delivery on the pallet and the type of pallet - e.g., Euro pallet, Düsseldorf pallet;
- specific marking such as product description, system product number, barcode, quantity;
- the number of cartons or packages;
- method of transport, requirements related to the storage temperaturę.

Many of today's WMSs allocate product locations in advance and instruct the operator where to place the goods. This can be directly to the dispatch area if the product is to be cross-docked, to the picking area as a form of replenishment, or to a reserve or collective storage area. In order for this system to work effectively, a lot of information is programmed in the warehouse prior to operation. Another decision made in the warehouse is whether the products are placed in fixed or random locations.

In the case of permanent locations, a specific location is determined for a given product. In a random location, the pallet is placed in the most efficient location available. Fixed locations make it possible to remember the current location and speed up the picking process. However, if there is no stock for the product at any given moment, the location remains empty and the use of the pallet warehouse is significantly reduced.

Picking orders is the most expensive activity in the warehouse. It is not only labor-intensive, but also difficult to automate, difficult to plan, prone to errors and having a direct impact on the client. Firms point to picking as an area where efficiency improvements can have a significant impact on overall costs. In this case, the tradeoffs are speed, cost and accuracy.

Managers are looking for fast response times, high accuracy, and high efficiency, but at the lowest possible cost. Satisfying these factors will determine the types of picking systems and processes. In the warehouse in question, order picking accounts for approximately 50 percent of direct labor costs. It is still largely done by hand, however there are a few helpful devices that can be used to ensure a high level of efficiency and accuracy.

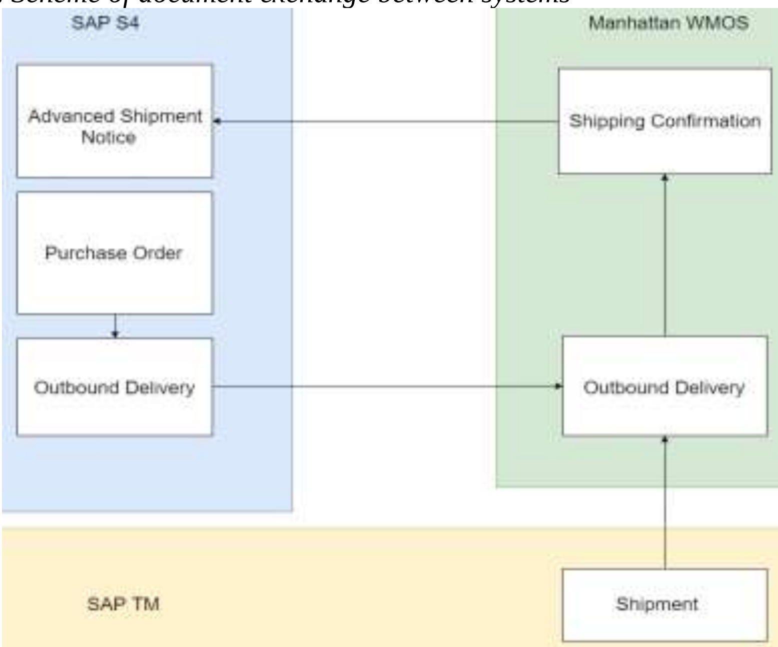
As with stock picking, the warehouse also needs to replenish its inventory on a regular basis to ensure the efficient operation of pickers. Poor replenishment processes result in missing orders, extended picking times and therefore increased cost per picking, and an overall reduction in service levels. In the warehouse under study, the warehouse management systems operate in real time and recognize the need to replenish the picking locations thanks to real-time data transmission. These systems are also able to identify the total actual number of orders and therefore complete them before the next wave of orders reaches the warehouse.

4. Functioning of the WMOS System

Manhattan WMOS (Warehouse Management for Open Systems) is a strictly IT-based warehouse management system. It has extensive functionalities responsible for warehouse management processes. However, it is devoid of modules responsible for sales and distribution, finance or transport - processes indispensable in logistics activities. This gap must be filled by other ERP systems, e.g., SAP.

Figure 2 shows the document flow process in the outbound order process. The process begins with placing an order by the customer, i.e., a store or other warehouse. The Purchase Order has information about the products ordered, their quantity, place of shipment and receipt, and the expected date of receipt of the goods. It is the base document on the basis of which further documents will be created (Manhattan Associaties, 2022).

Figure 2. *Scheme of document exchange between systems*



Source: *Own elaboration.*

Wave picking in the Manhattan WMOS system is the process of selecting groups of distribution or freight orders based on user-defined criteria, who prepares these orders for picking. The Picking Wave Parameters option is used to configure various wave templates. Each wave template is a set of predefined configurable parameters that govern how the wave is processed, where the inventory is allocated from which the inventory is allocated, and how the order is picked.

The Ship Wave Templates option is used to configure the individual stages of the wave completion process (picking, order consolidation, routing). Finally, the Run Wave option is used to define the logic (rules) used to select orders, based on the information contained in the distribution order (e.g., order number, order type, ship date).

An outbound delivery note is automatically created on the basis of the order. It is also the most important document in the process, as an invoice for the customer will be created on its basis and filled in. If multiple waves are running, Manhattan WMOS places all running waves in a queue. The Wave Master uses the Waves option to monitor the status of waves' activities - replenishment, picking, packing. WMOS shows the status of tasks (replenishment, picking) by type and area, orders and label numbers. WMOS cancels all tasks, assignments, item assignments and restores the orders to their base status so that they can be used in subsequent waves.

During a wave, the WM system goes through the following processes:

- selecting and sequencing distribution orders,
- allocation,
- cartonization,
- consolidation of orders,
- routing,
- creating and distributing tasks,
- printing of labels and documentation.

The waves' picking process will also create tasks for forklift operators. The task creation criteria define the exact rules, sequencing, and logic used to create tasks using waves. Each of the tasks generated by the wave picking process is assigned a group of tasks. A group of tasks, along with the type of task, is used to define the kind of activities a user can perform and the different areas (workgroup / workspace) he can reach. The picking strategy allows you to assign a user to one aisle or pick in different aisles during the day.

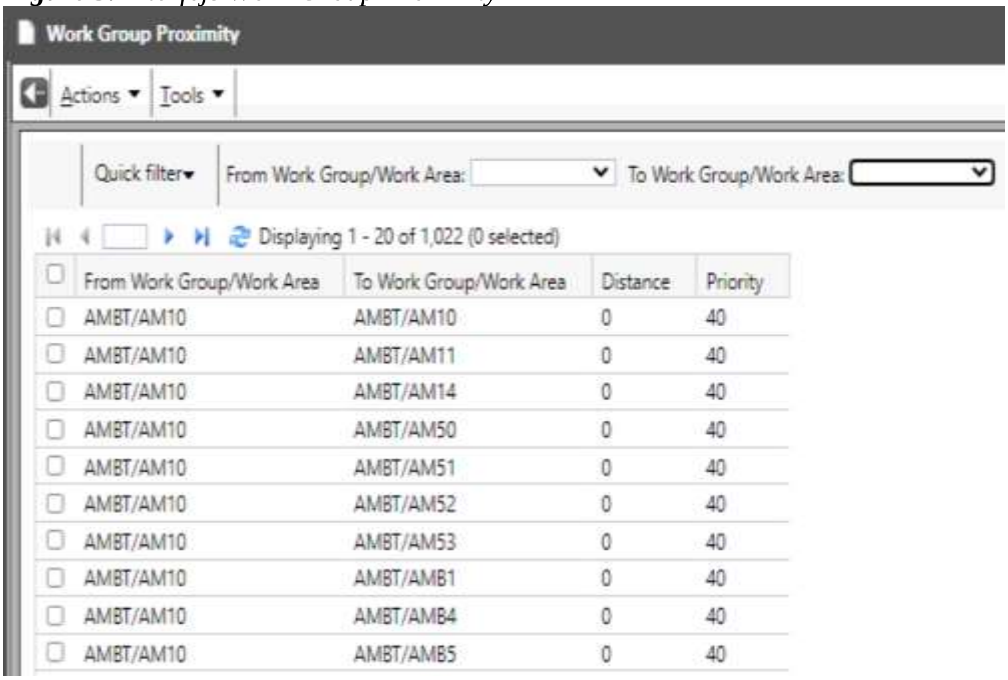
The task management in the wave picking process is done with the use of many different attributes. Firstly, it define a finite list of needed task groups. They are based on the different types of users (warehouse workers) and the different types of equipment available in the warehouse. Secondly, each warehouse location assigned to a Work Group, Work Area.

The Concept of Workgroup and Workspace is used to define a logical part of the warehouse - Workspace is a subset of locations within a Workgroup, and this one can have multiple Workspaces. Thirdly, the ability to define the proximity of each Workspace / Workgroup to the others to ensure that the task creation process allocates tasks that are near the user's assigned location. Fourthly, each storage user has one or more task groups assigned to them.

Finally, the task path definition table determines how two different task groups operate if both are needed to complete the task. This configuration allows you to restrict users working in one area of the warehouse from accessing jobs generated for other areas of the warehouse and vice versa.

The user can be assigned to the default task group as well as to other authorized task groups in which the user can work. Thanks to this, the IT warehouse system controls the types of tasks that the user has to perform, as well as the order in which the tasks are assigned (Figure 3).

Figure 3. *Interfejs Work Group Proximity*



From Work Group/Work Area	To Work Group/Work Area	Distance	Priority
AMBT/AM10	AMBT/AM10	0	40
AMBT/AM10	AMBT/AM11	0	40
AMBT/AM10	AMBT/AM14	0	40
AMBT/AM10	AMBT/AM50	0	40
AMBT/AM10	AMBT/AM51	0	40
AMBT/AM10	AMBT/AM52	0	40
AMBT/AM10	AMBT/AM53	0	40
AMBT/AM10	AMBT/AMB1	0	40
AMBT/AM10	AMBT/AMB4	0	40
AMBT/AM10	AMBT/AMB5	0	40

Source: *Own elaboration.*

The example in Figure 4 shows the same structure (as in the Figure 3) of the Workgroup and Workspace in a racking environment (A - active locations, R - redundant locations over active locations) with dedicated picking lanes and replenishment lanes.

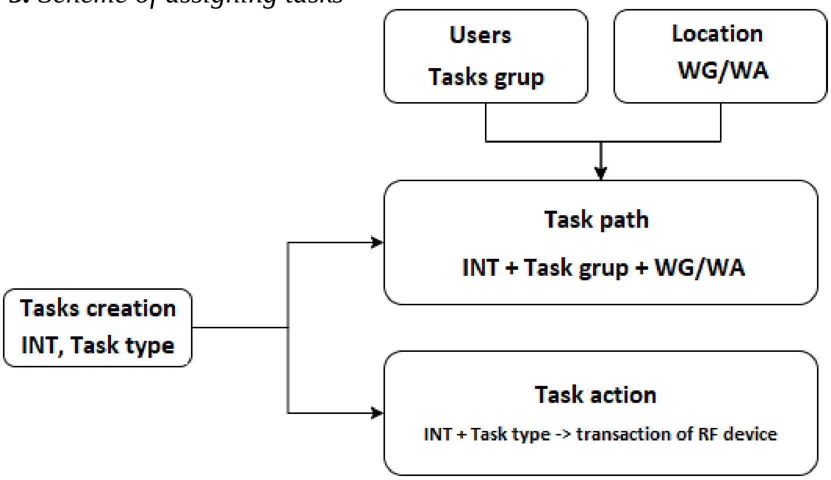
Figure 4. *Setting up shelves and lanes for complementation and supplementation*

	suplementing lane		picking lane		suplementing lane		picking lane		suplementing lane		
R17		R27		R37		R47		R57		R67	WG/WA
R16		R26		R36		R46		R58		R66	1
R15		R25		R35		R45		R59		R65	2
R14		R24		R34		R44		R60		R64	3
R13		R23		R33		R43		R61		R63	4
R12		R22		R32		R42		R62		R62	5
R11		R21		R31		R41		R63		R61	6
A10		A20		A30		A40		A50		A60	7

Source: *Own elaboration.*

The above strategy allows you to allocate users to dedicated corridors based on device paths. In this example, products for locations A30 and A40 are replenished from locations R31-R37 and R41-R47. This configuration restricts users working in one area of the warehouse from accessing jobs generated for other areas of the warehouse. The user is assigned to the default job group as well as any additional, qualifying job groups in which to work. Users can change a group of tasks on the basis of a supervisor's command (Figure 5).

Figure 5. *Scheme of assigning tasks*



Source: *Own elaboration.*

5. Impact of the Manhattan WMOS System on the Resilience of Warehouse in the Studied Enterprise

For the purposes of the research, data was collected from the managers of individual warehouses, on the basis of which the Manhattan warehouse management IT system was run. From the collected data, individual thematic groups were selected, such as:

• time needed to complete warehouse processes,
• level of completion of prepared deliveries,
• time of performing individual tasks,
• Dock-to-warehouse time and the degree of inventory synchronization.

The collected data was used to find sensitive points and compare them with the system used previously. Before the implementation of the Manhattan WMOS system, an indirect system was used, which consisted of: an older warehouse management system, Excel program and the implementation of tasks on the basis of lists of goods printed on paper, on which certain operations were to be performed. The previous system was not uniform and integrated.

5.1 Warehouse Performance Measures

Measurement of warehouse performance measures is critical to providing managers with a clear vision of potential problems and opportunities for improvement. In-warehouse performance metrics fall into three main categories, which include order fulfillment, inventory management, and warehouse performance. There are many examples of performance measures given in the literature (Caplice and Sheffi, 1995).

Goods receipt and picking are multi-step processes. Some are performed immediately when the goods are unloaded, e.g., by scanning labels and order numbers. Others, such as putting the goods to the right location, may take place even a few hours later due to the priority of tasks. Immediately after unloading, the goods will be held in a temporary location, and only then delivered to the desired location.

For this reason, the study will ignore the "inactivity" period, and only the time of actual operations and activities on the goods will be taken into account. Due to the large number of orders, which differ in the number of goods (pallets) that must be received, the average operation time will be taken into account.

5.2 Completeness of Orders

It is absolutely essential for a warehouse to keep stock at a level that will allow to complete the entire order. Delivery of the goods specified in the order on time and in the best possible condition is directly reflected in the income.

Managers must focus both on orders coming to the warehouse to be able to maintain the required inventory, as well as on the control of warehouse work, so that as few goods as possible originally intended for outgoing orders are omitted, lost, not considered ready for picking by the system. Table 2 shows the results for the completeness of the orders.

Table 2. *Completeness of the order*

Order Type	Complete Before Percent	Percent Complete After
Incomming	83,2%	84%
Outgoing	72,7%	88,1%
Returns	100%	100%

Source: *Own elaboration.*

When analyzing the obtained results, it can be noticed that the introduction of the Manhattan WMOS system was of the greatest importance for outgoing deliveries (improvement by 12.4%). It should be assumed that the introduced functionalities of the system had a significant impact on the improvement of completeness of order preparation. In the remaining cases, the change was within the limits of the statistical error.

No significant impact on inbound orders is most likely due to the fact that the Manhattan system is only partially used and therefore has little effect. By their nature, return orders are both rare and limited to a very small number of items - usually one item per order and the whole batch is returned.

5.3 Time of Completing Tasks

The main task of logistics is to deliver goods on time. Stoppages or delays in the performance of warehouse tasks will have a direct impact on the time of delivery of goods to recipients. Table 3 presents the test results for this parameter.

Table 3. *Time of completing tasks*

Type of task	Average time per pallet [s] before	Average time per pallet [s] after
Receipt of goods	145	121
Replenishment of goods	273	223
Unit picking	689	620
Pallet picking	451	423
Inventory	303	259

Source: *Own elaboration.*

When analyzing the obtained results, it can be noticed that the introduction of the Manhattan system had a significant impact on reducing the duration of selected tasks. The average time of unit picking of goods, which is essentially the most critical task in warehouse operations, decreased the most, by as much as 69 seconds.

Overall, the time reduction for all other tasks is noticeable, which clearly indicates an increase in the efficiency of the warehouse operation as a result of the implementation of the new system.

5.4 Time from Dock to Warehouse

The time from the dock to the warehouse is the time counted from the transport approach to the gate, to the unloading of the goods and their full acceptance into the warehouse, and thus the possibility of subjecting the goods to further operations - such as inventory, audit or completion. The test results are presented in Table 4.

Table 4. *Time from dock to warehouse (in minutes)*

Type of task	Average time per pallet [s] before	Average time per pallet [s] after
Receipt of goods	31	25
Returns	5	4,5

Source: *Own elaboration.*

The obtained results revealed that after applying the new system, the time from dock to warehouse for incoming deliveries decreased significantly, by as much as 6 minutes. However, the change in the case of returns of deliveries is not noticeable, which can be explained by a small inventory of such deliveries - usually one pallet.

5.5 Inventory Synchronization

As the Manhattan system also works with other ERP systems (e.g., SAP), it is essential to keep your inventory synchronized on both sides. The first system to be updated with this data was, of course, the newly implemented WMS. The very synchronization of the actual state and the system state is based on periodic inventory. This is especially true for goods with a long shelf life. The test results are presented in Table 5.

Table 5. *Inventory synchronization*

	Percent before	Percent after
Degree of physical synchronization	89%	98%
Degree of synchronization between systems	87%	89%

Source: *Own elaboration.*

The obtained results indicate that the degree of inventory synchronization between the physical and the systemic condition reached as much as 98% correctnes. This means that almost full synchronization. The situation is worse in the case of data synchronization between the Manhattan system and other ERP systems - here the value increased by only 2 percentage points, which may suggest jams at the level of interfaces between the systems.

6. Conclusion

The main purpose of the work was to examine the impact of the implementation of the Manhattan WMOS system on the reliability of the warehouse operation in the logistics supply chain on the example of a food industry company selected for research. For the purposes of the work, the concept and operation of the WMOS Manhattan system were described, as well as internal data in the company was collected, thanks to which the indicators of warehouse operations efficiency were determined.

Thanks to the conducted research, it has been shown that the correct implementation of the warehouse system brings measurable benefits for the reliable and safe functioning of the company's logistics chain. On the one hand, it makes it easier for managers to control warehouse processes, create tasks for warehouse employees, as well as create detailed reports on the effectiveness of warehouse operations. On the other hand, it allows the entire process to run more efficiently.

As shown on the basis of research, the implementation of the Manhattan WMOS system to a selected warehouse has brought relatively large benefits and facilities in effective warehouse management, and thus had a positive impact on its resilience. As a result of the introduced changes, not only the time needed to perform tasks or processes related to warehouse works has decreased, but also the efficiency in operating warehouses has increased.

The ERP systems market is huge. There are many solutions, and many of them specialize in a specific industry, be it food or manufacturing. Choosing the right solution and system is an extremely important decision with long-term consequences. The costs of implementing and maintaining such systems amount to millions of zlotys, and yet the implementation itself takes up to several years, and yet no system guarantees full reliability.

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