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EVALUATION OF THE EFFECTIVENESS OF INFORMATION SYSTEM IN OPTIMIZING WAREHOUSE PROCESSES

Abstract
The aim of the article was to present research on the application of information systems in optimizing warehouse processes. The theoretical aspects describing the fundamentals of warehouse processes were discussed. The theoretical foundations of information systems were also developed, with particular emphasis on systems used in warehouse processes. The results of conducted research among manufacturing organizations with complex warehouse processes were presented, which declared the implementation of ERP, WMS, and SCM systems. Based on the research findings, conclusions were drawn along with the direction of development in the area of digitizing warehouse processes.

JEL classification: O32, O33

Key words: process optimization, IT systems, management, ERP, WMS, SCM

Introduction

The aim of the article was to present research on the application of information systems in optimizing warehouse processes. In today's world, where every business strives for efficiency and competitiveness, managing warehouse processes plays a crucial role. Each such process is characterized by complexity, and its elements need to be harmonized and

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executed smoothly to achieve the shortest possible completion time. This is particularly important in processes where the flow of materials, semi-finished products, and finished products plays a major role, aiming to minimize losses resulting from production downtime and deliver the final product to the customer within the specified deadline.

In today's times, it is essential to make decisions based on solid, well-documented data that provide not only the necessary information for planning, production, sales, and accounting but also serve as a foundation for making strategic business decisions. In fact, it is unimaginable to envision the functioning of a modern 21st-century enterprise without reliable IT solutions that support and streamline daily operations.

Well-performing companies are those that have access to essential data at any given moment and are aware of their resources and the progress of ongoing processes. In this context, tools that support warehouse processes and assess their effectiveness become indispensable. The article presents the results of research conducted among manufacturing organizations that deal with complex warehouse processes.

1. Characteristics of warehouse processes

Warehouse processes are among the most crucial aspects of efficient functioning for manufacturing organizations. They are defined as a set of activities carried out during the flow of specific values (materials, semi-finished or finished products) through the warehouse, starting from the unloading of external transport vehicles, through receiving, storage, recording, preparation, issuance for production, and packaging and loading of finished products (Niemczyk A., 2008, p. 62). To organize warehouse processes, it is necessary to have space where they are conducted, loading and transportation means, personnel, and a data recording system for material or product flow (Dudziński Z., Warsaw 2000).

The complexity level of warehouse processes depends on various factors, including the size of the warehouse, the characteristics of materials and products, the role of the warehouse in the logistics chain, and the organization of work system in the warehouse.

The average warehousing process is carried out in multiple stages, where it is necessary to determine the chain from material delivery to the dispatch of the finished product for transportation. It is crucial to define functional areas in the warehouse, commonly referred to as zones (C. Skowronek, 2008, p. 142), intended for the execution of the successive stages of this process.

Receiving zone - an area where material is received from inbound transportation, and the verification of the conformity of goods with the declared quantity and quality takes place, along with operations related to the acceptance of goods into the warehouse (sorting, sorting, repackaging, and labeling the delivery according to the established warehouse organization). Proper registration of these goods in warehouse data is also crucial.

Storage zone - an area that constitutes the largest part of the warehouse and its size is determined by the type of stored material and the method of storage. In this zone, racks, automated high-storage warehouses, or designated handling paths for warehouse purposes may be used. In these areas, goods can be stored for short or long term, but their control and proper management of warehouse data are necessary. Depending on the industry, specific environmental conditions related to temperature or air density may also be required.

Picking zone - tasks related to order preparation are carried out in this area, strictly according to the customer's order (rearranging and selecting materials based on the orders, moving materials for issuance).

Dispatch zone - located near the loading docks. In this area, goods are issued from the warehouse, and the necessary loading operations take place, utilizing transportation means. Often, the dispatch zone is combined with the receiving zone, serving both purposes and referred to as the receiving/dispatch zone.

In addition to the mentioned zones, other elements of the internal structure associated with the operation of warehouses include: administrative area, social area, vehicle parking area, battery charging area, evacuation routes, and fire protection areas (Szałek B., 1994).

A method to increase the efficiency of warehouse operations is to adopt specific rules for its functioning in relation to the flow of materials and goods. Describing the flow through the warehouse must be done using fundamental warehouse data. Procedures for selecting the order of outbound and inbound units of goods constitute a significant element of advanced warehouse process management. However, for these procedures to be useful, at least two batches of a specific type of assortment should be stored, differing from each other in any assessable parameter. The primary criteria for selecting the order of outbound and inbound flows in warehouses typically include:

The FEFO (First Expired First Out) principle is applicable wherever there is a concern for expiration dates, such as in the case of perishable goods, pharmaceuticals, etc. It is used when the stored assortment has a short

shelf life. Among units of the same product, the one with the earliest expiration date is issued first.

The FIFO (First In First Out) principle ensures that the batch of goods that arrived at the warehouse first is issued first. It is the most commonly used strategy as it is the most natural approach. It is undesirable for a specific batch of goods to remain in the warehouse for too long. FIFO is typically applied where there is no need for the FEFO principle.

The LIFO (Last In First Out) principle is based on the assumption that the most recent batch of goods received is issued first. It is used less frequently and typically applied when driven by cost accounting strategies and inflationary conditions.

In practice, the HIFO (Highest In First Out) and LOFO (Lowest In First Out) methods are also utilized:

The HIFO (Highest In First Out) principle dictates that the batch of goods with the highest unit cost, among the inventory received, should be issued first.

The LOFO (Lowest In First Out) principle is based on the assumption that the batch of goods with the lowest unit cost, among the inventory received, should be issued first.

These principles provide specific guidelines for determining the order in which goods are issued from the inventory based on their respective unit costs. The HIFO principle prioritizes the higher-cost batches, while the LOFO principle prioritizes the lower-cost bat (Ratkiewicz A., 2019)

The described methods are not rigid rules for storing goods in a warehouse. In practice, it is common to apply multiple criteria for determining the order and location of an order, with each criterion having different weights. Developing algorithms that implement these criteria is a complex task. By following the discussed principles during the storage and issuance processes, the speed of fulfilling customer orders can be improved, leading to lower costs.

The methods of data collection and efficient functioning based on them play a crucial role in organizing the warehouse process described above. Everything that is received and everything that is issued from the warehouse must be recorded in the organization's databases. This is essential not only for production planning and estimating the available materials but also for accounting purposes.

2. Information System in Warehouse Processes

In the context of improving organization and implementing Lean Management philosophy, it is necessary to take specific actions to optimize the execution times of processes and subprocesses based on analyzed data. In the case of warehouse operations, knowledge about the quantity

and type of available materials and goods is crucial. Key directions of development in the logistics context for every management team include supply chain control, internal transportation control, and automation of warehouse processes. This is not possible without a well-functioning flow of information that is faster than the physical flow of materials and goods.

Taking into account the aforementioned elements related to the flow of information and goods, as well as the diversity of warehouses and the standardized, repetitive processes and exceptions occurring within them, three groups of products supporting computerization can be mentioned. They include (Majewski, 2008):

ERP systems (Enterprise Resource Planning) - encompassing the area of supporting the management of the entire enterprise, including the accounting and sales departments, including warehouse processes. Support for warehouse processes is often weakly implemented in these systems, but there is usually the possibility of implementing additional warehouse modules that allow for efficient and effective management of inventory levels.

WMS systems (Warehouse Management System) - specialized systems for managing warehouse processes. They are independent of ERP systems and provide the opportunity to use more advanced functionalities. There is the possibility of integrating them with ERP systems depending on the needs and nature of the organization's production. However, they are characterized by high costs and long implementation times, and usually have limited capability for independent modifications.

SCM systems (Supply Chain Management) - used for managing supply chains. These systems are designed to optimize and coordinate the flow of materials, information, and resources across the entire supply chain, from suppliers to manufacturers to distributors and customers. They enable organizations to monitor and control various aspects of the supply chain, such as inventory management, demand forecasting, order fulfillment, and logistics.

In some sources, you can find information about Warehouse Execution Systems (WES). These systems combine WMS functionality focused on executing processes using existing information in ERP, often in the form of mobile applications on handheld devices with barcode scanners. This solution is relatively easy and quick to implement. However, it requires high costs associated with organizing the infrastructure to leverage these systems.

Regardless of the type, an information system plays a crucial role in managing warehouse processes. It enables organizations to respond adequately to market needs, effectively solve current problems, reduce uncertainty in processes, identify areas requiring corrective actions, and introduce process and product innovations. Investments in an efficient

information system allow for taking actions that result in improved operational efficiency, continuous revenue growth, increased market share, and gaining a competitive advantage over competitors. Therefore, it is necessary to assess the application of information systems in logistics processes.

3. Research on the evaluation of information systems in optimizing warehouse processes

3.1. Characteristics of the research sample.

For the purpose of this article, a study was conducted among 100 organizations utilizing information systems in warehouse processes. The research was carried out using a survey method in the second quarter of 2022. Four criteria were adopted to characterize the research sample: type of business activity, company's scope of operation, number of employees, and type of information system used.

Table 1. Characteristics of the research sample include the following

Form of conducted economic activity	Number	Percentage
Limited liability company	63	63%
General partnership	11	11%
Partner company	14	14%
Sole proprietorship	12	12%
Scope of business		
Local	3	3%
Regional	6	6%
National	13	13%
International	78	78%
Number of employees		
1-9	2	2%
10-49	6	6%
50-249	32	32%
Powyżej 250	60	60%
The type of system used		
ERP	45	45%
WMS	35	35%
SCM	20	20%

Source: own study.

According to the analysis of the data presented in Table 1, the largest group of respondents was comprised of limited liability companies (63%), while other forms of business operations fell within the range of 11-14%. Regarding the scope of business operations, a significant majority of

companies (78%) declared cooperation with foreign entities. Only 3% indicated operating at a local level.

More than half of the companies (60%) employ over 250 employees, while 32% of companies have a workforce ranging from 50 to 249 employees. Only 2 companies employ less than 10 people. The most commonly used information system among the respondents was the ERP system (45%). The WMS system is used by 35% of respondents, while the utilization of SCM solutions is declared by 20%.

3.2. Descriptive statistics of observable variables

In the next stage of the survey, organizations evaluated the variables related to the warehouse information systems used in their operations using a Likert scale presented in the questionnaire.

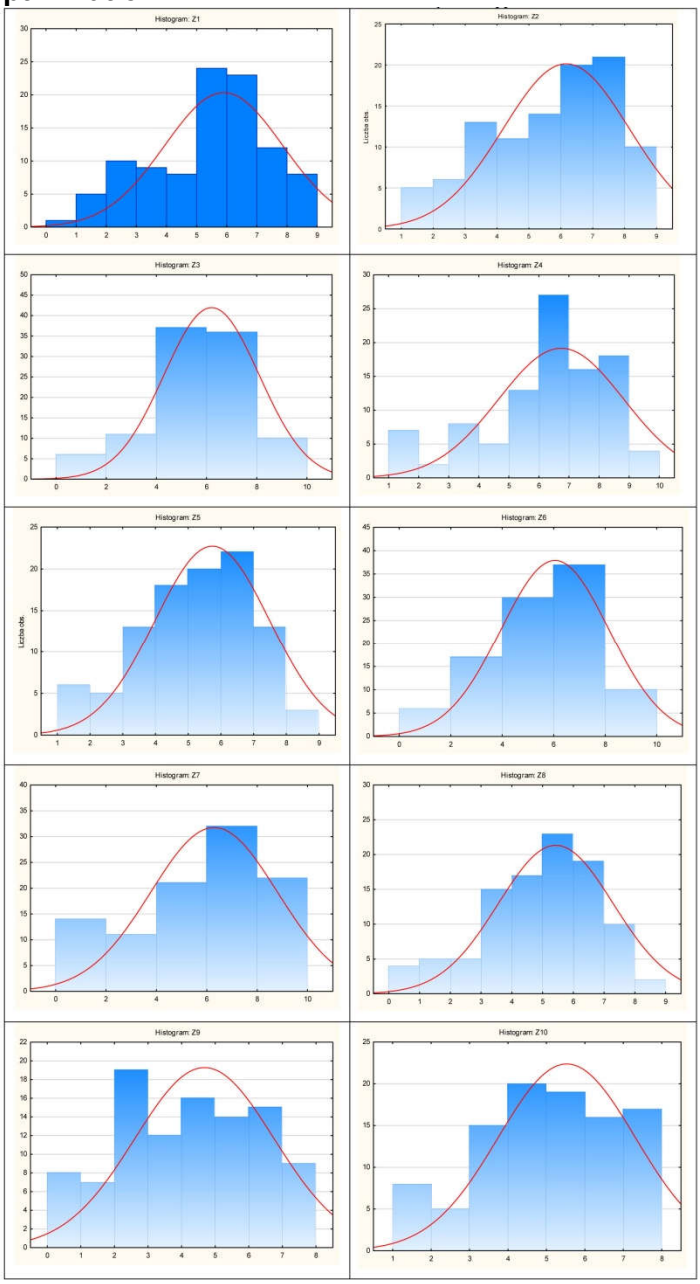
Table 2. Descriptive statistics of the observed variables describing

No.	Specification	Mean	Standard deviation
Z1	Level of advancement of information systems in warehouse processes	5,90	1,96
Z2	Level of training of employees using information systems in warehouse processes	6,17	1,98
Z3	Impact of information systems on streamlining warehouse processes	6,20	1,90
Z4	Level of avoiding quantity errors in material warehouse coordination	6,74	2,08
Z5	Level of avoiding quantity errors in goods warehouse coordination	5,74	1,76
Z6	Evaluation of time optimization of warehouse processes using information system	6,05	2,11
Z7	Level of integration of the information system in the warehouse with accounting document issuance	6,29	2,51
Z8	Economic efficiency of the information system - level of preventing losses in material and goods issuance	5,43	1,87
Z9	Evaluation of the maintenance costs of the information system in the warehouse relative to the benefits of its use	4,68	2,07
Z10	Evaluation of the potential for improving the information system in warehouse processes	5,53	1,78

Source: own study.

Based on the analysis of Table 2, no significant deviations from the mean ratings were observed. The average responses on the Likert scale

Figure 1. Distribution of Observable Variables for the Assessment Parameters of Information Systems Applications in Warehouse Process Optimization



Source: own study.

for all variables ranged from 4.68 to 6.74. This indicates that the respondents rated the variables very highly. The variable regarding the level of avoiding quantity errors in material warehouse coordination received the highest rating. This pertains to the coordination of the receiving and data registration of materials, as well as their issuance for production. It indicates that the implemented system allows for better control over organizational chaos and effectively organizes the quantity flow of materials in the production process. The lowest rating was given to the assessment of the costs of implemented systems, suggesting that they are still a relatively costly endeavor in supporting management. The highest discrepancy between respondent answers, measured by the standard deviation, was observed for the variable regarding the level of integration of the information system used in warehouse processes with accounting document issuance. However, this depends not only on the information system but also on the level of personnel qualifications and collaboration. On the other hand, the most consistent answers were observed for the variable concerning the level of avoiding errors in the registration and issuance of finished products for transportation and sale.

Based on Figure 1, it was observed that all distributions of the observable variables for the assessment parameters of information systems applications in warehouse process optimization were above the mean.

Table 3. Descriptive statistics of observable variables describing

No.	ERP		WMS		SCM	
	Standard deviation	Mean	Standard deviation	Mean	Standard deviation	Mean
Z1	1,81	6,04	1,98	5,85	2,17	5,74
Z2	1,92	6,02	2,08	6,30	2,04	6,29
Z3	1,62	6,22	2,14	6,05	2,13	6,26
Z4	1,94	6,87	2,21	6,40	2,22	6,77
Z5	1,61	5,64	2,05	6,10	1,78	5,66
Z6	2,04	6,04	2,21	5,95	2,18	6,11
Z7	2,52	6,42	2,57	6,25	2,53	6,14
Z8	1,80	5,60	1,96	5,55	1,93	5,14
Z9	2,03	4,84	1,98	5,15	2,13	4,20
Z10	1,80	5,56	1,88	5,80	1,73	5,34
	Mean	**5,925**	**Mean**	**5,94**	**Mean**	**5,765**

Source: own study.

Based on the comparative analysis presented in Table 2, it was observed that both the ERP and WMS systems received the highest ratings, as indicated by the small differences. The SCM system, on the other hand, received lower ratings, which may suggest its less frequent utilization in industrial practice or its greater focus and specialization specifically on the supply chain.

Conclusions

Information systems are essential management tools for organizations. This applies to both organizational and managerial processes, as well as supporting processes, including the storage process. There are many solutions available on the market, including ERP, WMS, and SCM systems examined in this study. This article provides an assessment of the practical application of these systems in the industrial practices of manufacturing companies.

It is worth emphasizing the high ratings of the presented parameters, which exceed the average. Furthermore, the issue of implementation and maintenance costs of these systems remains relevant. Consideration should be given to grants supporting the digitization process through funding consulting or training for companies that already have systems and want to further enhance their utilization. The high ratings of error avoidance in both material storage and finished products, as well as the economic efficiency of the systems, should not be overlooked. In this case, it can be stated that their implementation is advantageous for every organization.

The low standard deviations observed in the conducted research are noteworthy, indicating a consistent evaluation among all respondents. There are individual aspects that influence the assessment of specific variables. However, the effectiveness of information systems in the storage process is a common factor.

In conclusion, it can be stated that information systems are the future of warehouse management, and their digitization cannot be overlooked. Moreover, the efficiency of their implementation directly impacts the finances of companies through optimizing intra-warehouse logistics and minimizing losses.

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