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INNOVATION MANAGEMENT AND AUTOMATED ACCOUNTING IN THE CHAOTIC STORAGE LOGISTICS

Abstract. *The formation of the digital economy and the information society requires a revision of traditional concepts of business management. The growth of the assortment and nomenclature of material values, a complication of their accounting reflection in the enterprises of logistics business necessitates the implementation of a new logistics system of chaotic storage. The article substantiates the expediency of the evolutionary replacement of the technology of automated identification of material values (bar code for radio frequency) in the conditions of organization of warehousing on the principles of chaotic storage, which requires improvement of accounting at modern enterprises. The purpose of the scientific research is to develop organizational and methodological provisions for the accounting of material values at the warehouses of enterprises in the conditions of implementation of a logistic system of chaotic storage and the use of radio frequency identification technology to optimize the automated warehouse management. The experience of the chaotic storage of material values by Amazon Corporation and the systematization of literature sources for the introduction of a new concept of logistics flow management showed the lack of scientifically reasoned proposals and practical developments in the automation of accounting of storage and movement of material values. The peculiarities of the organization of accounting and management of the movement of material values in the logistic system of chaotic storage are investigated in the article. The documentation procedure and documenting the logistical operations of the movement of material values using radio frequency identification technology have been developed. The technique of inventory control over the storage of inventory objects in the conditions of automation of warehouse management has been improved. The choice of the method of the identified estimation of receipt and disposal of material values for optimization of the warehouse stocks of the enterprises in the logistic system of chaotic storage is substantiated. The practical significance of the conducted research lies in the possibility of implementing a logistic system of chaotic storage with the use of technology of radio frequency identification of material values at enterprises, which will provide: automated without the direct participation of accounting personnel collecting accounting data on the movement and storage of material values; permanent automated inventory of objects to control their storage; optimization of management of logistic processes based on the use of robots-conveyors for the automated movement of inventory from warehouse positions to destinations; electronic documentation and documentation procedure in the warehouse accounting system of enterprises; reducing inventory levels with lost consumer value (shelf life) or low*

market demand, etc. The results of the study may be useful for enterprises that are focused on innovative management techniques, regardless of ownership, size of business or industry.

Introduction. The implementation of the concept of logistics flows management «just-in-time» positions certain requirements for the warehouse economy of enterprises. The absence of the need for large volumes of accumulated production stocks required for the smooth operation of the enterprise contributes to the abandonment of complex warehouse systems; effective control over the preservation of material values prevents their unproductive losses; efficiency of transfer and transportation of material flows determines the competitiveness of the entity in the market of goods and services. Ultimately, all requirements for the efficiency of warehouse operations are aimed at minimizing the costs of the enterprise.

The "just-in-time" concept and minimizing warehousing costs are in line with the logistics system – the "chaotic storage" of material values developed by Amazon Corporation. «Chaotic storage» is a holistic system of placement of material values on shelves without permanent sections, when no characteristics, storage periods, attributes, and consumer properties of the goods play a role (Tekhnologiya raboty sklada Amazon, 2020). In other words, material values are stored in an arbitrary sequence without any systematic nature. The implementation of the logistics system of chaotic storage leads to dramatic transformations in the methodology and organization of accounting and management of warehouse operations.

Literature Review. As the logistic system of chaotic storage is quite innovative and new for the management of enterprises, there is a small amount of research on this issue in modern scientific space. In particular, Zijm W.H.M., Klumpp Matthias, predicted the prospect of chaotic warehouse management in trade logistics for trading enterprises (Zijm et al., 2017). Muralidhara G.V., Vijai J.P., explained the methodology of operating processes in warehouses with the chaotic storage of the Amazon Corporation – the developer of the logistics concept (Muralidhara and Vijai, 2016). Neukirchen Thomas supplemented scientific research by substantiating the interconnection of the processes of receipt, storage, and sale of goods on the principles of chaotic warehouse management (Neukirchen, 2018). Guo X., Yu Y., De Koster R. B. M. explained the impact of warehousing and movement of goods (including the logistic system of chaotic storage) on the choice of warehouse policies of commercial establishments of different size, trade format and market share (Guo et al., 2015).

The popularity of chaotic warehousing of material values at trading enterprises is explained by the scientists as considerable variability of the terminology and assortment of goods, which requires the use of effective methods of managing the warehouse economy. However, it is expedient to realize the logistic system of chaotic storage for the enterprises of other branches of economic activity, the material values of which are characterized by different sources of income (from suppliers, as raw material, own production), weighing instruments (simultaneous operation of tons and grams), degree of readiness processing, several stages of processing, semi-finished products, finished products, packaged products), etc.

Quintanilla S., Pérez A., Ballestín F., Lino P. attempted to provide a mathematical explanation of the chaotic storage algorithm in enterprise warehouses using heuristic methods of modeling economic processes (Quintanilla et al., 2015). Hausman W.H., Schwarz L.B., Graves S.C. were involved in the development of algorithms for the automated control of material placements, including in the event of chaotic accumulation in warehouses (Hausman et al., 1976). The scheme of warehousing of material values in warehouses with chaotic management from the branding was developed by Yapicioglu H., Smith A.E. (Yapicioglu et al., 2012). Ghazavi Elaheh & Lotfi Mohammad formed a model of warehousing of

material goods on the principles of chaotic warehousing using a situational approach (Ghazavi et al., 2016). In scientific works, the emphasis is placed on the management of logistics flows in warehouses, accounting information management of the enterprise remains out of the researchers' attention. Scientific developments in the field of chaotic warehousing management are partial without accounting association.

The implementation of the principles of the system of chaotic storage of material values requires the implementation of effective accounting and management at the warehouses of enterprises. The versatility of accounting information on the variational material values of enterprises can complicate warehouse management. To increase the efficiency and reliability of accounting and warehouse management, they use the bar code technology, which was introduced in practice in 1974 (Vnov ob avtomatizatsii inventarizatsii). Nowadays, the practice of accounting and management using barcode identification of material values has significant organizational limitations and is outdated. To optimize the management of warehouses of enterprises, it is recommended to implement a logistic system of chaotic storage using radio frequency identification technology.

Radio Frequency Identification (RFID) is radiofrequency recognition using special labels affixed to an object, containing identification and other information to control the movement of inventory in production and trade. Today, 16% of enterprises in European countries use radio frequency identification technology for economic purposes (Figure 1). Two thousand twenty data are predictive based on the use of extrapolation methods within the previous years.
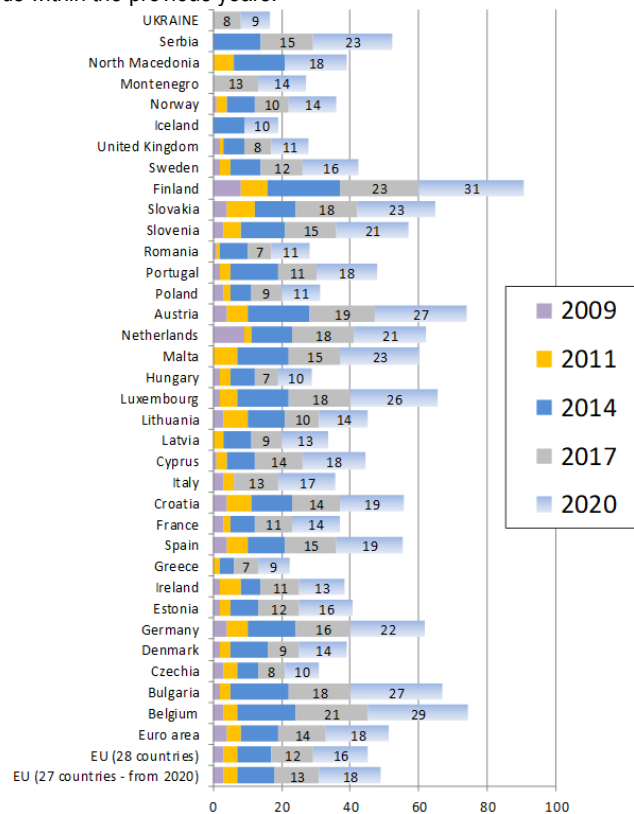

Figure 1. The share of enterprises using radio frequency identification technology in European countries in 2009-2020,%

Source: systematized by the authors based on (Eurostat, 2017)

Compared to 2009, the share of enterprises with integrated RFID technologies increased by 13%. The most progressive countries in 2020 about the introduction of radio frequency identification technology are Finland (31% of economic entities), Belgium (29%), and Austria (27%). In Ukraine, the share of enterprises implementing this technology is only 9%, which is one of the lowest in Europe.

The increasing popularity of RFID technology is explained by the presence of positive differences compared to barcode identification, which is useful for accounting for material warehousing operations (Table 1).

Table 1. Advantages and Disadvantages of Material Values (MV) Identification Technologies:
Radio Frequency Identification and Bar Coding

No	Characteristic features of technology («+» is an advantage, «−» is a disadvantage)	Radio Frequency Identification	Barcode identification
1.	Direct visibility between the scanner and the mark placed on the MV	No +	Yes −
2.	Monitoring of movement of MVs in space and time	Yes +	No −
3.	Identification of a significant number of MVs at a time	Yes +	No −
4.	Recognizing each MV unit individually (not just lots, items)	Yes +	No −
5.	The use of a large number of different identification devices	No +	Yes −
6.	Involvement of personnel of the enterprise in the processes of identification of MVs	No +	Yes −
7.	Application for entering primary data into the database	Yes +	Yes +
8.	A large amount of markup memory that can accommodate various MV characteristics	Yes +	No −
9.	Significant duration of identification tag operation	Yes +	No −
10.	Repeated use of identification tags	Yes +	No −
11.	Impact of environmental conditions on the tags	No +	Yes −
12.	Probability of falsification and manipulation with the identification tags by company personnel	No +	Yes −
13.	Use of the system of protection and control of an unauthorized taking away of MVs outside the enterprise	Yes +	No −
14.	Producing of own identification tags by the enterprise	No −	Yes +
15.	Low cost of technology implementation and maintenance	No −	Yes +

Source: developed by the authors.

A significant advantage of the technology is the ability to identify items of material values, which, in contrast to the barcode detection of commodity lots, provides better accounting analytics. The difference is the ability to identify each item of inventory, which is especially important for warehouse management based on the principles of chaotic storage. Thus, an individual radio transmitter (RT-tag), which contains a unique code, is attached to the property. Reading the identification code reveals a unit of the material value in the database accounting system.

Marking with a separate chip of each product provides complete control over storage in the warehouse and movement of material values by their quantity. Unlike barcodes, there is no need to read line readings between the source of information and the receiver to read RT tags. At the moment when the material value is in the radio field, it is identified with the corresponding reflection in the accounting system. As a consequence, warehouse management in a logistical chaotic storage system requires detailed information about the storage location and movement of each unit of the material value, which can be provided by a computerized accounting system using only radio frequency identification technology.

The purpose of the article. The purpose of the scientific research is to develop organizational and methodological provisions of accounting of material values at warehouses of enterprises in the conditions of implementation of a logistic system of chaotic storage and use of radio frequency identification technology for optimization of warehouse management. Disclosure of the purpose of the article involves the following tasks:

- to find out the order of the organization of accounting and management of the movement of material values in the logistic system of chaotic storage;

- to investigate the features of computerized accounting at the warehouses of enterprises with the use of radio frequency identification of material values;

- to develop a methodology for documenting, inventorying, and valuation of material values, which are automatically identified in the logistic system of chaotic storage.

Methodology and research methods. To prove the necessity of accounting modernization in the conditions of using the latest management concepts and information processing technologies, the energy-entropy methodology of cognition of economic processes was used. The study is based on systemic and innovative approaches. The systemic approach to scientific knowledge provides the study of economic phenomena and processes in the context of the cause and effect relationships of the implementation of the logistics system of chaotic storage and optimization of accounting and warehouse management. For the realization of the set tasks of the research, the general methodological bases of the systemic approach were used in determining the properties of accounting as a system, refining its subject and methods in the conditions of using modern information processing technologies. The systemic approach is applied to reveal the essence of accounting as a type of social and economic activity as well as to identify its relationship with the digital society and the economy. The evolution of computerized accounting using the technology of automated material values identification has been studied using a combination of historical and logical methods. At the same time, the emphasis is put on the use of methods of economic and mathematical modeling, forecasting, and extrapolation of retrospective information to predict the development of radio frequency identification technology in Ukraine and abroad.

The innovative approach to the theoretical and methodological principles of accounting at the warehouses of enterprises will be based on the idea of its social and economic role and importance in managing the activity of enterprises of different branches of economic activity. The novelty of the accounting research approach lies in the complexity and systematic nature of scientific methods, which makes it possible to improve the method of documenting, inventorying, and estimating material values in the context of the introduction of a chaotic storage system and the use of radio frequency identification technology.

Results. The system of «chaotic storage» significantly optimizes the management of the warehouse. The material values are transferred to the free space in the warehouse in the section with marked serial numbers. After the physical placement of inventories in a specific section, a nomenclature name is attached to its number in the accounting system. Sections do not have a clear product purpose and are filled as they are released. To search for material value, it is identified in the accounting and management system according to the spatial location. It is advisable for the employee of the enterprise, who has to pick up the goods, about the location of goods on the warehouse map with the numbering of rows and sections

(shelves in sections). The scheme of material and information flow of the accounting and control system «chaotic storage» is shown in Figure 2.
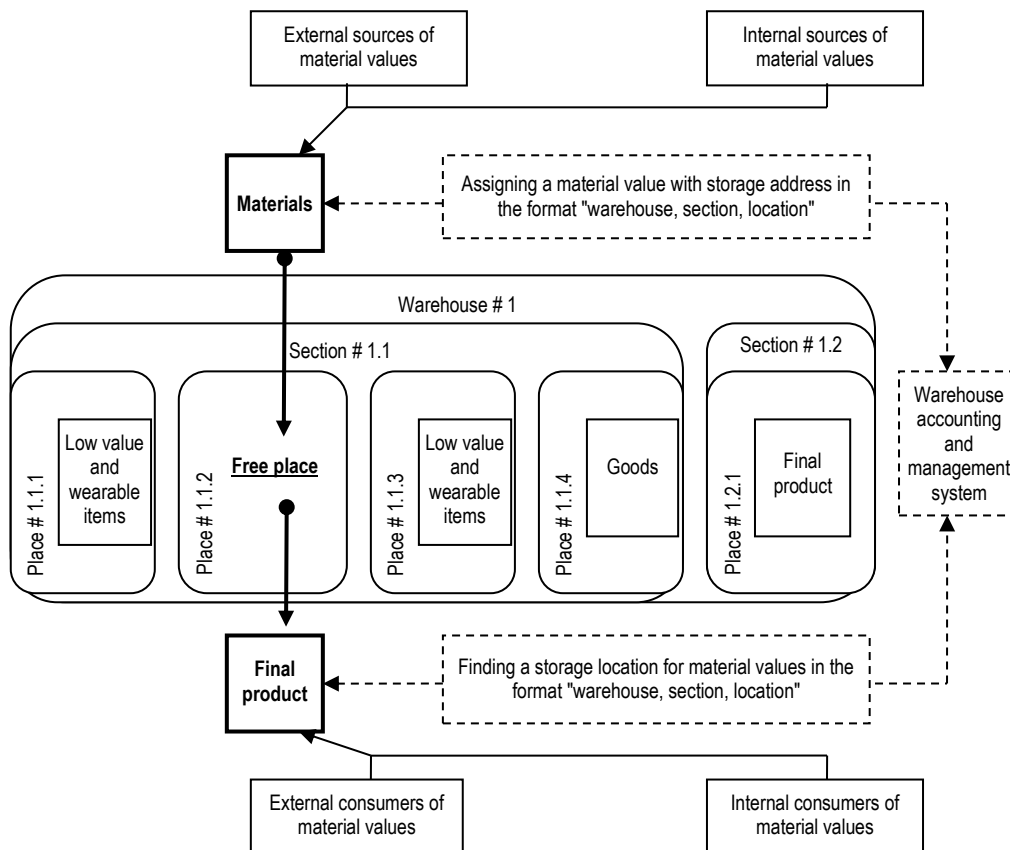
Figure 2. Scheme of material and information flow of accounting and warehouse management system «chaotic storage»

Source: developed by the authors.

The advantage of a chaotic storage system for enterprises is to optimize the size of warehouse space. By minimizing storage space that is not involved in the expected material values of a particular type, it is possible to reduce the physical size of the warehouse significantly. It also makes it easier to prepare personnel for warehouse work because there is no need to remember the location of different types of material values.

Logistic flows are optimized in conditions where it is necessary to collect a set of different material values from a warehouse at a time. Workers are informed about the location of the sections, not the specific material values. Accordingly, the selection of a batch of goods promptly carried out without the need to involve a large number of warehouse personnel of the enterprise.

The efficiency of warehouse management depends on the accuracy and timeliness of accounting information, which requires effective documentation of transactions with material values. Documentation in the logistic system of chaotic storage requires a personalization requirement. Each primary document

must contain multifaceted personalized material value information. In the primary documents, it is advisable to record all consumer characteristics of material value, their exact location, and financially responsible persons to form a complete database of the enterprise. Multidimensional primary accounting is important for a chaotic storage system since all subsequent inventory related documents will only show their name and storage location.

To simplify the entry of accounting information and the future search for material values, it is advisable to carry out their radio frequency marking. The manufacturer's or buyer's RT tags on entry into the warehouse shall include the accounting data on production, quantity, and weight and consumer characteristics of material value. At the time of receipt of the material, the employee ties them to a specific storage location using RFID technology. There is an informal association of the RT tag attached to the material value, with a spatial placement on the storage shelves (storage sites).

When entering a warehouse, moving or disposing of material values, the Warehouse Management System collects credentials from accounting inventory RTs. The collected credentials are the basis for the automated generation of forms of electronic primary documents and their content. Primary collection and processing of accounting information may be performed by RFID technology devices without the direct involvement of accounting professionals. It is advisable to use primary electronic documentation for further accounting procedures and transfer to stakeholders. The information scheme of electronic documentation of material values using radio frequency identification technology is shown in Figure 3.

The accounting information obtained using radio frequency identification technology should be further used for automated warehouse management. Based on Amazon's positive experience with the use of conveyor robots, it is recommended that they automate the process of searching, unloading (loading), and physically moving material values. Robot-conveyors can automatically identify the storage location and retrieve the material value for delivery to the destination by the RT tag. If the warehouse is large and contains several warehouses, the automated control system can simulate the shortest route to the storage location of the required material value. This model of warehouse management minimizes warehouse costs for the operation of the internal transport of enterprises.

According to a similar algorithm, it is advisable to make an inventory of material values at their storage sites. By scanning the RT tags from inventory objects and storage locations, they can permanently monitor the storage process. The procedure of radio frequency identification is carried out automatically without the direct involvement of accounting specialists. Any change in the location of material values is immediately recorded in the accounting and management system. The credentials are automatically compared with the actual metrics. If infringements are detected, accounting records are formed to write off the shortage or post the surplus of material values.

Based on the credentials from the RT tags, it is advisable to automate electronic documents based on the inventory results (Figure 3). Accounting information on the presence and movement of inventory is provided by RFID technology through electronic communications networks. After the inventory is automatically identified, credentials from the RT tag are retrieved. The accounting information is automatically entered into a single database and used to generate electronic documents based on inventory results. All required document details are automatically filled in without direct involvement of accounting specialists. Generated inventory descriptions and comparative information can be printed out and provided to interested parties as needed.

Permanent inventory will help to obtain prompt and reliable accounting information about the remains of material values, which is essential for a logistic system of chaotic storage. In case of breach of the periodicity of the inventory check, the accounting information may be out of date. De-actualization of the system of accounting in the conditions of minimum warehouse stocks can lead to suspension of economic activity, as well as a critical increase in the duration of logistics flows due to errors in determining the location of goods in a warehouse with chaotic storage.

Once a week, it is appropriate to entrust the internal control service by checking the availability of material values and monitoring the correctness of the work of financially responsible persons. Internal controllers will be able to control the work of the automated system of accounting and warehouse management, detect unauthorized movement of material values, establish responsible persons for committing an offense.
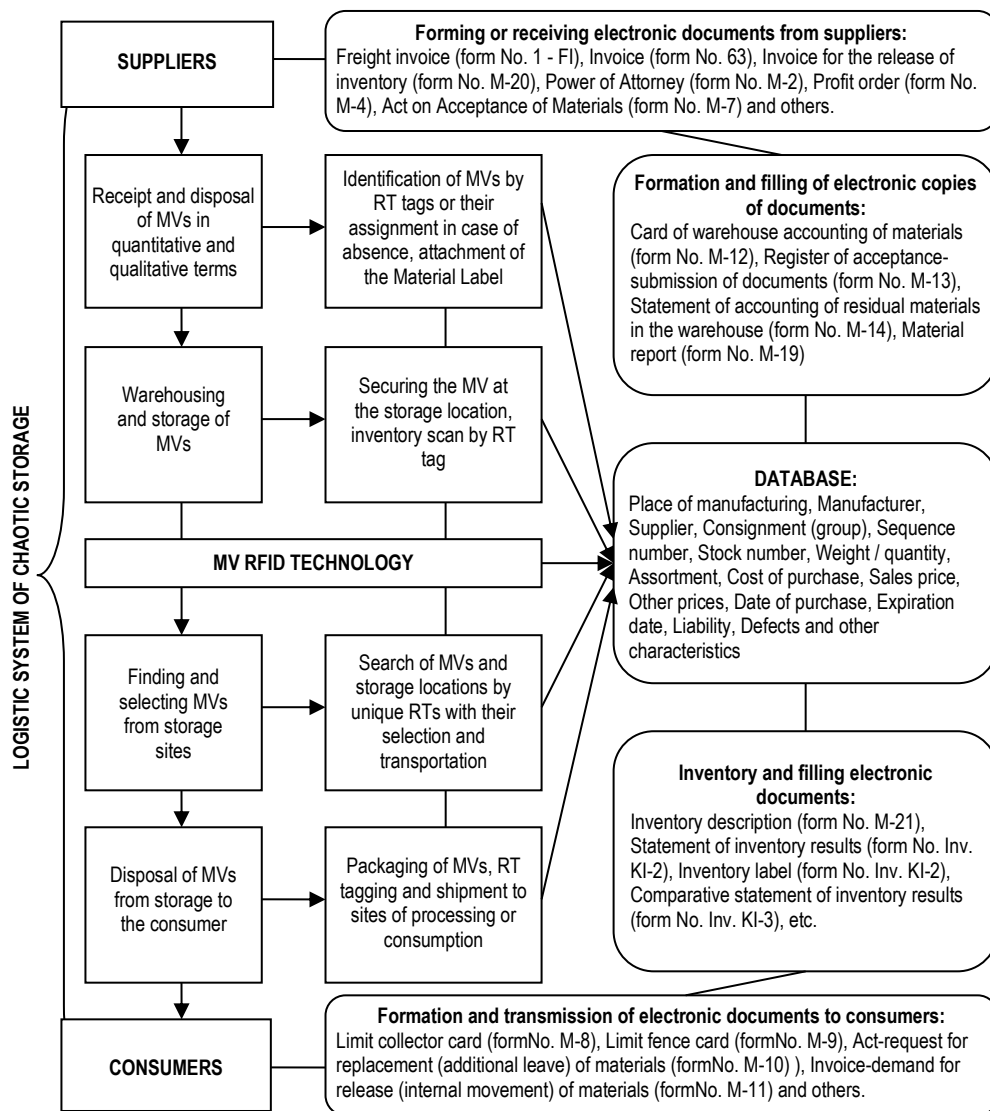

Figure 3. The procedure of electronic documentation and handling of material values (MVs) in the warehouse using RT tags

Source: developed by the authors.

The technology of identifying locations of certain material values by RT tags should also be used to estimate the receipt and disposal of accounting items. The control is important: the shelf life of purchased raw materials and manufactured products; the accumulation of unclaimed stocks with low demand. And if in industrial and commercial establishments (especially in non-food trade) in the case of chaotic storage of material values the valuation of disposal is made by the FIFO method based on party accounting of material values, then for the enterprises of other branches of economic activity such method of estimation is ineffective if it is necessary to control by the shelf life or demand. Radio-frequency identification of material values contributes to the detailed accounting of each item by different consumer characteristics.

The best way to evaluate the receipt and disposal of material values in a logistic system of chaotic storage is the method of identified cost. It is advisable to integrate the identified valuation methodology into the automated accounting and warehouse management system using RFID technology. At the time of receipt and storage of raw materials, along with other accounting information, the date of manufacture and shelf life is determined. Upon receipt of a request for the removal of certain material values from the warehouse, their identified search is performed by the date of manufacture and the date of completion of the consumer value. They are eliminated from a warehouse with chaotic storage material inventories, depending not on the place of their storage or date of receipt, but in the order of their expiry date. Similarly, first, they are directed to the disposal of material values with little demand to adjust the balance of unclaimed inventory.

As a consequence, the use of the identified cost method of valuation contributes to the optimization of warehouse management by reducing the number of inventories that have lost consumer value, acceleration of the circulation of goods with low market demand, accurately determine the cost of accounting units leaving the enterprise.

At the same time, the chaotic storage system has some functional limitations. It is advisable to formulate the following recommendations for the optimization of the automated system of accounting and warehouse management based on radio-frequency identification of goods and storage sites:

- the separate accumulation of raw materials, which periodically arrive in the unpacked form due to the impossibility of marking the material values with RT tags and, accordingly, automated individual accounting;

- storage of final products, which is in high demand, closer to the places of loading to transport for transportation to the buyer, which will save time and storage costs for the removal, internal movement of material values when the fact of realization occurs.

Conclusions. The implementation of a logistic system of chaotic storage positions the functional requirements for the warehouse economy of enterprises to accelerate the turnover of material values, reduce inventory in a warehouse, minimize warehouse costs. Improvement of the method of accounting for the process of receipt, storage, and release of material values at warehouses of enterprises organized on the principle of chaotic storage should be aimed at providing electronic documentation of logistics operations, inventory of material values using radio frequency identification technology and identification method. Information support for the warehouse management system should be based on the principles of chaotic storage to automate the process of warehousing and optimization of logistic processes.

Implementation of the logistics system of chaotic storage with the use of radio frequency identification of material values will ensure: automated collecting accounting data on the movement and storage of material values without the direct participation of accounting personnel; permanent automated inventory of objects to control their storage; optimization of management of logistic processes based on the use of robot-conveyors for the automated movement of material values from warehouse positions to destinations; electronic documentation and workflow in the warehouse accounting system of enterprises; reducing inventory levels with lost consumer value (shelf life) or low market demand, etc.

Further research requires the need to develop a methodology for the formation of internal and external reporting on the results of the activities of enterprises whose logistics processes are focused on the chaotic storage of material values using radio frequency identification technology.

Author Contributions. All authors contributed equally to the development of the research, the literature, data collection, research methodology, and concluding sections.

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Інноваційний менеджмент та автоматизований облік в логістиці хаотичного зберігання

Формування цифрової економіки та інформаційного суспільства потребує перегляду традиційних концепцій управління господарською діяльністю. Зростання асортименту та номенклатури матеріальних цінностей, ускладнення їх облікового відображення на підприємствах логістичного бізнесу зумовлює необхідність імплементації нової логістичної системи хаотичного зберігання. У статті обґрунтовано доцільність еволюційної заміни технології автоматизованої ідентифікації матеріальних цінностей (штрих-кодової на радіочастотну) в умовах організації складського господарства на принципах хаотичного зберігання, що потребує удосконалення бухгалтерського обліку на сучасних підприємствах. Метою наукового дослідження є розробка організаційних та методичних положень обліку матеріальних цінностей на складах підприємств в умовах впровадження логістичної системи хаотичного зберігання та використання технології радіочастотної ідентифікації для оптимізації автоматизованого управління складським господарством. Опрацювання досвіду хаотичного зберігання матеріальних цінностей корпорацією «Amazon» та систематизація літературних джерел щодо впровадження нової концепції управління логістичними потоками засвідчило відсутність науково обґрунтованих пропозицій та практичних розробок щодо автоматизації обліку зберігання та руху матеріальних цінностей. У статті досліджено особливості організації обліку та управління рухом матеріальних цінностей в логістичній системі хаотичного зберігання. Розроблено порядок документування та документообігу щодо логістичних операцій руху матеріальних цінностей з використанням технології радіочастотної ідентифікації. Удосконалено методику інвентаризаційного контролю за зберіганням інвентарних об'єктів в умовах автоматизації управління складським господарством. Обґрунтовано вибір методу ідентифікованої оцінки надходження та вибуття матеріальних цінностей для цілей оптимізації складських запасів підприємств у логістичній системі хаотичного зберігання. Практичне значення проведеного дослідження полягає у можливості імплементації логістичної системи

хаотичного зберігання з використанням технології радіочастотної ідентифікації матеріальних цінностей на підприємствах, що забезпечить: автоматизований без прямої участі облікового персоналу збір облікових даних про рух та складування матеріальних цінностей; перманенту автоматизовану інвентаризацію об'єктів з метою контролю за їх зберіганням; оптимізацію управління логістичними процесами на основі застосування роботів-транспортерів для автоматизованого переміщення матеріальних запасів зі складських позицій до місць призначення; електронне документування та документообіг в системі обліку на складах підприємств; зменшення рівня складських запасів із втраченою споживчою цінністю (терміном придатності) чи незначним попитом на ринку тощо. Результати проведеного дослідження можуть бути корисними для підприємств, які орієнтовані на інноваційні методики управління незалежно від форми власності, розміру господарської діяльності чи галузі економіки.