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WORLD TRENDS IN WAREHOUSING LOGISTICS

Marchuk Volodymyr, Harmash Oleh, Ovdiienko Oksana. "World Trends in Warehouse Logistics". *Logistics as well as supply chain management is a fast changing field of economic activity, because it deals with different types of companies, different goods, different countries and continents, different cultures and management styles. It is reasonable that further prosperity of such entities are impossible without tracking modern trend and innovative technologies, which are providing the opportunity to rise, develop and stay profitable. Warehouse logistics is an essential part of companies' activity and takes on a significant part of the costs. Following the main worlds trend and their implementation designed to improve the financial result and quality of services. That's why this paper is devoted to analysis of the warehousing logistics innovative development and the ways how to reach it, of the most progressive world trends, namely robotics (manipulator robots, palletizer robots, sorting robots, mobile robotic carts, etc., due to whom automation of warehouse operations is carried out), Big Data (as an efficient processing of structured and unstructured huge amounts of analytical data from various sources coming at high speed), electronic data exchange technology – EDI (allows to automate the creation, sending, receiving and processing of any electronic documents and integrate them with existing business applications), drones (automated unmanned aerial vehicles, which can be used in the warehouse to gain access to goods at high altitudes, where other modes of transport will not be able to get), Internet of Things (IoT, which would give the opportunity to maintain communication between sites or premises and to control business processes of the warehouse complex), additive technologies (allows to create the* *necessary products and various components using 3D-printing technology), etc. Moreover, it is not only given the general characteristic of each type of innovative ways of developments, but also presented the advantages, disadvantages and prospects of using global trends in warehousing infrastructure. It is shown that implementation of modern technological solutions and automation of processes promotes the development of multi-storey warehouses.*

Keywords: world trends; innovative developments; warehousing logistics; automation; digital technologies; processes.

Марчук Володимир, Гармаш Олег, Овдієнко Оксана. «Світові тренди складської логістики». *Логістика та управління ланцюгами поставок завжди були швидко змінними сферами економічної діяльності, оскільки постійно працюють з різними типами компаній, різними товарами, різними країнами та континентами, різними культурами та стилями управління. Цілком зрозуміло, що подальше процвітання таких організацій неможливе без відстеження сучасних тенденцій та інноваційних технологій, які надають можливість рости, розвиватися та залишатися прибутковими. На складську логістику припадає значна частина не лише операційної діяльності компаній, але і загальних витрат. Відслідковування основних світових трендів та їх впровадження у своїй діяльності покликане покращити фінансовий результат та якість пропонованих послуг. Саме тому особлива увагу у статті надана аналізу інноваційного розвитку логістики складських приміщень та шляхів її досягнення, найбільш прогресивних світових тенденцій, а саме робототехніці (роботи-маніпулятори, роботи-палетизатори, сортувальні роботи, мобільні роботизовані візки тощо, завдяки яким впроваджується автоматизація складських операцій), Big Data (ефективна обробка структурованих та неструктурованих аналітичних даних з різних джерел, що надходять з високою швидкістю), технологія електронного обміну даними - EDI (дозволяє автоматизувати створення, відправлення, отримання та обробку будь-яких електронних документів та інтеграція їх до існуючого програмного забезпечення), безпілотники (автоматизовані безпілотні літальні апарати, які можна використовувати на складі для отримання доступу до товарів на великій висоті, куди не зможуть дістатися інші види транспорту), Інтернет речей (IoT, що дасть можливість підтримувати зв'язок між різними приміщеннями складу та контролювати бізнес-процеси всього комплексу), адитивні технології (дозволяють створювати необхідні продукти та їх комплектуючі за допомогою технології 3D-друку) тощо. Також надано не лише загальну характеристику кожного типу інноваційних шляхів розвитку, але й проаналізовано переваги, недоліки та перспективи використання світових трендів у складській інфраструктурі. Показано, що впровадження сучасних технологічних рішень та автоматизація процесів сприяє розвитку багатоповерхових складів.*

Ключові слова: світові тренди, інноваційні розробки, складська логістика, автоматизація, цифрові технології, процеси

Марчук Владимир, Гармаш Олег, Овдиенко Оксана. «Мировые тенденции в складской логистике». *Логистика, а также управление цепочками поставок - это быстро меняющаяся сфера экономической деятельности, поскольку она имеет дело с разными типами компаний, разными товарами, разными странами и континентами, разными культурами и стилями управления. Разумно, что дальнейшее процветание таких предприятий невозможно без отслеживания современных тенденций и инновационных технологий, которые дают возможность расти, развиваться и оставаться прибыльными. Складская логистика является неотъемлемой частью деятельности компаний и берет на себя значительную часть расходов. Следование основным мировым тенденциям и их реализация призваны улучшить финансовый результат и качество услуг. Именно поэтому данная статья посвящена анализу инновационного развития складской логистики и путей ее достижения, самых прогрессивных мировых тенденций, а именно робототехнике (роботы-манипуляторы, роботы-штабелеры, сортировочные роботы, мобильные роботизированные тележки, использование которых обеспечивает автоматизацию складских операций), Big Data (как эффективная обработка структурированных и неструктурированных* *огромных объемов аналитических данных из различных источников, поступающих с высокой скоростью), технология электронного обмена данными - EDI (способ автоматизировать создание, отправку, прием и обработку любых электронных документов и интеграция их с существующими бизнес-приложениями), дроны (автоматизированные беспилотные летательные аппараты, которые можно использовать на складе для получения доступа к товарам на больших высотах, где другие виды транспорта не работают), Интернет вещей (IoT, который дает возможность поддерживать связь между помещениями склада и контролировать бизнес-процессы всего комплекса), аддитивные технологии (создание необходимых продуктов и различных их компонентов с использованием технологии 3D-печати) и т. д. Кроме того, в статье не только дана общая характеристика каждого типа инновационных способов развития, но и представлены преимущества, недостатки и перспективы использования мировых трендов в складской инфраструктуре. Показано, что внедрение современных технологических решений и автоматизация процессов способствует развитию многоэтажных складов.*

Ключевые слова: мировые тренды, инновационные разработки, складская логистика, автоматизация, цифровые технологии, процессы.

Introduction. The dynamics of the world business ecosystem development is characterized by rapid development in recent years. To gain a competitive advantage, maintain their market position and generate additional profits, the world's leading corporations are thinking about using the innovative technologies and solutions potential that are rapidly changing not only business methods but also the essence of the product offered to the end user.

One of the focuses of close attention is warehousing logistics, which always remains a pool of costs (for example, Amazon lost about $ 7 billion in logistics in 2017), and often the cost of delivery significantly exceeds the revenue from the delivery itself [1].

Modern warehouses, as the most important component of warehousing logistics, are a complex technical structure, which includes a number of interacting and complementary elements of the logistics system, providing the functions of accumulation, processing and distribution of goods between end users. The warehouse is considered as an integrated component of the logistics chain, which allows to achieve a high level of profitability. Warehousing and processing of goods are important components of the logistics activities of retailers, manufacturers, distributors and industrial enterprises. The cost of their implementation absorbs up to 40% of logistics costs.

The area in which warehousing logistics has the greatest influence today, where turnover is growing in the fastest way, is e-commerce online retail. The global e-commerce market continues to grow at a steady pace: in 2018 its volume increased by 18%, and the total value of all online orders amounted to $ 2.86 trillion. Thus, according to EVO business, in 2018, compared to previous year, the e-commerce market in Ukraine grew by a third - up to UAH 65 billion and was expected to continue to grow in 2019 not so fast - by 25%. According to Gartner, by 2020, online retailers who have personalized their service through artificial intelligence technologies will increase profits by 15%. Confirmation of this can be seen now: when the online store Very.co.uk made a home page that adapts to weather conditions, its revenue jumped by € 5 million [2, 3].

The spread of COVID-19 and related quarantine measures have increased the share of e-commerce in the overall structure of commercial real estate. This gave impetus to the creation of a developed logistics and terminal-warehousing infrastructure, and also to the changes in the warehouse real estate market in the direction of increasing demand for warehouses premises (Fig. 1).

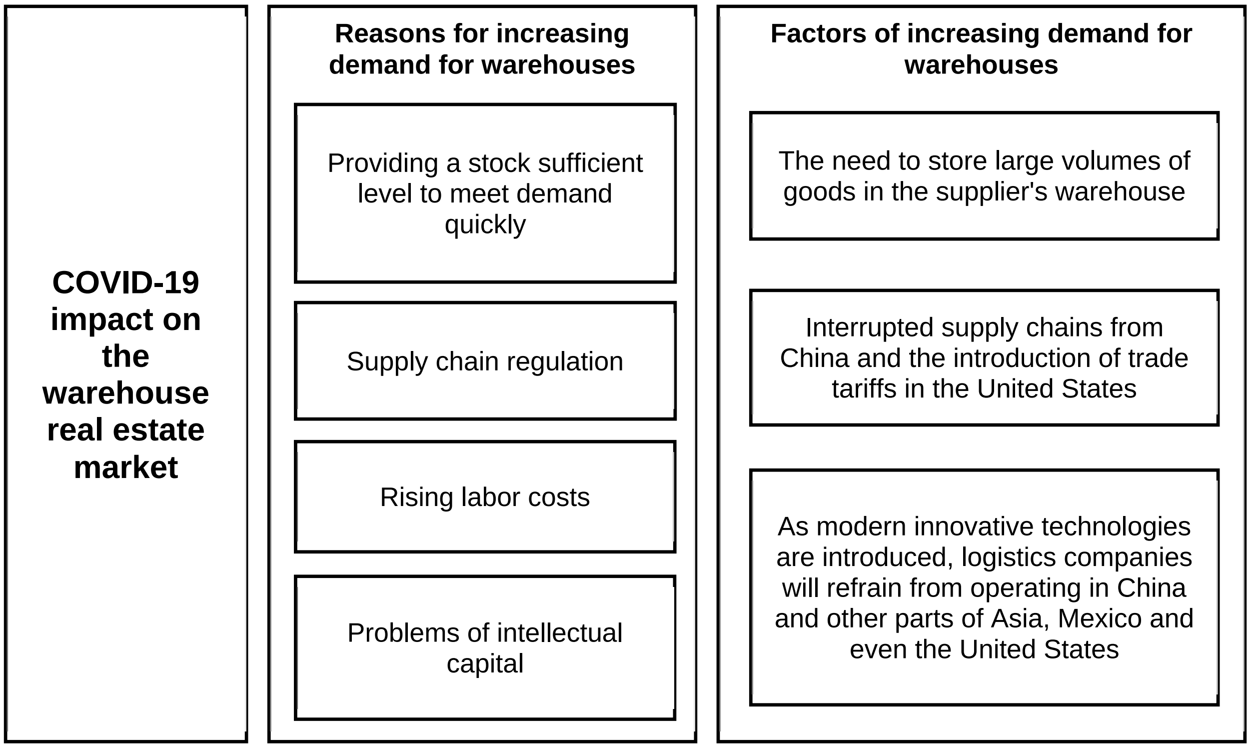


Fig. 1. Impact of COVID-19 spread and related to it quarantine measures on the warehouse real estate market (compiled on the basis of [4])

But despite this, among the main barriers to the development of e-commerce online retail could be noted the imperfection of the logistics process in the warehouse, errors and low speed of order processing. To develop online sales, it is needed to change the common technological approach used in warehousing and distribution. It should be aimed at the introduction of modern and promising innovations, global trends in the field of warehousing logistics.

The aim of the article. Analysis and development trends of promising global trends in the field of warehousing logistics.

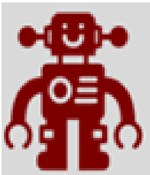
The main material. The warehousing logistics development is impossible to imagine today without the use of modern innovative technologies and solutions. This is due to the active development of both domestic and global markets, as well as the rapid development of warehousing infrastructure (terminal warehouses, logistics centers). Innovative technologies are aimed at automating internal warehousing, integration of logistics business processes that ensure the interaction of all participants in the logistics chain in the supply and distribution of finished products.

Recent advances in artificial intelligence and automation, as well as the ever-increasing capabilities of intelligent devices have created completely new conditions for revolutionary changes in the development and application in warehousing logistics of promising global trends based on innovative nature (Table 1).

The use of robots plays an important role in increasing the level of warehouse automation, which is becoming a global trend today. Robotization, according to FNC experts, will be the leading driver of business over the next five years, along with such trends as global distribution platforms and digital identifiers [5]. This is due to the need to accelerate logistics business processes in large warehouses, where human capabilities have reached the limit. Inventory management with robotic systems eliminates possible errors and accidents and simplifies most processes. Integration of software and hardware solutions for efficient accounting and management of major warehousing processes accelerates warehousing operations, reduces the amount of routine work and increases staff efficiency.

Table 1.

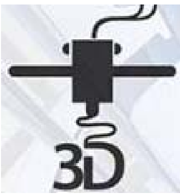
World trends in warehousing logistics

Technology	General description	Advantages	Disadvantages
Robotization 	With the help of warehouse robots (manipulator robots, palletizer robots, sorting robots, mobile robotic carts, etc.) automation of warehouse operations is carried out	1. Eliminates mistakes, reduces defects and minimizes accidents and risks to people. 2. Accelerates the efficiency of warehousing operations. 3. Increases productivity, reduces costs	1. Problems of providing navigation inside warehouses. 2. Insufficient development of technologies
Big Data 	Efficient processing of structured and unstructured huge amounts of analytical data from various sources coming at high speed, using horizontally scalable software tools for their further effective application	1. Minimization of human involvement in the decision-making process. 2. Continuous self-learning process to optimize business processes in the warehouse. 3. Analysis of results and implementation of necessary changes (forecast of fluctuations in demand, detection of seasonality, adjustment of processes in the warehouse, etc.)	1. Not fully used the potential of technology. 2. Risks that may arise during the collection, processing and use of data
Radio frequency identification – RFID 	Uses radio waves to record and read information stored on labels attached to the product. Widely used in warehousing, and in the coming years will become more perfect	1. Fuller control and greater transparency of inventories. 2. Reduction of inventory stock-taking. 3. Reduction of theft	Increased costs compared to paper medium

Continuation of the table 1.

Electronic data exchange technology - EDI 	Allows to automate the creation, sending, receiving and processing of any electronic documents and integrate them with existing business applications between the computer systems of the customer and the contractor in a structured digital form based on standard formats	1. Allows to significantly speed up document management processes. 2. Increase sales to retailers and purchases from suppliers. 2. Reduces the number of human errors in the execution of documents in the warehouse. 3. Reduces inventory. 4. Optimizes goods delivery routes to customers	Low level of information security
Drones 	Automated unmanned aerial vehicles, which can be used in the warehouse to gain access to goods at high altitudes, where other modes of transport will not be able to get. The real scope of drones is inventory stock-taking.	1. Flexibility of goods storage at height. 2. Reduction of time for inventory stock-taking	1. Limited safety when moving. 2. Imperfection of energy sources. 3. Insufficient power and autonomy. 4. Restriction of orientation in space by GPS indoors. 5. Lack of legal framework
Internet of Things (IoT) 	Would give the opportunity to maintain communication between sites or premises and to control business processes of the warehouse complex, productivity, energy costs, track stocks of resources and materials, improve customer service, efficiency of warehouse equipment, monitor the safety and work of warehouse staff	1. Real-time control of business processes. 2. Ensuring security and reliable safety. 3. Improving the efficiency of warehouse equipment. 3. Implementation of successful business models. 4. Improving the quality of customer service and minimizing risks in case of unforeseen circumstances	

End of table 1.

Additive technologies 	Allow to create the necessary products and various components from metals, plastics, mixed materials and even human tissues in layers on the basis of computer 3D-model using 3D-printing technology at the request of customers, which will reduce the supply chain, eliminating the need to store large volumes of finished products in warehouses	1. Increasing the speed of production and reducing costs. 2. Customer orientation: without the material resources spending, the consumer can make individual changes to the product. 3. Opportunity for companies to abandon outsourcing after the transition to 3D printing. 4. Reduction of negative impact on the environment	1. Limited product sizes. 2. High cost of some materials used for printing. 3. High energy consumption of production. 4. Relatively narrow choice of materials
Cross-docking 	The process of acceptance and shipment of goods through the warehouse without placement in the area of long-term storage	1. The cost of processing the goods decreases. 2. The minimum period of goods staying in the warehouse. 3. The turnover of warehouse space is growing. 4. Reducing warehousing costs	1. It is necessary to constantly analyze consumer demand for products. 2. The incoming goods must be immediately ready for shipment or require minor additional operations. 3. The need for well-managed organization of traffic flows
Multi-storey warehouses	Represents the multi-storeyed construction in which access to floors is organized, as a rule, on a ramp that gives the chance to divide warehouse area on separate warehouses	1. Low operating costs. 2. Decrease delivery costs and reduction of delivery time due to proximity to potential customers. 3. Ability to use the whole modern infrastructure complex	1. High capital costs for construction. 2. The need for higher energy capacity. 3. Additional costs for support and modernization technological and operational systems

In general, there are three main groups of robots that are currently used in warehouses for moving goods: Automated Guided Vehicle, Autonomous Mobile Robots, automated warehouse forklifts RLT (Robotic Lift Truck). With new advances in navigation technology and functionality, companies are beginning to use robots in warehouses for a variety of operations, namely: loading, moving, unloading, packaging, depalletizing, sorting, packaging, inventory stock-taking.

In its report on the future of warehouse automation ("The Future of Warehouse Automation - 2019"), the specialized analytical agency Interact Analysis singled out the introduction of mobile robots that displace traditional conveyor systems as a trend #1 [6]. The robots are already used by many foreign manufacturers to perform such simple tasks as cleaning the floor, issuing orders, checking and tracking the location of goods on the shelves, etc.

From the point of view of digital transformation of business, autonomous mobile robots in warehouses provide the mechanism of autonomous data collection on movement of materials and use of stocks within the limits of warehouse operations. In addition, the integration of robots with operational-level systems such as WMS (Warehouse Management System) and WES (Warehouse Execution System) will help align between the physical execution of tasks and a digital copy of the operation in Digital Twins systems.

Now there are more than 30 manufacturers of logistics robots. Some developments are given in table. 2.

Table 2.

Promising world developments of warehouse robots

Purpose of the robot	Producer	General description	Source
Robot loader Handle version	American company Boston Dynamics	The robot loader is equipped with a manipulator with suction cups, which are used to capture and hold the boxes. The on-board robot inspection system tracks marked pallets for navigation and finds separate boxes to capture and move. When the robot places the boxes on the pallet, it uses force control to press each box to the next. It can simultaneously lift a load of up to 15 kg inclusive. This version of the robot is able to work with pallets with a depth of 1.2 m and a stack height of 1.7 m.	[7]
SpotMini security robot	American company Boston Dynamics	Amazing mobility and "passability". Can deftly go up and down the stairs, and, if necessary, open the locked door	[8]
Digit robot courier	Ford Company	The robot looks like a human, has two legs and a pair of arms that can not only lift weights, but also catch falling objects. The robot can navigate in space and in complex situations, including stairs and blockages in the room.	[9]

End of table 1.

Robot-assembler	British company Ocado	The robot moves along the paths on the upper tiers, selects containers and sends them to the sorting point, where the order is completed. The special lattice design allows to work at the same time more than one thousand robots which pass on 60 km with a speed of 4 m/s each. Thanks to automation, the selection and packaging of goods takes about 5 minutes.	[10]

Several robot manufacturers from different countries, including Kiva (now called Amazon Robotics), Swisslog and Grenzebach offer robotic solutions that speed up inventory stock-taking and ordering processes. At the same time, the analytical agency Interact Analysis emphasizes that the acquisition of Kiva Systems by Amazon gave rise to two significant trends in the warehouse logistics market [11]: first, the vacuum, created after the departure of Kiva, was very quickly filled with new players; second, the event forced retailers and logistics companies to implement automation to keep up with Amazon. The agency predicts an explosion of growth in the installed base of autonomous mobile robots for the warehouse (not including Amazon) - 100 thousand in 2020 and about 600 thousand - in the next 5 years.

Comparative forecast of Interact Analysis by types of warehouse robots showed that it is the decision to move goods and equipment, according to analysts, will account for the bulk of the projected growth in robot production (Fig. 2).

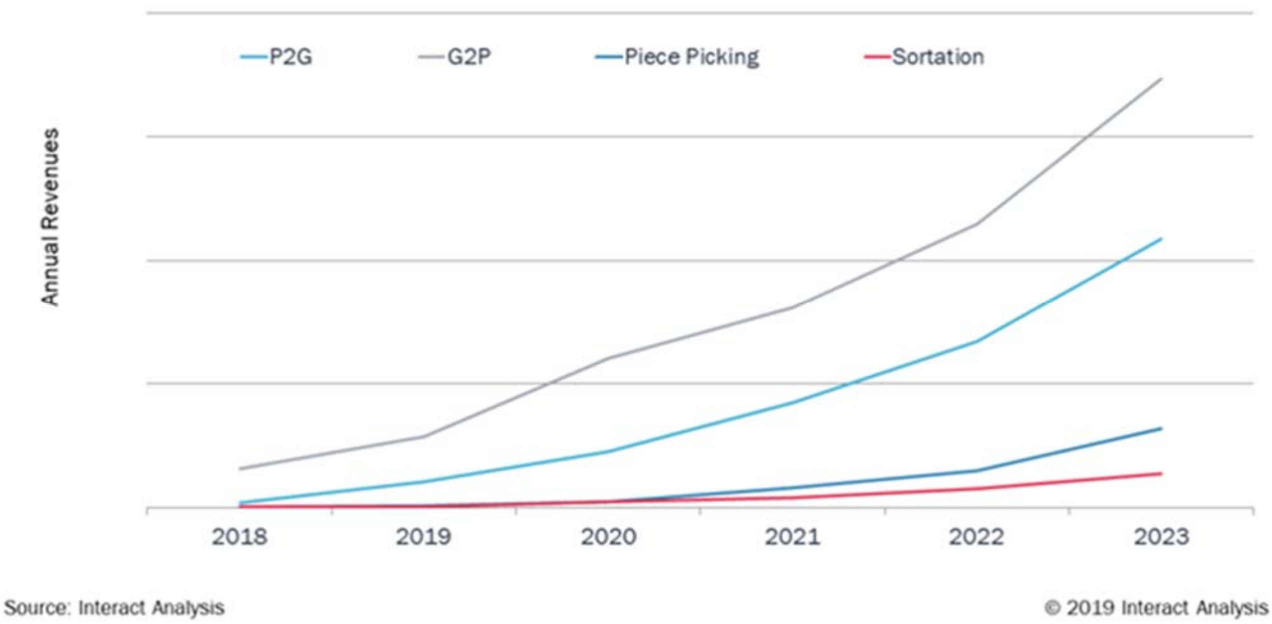


Fig. 2. The trend of production growth by types of robots: 1- P2G - Person-to-Goods; 2- G2P - Goods-to-Person; 3- Piece Picking - Artificial Selection; 4- Sortation - Sorting (Source: interactanalysis.com) [11]

The number of Amazon's warehouse robots is many times greater than the total worldwide. According to the Associated Press at the end of 2019, Amazon were using more than 200,000 warehouse robots, doubling its fleet compared to the end of 2018. In 2014, there were 15 thousand of them [12].

According to the NYT, without robots Amazon would not be able to cope with current tasks and deliver goods quickly. A study by Deutsche Bank showed that the cycle of Amazon Robotics takes 15 minutes, while people - 60-75 minutes. In addition, robotic warehousing systems reduce operating costs by 20%. The robots also relieve the workload of employees and helps save space in warehouses. A smart cargo transportation system does not require the extra free space that people would need to approach the shelves. Despite this pace of robotics, Amazon continued to hire new employees. Since the advent of Kiva robots, the company has hired 80,000 warehouse workers in the United States alone. Currently, the warehouses employ 125 thousand workers, but soon their number will increase, and work tasks will change [13].

Warehouse robotization also covers other global technology trends, namely: Big Data, the Internet of Things, unmanned vehicles and other technologies.

Big data is a term that describes the large volume of data – both structured and unstructured – that inundates a business on a day-to-day basis. But it's not the amount of data that's important. It is what organizations do with the data that matters, these data are efficiently processed by horizontally scalable software tools that appeared in the late 2000s and alternatives to traditional database management systems and solutions of the class "Business Intelligence". [14]. In fact, Big data is an alternative to traditional data management systems.

In a broad sense, "Big data" could be interpreted as a socio-economic phenomenon associated with the emergence of technological capabilities to analyze huge data sets, in some problem areas for their further effective application. [15].

The term "Big data" was coined by Nature's editor Clifford Lynch back in 2008 in a special issue on the explosive growth of global information. According to experts, more than 2.5 exabytes are generated every day. By 2020, every inhabitant of the planet will generate about 1.7 megabytes of data every second and humanity will generate 40-44 zettabytes of information. And according to IBS forecasts, by 2025 the entire global data volume will increase 10 times, compared to 2020. Data will become a vital asset, and security - a critical foundation of life. The technology will change the economic landscape, and the average user will communicate with connected devices about 4800 times a day [16].

In the near future, Big Data will be actively used in warehousing logistics. Analytics of big data will allow to predict fluctuations of demand, to reveal seasonality, to correct processes in a warehouse (the forecast of loading of reception and marking, smoothing of peak hours), etc. By means of Big Data it is possible to construct multifactor model results. In addition, it stores information not only about all products, their location, movement, but also a huge amount of additional data: all clicks in the interface, delivery schedule, weather, customer information, distance of suppliers from the warehouse (Fig. 3). At the same time there is a continuous process of self-learning. That is, the machine itself learns (the principle of Machine Learning) in real time and creates algorithms for optimizing business processes.

The principle of Big Data technology is based on the maximum informing the user about an object or phenomenon. The task of such acquaintance with data is to help to weigh all "pros" and "cons" to make the correct decision.

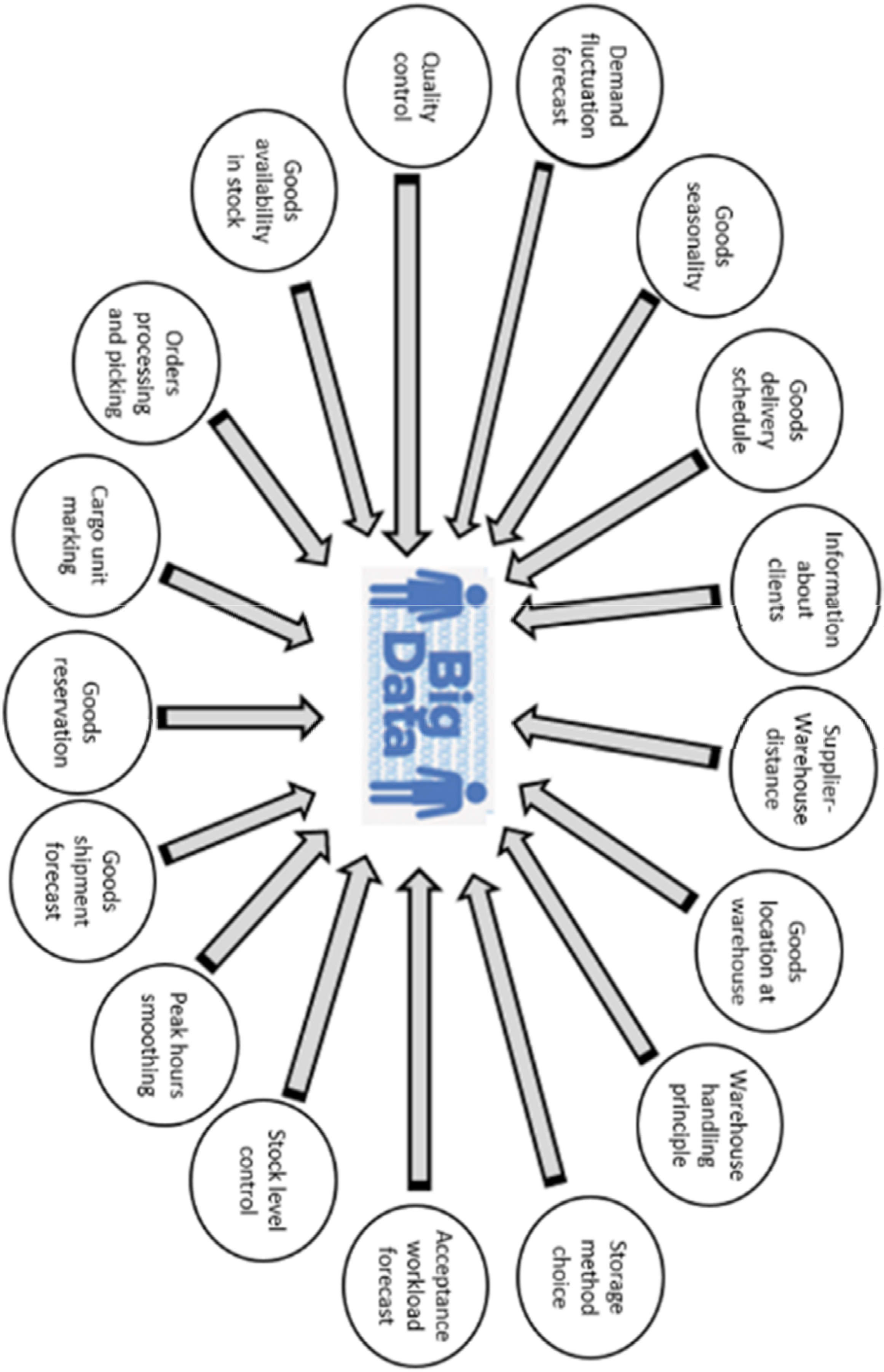


Fig. 3 – Big Data in warehouse logistics

In intelligent machines, a model of the future is built on the basis of an array of information, and then various options are simulated and the results are tracked. In an ordinary warehouse, such analytics allows to learn about the most popular products and store them close to the assembly lines, as well as to place similar goods or goods in high demand together in one part of the warehouse. This allows to complete orders with maximum speed. At the same time, the collected orders are immediately sorted by regions, transport companies, dimensions. All this increases the speed of processing and shipment by at least 30%.

The basic principles of working with Big data (Table 3) differ from traditional, centralized, vertical models of storage of well-structured data. Accordingly, new approaches and technologies are being developed to work with Big data.

Table 3.

Basic principles of working with big data (built on data [17])

Principle	Characteristic
Horizontal scalability	Increasing the number of computing nodes with the growth of big data should not impair the performance of data processing
Fault tolerance	Methods of working with big data should take into account the probability of failure of computer nodes of machines and provide preventive measures
Data locality	It is desirable to process big data on the same server on which it is stored to save time, resources, data transfer costs.

McKinsey, an international consulting firm specializing in strategic management, identifies 11 methods of analysis that can be applied to Big data (Table 4).

Table 4.

Methods of Big data analysis (based on data [16])

Methods of analysis	Characteristic
Data Mining methods (data mining, in-depth data analysis)	A set of methods for identifying previously unknown, non-trivial, practically useful knowledge needed for decision-making. Such methods, in particular, include teaching associative rules, classification (division into categories), cluster analysis, regression analysis, detection and analysis of deviations, and others.
Crowdsourcing	At the heart of this technology is the ability to receive and process streams in billions of bytes from many sources. The final number of "suppliers" is not limited to anything if only to the power of the system
Data fusion and integration	A set of technical solutions that allows to integrate disparate data from different sources for in-depth analysis
Machine learning	Using models based on statistical analysis or machine learning to obtain comprehensive forecasts based on core models
Artificial neural networks, network analysis, optimization	Heuristic search algorithms used to solve optimization and modeling problems by random selection, combination and variation of the required parameters using mechanisms similar to natural selection in nature

End of table 4.

Pattern recognition	Identify an object or determine any of its properties by its image, audio recording, or other characteristics
Forecasting analytics	Analysts try to set certain parameters for the system in advance and then check the behavior of the object based on the receipt of large arrays of information
Simulation	Allows to build models that describe the processes as they would take place in reality
Spatial analysis	A class of methods that use topological, geometric, and geographic information extracted from data
Statistical analysis	Time series analysis, A / B testing (A / B testing, split testing - a method of marketing research; when used, the control group of elements is compared with a set of test groups in which one or more indicators have been changed to find out which of the changes improve the target)
Visualization of analytical data	Presentation of information in the form of figures, diagrams, using interactive features and animation both to obtain results and for use as source data for further analysis. Allows to present the most important results of the analysis in the most convenient form

The effectiveness of Big Data technology and analysis tools in the warehouse implies the presence of a built-in logistics management system (which can be a source of data), formalized business processes, awareness of the need for additional data and motivation to use them in decision making.

The next global trend of warehousing logistics is the technology of electronic data exchange - EDI (Electronic Data Interchange), which allows to automate the creation, sending, receiving and processing of any electronic documents and integrate them with existing business applications. It supports the exchange of data between the customer's and contractor's computer systems in a structured digital form based on standard formats. In the process of sending documents, EDI translates the information into a standard format, saving the content.

EDI is used to exchange purchase order documents, shipment orders, warehouse receipts, shipment notices, etc. This significantly reduces the time to fill in the tables and compare data, reduces the number of human errors in the execution of documents in the warehouse, reduces inventory, optimizes routes for delivery of goods to customers.

For example, the Vehicle Loading setting [18] allows to transfer data for each individual pallet of both one and a group of orders; split orders between multiple vehicles. In addition, the customer sees the volume of shipped pallets online, and recipients know about the contents of each pallet before the arrival of the vehicle.

To implement EDI, it is necessary that all trading companies have an international identification number - GLN, and each product must have a global GTIN in the international system EAN (GS1). EDI operates on any platform: mainframe, client-server, personal computer. In general, the choice of platform for EDI depends on the specific needs of the company, the volume of transactions and the number of partners involved in the EDI project.

EDI exchange is based on the use of international standards designed to meet all possible requests. The application of standards increases the security of EDI-data transmission based on the principles (Table 5), which allow reliable transmission of electronic exchange documents over the Internet. This allows companies to improve management and control processes, significantly reduce warehousing costs.

Table 5.

Principles of EDI data transmission

Principle	Characteristic
Delivery guarantee	Automatic notification of the sender about receipt
Efficiency	About 170 types of messages are processed and transmitted within 10 minutes
Accuracy	Complete elimination of errors is achieved already at the stage of data input that considerably reduces time for an information exchange between contractors.
Economy	Allows to minimize the costs associated with the preparation of documents up to 7-10% of the total cost of the transaction
Confidentiality of information	Warrant the security of commercial information transmission is ensured through data encryption and the use of Internet standards for EDI
Certainty	Provided by the use of notifications about the location of messages for checksums and completely eliminates the possibility of making changes to the document without the knowledge of the recipient

The Center for the Simplification of Procedures and Practices in Management, Trade, and Transport (CEFACT) has been operating at the United Nations since 1997 to address the compatibility of international standards with US and European standards. The RosettaNet standard is currently being actively improved. In 1998, 40 of the world's leading IT organizations founded the non-profit consortium RosettaNet, one of the largest projects in the field of data exchange standardization, which continues to develop. It aims to globalize supply chains in the IT industry and bring companies from America, Europe, Japan, Korea, Singapore and Taiwan into a single e-commerce network. In particular, Intel, using the global RosettaNet infrastructure, reduced the average time to receive orders from the customer from 12 hours up to a few minutes [19].

Electronic document management (EDI) systems have been actively used in Ukraine since 2005. To date, most retail chains, manufacturers and distributors in Ukraine have switched to modern technologies to support commercial transactions. The use of EDI technologies to service legally significant document circulation is also becoming more widespread. Among the largest retailers that use EDI in Ukraine (according to Comarch) are: "METRO Cash & Carry Ukraine", GC Fozzy Group, "Velyka Kyshenia", "Auchan", "ATB", Watsons, "Furshet", WOG, "PACCO", "Tavria B", "Caravan" ("Retail Group of Ukraine"), Billa, "Obzhora" and many others. Business documents, such as: orders, shipment notifications, acceptance certificate, invoice, analogues of tax and goods invoices, sales report and stock balances in the warehouse and others, exchanged by retailers, manufacturers, distributors, logistics operators - can be transmitted using EDI technology (electronic data interchange) [20].

EDI technologies are still the most important element of medium and large companies' activity, which can significantly speed up document management processes, increase sales to retailers and purchases from suppliers, reduce inventory, optimize routes for delivery of goods to customers. Current trends are such that in the next few years EDI will remain the main driving force of the e-commerce market.

Radio Frequency Identification (RFID) is widely used in warehousing logistics, which will become more and more advanced in the coming years. RFID technology uses radio waves to record and read information stored on labels attached to the product. The benefits of RFID include greater control and greater transparency of inventory, which ensures ease of inventory stock-taking, as well as reduced theft.

Today, logistics companies are trying to combine drone technology with RFID in order to further automate the inventory process. RFID in combination with the maneuverability of drones will optimize the size of warehouse space by increasing the height of storage and significantly reduce the time spent on inventory stock-taking. When using drones, there is no need to remove pallets from a height, to attract additional staff, to spend a lot of time on the recalculation of products, the human factor is excluded completely.

It is important to note that it is used not only for the inventory stock-taking of pallets for high-altitude storage. As a result of high-altitude miscalculation, the availability of free storage spaces is detected and additionally confirmed. Both of these processes - inventory stock-taking and confirmation of vacancies allow to ensure further trouble-free work with replenishment, placement, acceptance of stocks [21].

With clear advantages (mobility, efficiency, cost and low payback time), there are a number of factors that limit the widespread use of drones in warehouses, namely: energy imperfections, insufficient power and autonomy, limited orientation in space by GPS indoors, lack of legislation.

Nowadays, these problems of drones are being actively addressed. So the modularity of drones allows to solve the problem with additional batteries. Recently, local positioning systems have been launched that allow the replacement of the GPS drone module with internal positioning. With the help of open SDKs, third-party programmers can interact with drones, assign them flight routes, receive data from scanners (cameras) of RFID tag readers, integrate existing WMS.

The Massachusetts Institute of Technology is testing a new system with small drones and RFID tags to monitor inventory. According to the research team, the most difficult task in developing a system that uses RFID is to find a way to make it secure. Drones, which are safe enough to fly in close proximity to humans, are usually small and light with plastic rotors. Unfortunately, these drones cannot carry RFID readers over long distances [22].

At LogiMAT in Stuttgart, Linde MH, a manufacturer of equipment and solutions for the warehouse, presented a prototype Flybox drone for work in the warehouse. The combination of a drone and a robotic stacker into a single system ensures uninterrupted power supply to the drones (usually the drone battery lasts for about 15 minutes) and constant tracking of the location of drones without the use of GPS within the warehouse space. Thanks to the innovative geological steering system, the developed Linde control system determines exactly where the drone is at a certain point of time [23].

At the Munich exhibition Transport Logistic 2017, the development of Fraunhofer IML - a ball drone "Bin: Go" was presented. A feature of this drone is the ability to work near humans. The spherical structure closes the structural elements of the drone and prevents the possibility of injury to a person in a collision, as well as allows the drone to move on the floor surface [24].

Of course, drones and robots are just the most effective part of the Internet of Things (IoT) technology that a modern warehouse can be equipped with. DHL and Cisco estimate that IoT technology will generate about $ 8 trillion assets in the next ten years, of which $ 1.9 trillion will have to logistics and supply chain management. The impact of the Internet of Things on the logistics sector cannot be overestimated. Solutions of this kind are beginning to be used both in warehousing operations and in the transportation of goods and for "last mile" delivery [25].

IoT solution in warehousing logistics allows to optimize the use of warehouse space, monitor the integrity of goods and other tangible assets, improve customer service, improve the efficiency of warehousing equipment, assess and improve the quality and safety of warehouse workers, conduct a "smart" stock-taking.

Thus, most modern warehouse complexes are already equipped with Warehouse Management Systems (WMS), which receive data from barcodes and RFID-tags placed on the packaging of goods. A more advanced level is Warehouse Control Systems (WCS). To determine the optimal capacity and speed of storage equipment (from forklifts and ending with conveyor belts), they are equipped with controllers and sensors. Also with the help of cameras located in the warehouse and in the area of shipment, it's possible to detect violations of the integrity of packaging, products.

Some warehouses are equipped with Building Automation Systems (BAS). Such systems can use special sensors to monitor and control lighting, air conditioning and ventilation, as well as ensure the operation of security subsystems and access control to the warehouse. Modern WMS, WCS and BAS systems are equipped with interactive interfaces - dashboards that allow warehouse workers to effectively manage the warehouse complex. Internet of Things technologies combine the data of these systems, provide their cross-interaction to solve more complex problems. For example, in the case of storage of perishable products that require a special temperature regime, the BAS system can monitor temperature fluctuations in the warehouse through sensors. And, if it has reached critical values, send a signal to the WMS system, and in turn - to inform warehouse workers about the situation [25].

Additive technologies are one of the main world trends, which is actively implemented in warehousing logistics. They allow almost any company to create products or parts of products from metals, plastics, mixed materials and even human tissues in layers based on a computer 3D model using 3D printing technology.

3D-printing technology significantly expands the production process, making it independent of specialized industries and enterprises. This will allow manufacturers to "print" the necessary products and various components on demand, which will reduce the supply chain, eliminating the need to store large volumes of finished products in warehouses [26].

The introduction of 3D printing for the logistics industry has huge growth potential. The logistics provider will be able to supply raw materials instead of finished products, provide 3D printing services at delivery points, which will be an additional source of income. For such purposes it will be possible to use the electronic library of projects, available on a local computer, and print the part. Worn parts can be scanned in 3D-mode and re-created.

Recently, additive technologies are developing rapidly in various industries. Thus, experts from the University of Wollongong (Australia) in 2015 introduced the first 4D printer that can print such details that will take into account the time factor, such as adapting to temperature variability [27]. To expand the possibilities of 3D printing in the food industry, a team of Korean scientists led by Jin-Kyu Rhee from Ewha Women's University developed and created a food printing system that allows to accurately control the composition and texture of food. The new technology allows to obtain food products with the required content of nutrients, with a given texture and controlled digestion rate [28].

A popular area of 3D-technologies application in Ukraine is the repair and direct production of equipment, namely: printing of parts and mechanisms that need immediate replacement. An example is Privatbank, which purchased a 3D printer and began printing gears for ATMs. Thanks to 3D printing, the cost of their production has decreased 20 times. In addition, the bank no longer needs to maintain stock - gears are printed as needed [29].

Lately, cross-docking or Merge-in-Transit (MIT) technology has become increasingly popular in warehousing logistics. This is primarily due to the reduction of costs in the organization of warehousing operations by

20-30%, which is due to the lack of storage space. That is, the process of acceptance and shipment of goods through the warehouse is carried out without placement in the area of long-term storage.

Unlike the traditional warehouse complex, which implies the availability of inventory that the distributor can send to customers, the functions of the cross-docking center are end-to-end warehousing, i.e. receiving, sorting and shipping parcels without placing in a long-term storage area. A feature of these properties is the low rate of land use, as they must provide the necessary free space for travel and maneuvering of trucks and vans [30].

In other words, cross-docking is essentially a Just-in-Time production system adapted for warehousing operations, when storage costs are reduced during the movement of cargo. Cross-docking provide the opportunity to speed up the delivery of goods to the final consumer, which is especially important when working with perishable products.

Newly, the number of cross-docking distribution centers located along city borders has been growing rapidly. They are focused on the delivery of "last mile" logistics and are the last link between the supplier and the final consumer of goods.

The trend towards the introduction of modern technological solutions and automation of processes will promote the development of multi-storey warehouses. The practice of building multi-storey warehouses first developed in Asia, where rapid economic growth and industrialization of the economy took place against the background of acute shortage of land resources and a sharp rise in land prices. As a result, Asian industrial warehouse real estate began to grow. So today, the average height of a warehouse building in Hong Kong is 12 floors, in Tokyo and Singapore - 5 floors.

In the United States is actively building multi-storey warehouses. In 2018, several sources reported that Amazon is going to build six automated multi-storey fulfillment centers in different regions of the United States. For example, in Minnesota, in the suburbs of Minneapolis, a 4-story warehouse Project Hotdish with a total area of 240 thousand m2 is being built, in Charlotte (North Carolina) it is planned to build a multi-storey fulfillment center Project Quattro with a total area of about 230 thousand m2 [30].

Access to the floors in a multi-storey warehouse is organized on a ramp, which makes it possible to divide the area of the building, in fact, into separate warehouses. Cargo is delivered to the upper floors by trucks, where there are unloading docks for their maintenance. Although it should be noted that the first multi-storey warehouses in Asia used freight elevators to move goods on the floors. According to forecasts, in the near future multi-storey warehouses will become a more common solution for the European logistics market, at least near or in large cities. In this case, large cities are megacities with extremely high land values. In small towns, the construction of a multi-storey warehouse is likely to be economically impractical.

Simulation technologies today are also an innovative approach to organizing the work of the warehouse and are designed in most cases for large customers with complex logistics processes. With the help of simulation, a virtual model of real processes and warehouse topology is created, which allows to quickly analyze and demonstrate to customers in the dynamics of development various options for improving the efficiency of warehouse business processes and, consequently, minimize costs. At the same time, up-to-date data on the required number of personnel, trucks and workload of different storage areas are promptly collected. The received information allows to estimate efficiency of variants, to calculate time of operations performance, to calculate expenses and to choose optimum algorithms of management and the organization of cargo flows [31].

Conclusions. The development of digital technologies has greatly influenced the innovative solutions in the field of logistics, which change the technical and economic structure of many economies around the world. Warehouse logistics was one of the first to respond to systemic changes in technology and introduced elements of robotics and artificial intelligence. Due to the emergence of modern world trends, namely: robotics, Big Data, electronic data exchange technology - EDI, drones, Internet of Things (IoT), additive technologies, etc. the efficiency of warehouse and supply chain management increases, especially for non-standard solutions, which significantly stimulates the market; accelerates the efficiency of warehousing operations, optimization of inventories in the supply chain, increases productivity and quality, reduces costs, etc.

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