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ARTIFICIAL INTELLIGENCE IN SUPPLY CHAIN MANAGEMENT: OPPORTUNITIES AND THREATS FOR PROFESSIONAL COMPETENCE

Mariia Hryhorak, Oleh Harmash, Tadeusz Popkovskiyi. «Artificial intelligence in supply chain management: opportunities and threats for professional competence». The article summarized the theoretical foundations of artificial intelligence and classified various technologies and algorithms related to it. Development prospects are also considered, starting from the automation of individual procedures and moving on to the development of complex autonomous systems for decision-making. Further, a detailed analysis of the transformation of key business processes in supply chains under the influence of artificial intelligence was carried out. This made it possible to discover how artificial intelligence technologies affect the organization and management of supply chains, which can lead to changes in management approaches and strategies. In the article, a matrix model of the interaction of specialists with artificial intelligence in supply chain management was developed and improved. It contributes to the understanding of how to effectively combine the role of humans and artificial intelligence systems to optimize processes in supply chains. Special attention is paid to the transition from supporting to autonomous role of artificial intelligence systems in supply chains. This change in dynamics may change the balance of power between humans and AI systems, and affect accountability and control mechanisms, as well as the ethical implications of delegating authority to AI systems. Accordingly, it is important to develop the digital skills of supply chain managers and increase their level of digital competence in order to implement artificial intelligence technologies effectively and ethically. The lack of such competencies can become an obstacle in the development and successful use of artificial intelligence in supply chain management.

Keywords: supply chain management, artificial intelligence, intelligent decision-making systems, automation and digitization of business processes, digital competencies of personnel.

Марія Григорак, Олег Гармаш, Тадеуш Попковський. «Штучний інтелект в управлінні ланцюгами постачання: можливості та загрози для професійної компетентності». У статті було узагальнено теоретичні основи штучного інтелекту та класифіковано різноманітні технології та алгоритми, що пов'язані з ним. Також розглянуті перспективи розвитку, починаючи від автоматизації окремих процедур і переходячи до розробки складних автономних систем для прийняття рішень. Далі, проведений детальний аналіз трансформації ключових бізнес-процесів у ланцюгах постачання під впливом штучного інтелекту. Це дозволило виявити, як технології штучного інтелекту впливають на організацію та управління ланцюгами постачання, що може привести до зміни підходів і стратегій управління. В статті була розроблена та удосконалена матрична модель взаємодії фахівців зі штучним інтелектом в управлінні ланцюгами постачання. Це сприяє розумінню того, як ефективно поєднувати роль людей та систем штучного інтелекту для оптимізації процесів у ланцюгах постачання. Особлива увага приділена переходу від допоміжної до автономної ролі систем штучного інтелекту у ланцюгах постачання. Ця зміна в динаміці може змінити баланс влади між людьми та системами штучного інтелекту, а також впливати на механізми підзвітності та контролю, а також етичні наслідки делегування повноважень системам штучного інтелекту. Відповідно, важливо розвивати цифрові навички менеджерів, які працюють з управління ланцюгами постачання, та підвищувати їх рівень цифрової компетентності, щоб впроваджувати технології штучного інтелекту ефективно та етично. Відсутність таких компетенцій може стати перешкодою у розвитку і успішному використанні штучного інтелекту в управлінні ланцюгами постачання.

Ключові слова: управління ланцюгами постачання, штучний інтелект, інтелектуальні системи прийняття рішень, автоматизація та цифровізація бізнес-процесів, цифрові компетенції персоналу

Introduction. Artificial intelligence is not the future, but our present, so logistics companies, manufacturing and trade enterprises are trying to actively use it and adapt it to their tasks. In the report "Future of Jobs Report 2023" ("The Future of Jobs 2023"), which was published within The World Economic Forum (WEF) has predicted that over the next five years, 83 million jobs will disappear, while 69 million will be created, artificial intelligence will play an increasingly important role in various sectors of the economy [1]. This is facilitated by the "end-to-end" nature of technological solutions based on artificial intelligence, the high degree of influence of these solutions on the effectiveness of activities and the availability of tools for the development of software and robotics products.

A new impulse of scientific and practical interest in the problems of artificial

intelligence has made the ChatGPT generative chatbot available to everyone by the OpenAI company. The launch of the technology late last year saw ChatGPT reach over 100 million monthly active users in just two months. A new version of ChatGPT-4, which is an advanced language model capable of generating and editing text, processing images, and performing creative and technical tasks, has already been launched.

The active development of artificial intelligence and its application in various spheres of activity gives rise to discussions in scientific circles about the possibilities and threats of this technology and its impact on society and the labor market.

Processes are also taking place in Ukraine that testify to the relevance of the issue of artificial intelligence. In particular, at the end of 2020, the Concept of the Development of

Artificial Intelligence, which was prepared by the Ministry of Digital Transformation of Ukraine, was adopted. This concept envisages, on the one hand, the deepening of fundamental research for the creation of a competitive new-generation computing machine based on traditional technologies and quantum computing technology, and on the other hand, the expansion of the areas of use of the latest technologies and systems with artificial intelligence in the military-industrial complex, education, medicine, industry, agriculture, etc.

Of course, what has been said applies to the field of logistics and supply chain management, which are essentially innovative and leaders in the implementation of the latest information technologies. According to analysts, by 2030 the market of artificial intelligence in logistics will be valued at 36 billion US dollars [2]. This forecast confirms the hypothesis that the spread of artificial intelligence will contribute to the creation of new jobs and higher-skilled specialties, will encourage companies to support advance training of personnel, stimulate intra-company mobility of employees with additional payment for learning additional skills and abilities. To work effectively with artificial intelligence, it is important to have a good understanding of the algorithms and data underlying the technology. This includes understanding how to preprocess and clean data, how to choose the right algorithm for a given problem, and how to interpret the results of an AI system.

However, knowledge of algorithms and data alone is not the only important aspect. It is also necessary to understand the limits and possibilities of artificial intelligence in order to understand where it can be used with benefit and where it is better to use other approaches. When developing artificial intelligence systems, it is also necessary to take into account ethical issues and problems related to the protection of privacy and data security. The use of artificial intelligence can have a significant impact on society and people, so it is important to consider potential

risks and ensure responsible use of this technology. For success with artificial intelligence, it is also important to have a team with a variety of specialists - from experienced researchers of intelligent systems to experts in the field of data and programmers. Cooperation between different specialists helps to create complex solutions that effectively solve various tasks.

It is also necessary to remember that artificial intelligence is not a universal solution for all problems. Some tasks may require different approaches, different methods of analysis, or may be too complex for the current state of the technology. Therefore, it is important to maintain a balance and realistically evaluate the capabilities of artificial intelligence in the context of specific tasks and problems.

In general, the successful use of artificial intelligence requires a combination of deep knowledge of algorithms and data, analysis of ethical aspects and the involvement of highly qualified specialists. This will allow the creation of powerful artificial intelligence systems capable of solving important tasks and contributing to the progress of society.

An analytical report by McKinsey&Company concluded that almost a quarter of surveyed companies plan to implement artificial intelligence [3]. According to McKinsey estimates, logistics costs for businesses that adopt supply chain management with artificial intelligence have decreased by 15%, while inventory levels have increased by 35% and service levels have increased by 65%.

Literature and researches review. The issue of artificial intelligence occupies a leading place in scientific research in recent years. Scopus[3-7] literature reviews state that dynamic supply chain processes require the use of artificial intelligence tools and techniques to cope with increasing complexity and improve efficiency. As early as 2010, HokeyMin outlined the areas of application of artificial intelligence in supply chain management, focusing on inventory planning, demand forecasting, transportation

network design, etc. [7, 8]. With the help of artificial intelligence, companies can identify weaknesses in supply chain management and allocate resources accordingly [8,9], detect consumer requests, build customer profiles, and develop products [10]. B. Mohsen claims that artificial intelligence can be used to analyze data and forecast demand, optimize logistics and transport routes, and identify inefficiencies in supply chains [10, 11]. The work [12] analyzed the ability of artificial intelligence to control the forwarding of goods on a large scale and predict delivery needs.

The problems of disruptions in supply chains and risk management caused by the global pandemic of COVID-19 are of particular interest to researchers. Ivanov and Dolgui demonstrated the impact of this unprecedented pandemic on demand, supply, production, and other logistics operations. Demand fluctuations and uncoordinated logistics operations were typical scenarios in this case. To increase resilience, the authors proposed game-theoretic modeling using artificial intelligence [13, 14]. Belhadi and others, continuing to explore the impact of artificial intelligence on mitigating supply chain disruptions related to COVID-19, argued for the need for real-time information sharing. Based on data from 479 manufacturing companies, they showed that fuzzy logic programming, big data machine learning, and agent-based systems are the most promising methods used to increase the resilience of supply chains [16]. The work [15] also used multi-criteria optimization methods with the use of artificial intelligence to increase the stability of supply chains in the conditions of the COVID-19 pandemic.

In recent years, many studies have focused on green supply chains. Of course, artificial intelligence can play a key role in finding better solutions related to reducing the harmful impact on the environment. Let's note some publications in this area. In particular, the authors [16] conducted an analysis of 144 articles over 14 years to

classify, summarize and analyze the literature in two dimensions - from the perspective of digital technologies and environmental supply chain practices. They have proven that the Internet of Things, big data, cloud computing, blockchain and artificial intelligence can reduce resource and energy consumption, as well as pollutant emissions, ultimately improve the efficiency of green supply chains and achieve economic, social and environmental benefits. Bochao Liu combined artificial intelligence deep learning technology to build an ecological supply chain management system, improving the intelligent algorithm and creating an intelligent model. These two factors together improve the effect of green supply chain management for small and medium-sized enterprises, reducing carbon emissions [17].

A separate direction can be singled out the research of artificial intelligence as a breakthrough innovation and a tool of the knowledge economy. In particular, Mariani M.M. and Borghi M. considered the theoretical and practical implications of the integration of artificial intelligence in supply chain management, identified the technological, social and economic reasons that encourage firms to use AI for firm product innovation, process innovation, business models, etc. [18]. Christian Hendriksen proposed a new theoretical framework for AI Integration, which is based on two key dimensions: the level of AI integration in the supply chain and the role of AI in decision-making. Considering these two dimensions, AI provides a comprehensive view of the integration of AI in SCM, considering the potential disruptions and transformations that may arise from the implementation of AI [19].

Jarrahi H. revealed the possibilities of using artificial intelligence for knowledge management, in particular, for the creation, storage, search, exchange and application of knowledge. They propose practical ways to build partnerships between humans and artificial intelligence in support of organizational knowledge management activities, and assess the implications of

managing artificial intelligence systems based on human, infrastructure, and process components. [20].

Despite the fact that the use of ChatGPT in business became possible not so long ago, the first studies appeared. Thus, the work of Indian authors [21] shows that ChatGPT can be fine-tuned for specific use cases, such as customer service, e-commerce and supply chain management, training it on additional domain-specific data. ChatGPT can handle multiple simultaneous interactions and provide real-time responses to customer queries, making it well-suited for use in customer-facing applications [22, 23].

The above indicates a significant increase in the number of foreign scientific publications related to applications of artificial intelligence in logistics and supply chain management. However, in our opinion, there are still few such studies in Ukraine. To prepare this article, the materials of the collective monograph edited by S. I. Dotsenko and V. S. Kharchenko [38] were used, in which a thorough theoretical analysis of the concepts of artificial intelligence and intelligent decision-making systems was made. The recently published monograph under the scientific editorship of A. I. Shevchenko summarizes the results of a two-year scientific discussion and the results of a survey of over 300 organizations with the aim of determining the need for the introduction and use of artificial intelligence technologies in their activities, as well as the prerequisites and scientific foundations of the creation of the Strategy for the Development of Artificial Intelligence in Ukraine [38].

Usually, in the scientific literature on supply chain management, we are talking about information or digital technologies, among which artificial intelligence is mentioned. Articles that are devoted to the practical aspects of the use of technologies related to artificial intelligence are mainly descriptive in nature or justify certain management decisions using mathematical methods and algorithms. Thus, in the work of Skitsko V.I. the application of the bat

algorithm for solving a multi-index transport problem, in the formulation of which logistic risk is taken into account, is shown [24]. Article Poznyak O.V. and Melnyk K.O. devoted to the study of trends in the transition of logistics from automation to the use of artificial intelligence technologies in the management of goods of strategic purpose [25]. O. Yu. Kyryk analyzed the directions and advantages of using artificial intelligence in logistics processes, and also justified the need to combine human intelligence with established artificial intelligence and automated processes [26].

AI and objectives. The purpose of this article is to address the current gaps in research on the impact of artificial intelligence as an integrated technology on the productivity and efficiency of SCM, to identify a set of technologies that are related to artificial intelligence, methods and algorithms capable of optimizing both individual business processes in supply chains and in general. The article begins with an analysis of the definitions of artificial intelligence and structures a set of technologies, methods and algorithms related to this field. This allows you to identify the prospects and potential opportunities offered by artificial intelligence. Next, the author conducts an analysis of business cases and highlights trends in changing the nature of the use of artificial intelligence in various fields. This analysis helps identify trends and directions in the development of artificial intelligence, as well as its impact on modern society and the economy. The last block of the article is devoted to defining the competencies that are necessary for the successful implementation and use of artificial intelligence. Skills in the field of programming, statistics, data analysis, understanding of business processes, as well as the ethical aspect of using artificial intelligence technologies can be indicated here. In general, the article offers the reader a systematic approach to understanding artificial intelligence, starting with basic definitions and technologies, moving to

business aspects and potential trends, as well as highlighting the necessary competencies for the successful implementation of intelligent systems in various spheres of life.

Results, analysis and discussion.

Artificial intelligence is one of the most promising technologies of today, which affects various areas of the economy and business. It is able to revolutionize the way of decision-making, optimize processes, strategy and business tactics. First of all, research on the application of artificial intelligence helps to better understand the potential and limitations of this technology. They make it possible to discover exactly where artificial intelligence can be most useful and what specific tasks can be solved with its help.

It is known that any scientific research needs to define the object and subject of research. Currently, there is a very wide divergence of views on the issue of artificial intelligence among scientists and practitioners. The vast majority of researchers refer to artificial intelligence as a "black box", without specifying what exactly is contained in this box. This leads to the fact that supply chain management specialists focus their attention on improving existing information technologies and often do not understand that artificial intelligence requires radical changes in the organization and management of not only the movement of goods, but also the external business environment. Therefore, let's start with an analysis of terminology.

1. Theoretical basis of artificial intelligence.

The analysis of various literary sources shows the ambiguous interpretation of the concept of "artificial intelligence", as there are currently more than a hundred of its definitions. In the early 1980s, scientists in the field of computational theory Barr and Feigenbaum proposed the following definition of artificial intelligence - it is the field of computer science that deals with the development of intelligent computer systems, that is, systems that have capabilities

that we traditionally associate with the human mind, - language comprehension, learning, the ability to reason, solve problems, etc. [27]. The international standard ISO/IEC TR 24028:2020 considers artificial intelligence as "the ability of an engineering system to acquire, process and apply knowledge and skills"[28].

An examination of the terms presented in the literature reveals the existence of four characteristics that are commonly mentioned in the scientific literature on artificial intelligence:

- a) is a field of technology that deals with the development of systems capable of performing tasks that require human mental abilities;
- b) methods and algorithms of information processing;
- c) programs that perform complex tasks and at the same time increase their capabilities based on pre-processed data;
- d) a mathematical model capable of self-improvement, obtaining new information and improving its own algorithms based on it [29,30].

Almost all authors agree that artificial intelligence should be similar to human intelligence and related to data, information and knowledge, and its main characteristics are the understanding of natural language, the ability to learn, the ability to think (generalize and draw conclusions), as well as to accept decision.

It is interesting to define artificial intelligence as an algorithm for solving creative tasks formed by artificial consciousness [31]. The scientific school of the Institute of Cybernetics of the National Academy of Sciences of Ukraine connects the development of artificial intelligence with the application of the principles and mechanisms of the functioning of the human brain. In particular, work [32] proposed a noospheric concept of artificial intelligence, which is based on the concept of smartenvironmental (intelligent environment), created by a three-level info sphere (sphere of information technologies).

In the Concept of the Development of Artificial Intelligence in Ukraine adopted in 2020, prepared by the Ministry of Digital Transformation of Ukraine and approved by the Decree of the Cabinet of Ministers of Ukraine dated 02.12.2020 No. 1556-r, artificial intelligence is defined as an organized set of information technologies that can be used to perform complex tasks by using a system of scientific methods of research and algorithms for processing information obtained or independently created during work, as well as creating and using own knowledge bases, decision-making models, algorithms for working with information and determining ways to achieve set tasks [33, 34].

In our view, artificial intelligence is a specialized branch of computer science rather than computer science because it focuses on developing algorithms and models that allow computers to analyze data, use logic, and learn from data. Artificial intelligence deals with the research and development of machine learning, deep learning, neural networks, decision-making, and other algorithms that allow computers to detect imitation of intelligent behavior. Although computer science may include elements of artificial intelligence, artificial intelligence stands out as a separate field that focuses on mental functions, self-organization, learning, and other aspects related to the simulation of human intellectual activity in computer systems.

Since most researchers associate the concept of artificial intelligence with information technologies and algorithms, let's consider in more detail which technologies we are talking about, Fig. 1 [35].

Our core AI technologies include machine learning and deep learning, natural language processing, and various object recognition technologies, including image processing, object recognition, and video analytics. Accordingly, each of the named technologies involves the use of various

methods and algorithms, which are also classified in Fig. 1.

Note that the field of artificial intelligence is constantly developing and new technologies, methods and algorithms are emerging. Scientists continue to work on expanding and improving deep learning, including creating more efficient neural network architectures, developing new methods for learning and understanding complex data such as graphs and sequences, and improving generative pre-trained and transformers (Generative Pre-trained Transformers). In the near future, more complex and independent artificial intelligence systems may appear, capable of making independent decisions, taking into account unpredictable situations and changing conditions.

The question of the ratio of artificial intelligence technologies and other technologies, in particular, the Internet of Things (IoT), which is interpreted as a system of data collection and transmission by connecting the Internet to various objects, sensors, devices through software or other devices, is a controversial issue. That is, the goal is to connect simple objects to computers and other computing machines. In this sense, both technologies are important components of an intelligent system, where artificial intelligence plays the role of the "brain", and the Internet of Things - the "body". Artificial intelligence can manage and automate the operation of connected IoT devices. It can analyze data from sensors, make decisions and send instructions to control devices in order to optimize energy consumption, ensure safety and improve comfort. The interaction of these two industries creates powerful opportunities to develop innovative technologies and improve the efficiency and functionality of various areas of life, including industry, transportation, health care, agriculture, and many others.

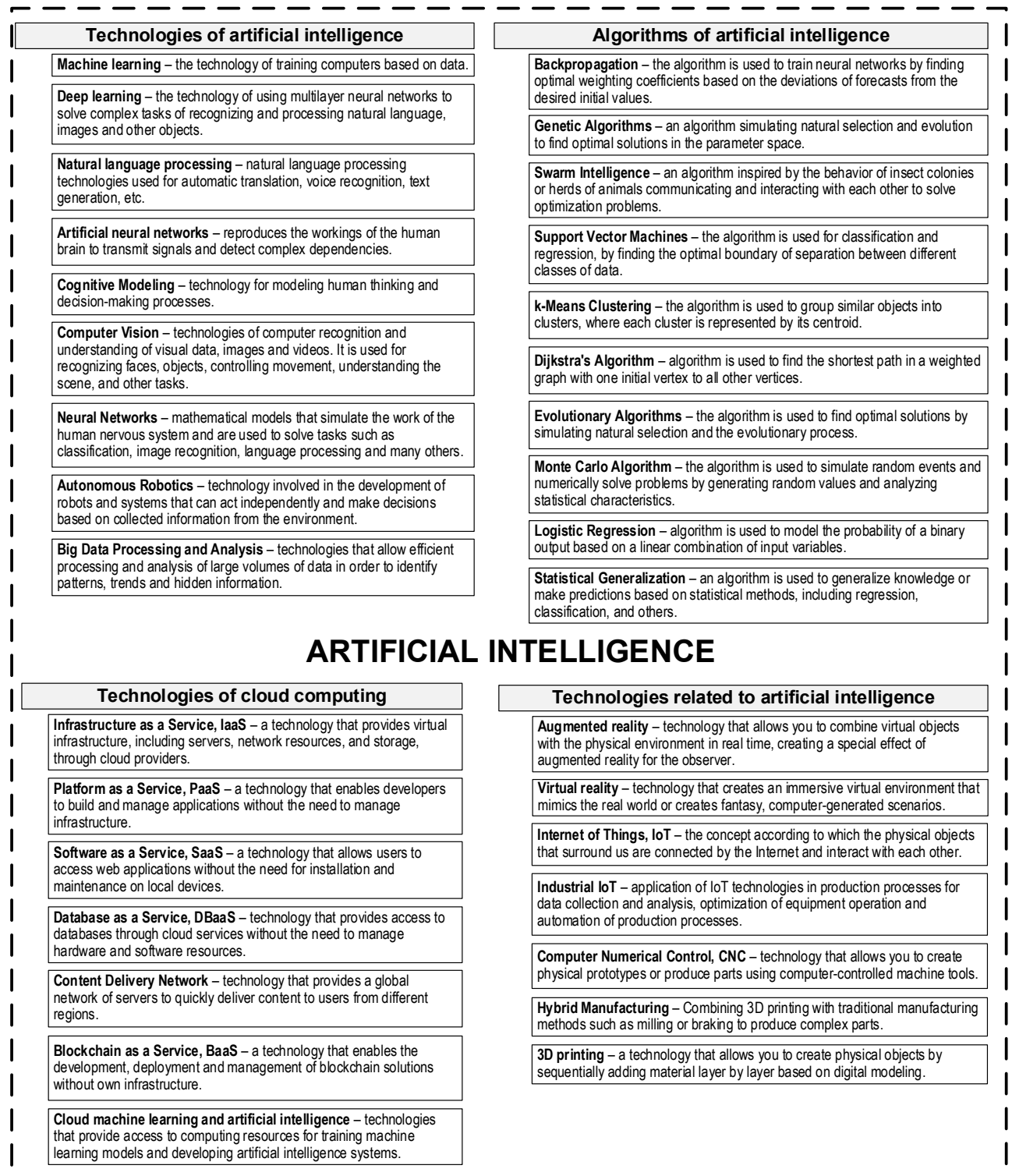


Figure 1 – Generalized classification of technologies, methods and algorithms of artificial intelligence (developed on the basis of [35])

The same can be said about the connection of artificial intelligence technologies with blockchain technology, which provides a distributed data storage system. Blockchain can be used to record the

results of AI models, allowing third parties to verify the authenticity and immutability of these results. The combination of artificial intelligence and blockchain can lead to the development of augmented intelligence,

where smart agents on the blockchain can communicate, share data, and learn from each other [36]. In augmented intelligence, intelligent agents can have their own learning algorithms and models that allow them to improve their abilities and skills over time. They can exchange experience, knowledge and information, which makes it possible to collectively acquire new knowledge and solve complex tasks.

So, the collection of technologies, methods and algorithms depicted in Fig. 1 reflects a wide range of scientific achievements and opportunities for the practical use of artificial intelligence in various spheres of human activity. Existing algorithms make it possible to process colossal amounts of information, to identify cause-and-effect relationships that are beyond the power of humans, which means that forecasts can be made more accurately and decisions made more effective.

In work [18], artificial intelligence is called a breakthrough innovation and a key driver of the digital transformation of the economy. Technologies based on artificial intelligence provide a unique opportunity to transform business operations by reducing the number of repetitive, routine tasks, significantly increase labor productivity, create new products, create new models of economic growth, improve the efficiency of government institutions, especially at the level of developing solutions aimed at ensuring welfare of citizens.

The authors of the monograph [37] associate the concept of artificial intelligence with the formation of intelligent information systems capable of transforming data, information, and knowledge into purposeful activity and learning. Artificial intelligence itself is not an intelligent system in the traditional sense, as it does not possess consciousness or self-awareness. Intelligent systems can be implemented on the basis of artificial intelligence, using machine learning methods, neural networks, expert systems and other technologies. They can optimize processes, recognize patterns, analyze data,

make predictions and automate a variety of tasks.

So, to date, the concept of artificial intelligence is developing and describes a set of multi-level systems capable of fully understanding and representing the world, as well as generating creative and new ideas. Generative artificial intelligence refers to systems that have the ability to generate new, creative ideas, solutions, or content. They can create something original and unpredictable, using their ability to associative thinking, combining ideas and using their own "creative" potential. Full artificial intelligence refers to systems that have the ability to understand, perceive and analyze information in the same way that humans do. This means that they can have a broad contextual understanding, take into account social, cultural and emotional contexts, recognize complex relationships between objects and events, and perform abstract thinking and draw conclusions.

The concept of full and generative artificial intelligence is intended to describe the desired level of development of intelligent systems that can have a deep understanding of the world, the ability to create something new and use their abilities to achieve highly intellectual tasks. However, to date, the implementation of full and generative artificial intelligence remains a challenge and the subject of active research in the field of artificial intelligence.

2. Using AI in supply chain management

The authors [38] believe that the use of artificial intelligence in the management of supply chains fundamentally changes the concept of SCM both at the organizational and individual levels. The main idea of SCM theory is that people and organizations are the links of SC, and the chains themselves arise as a result of these interactions. Since enterprises constantly interact with a significant number of different counterparties (buyers, competitors, wholesalers and retailers, suppliers, distributors, dealers, government institutions), this leads to high

transaction costs for enterprises. From the point of view of the theory of transaction costs, supply chain management should contribute to the reduction of total costs, primarily transaction costs.

The active use of artificial intelligence technologies can help reduce overall costs, providing new opportunities for automating routine procedures and operations, optimizing the use of resources, reducing costs for individual operations, etc.

First, artificial intelligence can help automate routine and repetitive processes that usually take a significant amount of time and effort. For example, in the field of manufacturing, the use of robots and machine learning systems can help perform monotonous tasks that previously required a lot of manual labor.

Second, artificial intelligence can help optimize the use of resources, such as energy, raw materials, time, and labor. By analyzing data and using predictive models, artificial intelligence systems can make more accurate demand forecasts, use resources more efficiently and avoid excess costs.

Thirdly, artificial intelligence makes it possible to reduce the costs of certain operations, for example, in the field of medicine and diagnostics. The application of intelligent systems to analyze medical images or other diagnostic data can help in the early detection of diseases and the implementation of more effective treatment strategies, which reduces the cost of treatment in general.

On the other hand, artificial intelligence enables the collection, analysis and interpretation of large volumes of data from various sources in real time. This enables companies and organizations to make more informed decisions based on up-to-date information. For example, artificial intelligence systems can analyze data about customers, their preferences and habits in order to adjust the range of products and personalize offers.

In general, artificial intelligence has significant potential to reduce costs and improve business processes. However, the

successful implementation of this technology requires a proper understanding of its capabilities and limitations, as well as careful attention to ethical and privacy issues, ensuring the responsible use of artificial intelligence for the good of society and people.

This provides businesses with greater transparency throughout their supply chain, allowing them to identify problem areas, improve processes and make informed decisions. This improves the quality of service, customer trust and provides timely and accurate information on the status of orders.

Virtualization and intellectualization of supply chain management is changing the nature and forms of integration of business entities - a transition is being made from traditional vertical or horizontal integration to the formation of supply networks and network interaction. Traditionally, the supply chain was characterized by a linear model, where information and resources flowed from suppliers to manufacturers, distributors and end users. However, the development of artificial intelligence opens up new opportunities for networked cooperation and coordination within the supply chain. Artificial intelligence enables the creation of intelligent agents that can collaborate, share information and make decisions based on common goals. This creates an opportunity for more flexible, efficient and transparent interaction between the various participants in the supply chain. Instead of simply passing information in one direction, network interaction allows for more dynamic and adaptive systems where decisions can be made collaboratively and based on data from multiple sources. This can lead to better coordination, solving complex problems and increasing innovation in supply chains.

In work [38], supply chain management specialists are offered to classify forms of interaction with artificial intelligence depending on its participation in the integration of supply chain links and decision-making (Fig. 2).

		Integrating artificial intelligence into supply chain management	
		Partial	Full
The role of artificial intelligence in decision-making	Supporting role	<p>A person manages all operations in the supply chain.</p> <p>Artificial intelligence is partially integrated and plays a supporting role, expanding human capabilities, exchanging and processing data, automating routine operations</p>	<p>A person makes final decisions and supervises the work of artificial intelligence.</p> <p>AI manages supply chain operations, increasing its reliability and flexibility, as well as analyzing data, forecasting demand, analyzing risks, monitoring suppliers and more.</p>
	Autonomous role	<p>The person reserves the right to make final decisions and can change the choice of artificial intelligence.</p> <p>Artificial intelligence has the power to make individual decisions, for example, to analyze suppliers according to a set of criteria and choose the best.</p>	<p>A person minimally interferes with the work of the ecosystem, which learns and adapts, forming a complex interconnected network.</p> <p>Artificial intelligence is fully integrated into all functions of the supply chain and has the authority to make decisions independently.</p>

Figure 2 – Forms of interaction of specialists with artificial intelligence in supply chain management (developed on the basis of [38])

Each quadrant of the 2×2 matrix expresses ways of human (specialist) interaction with artificial intelligence in supply chain management. The level of integration of artificial intelligence into the supply chain refers to the degree of integration of artificial intelligence into the various activities and processes of the supply chain. At one end of the spectrum, the integration of AI is low, where only a few actors in the supply chain use AI or use it only for specific tasks. This can be compared to the early stages of AI implementation, where AI is used as a tool to perform specific tasks, such as demand forecasting or inventory management, but in a limited capacity. At this stage, AI acts as a support system, augmenting human capabilities but not replacing them, and never makes autonomous decisions or executes without human guidance. At the peak of AI integration, many supply chain actors are embedding AI deeply into their operations, spanning tasks from demand forecasting to delivery and broader operations

management. A high level of integration means not only the extensive infrastructure of one company, but also the involvement of all participants in the use of artificial intelligence tools for all functions. While the tools may be individualized, their shared use across the supply chain results in a robust AI-driven supply chain.

The second axis (vertical) reflects the role of AI in decision-making. This refers to the extent to which artificial intelligence systems are given autonomy and decision-making authority. At the initial stage, AI plays a supporting role, providing data analysis, information retrieval and providing certain recommendations. In this case, AI is primarily a tool that augments human capabilities by providing decision support but not autonomous decision making. At the other end of the axis, AI is assuming decision-making power, potentially making decisions that significantly affect the supply chain. The shift from a supportive to an autonomous role is a significant shift in supply chain dynamics as it changes the balance of power between

humans and AI systems, accountability and control mechanisms, and the ethical implications of delegating decision-making authority to AI systems.

The first aspect to consider is the balance of power between humans and AI systems. When implementing autonomous systems in the supply chain, the role of people can change from direct management of processes to a more strategic and supervisory function. This can lead to efficiency and speed of work, but it can also raise questions about liability and risks associated with uncontrolled functioning of systems.

The second aspect concerns accountability and control mechanisms. When artificial intelligence systems operate autonomously, their actions can become less predictable to humans. This can make it difficult to determine the cause and effect of certain decisions, especially in cases where problems or errors occur. Providing accountability and control mechanisms is an important aspect to ensure that AI systems can be understood and intervened when needed.

The third aspect is the ethical consequences of delegation of authority to artificial intelligence systems. Autonomous systems can make decisions based on large amounts of data and use complex algorithms that can exceed the capabilities of the human mind. This can give rise to ethical dilemmas, for example, when artificial intelligence systems are forced to choose between different groups of people or risk their lives to achieve a goal. Developing ethical standards and regulations for the use of autonomous systems is critical to ensuring fairness, safety, and trust in this technology.

Overall, the transition from a supportive to an autonomous role in the supply chain has many advantages, but also raises challenges related to power, control and ethical aspects. For the successful implementation of autonomous artificial intelligence systems, it is necessary to actively explore these issues and find a balance between automation and

maintaining a humanitarian approach in decision-making.

Let us consider in more detail the transformation of traditional business processes and functions in supply chains under the influence of artificial intelligence technologies, summarizing the results of research [39-41] and focusing on the possibilities of interaction of decision-makers with new technologies.

A. Management of relations with counterparties (suppliers, subcontractors, intermediaries, etc.).

AI can automate many routine tasks related to interaction with counterparties. For example, automatic ordering, payment, delivery tracking, etc. This reduces the time and effort required to perform such tasks and enables more efficient interaction with suppliers, while providing improved communication and real-time information sharing. For example, AI-based data sharing systems can enable automatic exchange of orders, tracking of delivery status, sharing of product information, etc. This helps to increase transparency and mutual understanding between the parties and reduce errors and delays. It can also be used to analyze large amounts of data about counterparties, including transaction history, product quality, delivery times, and other parameters. Based on this data, AI can make predictions and optimize decisions about supplier selection, optimal order allocation and inventory management, as well as supplier risk analysis, including financial stability assessment, reputation assessment and other parameters. This allows you to identify potential risks and take appropriate measures to manage them.

B. Customer relationship management

AI helps analyze large amounts of data about customers, their preferences, purchases and behavior. Based on this data, AI can create personalized marketing offers, recommendations and predict customer needs. This allows companies to attract and

retain customers by providing personalized services and offers, increase customer loyalty, and accelerate the return on investment in CRM. Advanced CRM can learn and improve over time using machine learning techniques. AI-powered chatbots can provide quick and accurate answers to frequently asked questions, as well as engage in real-time dialogue with customers. This creates an opportunity for more natural and human interactions with customers, facilitates the process of ordering goods, improves the speed and quality of customer service, and also ensures 24/7 availability of support. The application of AI can include analyzing the emotions and sentiments of customers based on their interactions with the company, their messages on social networks, etc. By analyzing data about customers, their interactions and feedback, AI can identify trends in customer satisfaction and recommend actions to improve them.

C. Demand planning and forecasting

Artificial intelligence helps analyze and process large amounts of data, including historical sales data, trends, seasonality, advertising campaigns, social media, and more. This allows for more accurate demand forecasts and reveals complex patterns that may be imperceptible to human analysis. Machine learning algorithms and mathematical models and multivariate analysis methods analyze data in real time and allow businesses to quickly respond to changes in demand and take the necessary measures to optimize inventory and production processes. In conditions of market instability or variable supply conditions, an artificial intelligence system can simulate various scenarios and evaluate their impact on demand and supply chain management [42].

D. Inventory control and planning

AI can analyze large volumes of data about sales, purchases, market trends, forecasts, delivery times, inventory constraints and other factors to predict future

demand. It helps companies reduce the risk of stockouts or overstocks, optimize production and supply planning, and detect anomalies and respond to unusual trends or supply issues. For example, an expert system can be incorporated into a materials requirements planning system so that it can maintain databases of historical master production schedules, bill of materials, and order patterns, and then develop systematic lot-sizing rules to estimate optimal future order levels and optimal replenishment times.

For example, machine learning helped Otto Group, an e-commerce retailer, reduce its alarming inventory by 80%, making it more profitable and better able to adapt to market changes [43]. The authors [44] prove that the use of artificial intelligence without code (NCAI) can increase sales by 10.3%.

E. Procurement and supply management

On the one hand, artificial intelligence allows you to automate many routine tasks related to procurement, such as finding suppliers, reviewing and comparing offers, processing documents, etc. This helps reduce manual labor and increase the speed and accuracy of the process. On the other hand, the use of machine learning algorithms allows processing large volumes of data and identifying trends, predicting demand for products or services, and avoiding shortages or overstocking of goods. Taking into account various factors, such as prices, delivery times, product quality, intelligent systems can develop optimal purchasing strategies that ensure maximum efficiency and reduce costs. Artificial intelligence can support electronic marketplaces where suppliers and buyers can find each other, interact and make deals in virtual space. These changes help to improve efficiency, reduce costs, improve the quality of products and services, and improve risk management in procurement management.

F. Logistics management

Logistics operations play an extremely important role in managing supply chains and creating added value for goods and services

for consumers. Logistics costs can reach half or more of the added value of products. AI can be used to determine the shortest and optimal delivery routes, taking into account various factors such as fuel consumption, road conditions, time, volume and weight of cargo, as well as efficient use of resources. Coordination and synchronization of the movement of vehicles and cargo flows in the territory of logistics centers, ports or warehouses helps to speed up the delivery of goods to the final consumer. Thanks to sensors, GPS trackers and other technologies, it is possible to accurately track the location of goods and monitor delivery conditions such as temperature, humidity and the condition of the cargo. Using artificial intelligence techniques such as optimization algorithms, genetic algorithms, neural networks and other techniques, intelligent scheduling tries to find the best solutions that take into account the constraints, requirements and priorities arising in a specific situation. This helps reduce logistics costs, improve delivery quality and safety, and ensure customer needs are met. Timely identification of potential problems, such as delivery delays, equipment malfunctions, or supply instability, allows for timely decisions and the development of emergency action plans to avoid problems and reduce risks [44].

It should also be noted that intelligent transport systems based on artificial intelligence can help to improve the management of traffic flows in real time, reduce congestion and improve road safety. ML algorithms can analyze traffic patterns and optimize signal timing at intersections, while DL algorithms can identify potential hazards and warn drivers in real time. Smart cameras and traffic lights controlled by artificial intelligence can monitor and analyze traffic patterns to improve the efficiency of traffic management systems. Installing sensors on vehicles allows you to predict when maintenance is needed. Electronic toll collection systems and intelligent parking systems also help to optimize the transport system of a city or agglomeration.

Autonomous vehicles are able to perceive and interpret the environment, make decisions based on data, and safely navigate roads without human intervention [45].

Thus, the analysis of the possibilities of using artificial intelligence in the optimization of supply chain management processes and procedures shows its great potential for solving various tasks. However, as noted by the authors [46], most of the tasks that are currently solved with the help of artificial intelligence technologies are well structured (or rarely defined, narrowly defined) and are operational and tactical in nature. The vast majority of tools used allow generating a better alternative from a set of possible solutions, such as supplier selection, inventory planning, route optimization, etc. The authors link future research and prospects for expanding the use of artificial intelligence tools with the techniques of multi-criteria optimization and fuzzy logic, as well as hybrid models and methods. Figure 3 summarizes the set of main drivers stimulating the implementation of artificial intelligence technologies in supply chain management processes, as well as software applications, cognitive methods and possible results in terms of increasing productivity and efficiency.

Therefore, artificial intelligence consolidates the main drivers of supply chain management in improving productivity and efficiency. The effectiveness of artificial intelligence tools largely depends on the efficiency and accuracy of the software, the quality of the data, and the chosen methods and algorithms.

We should not ignore the threats and challenges that the use of artificial intelligence also creates, in particular:

- insufficient data quality: Artificial intelligence needs a large amount of quality data to function properly. If the data on which the system is based is imprecise, noisy or incomplete, it can lead to incorrect analytical conclusions and incorrect decision making;
- incompatibility with the human factor: Artificial intelligence can be difficult to take

into account human aspects, such as personal relationships, ethics and intuition. Some decisions made by artificial intelligence may be technically sound, but not always acceptable to humans;

- dependence on technology: Artificial intelligence relies heavily on computer software, which can lead to incorrect decisions if programmed incorrectly. The development of artificial intelligence depends on technological innovation, which means that there is a risk of obsolescence and cost of the system. It is necessary to ensure constant updating and support so that

artificial intelligence remains effective and modern;

- privacy and security issues: The use of artificial intelligence requires the collection and processing of a large amount of data, which can create privacy and security issues. Insufficient protection of information can lead to data leakage or unauthorized access to it;

- impact on jobs: The use of artificial intelligence may lead to the automation of certain work processes and the replacement of humans by robots. This can have a negative impact on employment and the socio-economic situation.

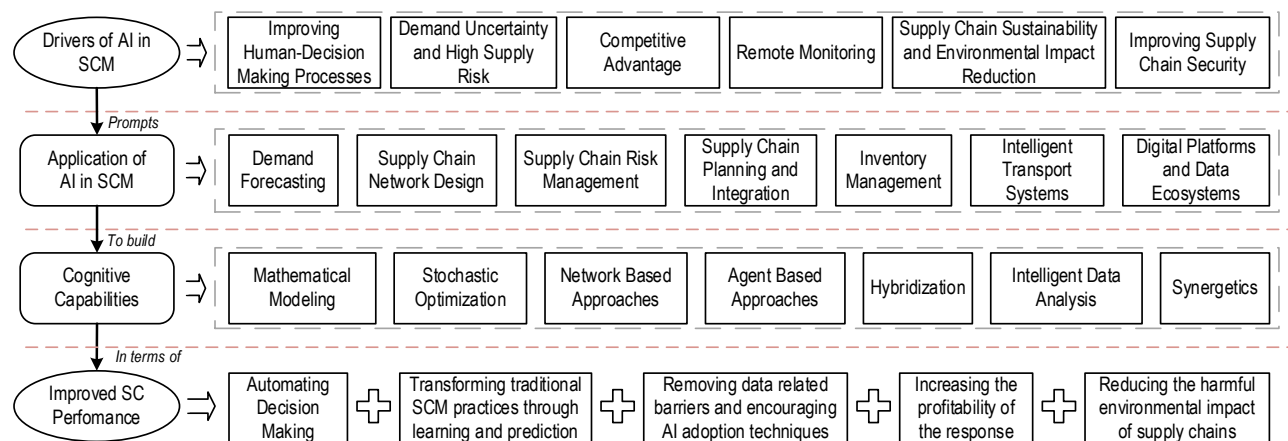


Figure 3 – Scheme of the synergistic effect of artificial intelligence tools on the productivity of supply chains (modified on the basis of [46])

To reduce the risks of using artificial intelligence in supply chain management, it is necessary to conduct thorough analysis and planning, ensure data quality, develop ethical standards and information protection procedures, and actively involve personnel in the implementation and use of these technologies.

3. Professional competence and training of supply chain managers

The impact of artificial intelligence on the labor market and the personnel training system is being actively discussed in scientific and business circles. There is a common myth that artificial intelligence can replace workers, take jobs away from people, etc., but in reality this is not the case. While AI can automate

routine tasks and provide valuable insights, it still requires human expertise to make sense of data and make strategic decisions. Supply chain managers should not compete with artificial intelligence, but learn to work effectively with it, and develop new skills and abilities [47].

Let's consider in more detail how artificial intelligence affects the professional competence of supply chain management specialists.

One of the key reasons for the need to improve professional competence is the understanding of artificial intelligence technologies, which underlie many innovations in the field of supply chain management. Specialists must be familiar with the fields of machine learning, deep

learning, data analytics and pattern recognition in order to effectively use these technologies in their work. Understanding the capabilities and limitations of artificial intelligence allows professionals to effectively use it to perform demand forecasting, inventory optimization, route planning, and many other supply chain management tasks.

A second important competency is the ability to analyze and interpret large volumes of data. With the help of artificial intelligence, specialists have access to a significant amount of information from various sources. The ability to analyze this data, extract key information and use it to make decisions becomes a necessary skill. Understanding data processing and analysis techniques, such as machine learning and statistical analyses, helps professionals identify trends, forecast demand, and perform other analytical tasks.

The application of artificial intelligence technologies also requires specialists to have the ability to cooperate and communicate with artificial intelligence systems. Understanding how to properly interact with these systems, including communicating information and making decisions based on their results, becomes a key skill. Communicating with AI requires the ability to explain, interpret, and use analysis results, and to interact with colleagues and customers based on that data.

Since artificial intelligence technologies fundamentally change the logistics business and supply chain management systems, it is necessary to make changes to the curricula and training programs of relevant specialists, namely: big data processing methods, real-time decision-making methods and procedures, system analysis and business optimization - processes. From modern graduates as future specialists, employers expect the ability to look at a work task from different angles and find non-trivial solutions for it, the ability to work in cross-functional teams, where each member is an expert in his field. But the main task of such a specialist is the ability to think with one's head, include critical thinking, analyze information and

integrate one's share into the general whole, under the specific request of a task or project. A robot and no chatbot can do this (yet).

Therefore, continuous learning and improvement of digital skills will help professionals to be successful and competitive in supply chain management. It is important to stay on top of the latest trends, learn new things, and constantly improve your skills to effectively use the opportunities that artificial intelligence provides in supply chain management. In general, supply chain managers can co-operate their activities with artificial intelligence using an approach known as "human-machine collaboration" or "collaborative intelligence", which manifests itself in the use of artificial intelligence to cover human weaknesses or automate routine tasks. In particular, an expert can have strategic thinking and creativity, while artificial intelligence can ensure the speed of processing large amounts of data, find correlations, make predictions and provide recommendations.

The development of the digital infrastructure of Ukraine and the adaptation of international rules and standards related to the formation of a single digital market will contribute to the development of digital competencies of supply chain management managers. The reduction of cross-border barriers for digital trade and the development of the Diya online platform encourages businesses to more actively develop digital business models and multi-channel strategies, including for international supply chains.

To increase the level of motivation regarding the use of digital public services, the Ministry of Digitization of Ukraine launched the Index of Digital Transformation of the Regions of Ukraine, which allows determining the effectiveness of government bodies in the direction of digitalization. The results of the 2022 study show that the Index within Ukraine is 0.650 points out of 1 possible. According to the results of the study, the share of Ukrainians with digital skills at the "basic" and "higher" levels is 52.2%. At the

same time, the ambitious goal of the state is the integration of digital technologies in all areas of business, which should lead to fundamental changes in the way citizens, enterprises and organizations act, how they provide value for themselves, their employees, customers, partners, achieving their own and common, economic and social goals faster, cheaper and with new quality. The strategic goal of the digital transformation of Ukraine is to enter the list of the top 50 countries in the world in the field of artificial intelligence.

Conclusions. The analysis of scientific publications on the issue of artificial intelligence made it possible to establish the ambiguity of its interpretation from the point of view of the object and subject of research, as well as the field of knowledge. Almost all authors agree that artificial intelligence should be similar to human intelligence and related to data, information and knowledge, and its main characteristics are the understanding of natural language, the ability to learn, the ability to think (generalize and draw conclusions), as well as to accept decision. According to the authors of this article, artificial intelligence focuses on developing algorithms and models that allow computers to analyze data, use logic, and learn from data using various technologies. The classification of methods, algorithms and technologies of artificial intelligence is proposed and it is concluded that the set of technologies used determines the level of development of intelligent systems from those that perform an auxiliary role to more complex autonomous systems of artificial intelligence capable of making independent decisions, taking into account unforeseen situations and variables conditions.

From the point of view of practical use, according to experts, in the coming years, AI

will become the only and best tool for the promotion and development of products and services on the market. Analysts predict that around 70% of companies worldwide will adopt at least one form of AI by 2030 as part of scaling their operations, and a significant proportion of large enterprises will use the full range of available innovations to enhance existing lines of business. The paper provides a thorough analysis of the transformation of traditional business processes and functions in supply chains under the influence of artificial intelligence technologies. It was concluded that most of the tasks that are currently solved with the help of artificial intelligence technologies are well structured and are operational and tactical in nature. The vast majority of tools used allow generating a better alternative from a set of possible solutions, such as supplier selection, inventory planning, route optimization, etc. The authors link future research and prospects for expanding the use of artificial intelligence tools with the techniques of multi-criteria optimization and fuzzy logic, as well as hybrid models and methods.

For the practical use of advantages and prevention of risks of artificial intelligence, the competence of management personnel is extremely important. While AI can automate routine tasks and provide valuable insights, it still requires human expertise to make sense of data and make strategic decisions. Supply chain managers should not compete with artificial intelligence, but learn to work effectively with it and develop new skills and abilities. Communicating with AI requires the ability to explain, interpret, and use analysis results, and to interact with colleagues and customers based on that data. Continuous learning and improvement of digital skills will help professionals to have strategic thinking and creativity, as well as to be successful and competitive in supply chain management.

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