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INDUSTRY 4.0 TECHNOLOGIES AS A FACTOR IN ECONOMIC DEVELOPMENT

Introduction. Economic development is inextricably linked to the introduction of new technologies that improve production processes, resource management, and business organization. However, the scale and nature of this impact vary significantly depending on the industry, region, and level of technological system integration in production, leading to ambiguous consequences for the economy. Given this, it becomes relevant to study the economic effects of the widespread adoption of Industry 4.0 technologies, such as artificial intelligence (AI), the Internet of Things (IoT), blockchain, and 3D printing.

As Klaus Schwab notes, we are currently in the era of the Fourth Industrial Revolution, which involves transitioning industrial production to the Industry 4.0 model. In his key works, The Fourth Industrial Revolution [1] and Shaping the Future of the Fourth Industrial Revolution [2], he focuses on the production and social implications of this process. However, the issue of structural changes in the economic system due to the influence of Industry 4.0 technologies remains insufficiently explored. This highlights the need for further research in this area.

The purpose of this article is to determine the consequences of Industry 4.0 technologies on the economic system.

Research Results. The key technologies of the Fourth Industrial Revolution include artificial intelligence, the Internet of Things, 3D printing, and blockchain. Each of them influences specific aspects of production activities while also indirectly affecting the economic system as a whole. Their combined use amplifies their impact, enhancing efficiency in industrial applications and transforming social mechanisms.

Artificial intelligence (AI) is the most influential technology in both the production and social spheres. AI is a digital technology designed to perform complex and diverse tasks traditionally requiring human intelligence. According to interdisciplinary research in cognitive sciences, mathematics, computer technology, neuro-science, and philosophy, AI is classified into three levels:

- Narrow AI – Systems specialized in solving specific tasks and capable of performing only a limited number of functions.
- General AI – A hypothetical system capable of performing any intellectual tasks inherent to humans. It can learn, reason, adapt to new situations, and solve problems across various domains.
- Superintelligence – A hypothetical system that surpasses human intelligence in all aspects.

Currently, only the first level of AI exists. However, even its limited functionality has been sufficient to initiate fundamental changes in production models and social relations. To determine the structure and assess the scale of these changes, it is necessary to study the areas of AI application and evaluate its local impacts.

First and foremost, attention should be given to the general industrial aspect of AI application – its functionality, which, with certain variations, can be relevant to most types of industrial enterprises. The most effective use of AI in this context lies in the automation of production processes through robotics controlled by AI. This functionality enables continuous, round-the-clock production while minimizing the involvement of workers engaged in routine tasks. An additional advantage is that AI algorithms efficiently perform quality control tasks and can optimize production processes by reducing errors. As a result, operational costs decrease due to reduced manual labor, while the rational use of materials and resources contributes to lowering overall production expenses.

Another effective general industrial function of AI is resource planning and management. The principle of this functionality is that AI algorithms, based on the analysis of retrospective and real-time data, calculate optimal solutions for supply chain organization, inventory management, production planning, and workforce allocation. This helps minimize transaction costs, including expenses related to partner searches, inventory control, and production process coordination. As a result, overall production costs are reduced, positively impacting the profitability of the enterprise.

Another important AI function from a cost-saving perspective is energy consumption optimization. This effect is achieved through analyzing energy consumption data at each stage of the production process, from equipment startup to product completion. Based on this analysis, AI algorithms can identify peak loads, reduce energy losses, and find ways to use equipment more efficiently. For example, AI can optimize machine operating times to prevent power grid overloads or redistribute tasks to lower energy consumption during peak hours. Implementing such functionality significantly reduces energy costs and enhances overall production efficiency.

▪ In the context of sectoral improvements, the following AI functions should be highlighted:

▪ Manufacturing of new products in the mechanical engineering sector, such as autonomous vehicles.

▪ Optimization of chemical reactions through modeling in chemical production.

▪ Quality control of metals using AI-powered image analysis systems in metallurgy.

▪ Optimization of energy equipment performance and management of smart grids in the energy sector.

▪ Personalized product design (customized based on customer requests) in the textile industry.

▪ Development of new drugs through disease data analysis in pharmaceuticals.

▪ Project planning and the use of robots in construction for building projects.

All these sectoral applications complement the general (universal) advantages of AI, making it an effective tool for improving production quality and profitability. Despite its obvious technical advantages, the economic feasibility of AI implementation in production is not always justified. The high cost of equipment and long payback periods may lead entrepreneurs to prefer human labor, especially in countries where labor costs are low. Even in wealthier countries, long-term AI adoption may present challenges. Based on economic theory, it can be predicted that, initially, high labor costs in these countries will encourage businesses to replace human workers with AI-driven automation. However, after mass layoffs of low-skilled workers, the cost of labor in the market will decrease, making AI-based automation less attractive to investors – as hiring human workers will once again become more cost-effective.

To sustain the dynamic development of AI-based production, governments of developed countries may implement several measures. In particular, they could introduce progressive taxation to increase the volume of social benefits, which may reduce the dependence of low-income groups on low-paid jobs. This, in turn, would encourage workers to demand higher wages. Additionally, governments could invest more funds in education, which would potentially reduce the number of low-skilled workers, thereby increasing their market value. Furthermore, quality, safety, and production control standards could be introduced at the national level, making routine tasks performed by low-skilled workers less competitive compared to automated AI solutions.

However, the current cost of AI-powered equipment is not fixed. Several factors have already contributed to its cost reduction, and this process is likely to continue. The primary reason for this is the declining cost of semiconductor production, which is explained by Moore's Law [3]. According to this law, the number of transistors on an integrated circuit doubles approximately every two years, leading to exponential performance growth and a reduction in computing power costs per unit. Although the effect of Moore's Law has slowed somewhat in the 2020s, its impact is being sustained through new approaches, such as the introduction of 3D chips and optimization of semiconductor architectures.

Another important factor that may contribute to the cost reduction of AI equipment in the future is the increase in competition within this industry. As demand for such equipment grows, new manufacturers are expected to enter the market, while existing companies will be forced to introduce innovations to maintain their market positions. This market dynamic will not only improve equipment quality (e.g., increasing performance or energy efficiency) but will also lower costs, as increased supply will naturally drive prices down.

At the same time, software-related factors play a crucial role, as they directly impact the efficiency of AI hardware and, consequently, its economic viability. Innovations in AI algorithms, particularly in machine learning and deep learning, significantly optimize computational processes, reducing hardware resource requirements. New algorithms, better adapted to specific tasks, can greatly reduce the need for high-performance computing systems for complex operations. As a result, the demand for high-end hardware decreases, lowering development and operational costs. Moreover, the integration of software solutions for data processing and access optimization helps reduce the load on hardware components. Collectively, all these factors contribute to the overall reduction in the maintenance costs of AI-driven management systems.

If the above-mentioned factors contributing to the cost reduction of AI equipment are confirmed, we can expect a rapid increase in the share of AI-driven production in the near future. This trend will primarily affect developed economies, where high labor costs, innovation-driven competition, and stringent quality standards will encourage entrepreneurs to replace low-skilled workers (and, in some cases, even highly skilled professionals) with AI-based equipment. Under these conditions, the structure of the economy will largely depend on the domestic policies of each government. If a government implements social support programs for low-income groups, funded by wealthier citizens (including through progressive taxation), a significant portion of low-skilled workers who lost their jobs due to

AI adoption in enterprises may remain outside economic processes. In this scenario, they would rely on social benefits instead of contributing to economic development. However, if the government does not provide special support to low-income groups, it is highly likely that most displaced workers will find employment in the service sector, which will expand due to the overall economic growth driven by AI technologies in production.

From the perspective of overall economic development, the second scenario is more promising. Competition in AI-powered production should lead to an increase in the supply of consumer goods, thereby reducing their prices. This, in turn, will enhance the purchasing power of the population, with some of that increased spending redirected toward the service sector. As a result, demand for services will grow, stimulating capital inflows and labor absorption in this sector. Ultimately, the economy will expand, and citizens will gain access to a broader range of goods and services.

Based on its impact on the economy, AI can be classified as a disruptive technology. Similar to the technologies analyzed by Carlota Perez [4], AI has already partially realized its potential for structural transformations within the economic system. Today, new types of production exist (e.g., autonomous drones and vehicles, household robots, AI-driven systems) along with new labor organization models (e.g., hybrid workplaces, robotic production lines, autonomous logistics systems) – all of which were unknown twenty years ago. Additionally, a new infrastructure has been created to support AI development, including data centers, cloud computing platforms, and more. All these factors indicate that AI meets the criteria defining technologies capable of initiating technological revolutions, according to Carlota Perez's theory. It can be assumed that if she were writing her work today, a new concept – the "Sixth Technological Revolution" – would likely emerge.

It is also important to note that, similar to other disruptive technologies described by Carlota Perez, AI drives the development of numerous complementary innovations, which, in turn, Klaus Schwab has identified as the "pillars" of the Fourth Industrial Revolution. One of the most prominent of these is the Internet of Things (IoT) – a network of internet-connected physical devices that automatically collect, transmit, and exchange data without human intervention. These devices are equipped with sensors, software, and communication modules, enabling them to interact both with each other and with other systems via the internet. AI's role within the IoT is to process real-time data, identifying patterns upon which production decisions are made. Furthermore, AI implements algorithms that enable the automatic execution of these decisions.

The Internet of Things (IoT) driven by AI (Intelligent Internet of Things) is one of the key technologies of the Smart Factory. This concept involves the creation of a fully integrated, automated, and self-learning environment that ensures high productivity and efficiency in manufacturing processes. This result is achieved by reading large datasets from manufacturing devices and processing them, based on which AI algorithms make optimal production decisions and implement them in the physical environment. Workers at smart factories focus on system setup, quality control, and occasionally make complex strategic decisions.

One example of a smart factory is the Siemens plant in Amberg, Germany, which specializes in electronics manufacturing. It uses advanced AI-controlled robotic production systems via IoT infrastructure. Around 75% of all processes at the factory are automated, leading to significant resource savings and productivity gains. Similarly, German BMW factories use AI and IoT infrastructure to automate the assembly of cars.

It is also worth noting the sectoral aspects of IoT applications. In particular, this technology is used in agriculture for monitoring soil moisture and temperature. In energy – for collecting information on electricity consumption, based on which its distribution is optimized. In metallurgy – for detecting defects in furnaces, rolling mills, and other equipment. In the chemical industry – for tracking production parameters such as temperature, pressure, and substance concentration. And in many other sectors as well.

However, the global impact of IoT on the economy is not limited to just efficient manufacturing. The communication capabilities created by this technology lead to a transformation in the model of relations between producers and consumers in the market. By providing a connection between physical devices (production equipment), digital platforms (market-places), and consumers, IoT enables manufacturers to collect real-time data on product sales, analyze it, and quickly adjust production processes to meet changing demand. At the same time, IoT helps manufacturers "stay ahead of the curve" by providing the ability to analyze consumer preferences (such as browsing history or views of specific products), allowing them to create personalized products and offers.

The economic effect of collecting information through IoT is enhanced when this data is directed to "smart factories." At such enterprises, AI analyzes the received data and adjusts production processes according to current demand. This helps avoid overproduction, minimize waste, and optimize costs.

The demand and supply principle shaped by IoT leads to a shift in the economic system toward the model of the so-called "pull economy." This model is based on meeting actual consumer demand through the fastest and most accurate response to market requests. Today, most market segments operate under the traditional "push economy" model, where products are made based on demand forecasts. In contrast, within the "pull economy" model, production only begins when a real request from a specific consumer is made. This model is characterized by the absence of overproduction and excessive stockpiling of resources.

However, according to some scholars, the "pull economy," based on demand and supply signals transmitted through IoT infrastructure, threatens to cause an asymmetric redistribution of societal resources in favor of those who collect digital information. Professor Shoshana Zuboff of Harvard Business School described this phenomenon as "surveillance capitalism" [5]. Its essence lies in the collection, analysis, and monetization of users' personal data from digital content without their conscious consent. This data is used to develop predictive models and influence people's behavior, turning their actions and emotions into commodities. The system created in this way generates asymmetry of knowledge and power between technological corporations and society, violating privacy and freedom. In this context, Zuboff criticizes corporations like Google and Facebook for their data monetization practices, such as creating personalized advertisements and predicting consumer behavior. In her view, this enables tech companies to influence societal behavior for profit.

Despite the validity of the problem of "surveillance capitalism" caused by the use of the Intelligent Internet of Things, the paradigm of Industry 4.0 itself holds potential for partial resolution. This refers to data protection mechanisms using blockchain technology, which ensures decentralized data storage in the form of sequential and immutable records in a register (blocks) linked in chronological order. Through blockchain, consumers will be able to interact directly with manufacturers, reducing the involvement of third-party internet services (browsers, centralized digital platforms), thus reducing the risks of data collection by third parties. Furthermore, within this new communication model, manufacturers will only have access to the data necessary for fulfilling current orders, limiting the possibilities for gathering additional data about consumers. As a result, secondary data will become less accessible to businesses, thus limiting opportunities for monetizing it.

Strengthening the protection of data for economic agents is just one of the advantages provided by blockchain. In addition, the technology can contribute to reducing transaction costs related to accounting, auditing, counterparty verification, payments, and so on [6]. The mechanism for this reduction lies in the use of distributed ledgers as a source of reliable information, which is extremely difficult for third parties to alter. This information can include records of payments made, obligations of economic agents, movement of goods, and more. Thus, once data is recorded in the blockchain, it remains immutable, reducing the need for repeated verification of its authenticity. This helps save time and resources for economic agents, thereby reducing transaction costs in their activities. For example, by recording information about a money transfer for goods delivered in the blockchain, the parties to the agreement will not need to involve a third party (such as a bank) to complete the transfer. Instead, cryptocurrency, with significantly lower transaction costs, will be transferred to the seller's account, making the transaction more economically efficient for both parties.

The successful integration of blockchain technology with fundamental software solutions opens up opportunities for even further reduction of transaction costs in economic activities. In this context, it is worth noting smart contracts as part of the blockchain ecosystem, which automatically execute the terms of an agreement between parties without the need for intermediaries. The principle behind their operation is that the contract terms, in the form of code, are recorded in the blockchain, making them immutable. After that, the system waits for a signal indicating that one part of the agreement has been fulfilled, and upon receiving this signal, it automatically executes the other part. For example, when entering into a supply agreement, the entrepreneur transfers the required amount of funds or digital assets into the smart contract, where they are reserved. After the delivery of the product is confirmed, the system automatically transfers the funds to the supplier’s account, eliminating the need for additional verifications and intermediaries.

An analysis of blockchain's potential shows that, unlike other Industry 4.0 technologies that influence the economic system through the optimization of production processes and simplified communication, blockchain primarily transforms institutions. Moreover, this transformation occurs from the bottom up-driven by objective economic realities. In other words, economic agents find new, more effective mechanisms for protecting personal information, ensuring contract terms, and handling material transactions, while governments, in turn, respond to such changes retroactively. The response of regulatory bodies can vary, from adapting legislation to new forms of interaction between economic agents, to outright banning alternative informal institutions that have been built around the technological capabilities created by blockchain.

Although the institutions created under the influence of blockchain offer clear advantages in the form of lower transaction costs in economic activities, it cannot be confidently expected that governments will take measures to legalize them. In this case, much depends on various factors, including the political climate, the pluralism of the political system, the structure of financial flows, and the level of their concentration in the hands of certain influential entities. For example, in a country where the ruling party or president is funded by a group of people profiting from the banking business, it is unlikely that cryptocurrency payments will be legalized. On the other hand, in countries with less concentrated financial flows and a competitive political system, there is a higher likelihood that laws will be passed to formalize effective institutions. Thus, the ruling party or president will likely try to gain voter support to extend their time in power.

Similar motivations may drive political influencers, either restraining or encouraging the adoption of other Industry 4.0 technologies. In particular, regarding the disruption of established economic relations, the impact of 3D printing on rent distribution structures should be noted. This technology allows for the creation of three-dimensional objects by layer-by-layer deposition of material based on a digital model. Unlike traditional production methods, such as casting or milling, 3D printing enables the production of complex parts without the use of expensive molds and unnecessary material costs. The main stages of production using 3D printing include:

1. Creating a 3D model – the object is initially modeled in special programs (e.g., AutoCAD, Blender, SolidWorks).

2. Slicing the model into layers – the 3D printing software (e.g., Cura, PrusaSlicer) divides the model into individual layers for printing.

3. Printing layer by layer – the printer sequentially applies material until the finished object is formed.

Thus, production occurs without the use of traditional bulky equipment, parts, and components, which deprives the manufacturers of these components of their earnings. In particular, this affects producers of products for the aviation, automotive, construction, textile, food, and jewelry industries. Losses also threaten businesses that continue to use traditional production methods as opposed to 3D printing.

In cases where political influencers receive rents from industries that may incur losses due to the spread of 3D printing technology, it can be expected that they will oppose these innovations. For example, they might lobby for high import tariffs on 3D printers or their components, officially justifying this as a necessity to protect domestic producers. Conversely, if influential agents are interested in the development of manufacturing sectors that will benefit from 3D printing, they will promote the adoption of this technology.

From a purely economic perspective, 3D printing technology reduces the value creation chain while not diminishing the value and quality of the product. This aspect influences the acceleration of production speeds and the reduction of product costs, making it more accessible to consumers. Furthermore, 3D printing allows for the optimization of resource use, reducing waste levels compared to traditional manufacturing methods, which helps decrease raw material costs and environmental impact.

Just as conveyor belt manufacturing once displaced manual assembly, initiating the era of mass consumption, 3D printing, in combination with Artificial Intelligence and the Internet of Things, can fundamentally transform modern production processes, ushering in the era of customized consumption.

The concept of customized consumption represents a systemic approach to adapting products and services to the individual needs and preferences of consumers. It involves actively engaging buyers in the product creation process, allowing it to align with their expectations. From the perspective of production-consumption relationships, customized consumption is a logical extension of the principles of the "pull economy" and is effectively implemented in the context of smart factories. In such conditions, production processes become more flexible, automated, and focused on personalized demand, while technological solutions such as digital twins, artificial intelligence, and big data analytics ensure the rapid adjustment of production capacities to dynamic consumer preferences.

Based on the results of the study of the impact mechanisms of Industry 4.0 technologies on economic processes, it can be concluded that, with widespread implementation, these technologies could significantly alter the structure of the economic system, influencing its key characteristics: what to produce, how to produce, and for whom to produce. The potential driver of change in this case is the functionality of fast and almost lossless data exchange, managed by Artificial Intelligence. For instance, the integration of AI with 3D printing technology allows for the transmission of data about the properties of products to a 3D printer, which automatically and with minimal maintenance costs carries out the production process. The speed of data transmission and the production versatility of the 3D printer open up possibilities for manufacturing personalized products, stimulating the transition of the economic system to customized production. Along with this, the symbiosis of these factors contributes to the autonomy and localization of production processes, affecting the shortening of the value creation chain.

Decentralized storage of cryptographically protected and immutable data via blockchain opens up opportunities to reduce transaction costs for institutions that facilitate interactions between economic agents. In particular, the implementation of a digital business registration system at the state level based on blockchain will reduce bureaucratic barriers, ensure transparency of procedures, and, through data processing automation, significantly accelerate the registration process. A successful example of such a system is Estonia's e-Residency program, which enables non-residents to register a business, sign documents, and manage a company online. However, the program does not provide tax residency or the right to reside in Estonia [7].

In the context of reducing transaction costs for institutions that facilitate the interaction of private entrepreneurs, digital smart contract services – developed on the basis of blockchain – are highly effective. They contribute to reducing costs associated with: verifying the fulfillment of contract terms; the need for intermediaries; risk management; document circulation; and communication. This effect is achieved through the transparency and immutability of the data presented on the blockchain, which enhances trust between the parties. For example, in the logistics sector, smart contracts can automatically track the fulfillment of transportation conditions. All key stages, such as confirmation of loading, delivery, or payment, are recorded on the blockchain, eliminating the need for manual data entry and preventing fraud. This significantly reduces coordination costs between suppliers, carriers, and customers. In the financial sector, smart contracts ensure the automatic execution of loan agreements. In particular, if the borrower pays interest on time, the smart contract immediately records this and transfers the corresponding amount to the lender, thus excluding intermediary costs (banking institutions) and minimizing the risk of human errors.

The effectiveness of smart contracts is confirmed by the successful experience of their use by large companies. For example, the Danish shipping company Maersk, in collaboration with IBM, uses smart contracts through the TradeLens platform to manage container shipping [8]. Meanwhile, the Australian energy company Power Ledger uses smart contracts for buying and selling solar energy from decentralized producers-consumers [9].

As part of the Fourth Industrial Revolution, which is accompanied by technological shifts in the field of digitalization, data flows are the driving force behind the transformation of the economic system. A particularly important role in these changes is played by mechanisms for collecting, processing, and exchanging data. The use of outdated internet protocols to support Industry 4.0 technologies, such as blockchain and 3D printing, may significantly limit the economic impact of their application. In the context of blockchain, for example, this would lead to only a modest reduction in transaction costs, as economic agents would be forced to manually verify contract terms and update databases. Meanwhile, in the case of 3D printing, the absence of integrated communication channels between customers, designers, and manufacturers would significantly reduce the potential of this technology. However, the Internet of Things (IoT) can solve this problem by creating technological capabilities for automated data exchange between devices and real-time data processing. For example, IoT sensors installed on vehicles can automatically send information about successful product delivery to a blockchain system, based on which a smart contract would automatically transfer funds to the transport company's account. Similarly, in the case of 3D printing, production monitoring sensors can transmit information about the need for additional parts to the 3D printer, which would then automatically produce them.

It is also important to emphasize the role of the Internet of Things as a self-sufficient, system-forming technology. By enabling real-time communication between producers and consumers of products, IoT helps adapt the market to the actual needs of consumers. This is achieved through the dynamic optimization of business operations based on real-time information about current product orders, consumer preferences, inventory levels, and materials in warehouses, among other factors. As a result, manufacturers reduce the risks of overproduction, and consumers receive the desired products, which is a hallmark of the "pull economy."

Conclusions. At the current stage of the Fourth Industrial Revolution, particularly the transition to the Industry 4.0 production model, Artificial Intelligence technology is considered a breakthrough. On the one hand, it radically reduces production costs, and on the other hand, it enhances the effectiveness of complementary technologies such as the Internet of Things, 3D printing, and blockchain. Each of these technologies, both individually and in combination, contributes to changes in the established structural elements of the economic system. 3D printing, in combination with the Internet of Things infrastructure and the computational capabilities of Artificial Intelligence, simplifies the production of customized products. This changes the structural element of the economic system related to determining the product range, i.e., addressing the question of "what to produce." Moreover, 3D printing allows for the reduction of the value creation chain, which in turn impacts the production methods that define "how to produce." This structural element of the system is also influenced by blockchain technology, which provides opportunities for reducing transaction costs in the regulatory institutions governing relationships between economic agents. Finally, the structural element of "for whom to produce" is transformed under the influence of the Internet of Things technology, which enables producers to collect and analyze information about consumers, ensuring that production is adapted to their individual needs.

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Сердюк О. Технології Індустрії 4.0 як фактор розвитку економіки

В статті розглянуто потенціал технологій Індустрії 4.0 як фактора розвитку економічної системи. Проаналізовано ключові технології Четвертої промислової революції, зокрема Штучний інтелект (ШІ), Інтернет речей (IoT), блокчейн та 3D-друк, і їхній вплив на економічні процеси. Особливу увагу приділено ролі Штучного інтелекту, який є основним рушієм трансформації виробничих процесів. Досліджено можливості автоматизації виробництва за допомогою ШІ, його здатність до аналізу даних у реальному часі, управління ресурсами та оптимізації виробничих процесів. Встановлено, що впровадження ШІ сприяє зниженню операційних витрат, покращенню якості продукції та ефективнішому використанню ресурсів. Розглянуто Інтернет речей як технологію, що забезпечує інтеграцію виробничих процесів і комунікацію між пристроями в режимі реального часу. Наголошено на його ролі у формуванні "розумних фабрик" та переході до моделі "витягаючої економіки", яка дозволяє виробникам швидко адаптуватися до змін у споживчому попиті. Технологія блокчейн досліджується в контексті зниження трансакційних витрат та забезпечення прозорості економічних відносин. Аналізуються перспективи застосування смарт-контрактів у логістиці, фінансах та управлінні бізнес-процесами, а також потенційні загрози, пов’язані з централізацією контролю над даними. 3D-друк розглядається як інструмент для оптимізації виробничих процесів та персоналізації продукції.

Ключові слова: Індустрія 4.0, штучний інтелект, Інтернет речей, блокчейн, 3D-друк, економічна трансформація, автоматизація виробництва.

Serdiuk O. Industry 4.0 Technologies as a Factor in Economic Development

The article explores the potential of Industry 4.0 technologies as a factor in the development of the economic system. It analyzes the key technologies of the Fourth Industrial Revolution, namely Artificial Intelligence (AI), the Internet of Things (IoT), blockchain, and 3D printing, and their impact on economic processes. Special attention is given to the role of Artificial Intelligence, which is the main driver of the transformation of production processes. The possibilities of production automation through AI, its ability to analyze real-time data, manage resources, and optimize production processes are examined. It is established that the implementation of AI contributes to reducing operational costs, improving product quality, and more efficient resource utilization. The Internet of Things is considered as a technology that enables the integration of production processes and communication between devices in real-time. Emphasis is placed on its role in the formation of "smart factories" and the transition to a "pull economy" model, which allows manufacturers to quickly adapt to changes in consumer demand. Blockchain technology is studied in the context of reducing transaction costs and ensuring the transparency of economic relations. The prospects for the use of smart contracts in logistics, finance, and business process management are analyzed, along with potential threats related to the centralization of control over data. 3D printing is considered as a tool for optimizing production processes and personalizing products.

Keywords: Industry 4.0, artificial Intelligence, Internet of Things, blockchain, 3D printing, economic transformation, production automation.

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