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THE ROLE OF DIGITAL TECHNOLOGIES IN INNOVATIVE DEVELOPMENT OF THE INDUSTRIAL ENTERPRISE

In the article, the role of digital technologies in innovative development of industrial enterprises was investigated. It was determined that the main elements of Industry 4.0 are digital ecosystems, complex information systems, and big data analytics. The main prerequisites for innovative development of industrial enterprises are identified. It is proven that the strategy of innovative development of industrial enterprises in the digitalization context largely depends on the access to external international digital platforms that unite participants in the innovation market. It is argued that digitalization contributes to increasing labor productivity and competitiveness of enterprises, optimizing production costs, using three-dimensional models of product and product design, and using digital technologies allows existing industrial enterprises to increase competitive advantages in all areas of production. The main tools for development of digital technologies in the innovative activity of industrial enterprises are analyzed, namely: production process planning tools, production design tools, production management tools, monitoring tools, modeling of material flows and logistics, and marketing. Features of the modern innovative development of industrial enterprises are outlined, which reflect market changes, changes in the technological structure, and global trends, including: directions of technological transformation, which include introduction of digital technologies, automation of production using developments in the field of robotics, automated control systems, and development of additive manufacturing, which specializes in the use of 3D printing to create relevant prototypes and finished products, which allows reducing production time and costs. An Ishikawa cause-and-effect diagram is proposed that reflects the impact of digital technologies on innovative development of industrial enterprises, within which six main components are identified (materials, methods, personnel, equipment, environment, information), which include corresponding subcomponents. It is argued that digital technologies allow industrial enterprises to significantly improve production functions using modern software products that contribute to processing of large data sets and more accurate forecasting of market conditions for functioning of enterprises. Attention is drawn to the fact that support for industrial enterprises in the post-war period of state restoration is particularly relevant, since today industrial potential of the state has significantly decreased and its restoration on a post-war basis is extremely difficult, therefore it is necessary to implement measures to stimulate and support industrial enterprises that are trying to implement digital technologies in their activities in today's conditions to ensure innovative development and increase the competitiveness level.

Keywords: *digitalization, digital technologies, construction, innovative development, strategic development, industrial enterprises.*
Fig.: 4. References: 10.

Problem statement. The study of innovative development of industrial enterprises today is closely related to development of digital technologies. These issues are especially acute for enterprises in highly competitive market conditions. For Ukraine, this issue is also relevant in the context of the post-war restoration of the state's industrial potential, since most industrial enterprises have suffered significant destruction or are located in the territories of temporary occupation. Leading foreign enterprises actively use digital technologies in production, which is positively re-

flected in their financial and economic condition. Leading companies invest in development of new technologies both in the production sector, and in the management sector. Digital technologies are the engine of innovation and increased competitiveness in the world. This is due to the fact that digitalization increases available public and commercial services, helps reduce costs, reduces payment time and promotes emergence of new forms of employment for the population. In modern realities, implementation of digital solutions is much cheaper than a few years ago, which allows more enterprises to modernize their capacities based on digital technologies.

Analysis of recent research and publications. The research of issues of innovative development of industrial enterprises is conducted in publications of the scientists as follows: O. Arefieva, O. Shevchuk, O. Popelo, M. Dubyna, O. Kyrychenko, G. Tarasova, I. Vysotska, K. Verhala, V. Khaustova, O. Vovk, N. Tymoshenko, N. Ivanova, M. Palasevych, S. Tulchynska, N. Pavlishyna and others.

Highlighting unexplored parts of the general problem. However, despite significant achievements of scientists in determining the impact of digital technologies on innovative development of industrial enterprises, these issues require additional research.

The purpose of the article. The purpose of the article is a study of the role of digital technologies in innovative development of industrial enterprises.

Presentation of the main material. According to the National Economic Strategy 2030, industrial development includes four strategic goals (creating sustainable domestic demand for industrial products; integrating the domestic industrial sector into global value chains, expanding product exports; increasing competitiveness of domestic industrial products, introducing energy-saving technologies; creating new production capacities on an innovative basis due to the competitive advantages of the individual enterprise and region) [4]. Each strategic goal has several strategic objectives, which implementation will allow achieving the goal. However, despite the defined goals and directions of industrial development, strategies do not reflect tools for innovative development of industrial enterprises and digital transformation of their production.

Today, innovative development of industry is carried out in the open ecospace, which is formed based on digital platforms. Using these platforms allows significantly shortening the innovation cycle, due to outsourcing. Development of open innovation models allows you to use joint innovative solutions that are created based on the synergistic use of ideas, resources and technologies. In the conditions of these transformations, the role of consumers, who are co-authors and co-developers of innovative products improved to their needs, is also changing. The general direction of innovative development of industrial enterprises is compliance with the principles of Industry 4.0 [9]. The main property of Industry 4.0. is that it provides for fully automated types of production, and the management of all processes is carried out in real time. Implementation of this project is possible due to the fact that cyber-physical systems are able to create virtual copies of

physical objects, can control physical processes and make decentralized decisions. The important role is played by Internet technologies, which ensure communication between personnel and equipment.

Industry 4.0. is based on automation of production processes with minimal human involvement. For industry, especially the mining and processing industries, these mechanisms are necessary, since most industries are characterized by hazardous working conditions. With full automation of processes, the role of personnel is to monitor operation of machines and respond in a timely manner to non-standard situations. The main elements of Industry 4.0. are digital ecosystems, complex information systems and big data analytics (Fig. 1).

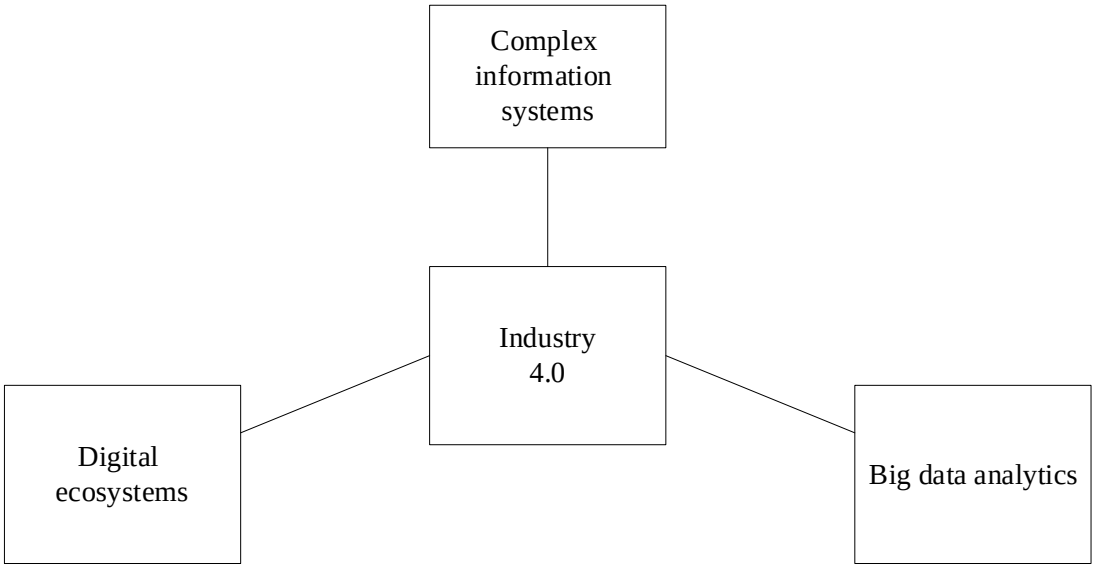

Fig. 1. Main elements of Industry 4.0.

Source: summarized by the author based on [9].

Digital ecosystems include physical objects, software systems and control controllers, which represents the single holistic system. In the digital ecosystem, physical and computational objects are closely interconnected. Management of these systems is carried out based on the IIoT technology, which involves interaction of computer and engineering models. Big data analytics includes large amount of information that is formed due to digitization of the physical world. Analytics and processing of these data is carried out based on cloud computing and artificial intelligence technologies. To make management decisions, this information is maximally adapted for perception and analysis.

Complex information systems are open and used by participants (clients, partners) for their needs and are most often represented by digital platforms. Various process control systems can be used to transform the Internet of Things into physical business. In addition to the Industrial Internet of Things, “Smart Manufacturing” is used, which is presented by the German government within the framework of high technologies development. Development of “Smart Factories”

allows for serial types of production while maximally reproducing flexible production, which is implemented based on maximum automation and robotization of production. In this case, technologies of the Industrial Internet of Things are used, based on which interaction between different types of equipment is carried out, which allows manufacturing products almost without participation of human resources. At the same time, the analysis of data arrays is carried out based on the big data processing technology [9].

Industrial Internet of Things technologies should be applied in the Ukrainian industry, but currently, enterprises cannot transit these principles of production on their own due to lack of funds. Figure 2 highlights the main prerequisites for innovative development of industrial enterprises.

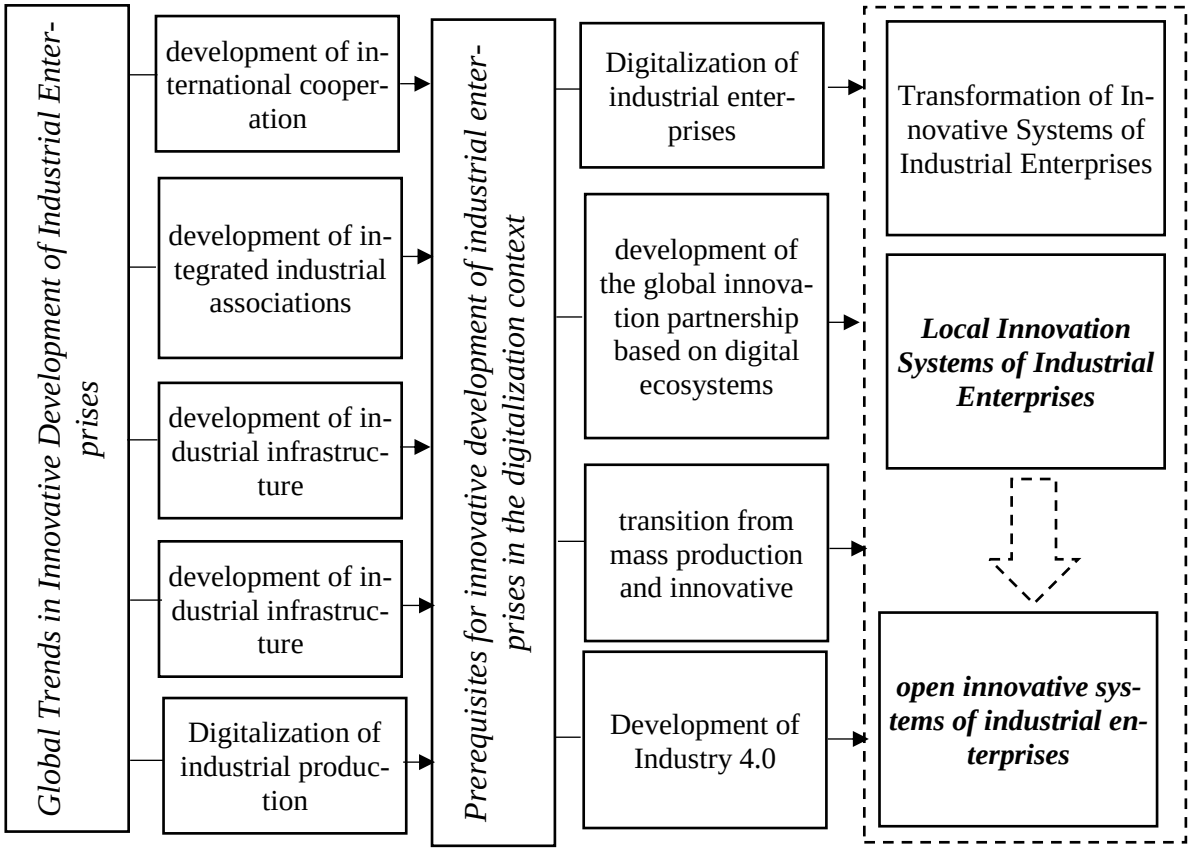

Fig. 2. Prerequisites for innovative development of industrial enterprises in the digitalization context

Source: compiled by the author based on [1; 4; 6; 8-10].

The strategy of innovative development of industrial enterprises in the conditions of digitalization largely depends on access to external international digital platforms that unite participants in the innovation market. For Ukrainian industrial enterprises, issues of innovative development remain pending. Most large industrial enterprises are located in territories that are temporarily occupied, which makes access to them impossible. Enterprises in frontline regions that are under constant shelling are forced to work at less than full capacity. Some enterprises have been completely destroyed and it is not known to what extent they can be restored.

Large mining and processing plants were forced to stop their activities due to the security situation. Metallurgical plants stopped part of production in the hot and cold freezing stages. Introduction of innovative technologies for operating enterprises is also a difficult task today, since investing funds in a country that is in the stage of hostilities has high risks. Therefore, the issue of introducing digital technologies and innovative development of industrial enterprises will become extremely relevant during the period of post-war reconstruction of the state.

Development of the innovative development strategy of industrial enterprises in changing security environment is unstable. It is more rational to develop tactical and medium-term plans that allow taking into account all factors of the external environment and calculate possible negative consequences and the profit level. Innovative development for modern enterprises in the industrial sector is not possible without support of the state, which forms appropriate environment for effective development of enterprises and attracting investments. In general, the innovative development strategy of industrial enterprises should focus on creation of these productions that have high added value and the closed production cycle. Raw material industrial production has low level of efficiency compared to productions with the completely closed cycle, where the output is a finished product.

Digitalization contributes to increasing labor productivity and competitiveness of enterprises, optimizing production costs, using three-dimensional models of product and product design. Uisng digital technologies allows existing industrial enterprises to increase competitive advantages in all areas of production (business processes, marketing, logistics, management, communication). Modern development of industry on the basis of Industry 4.0 involves using the high-tech base of productive forces in digitalization. High level of automation of technological processes of material production must be supported by the information infrastructure in investment and innovation activities of enterprises. The main tools for development of digital technologies in innovation activities of industrial enterprises include as follows: production of planning tools, production design tools, production management tools, monitoring tools, modeling of material flows and logistics, marketing (Fig. 3).

Modern innovative development of industrial enterprises has the number of features that reflect market changes, changes in the technological structure, and global trends. These main features include the areas of technological transformation, which include introduction of digital technologies, automation of production using developments in the field of robotics, automated control systems, development of additive manufacturing, which specializes in the use of 3D printing to create relevant prototypes and finished products, which allows you to reduce production time and costs. It is also worth noting development of environmental areas of production, including: green energy, which is based

on using renewable energy sources (solar, wind); implementation of circular economy approaches, which involves reuse, recycling and recovery of materials from various waste, which certainly has positive impact on the energy efficiency of production.

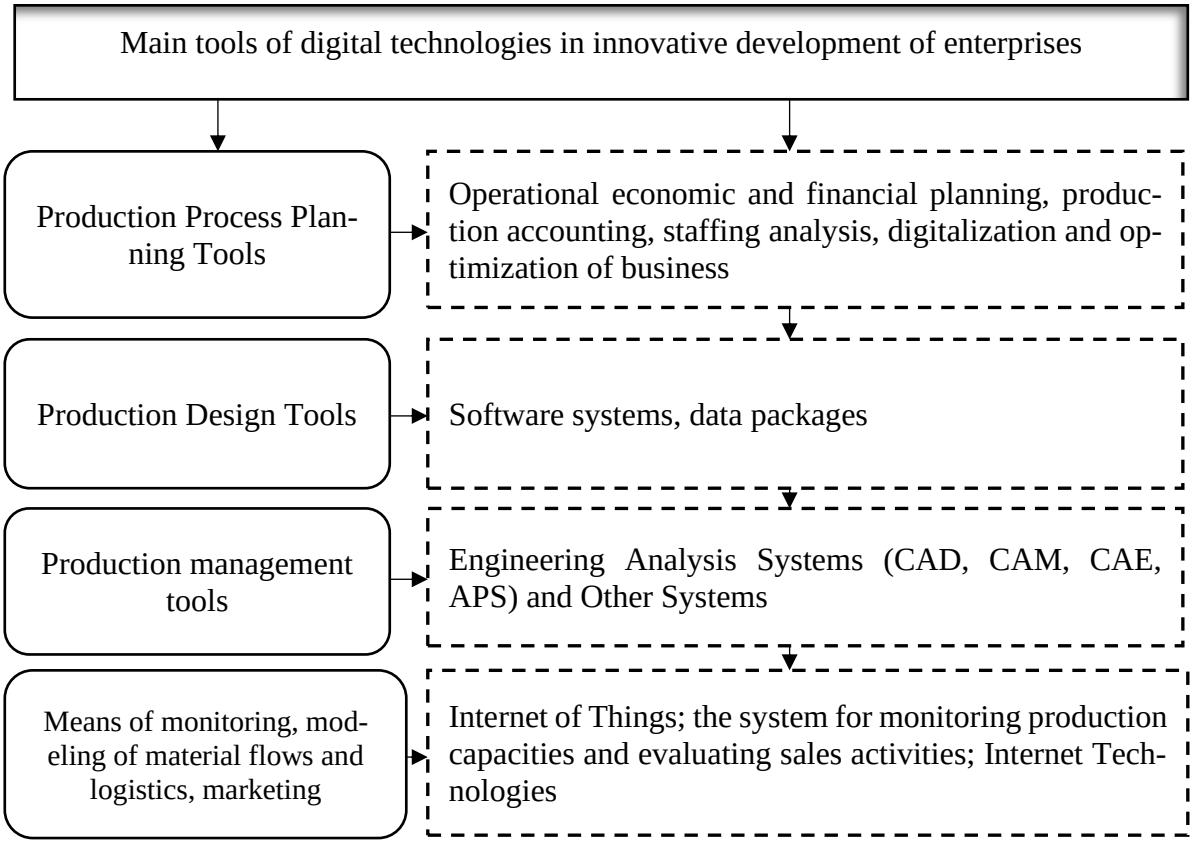

Fig. 3. Main tools of digital technologies in innovative development of enterprises

Source: summarized by the author based on [5, 2; 3; 7].

Development of digital technologies leads to expansion of international cooperation and integration into global production chains, due to which outsourcing and outstaffing have become widespread. With development of globalization, formation of regional and industry clusters is expanding, which contribute to development of innovations based on cooperation between business, scientific institutions and government. In the digital technologies era and innovative breakthrough, startup projects and business incubators have developed, based on new ideas and technologies. At the same time, significant attention is paid to development of human potential, which is the basis of innovative development and the generator of innovative ideas.

Despite difficult security and economic conditions, industrial enterprises operate at the limit of maximum possibilities of the economic and security situation in the country. This difficult situation for functioning of industrial enterprises does not prevent them from carrying out innovative activities, implementing previously formed innovation and investment projects, and attracting investors. Taking into

account modern trends of digitalization of all spheres of public life, innovative development of industrial enterprises is not possible without introduction of digital technologies.

To reflect causal relationships of the impact of digital technologies on innovative development of industrial enterprises, six main components can be distinguished, which include corresponding subcomponents (Fig. 4). Thus, the personnel category reflects insufficient level of personnel qualifications necessary for working with digital technologies. The important aspect is the lack of specialists with necessary qualifications in the field of digital and innovative technologies, low motivation for training, which leads to resistance to change. Methods category includes imperfection of the digital technology implementation and the lack of standardized procedures for digital innovations, inefficient management of digital technology projects. The resources category is characterized by limited financial resources for investments in implementation of digital technologies, lack of access to modern digital solutions, insufficient funding for research and development in the digitalization field. The technology category is characterized by available outdated equipment that does not support digital technologies, low level of automation and integration of digital solutions. Due to the lack of the necessary infrastructure for IoT, AI, Big Data technical support for new technological solutions is decreasing.

Sustainable development is not possible without taking into account the environmental component, which is characterized by the uncertainty of market requirements and conditions that affect the competition level in the industrial products market. Given that most industrial enterprises have high level of environmental pollution, the direction of innovative development of enterprises in this aspect is extremely important. The important aspect in management is the lack of strategic vision of digitalization, which is expressed in insufficient support from management for implementation of new technologies. The information category contains current data and analytics, assessment of the digital technologies market. Negative for innovative development of industrial enterprises in this aspect is insufficient internal communication and the lack of the data and knowledge exchange system.

The important role using digital technologies in innovative development of industrial enterprises. Productivity is closely related to the experience and qualifications of personnel involved in production. Investment and technological potential are interconnected with elements of production potential. Technical potential is realized through existing technical knowledge and resources that are necessary for the enterprise to develop and implement technology and technologies, expand employment, develop and modernize technical capabilities by updating equipment. Implementation of innovative solutions requires appropriate skills that are formed in human-machine interaction.

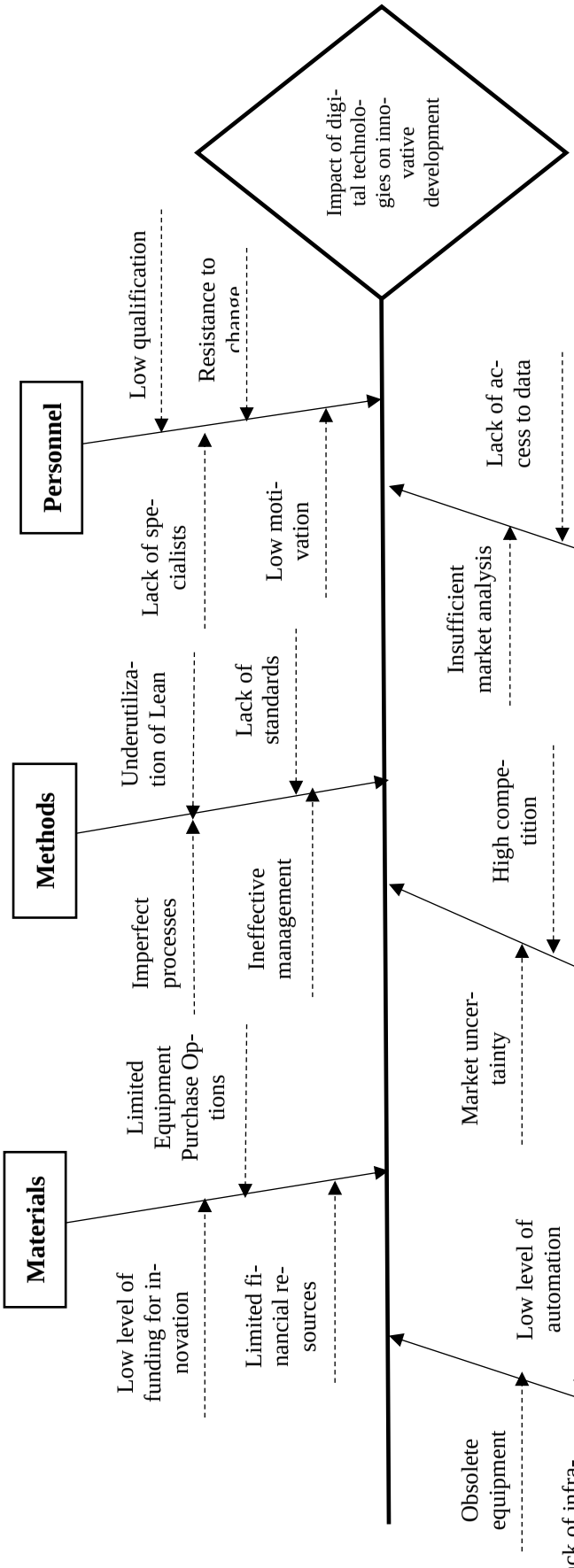

Fig. 4. Ishikawa causality diagram of the impact of digital technologies on innovative development of industrial enterprises

Source: developed by the author.

Conclusions and suggestions. In general, innovations improve parametric characteristics of goods, which leads to the increase in profits and the increase in competitiveness of the enterprise. Digital technologies allow industrial enterprises to significantly improve production functions using modern software products that allow processing larger data sets, more accurately predicting market conditions for functioning of enterprises. By monitoring the mood of target consumers, it is possible to predict demand and supply in the industrial goods market, which also has positive effect on inventory tracking, which is reflected in efficient supply chains. Introduction of innovative technologies into industrial production requires additional support from other sectors of the economy. This interaction has positive effect on the industry development, contributes to emergence of new jobs. In the social aspect, digital technologies require improving qualifications of employees, obtaining new competencies, and improving working conditions.

Support for industrial enterprises in the post-war period of state reconstruction is particularly relevant, since today industrial potential of the state has significantly decreased and its restoration on the post-war basis is extremely difficult. Therefore, it is necessary to implement measures to stimulate and support industrial enterprises that are trying to introduce digital technologies into their activities in current conditions to ensure innovative development and increase the competitiveness level. The existing tendency to reduce the level of allocations for development of science-intensive technologies may lead to the decline in demand for scientific research in the state and non-state sectors of the economy. To do this, it is necessary to introduce support for small and medium-sized businesses at the regional level and promote development of science-intensive industries, especially in the industrial sector.

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РОЛЬ ЦИФРОВИХ ТЕХНОЛОГІЙ В ІННОВАЦІЙНОМУ РОЗВИТКУ ПРОМИСЛОВОГО ПІДПРИЄМСТВА

У статті досліджено роль цифрових технологій в інноваційному розвитку промислових підприємств. Визначено, що основними елементами Індустрії 4.0. є цифрові екосистеми, складні інформаційні системи та аналітика великих даних. Виокремлено основні передумови інноваційного розвитку промислових підприємств. Доведено, що стратегія інноваційного розвитку промислових підприємств в умовах цифровізації багато в чому залежить від доступу до зовнішніх міжнародних цифрових платформах, які об'єднують учасників інноваційного ринку. Аргументовано, що цифровізація сприяє підвищенню продуктивності праці та конкурентоспроможності підприємств, оптимізації виробничих витрат, використання тривимірних моделей проєктування виробів та продуктів, а використання цифрових технологій дозволяє існуючим промисловим підприємствам збільшити конкурентні переваги в усіх сферах виробництва. Проаналізовано основні інструменти розвитку цифрових технологій в інноваційній діяльності промислових підприємств, а саме: інструменти планування виробничих процесів, інструменти проєктування виробництва, інструменти управління виробництвом, засоби моніторингу, моделювання матеріальних потоків та логістики, маркетингу. Окреслено особливості сучасного інноваційного розвитку промислових підприємств, які відображають ринкові зміни, зміни технологічного укладу, глобальні тенденції, серед яких: напрями технологічної трансформації, які включають впровадження цифрових технологій, автоматизацію виробництва за рахунок використання розробок в сфері робототехніки, автоматизованих систем управління, розвиток адитивного виробництва, яке спеціалізується на використанні 3D-друку для створення відповідних прототипів і готових виробів, що дозволяє скоротити час і витрати на виробництво. Запропоновано діаграму причинно-наслідкових зав'язків Ісікави що відображає вплив цифрових технологій на інноваційний розвиток промислових підприємств, у межах якої виокремлено шість основних

складових (матеріли, методи, персонал, обладнання, навколишнє середовище, інформація), які включають відповідні підскладові. Аргументовано, що цифрові технології дозволяють промисловим підприємствам значно удосконалити виробничі функції за рахунок використання сучасних програмних продуктів, які сприяють обробці великих масивів даних, більш точному прогнозуванню ринкових умов функціонування підприємств. Акцентовано увагу на тому, що особливо актуальною є підтримка промислових підприємств в повоєнний період відновлення держави, оскільки на сьогодні промисловий потенціал держави значно знизився і його відновлення на повоєнному підґрунті є вкрай складним, тому необхідно впроваджувати заходи щодо стимулювання та підтримки підприємств промисловості, які намагаються в умовах сьогодення впроваджувати цифрові технології в свою діяльність для забезпечення інноваційного розвитку та підвищення рівня конкурентоспроможності.

Ключові слова: *цифровізація, цифрові технології, стратегія, інноваційний розвиток, стратегічний розвиток, промислові підприємства.*

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