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Industry digitalization in the Republic of Kazakhstan

Abstract

Object: To investigate the trends of digitalization in the industrial sector of the Republic of Kazakhstan as a key factor of economic development in the conditions of technological transformation.

Methods: The content analysis method was used to succinctly analyze the data array concerning the scientific issues under the research; systematization of materials to present the results of the analysis in a comprehensive manner; the method of graphical interpretation, based on which the components of Industry 4.0 and the features of the SIMP technology platform were presented.

Findings: Key directions of digitalization of the Kazakhstan industrial sector were analyzed. The factors of the introduction of digital tools at industrial enterprises were considered, the key components of the digital transformation of industrial production within the framework of the Fourth Industrial Revolution were identified.

Conclusions: The results of analysis showed that the introduction of elements of Industry 4.0 allows to industrial enterprises improving production processes, significantly reducing time and increasing efficiency, also to create the products focused on the needs of individual consumers. An important factor of digital transformation is the support received by companies both as part of the implementation of state programs and through mutual cooperation of enterprises with each other. The research once again confirms that digitalization is not just a "fashionable" tool of the modern modernization but an effective way of gaining the competitive advantages.

Keywords: digitalization, digital economy, Industry 4.0, industrial enterprises, robotics, artificial intelligence, manufacturing, blockchain technology, Big Data.

Introduction

Digitalization is a modern factor in the economic development of many countries. Today in the Republic of Kazakhstan, there is a transition from introducing individual digital elements to the integrated application of the digital ecosystem within the framework of the Fourth Industrial Revolution, known as "Industry 4.0". Digital and communication technologies cover all sectors of the economy, primarily industrial production. Advanced industrial enterprises consider digital transformation as the most important indicator of socio-economic success not only within their activities but also within the state as a whole.

Digitalization and technologies in the framework of Industry 4.0 provide to industrial enterprises many new opportunities and advantages, including improving product quality, flexibility and productivity, process reliability, also creating technological goods with high added value. Introducing digital elements makes it possible to achieve a higher level of automation and intellectualization of all industrial production processes, starting with the engineering (creation of digital twins), using an automated component supply system, ending with aspects of the development and supply of customized products.

Digitization is a process that began many years ago and is showing increasing momentum. Since 2011, when the vision of Industry 4.0 was presented, there has been a positive trend in digitalization in the manufacturing industry (Figure 1).

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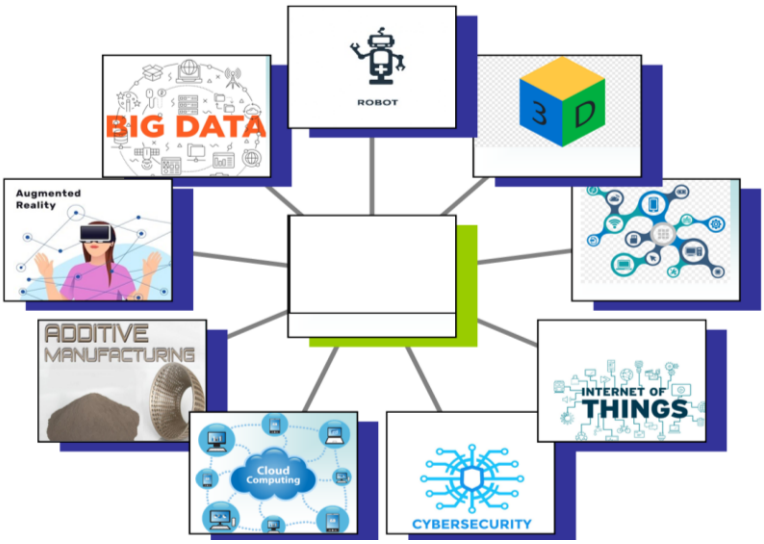

Figure 1. Key components of Industry 4.0

Note – Compiled by the authors based on "Recommendations for solving problems with the using of digital projects (solutions) and for improving of the efficiency of enterprises". JSC "Kazakhstan Center of Industry and Export "Qazindustry""

The President of the Republic of Kazakhstan has repeatedly spoken about the expediency of introducing elements of "Industry 4.0", in particular, in the annual Messages to the people of Kazakhstan, special attention is paid to the Fourth Industrial Revolution, which involves the implementation of a set of measures for the technological re-equipment of basic industries until 2025.

In the republic, the application and implementation of digitalization began in 2017 with the development of the "Digital Kazakhstan" State program, which involves the development of new technologies (3D printing, blockchain and others), while the emphasis is on increasing labor productivity in leading sectors of the economy, including in industry. During its implementation, it was revealed that over 80% of enterprises of the mining and manufacturing industry of Kazakhstan have an insufficiently high degree of automation and the introduction of digital technologies in comparison with enterprises of advanced countries (Figure 2).

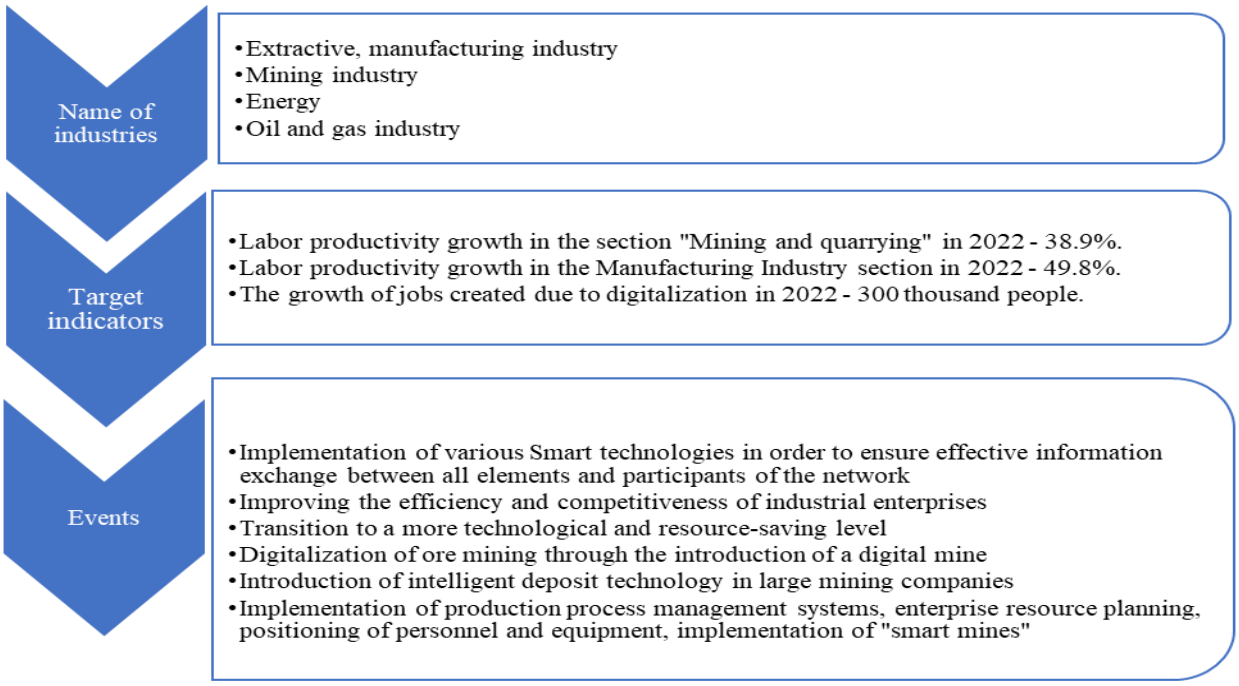

Figure 2. Directions of digital transformation of the industrial sector of Kazakhstan

Note – Compiled by the authors based on the key sections of the "Digital Kazakhstan" State program

Undoubtedly, in the conditions of modern economic development, the issues are relevant, concerning the study of the current state of digitalization development in the industrial sector, determining its specific features and trends. As a rule, the industrial sector, from the point of view of the organization of production, is difficult, therefore, it is hard to assess the degree of digitalization of the Kazakhstan's industry, but despite this, the authors analyzed digital tools that have already been introduced at industrial enterprises.

Literature Review

Many scientific works of both domestic and foreign researchers have been devoted to the development of the digital economy.

In the works of M. Perno, L. Hvam, A. Haug (Perno et al., 2022), A. Hallin, E. Lindell, B. Jonsson, A. Uhlin (Hallin et al., 2022), V. Vukadinovic, V. Majstorovic, J. Zivkovic, S. Stojadinovic, D. Djurdjanovic (Vukadinovic et al., 2021) it is noted that Industry 4.0 contributes to the transformation of many industries by creating new business models through the using of artificial intelligence, namely, machine learning (which is a subsection of artificial intelligence), the Internet of things (as a way to exchange information between several devices connected to a single network), the using of data analysis methods and the latest developments in the field of information and communication technologies.

Digitalization and Industry 4.0 technologies provide to industrial enterprises many new opportunities and advantages, such as improving product quality, reliability of technological processes, also increasing flexibility and productivity (Chirumalla, 2021).

Digitalization in industry affects the holistic processes, associated with production automation, building a business model, the further development of the industrial industry is associated with diverse expectations in terms of increased productivity and flexibility, support for artificial intelligence, human and robot collaboration, the using of smart-watches and information glasses, updated qualification requirements and completion of a new job profile. Thus, the impact of digitalization on industry has become a topic of scientific discussion both at the national and international levels (Jeske et al., 2021).

The special role of innovative and digital technologies is noted by scientists and in industry. Because the manufacturing and processing industries are characterized by long and complex supply chains, the efficient production of commodity and/or functional products should be based on using the modern technological processes. Technologies and technological innovations are often developed through collaboration with technological process suppliers (Blichfeldt & Faullant, 2021). Because the processing industry has a complex structure, aimed at developing of mature key technologies, innovation plays a central role in the success of the processing industries, combined with integrating information and intelligent technologies (Qian et al., 2017).

The analyzed topic of the research is worrying many Kazakhstani scientists. So, according to G.M. Aubakirova, F.M. Isatayeva (Aubakirova & Isatayeva, 2021), the driving force of digitalization of the Republic of Kazakhstan is the public sector. The state should create a favorable environment for the worldwide adoption of innovations, financing the development of digital infrastructure, providing a legal framework for the digitalization of the business environment and the adaptation of industrial enterprises to advanced technologies. Today, several state programs are being implemented in digitalization of industry, allowing to accelerate the pace of implementation of Industry 4.0 elements at all stages of production (Table 1).

Table 1. State programs and projects in the field of digitalization of industry in Kazakhstan

Name of the program	The purpose of the program and the implementation period	Economic effect of the program implementation
1	2	3
The state program "Digital Kazakhstan"	Improving the life quality of the population and the economy competitiveness of the Kazakhstan through the progressive development of the digital ecosystem; implementation years: 2017–2022	- labor productivity growth in the mining industry by 38,9%, in the manufacturing industry - by 49,8%; - increasing of the share of Internet coverage to 78%, mainly in regions and countryside; - coverage of 95% of the population by digital broadcasting; - increasing the digital literacy of the population up to 80%; - ensuring the development of information and communication technologies and the country's GDP up to 4,7%.

1	2	3
The State program of industrial-innovative development of the Republic of Kazakhstan for 2020–2025	Ensuring the competitive manufacturing industry of the Republic of Kazakhstan in the domestic and foreign markets; implementation years: 2020–2025	- real growth of labor productivity in the manufacturing industry by 1,6 times compared to the level of 2018; - growth the volume of exports of the manufacturing industry by 1,9 times; - increasing the index of the physical volume of investments in fixed assets in the manufacturing industry by 1,6 times, etc.
National project "Technological breakthrough through digitalization, science and innovation"	The formation of Kazakhstan as a country with modern effective public administration, including through digital transformation; years of implementation: 2021–2025	- 79 billion tenge of taxes annually from the crypto industry; - increasing the share of GDP in the ICT sector up to 5%; - the share of private co-financing of RNTD commercialization projects and applied scientific research – 50%.
"Digital Mine"	Improving operational efficiency, reducing production costs, improving staff performance through the using of best practices and innovative approaches of using a new information technologies and tools; implementation years: 2013–2025	- development and investment of 30% of mining enterprises in coordinated connectivity strategies via 5G, LTE, satellite networks by 2022; - 60% of large mining companies have digital production innovation centers; - reduction of costs by 20% in the operating environment of mining companies: exploration, production, transportation, crushing, processing, etc.
"Digital deposit"	Improving the efficiency of the oil and gas complex; implementation years: 2015–2022	- automation of oil and gas production; - increase of mining by 2-5%; - reducing the cost of materials and equipment by at least 10%; - increase of energy efficiency by 20%.
"Model digital factories"	Automation of almost all production cycles from processing of raw materials to delivery of goods using technologies, also ensuring of these processes control in a single digital system; years of implementation: 2012–2025	By 2025, 40 digitalization projects are planned to be implemented, 14 of them have already been implemented.
Note – Compiled by the authors according to the review and analytical portal "Strategy2050.kz"; the official Internet resource of the State program "Digital Kazakhstan".		

Beyond public sector involvement, enterprises need a strategy of continuous improvement for successful digital transformation, which must be reliable with a realistic business-oriented investment plan. Another important factor of digitalization is the competence of employees. Because Industry 4.0 entails the modification of the skills of employees, it is necessary to constantly train management personnel in the field of IT technologies to use the full potential of digital transformation (Turkyilmaz et al., 2021).

The works of the Russian scientist, doctor of economics, professor Babkin A.V. were among the first on the post-soviet space concerning aspects of the digital transformation of industry. In particular, in the works of the scientist, a structural and functional model of managing the digital potential of a system-forming innovation-active industrial cluster was proposed, which most fully and comprehensively reflects the features of the digital transformation of complex integrated industrial structures (Babkin et al., 2021), also the methodology of its evaluation (Tashenova et al., 2021).

Special scientific interest arouses works, reflecting the role and essence of digital platforms within the functioning of industrial enterprises and clusters (Babkin et al., 2020), crucial trends of the digital economy development and industrial clustering factors (Babkin et al., 2020), components of digital transformation of industrial production in the context of the Industry 4.0, also the technologies application directions in industrial production (Tashenova et al., 2019).

Modern trends in the process of digitalization are also revealed in the works of Z.K. Esymkhanova, Zh.D. Dauletkhanova, B.A. Baimamyrov, (Yesymkhanova et al., 2020), M.F. Baimukhamedov,

A.A. Zhikeev, A.S. Boranbaev (Baimukhamedov et al., 2021), K.P. Musina, D.G. Mamrayeva, M. Lemanowicz (Musina et al., 2020), K.A. Abdikarimova (Abdikarimova, 2018), O.G. Karpovich, B.N. Karipov, A.Sh. Nogmova, (Karpovich et al., 2020), etc.

Thus, the issues of industry digital transformation have been reflected in numerous works of both domestic and foreign researchers. Digitalization tends to spread to a huge number of economic processes and phenomena, which requires appropriate research and largely determines their relevance.

Methods

The research was carried out based on a systematic approach within the framework of this scientific article, on the process of using the content-analysis method, which includes the research and interpretation of data and acts as an objective and systematic means of describing relevant economic phenomena and processes. In relation to the literature review, the content-analysis method ensures the rigor, systematicity and reproducibility of information. The scientific-methodological basis was a retrospective, causal, current analysis of data about digitalization of industry. The theoretical basis of the research was the works of domestic and foreign scientists about the development of digitalization in industry, periodicals, also materials from the Internet. The authors have widely used scientific articles from scientometric databases Scopus, Clarivate Analytics (WoS), RSCI.

Results

Digitalization of economic sectors acts as an important factor of stimulating economic growth and a catalyst of the information technologies development in industry. The widespread using of digital technologies in industrial production allows it to significantly increase the efficiency of processes, ensure labor safety, also generate new sources of income by changing business models of companies, creating of a new formation product, including customized products with high added value.

Since the adoption of the State program "Digital Kazakhstan" at the end of 2017, the volume of financial and human resources in the development of digitalization in economic sectors has increased in the republic. Thus, over the past 2 years, the overall economic effect of the implementation of this program in the amount of over 600 billion tenge has been obtained; in particular, such areas as transport, healthcare, education, mining and metallurgical industry are already characterized by high results in the introduction of digital technologies.

Analysis of the global experience of industry digital transformation shows that the main directions of development in this direction became such concepts as "Industry 4.0", "Smart Manufacturing", "Digital Manufacturing" and others (Table 2).

Table 2. Brief description of Industry 4.0 components

Name of the technology	Brief description
Internet of things	With the help of loT technology, each product is assigned a personal identifier that provides an inextricable link to information about its origin, using and destination. This significantly increases the efficiency of production and distribution of goods, also reduces transaction costs associated with global production.
Big Data and analytics	A sharp increase of data transfer speeds and the introduction of cloud computing technology open access to almost infinite computing and storage capabilities from almost anywhere in the world. The era of cloud computing and big data makes it possible to create interaction schemes, including in commercial purposes, between industrial enterprises located at great distances from each other.
Robots	Software robots that simulate human actions at a computer involve using a keyboard and mouse in the process of routine, repetitive operations in order to automate smaller sections of business processes, including within the framework of industrial production.
Additive manufacturing technologies (3D printing)	3D printing is an additive process that creates the final product by overlapping subsequent layers of material, avoiding the need of component assembly. First, a digital model is created using computer modeling programs, and then a three-dimensional object is printed on a 3D printer made of liquid or powder materials.
Blockchain (block chain)	A blockchain is a distributed database in which data storage devices are equal (there is no central server). It stores an ever-growing list of ordered records called blocks. Each block contains a timestamp and a link to the previous block.
Note – Compiled by authors based on the research.	

It is well known that the Fourth Industrial Revolution means increasing automation of production processes and the mass introduction of technological phenomena such as 5G, “Smart Cities”, analysis of “big data”, “blockchain”, “digital assets”, innovative digital financial instruments, cyber-physical systems, modern digital platforms, etc., a brief description of which is presented in Table 3.

Table 3. Characteristics of digital technologies in industry

Name of the technology	Brief description	Examples of implementation / using in industry
1	2	3
Face identification system, video evaluation	Implementation of the miners' positioning system accelerates the location of a worker in any mine working, reporting information to the dispatcher in real time, prompt response in emergency cases. By using big data evaluation tools for a work with the information, supplied by the sensors, heat losses are reduced, and an optimal degree of accuracy in metal temperature prediction is ensured.	“Kazakhstanskaya” Mine, ArcelorMittal Temirtau mining Company, JSC “NC Kazakhstan Temir Zholy”, General Electric Aviation (USA)
“Digital Factory”	It implies the operation of seven model digital factories. Saving is achieved due to the reduction of equipment downtime and resource losses, the introduction of centrifugal devices with digital control, and the improvement of the technological enrichment program with the transition to a single cascade.	JSC “AK Altynalmas”, JSC “Eurasian Foods”, JSC “Kentau Transformer Plant”, JSC “Himpharm”, LLP “Karlskrona”, LLP “Baltextil”, LLP “Almaty Fan Plant”, Societas Europaea (Germany), Robert Bosch GmbH (Germany), Bosch (Germany)
Intelligent solution technologies “IntelliSense”	It’s made it possible to model neural networks for predictive study of the technological process and management by the huge information array of primary information. It implies the using of artificial intelligence for predictive evaluation of ball loading and wear of linings, preventing overloading of equipment.	Gold recovery factory of Aktogay branch of JSC “AK Altynalmas”, Li & Fung (China)
“Digital Mine”	It implies digital design of mining operations, which reduces the impact of the human factor.	JSC “Kostanay Minerals”, LLP “Kazakhmys Corporation”, JSC “Kazatomprom”, Dundee Precious Metals (Canada)
“Smart Quarry - Smart factory”	Technologies make it possible to increase the transparency of monitoring the effectiveness of the process, contribute to the improvement of the product portfolio due to the variety of digital functionality and the connection of innovative services. All stages are automated: drilling and blasting; transportation on a conveyor from the quarry directly to the factory; beneficiation process with the output of high-quality iron ore concentrate.	Kachar quarry of JSC “Sokolovsko-Sarbayskoye Mining and Processing Production Association”, BHP Billiton (Australia), Daimler AG (Germany)
“Intellectual field”	The technologies implemented at the fields, optimize energy costs by up to 15%, stabilize the production level by up to 2%, and establish remote monitoring of fields.	JSC “Ust-Kamenogorsk titanium-magnesium Combine”, JSC “Himpharm”, China Haier Group
“Automated control system of mining and transport complex”, mobile personnel management “Pitram”	The system made it possible to monitor the location of equipment and personnel in the mine, reducing injuries by 15%. In excessively difficult places, an industrial robot, advanced technologies are used: ERP sensors, on-board computers, satellite positioning in real time.	JSC “Kostanay Minerals”, LLP “Kazzinc”, Eurasian Resources Group, JSC “Ust-Kamenogorsk Titanium and Magnesium Combine”

1	2	3
SAP TOPO, Power Map of QA, Big Data (WinCC Open Architecture, WinCC Flexible и WinCC Classic), “BASF 4.0”, “Work Day” (cloud HR)	Automation of planning and accounting of routine maintenance and repair work; planning of human and material resources. The implemented solution has a direct impact on the production planning processes. A SCADA system with an open architecture allows you to collect a huge amount of data from a variety of devices using many protocols, including specialized ones.	JSC “Himpharm”, Siemens AG (Germany), BASF Societas Europaea (Germany), JSC “Ural-Chemical Company” (RF), PJSC “Nizhnekamskneftekhim”

Note – Compiled by the authors on the basis of “Recommendations for solving problems with using of digital projects (solutions) and improving the efficiency of the enterprises” JSC “Kazakhstan center of industry and export “Qazindustry””, also on the basis of the source (Li et al., 2021) and the official information resource www.primeminister.kz.

According to the results of a survey conducted in 2019 by JSC “Kazakhstan center of industry and export “Qazindustry”” (over 600 industrial enterprises), regarding their readiness for digitalization, it was revealed that 80% of manufacturing entities, also 60% of the extractive industry, are at the stage of transition to automated production, which corresponds to the level of “Industry 2.0”, and only 3% of manufacturing enterprises and 21% of the mining industry are characterized by the level of “Industry 3.0”.

Currently, many industrial enterprises have introduced digital technologies into various production processes, which are characterized by partial digitalization (Figure 3). The technical readiness of industrial enterprises of the republic for the using of digital technologies in most cases is established according to the basic level of production automation, namely, by evaluating the effectiveness of the automatic management system by technological process (AMS TP), management system by enterprise resource (MSER), automated system of commercial accounting of energy resources (ASCAE), production management system (PMS), maintenance and repairs (MR).

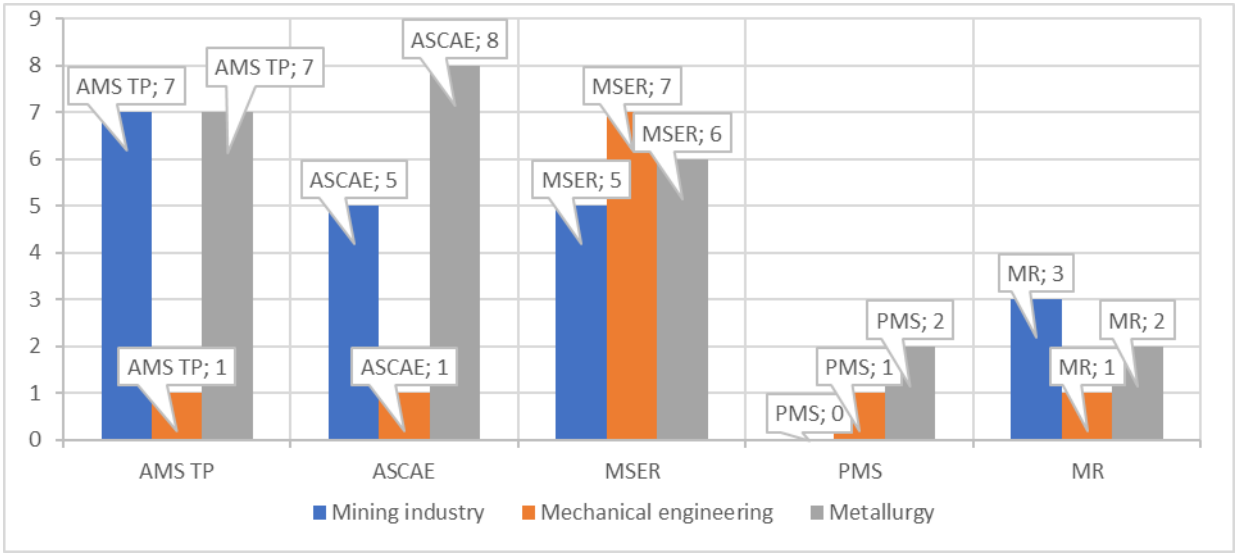

Figure 3. Number of implemented information systems by industry

Note – Compiled by the authors on the basis of “Recommendations for solving problems with the using of digital projects (solutions) and improving the efficiency of the enterprises” JSC “Kazakhstan center of industry and export “Qazindustry””

The introduction of automated information collection systems in real time, also the integration of information flows, positioning of personnel and techniques, automated management by techniques, accounting of material flows with using sensors and detectors, MSER, PMS information systems, etc., improved labor productivity indicators by an average by 10%, reducing injuries – by 15%.

It should be noted that the barriers hindering of the digital transformation of enterprises are the limited nature of cybersecurity; the presence of unauthorized access, and as a result, data leakage; the difficulties of compliance with digital standards, certain norms; not always correct nature of taking decisions on issues of new technologies; the low level of literacy of employees in the field of IT; lack of financial resources for investments in digitalization, also a clear idea of the benefits from its practical implementation.

For demonstration of the "Industry 4.0" advantages in 2018 the Ministry of Investment and Development within the framework of the "Digital Kazakhstan" State program, was taken a decision to select 7 enterprises and reorient the nature of their activities in the form of "model digital factories". Within the framework of this initiative, over 40 projects are already being implemented; 18 of them are planned to be implemented by 2025. This suggests that the business independently understands the expediency and timeliness of the introduction of digital technologies in production.

In 2020, by the cluster fund "Park of Innovative Technologies" operating under the brand "Tech Garden" conducted an analysis of 99 industrial enterprises of Kazakhstan, which showed that most of them (59,6%) are ready and would like to implement digital solutions and projects in this area; 17,2% declared about partial need for this kind of activity; and only 23,2% expressed unwillingness / lack of readiness in the introduction and active using of elements of digitalization.

It should be noted that in October 2021, the "Smart Industry Management Platform (SIMP)" technology platform was launched, the purpose of which is the digitalization of the industry of the Republic of Kazakhstan and the development of domestic IT companies. Consider the components of its digital ecosystem (Figure 4).

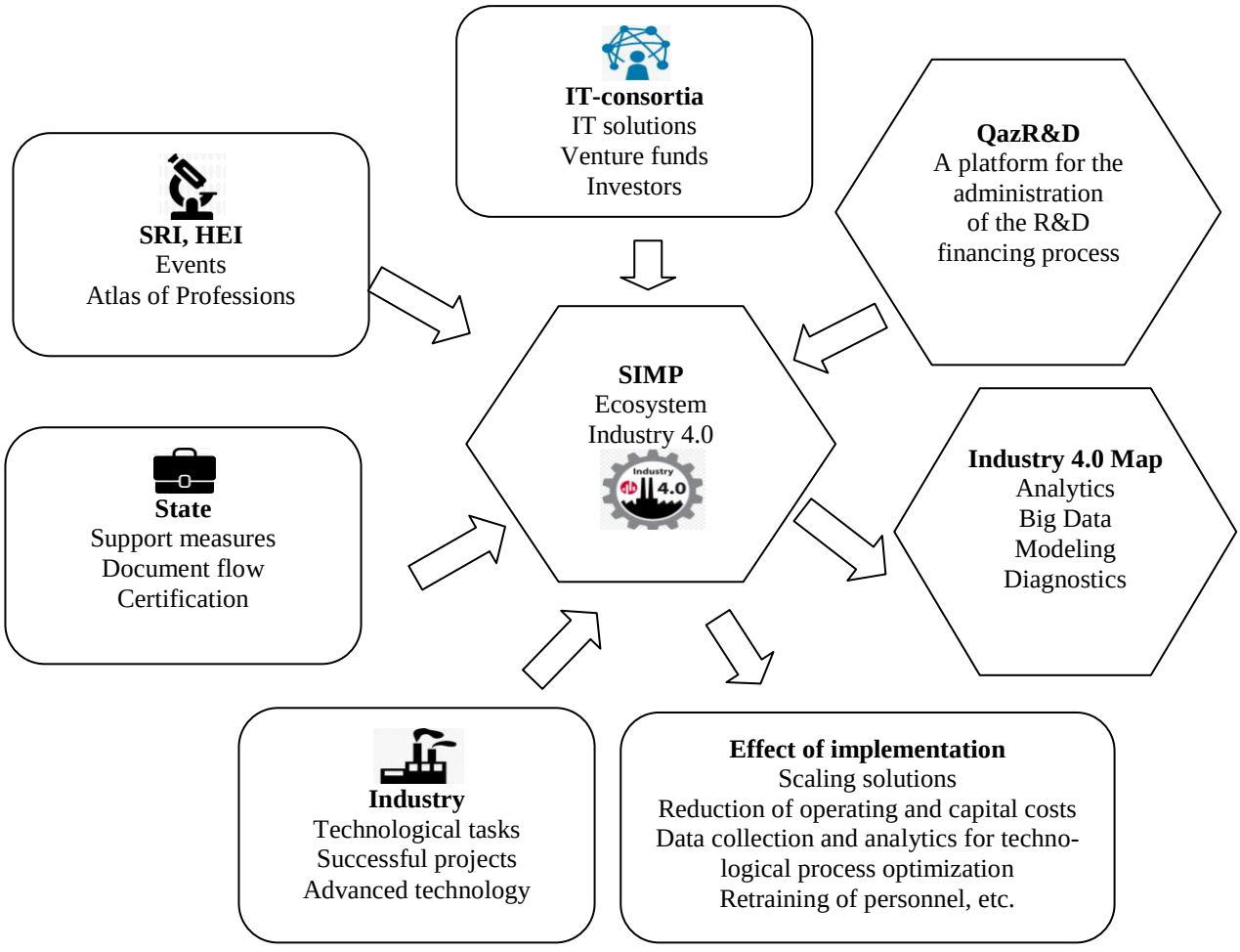

Figure 4. Features of the functioning of the SIMP technology platform

Note – Compiled by the authors based on data from the "Autonomous Cluster Fund "Park of Innovative Technologies "TechGarden""

The SIMP platform unites several stakeholders in this cluster: Subsurface users, performers-contractors of subsurface users, High Education Institutes, scientific-research institutes, scientific-research centers, also a comprehensive map of Industry 4.0, and, accordingly, the state (Figure 5).

The Smart Store module is an online supermarket of technological solutions and tasks from industrial enterprises. The objective of this module is to provide to industrial enterprises of access to the best domestic technologies. It consists of the following sections: IT-solutions; industry tasks; competence centers; virtual

IT-quarter; technology marathons; package solutions. Tasks solved within the framework of this module: the ability to post tasks/solutions; notification/ announcement system; conclusion of electronic contracts; participation and organization of technological marathons; ordering of package solutions. The effects of using the Smart Store module are as follows:

- prompt search and implementation of technologies;
- transparency of the interaction processes between the customer and the supplier;
- increasing the speed of search and processing information due to the "single window" principle;
- verified service providers.

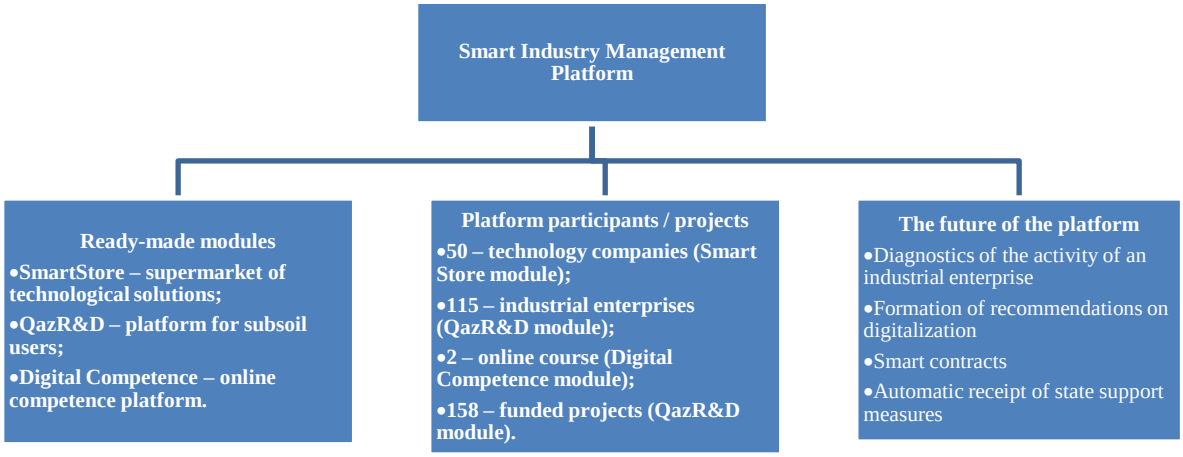

Figure 5. The system of the SIMP technology platform functioning

Note – Compiled by the authors based on data from the "Autonomous Cluster Fund "Park of Innovative Technologies "TechGarden""

The QazR&D platform is a module designed to assist subsoil users in fulfilling their obligations to deduct 1% of the SRS - total annual income (EC – extraction costs). The purpose of the module is to create a transparent platform for monitoring, administration and effective using of the tool for deducting 1% of SRS/EC for R&D. The sections of this platform are the following: R&D solutions; technical specifications of the industry; uploading reports; R&D database. In addition to the tasks solved within the SmartStore module, the QazR&D platform allows to connect Hyperledger, that is, a distributed blockchain network consisting of various functional components that are installed on network nodes. The module also implies the installation of an "integration tire" - a corporate application that ensures the interaction of all existing information systems through a single point, transactions, data transformation, message security, etc.

The Digital Competence module is an educational module aimed at increasing competencies in the field of Industry 4.0 (upgrading the skills of personnel and their retraining). The main sections of the platform are "e-courses", "knowledge base", "certification", "webinars/conferences", "vacancies". The module promotes of access to courses and certification in the areas of Industry 4.0; a unified conceptual apparatus and knowledge base, also improving the overall level of digital literacy in the enterprise.

Digitalization and robotization are the most important factor that allows mining enterprises to remain profitable and competitive already today. Large industrial giants of Kazakhstan, such as "Kazakhmys", "Kazminerals", "Kazzinc", "ArcelorMittal Temirtau", JSC "NAC "Kazatomprom"", "Altynalmas", ERG, JSC "Ust-Kamenogorsk Titanium-Magnesium Combine", JSC "Himpharm", etc. use a robotization system for mining of minerals. These enterprises have developed a digital modernization plan within the framework of the "Digital Mine" program, which provides the introduction of new technologies, such as advanced transducers, sensors, robotics. For these purposes, in the next 5 years, enterprises plan to invest in the amount of 800 billion tenge.

In Kazakhstan, work on the formation of innovative companies and start-ups that act as intermediaries in promoting digital solutions is accelerating. The key direction is the consolidation and coordination of the activities of organizations that support startups and innovative projects for attracting venture capital investors. Thus, in the IT-startup technopark "Astana Hub", where 17 research laboratories of domestic and foreign IT companies operate, conditions have been created for obtaining tax, labor and visa benefits, there are

startup promotion programs. A single portal has been created at the technopark site to support and stimulate both industrial, innovative and startup projects, where over 530 events were held in 2019, memoranda on innovative cooperation was signed with 25 international organizations (Aubakirova et al., 2020).

Thus, digitalization allowed to industrial enterprises not only to increase profits but also to reduce production costs, which leads to a reduction in the cost of production, also an upbuilding of labor productivity, an increase of technological level, and finding a new market niche. The digital transformation of enterprises confirms its economic feasibility.

Discussion

Today, the Republic of Kazakhstan is an active participant in implementing a comprehensive digitalization program that contributes to the country's entry into the 30th international ranking of digital competitiveness. Measures to stimulate the transition of Kazakhstan's industry to "Industry 4.0", automation, and robotization of Kazakhstani enterprises will have a positive impact on increasing the competitiveness of industrial production.

The process of digitalization is of a long-term nature, requiring constant technological renewal, the creation of infrastructure, and the training of personnel. As practice has shown, on the path of Industry 4.0 development in the Republic of Kazakhstan, the most pressing problems are lack of qualified personnel and financial resources necessary to make investments in the digital transformation of the industry; lack of suppliers, digital solutions for the enterprise, the infrastructure; lack of understanding by company management of the benefits of digitalization; the presence of barriers related with digital standards, norms, insufficient cybersecurity, maintaining data confidentiality.

The solution to these problems should be carried out systematically; all actions should be aimed at using actual digital technologies that will contribute to the formation of a favorable business climate, a modern digital ecosystem, competitive advantages; in turn, the using of tax incentives will increase the efficiency of technological modernization; at the same time, it is important to invest to the training and advanced training of relevant personnel who are directly involved in the digitalization of all production processes and subsequent maintenance of relevant software and digital solutions, including those represented by robotic equipment and automation systems.

Despite a wide range of scientific publications that widely, but not always succinctly reflect the aspects of industry digitalization in Kazakhstan, there are several debatable issues concerning the development of methods and algorithms of evaluating the digital tools implementation effectiveness (both individual and complex solutions). In this regard, the authors' subsequent research will be aimed at analyzing the specifics of the current organizational and economic mechanism functioning and factors of commercialization of innovations at Republic of Kazakhstan industrial enterprises and developing recommendations for its improvement.

Conclusions

During the research, the relevance of the IT-technologies introduction, related to the use of big data, blockchain technologies in production, robotics, etc., which will allow industrial enterprises to improve the processes of automation and optimization production processes, creating solutions with the using of artificial intelligence to reduce production costs, increase productivity, obtain higher profits and develop products having a high rate of added value, positioned in the market with a customized component, was determined.

Based on the results, we concluded that the transition of the Republic of Kazakhstan to the digital economy, the processes of digital transformation can significantly expand the range of industrial production and provide new opportunities for further development of industries and activation of technological modernization. The measures taken by the Government of Kazakhstan in this direction will lead to ensuring of highly competitive advantages of our country in the global technological arena and successful participation in the global digital services market.

References

Abdikarimova, K.A. (2018). O tsifrovizatsii promyshlennosti Kazakhstana [About digitalization of the industry of Kazakhstan]. *Nauchnyi vestnik: Finansy, banki, investitsii – Scientific bulletin: Finance, banks, investments, 1,* 167–174 [in Russian].

Aubakirova, G.M., Isataeva, F.M., & Kuatova, A.S. (2020). Tsifrovizatsiia promyshlennykh predpriiatii Kazakhstana: potentsialnie vozmozhnosti i perspektivy [Digitalization of industrial enterprises in Kazakhstan: potential opportunities and prospects]. *Voprosy innovatsionnoi yekonomiki – Issues of the innovation economy, 10(4),* 2251–2268 [in Russian]. https://doi.org/10.18334/vinec.10.4.111211

Aubakirova, G.M., & Isataeva, F.M. (2021). Tsifrovizatsiia promyshlennosti Kazakhstana: faktory, tendentsii, perspektivy [The digitalization of the economy of Kazakhstan: factors, tendencies, prospects]. *Ekonomika, predprinimatelstvo i pravo – Economics, business and law, 11(1),* 51–68 [in Russian]. https://doi.org/10.18334/epp.11.1.111527

Avtonomnyi klasternyi fond «Park innovatsionnykh tekhnologii». Tsifrovizatsiia promyshlennosti [Autonomous cluster fund "Park of innovative technologies". Industry digitalization]. Retrieved from https://techgarden.kz/about_fund [in Russian].

Babkin, A., Tashenova, L., Mamrayeva, D., & Andreeva, T. (2021). A Structural Functional Model for Managing the Digital Potential of a Strategic Innovatively Active Industrial Cluster. *International Journal of Technology, 12(7),* 1359–1368. https://doi.org/10.14716/ijtech.v12i7.5350

Babkin, A., Tashenova, L., Mamrayeva, D., & Makhmudova, G. (2020). Digital platforms for industrial clusters and enterprises: Essence and structure. *ACM International Conference Proceeding Series*, 3444486.

Babkin, A., Tashenova, L., Smirnova, O., & Burkaltseva, D. (2020). Analyzing the trends in the digital economy and the factors of industrial clustering. *ACM International Conference Proceeding Series*, 3444516.

Baimukhamedov, M.F., Zhikeev, A.A., & Boranbaev, A.S. (2021). Perspektivy razvitiia tsifrovizatsii i robotizatsii v promyshlennoi sfere Kazakhstana [Prospects of the development of digitalization and robotization in the industrial sector of Kazakhstan]. *Aktualnye nauchnye issledovaniia v sovremennom mire – Actual scientific researches in the modern world, 8–3(76*), 110–113 [in Russian].

Blichfeldt, H., & Faullant, R. (2021). Performance effects of digital technology adoption and product & service innovation – a process-industry perspective. *Technovation, 105,* 102275. https://doi.org/10.1016/j.technovation.2021.102275.

Chirumalla, K. (2021). Building digitally-enabled process innovation in the process industries: A dynamic capabilities approach. *Technovation, 105,* 102256. https://doi.org/10.1016/j.technovation.2021.102256

Esymkhanova, Z.K., Dauletkhanova, Zh.D., & Baimamyrov, B.A. (2020). Razvitie tsifrovoi transformatsii v globalnoi yekonomike [Development of digital transformation in the global economy]. *Materialy IX Mezhdunarodnoi nauchno-prakticheskoi konferentsii «Globalnye problemy modernizatsii natsionalnoi ekonomiki» – Proceedings of the X International Scientific and Practical Conference. Global problems of modernization of national economies*. Tambov: Publishing House «Derzhavinskii», Publishing House «Derzhavinskii», 160–166 [in Russian].

Iskusstvennyi intellekt i tsifrovye fabriki: kak vnedriaiutsia elementy Industrii 4.0 na kazakhstanskikh predpriiatiiakh. (2019). [Artificial intelligence and digital factories: how the elements of Industry 4.0 are being implemented at Kazakhstani enterprises]. Retrieved from https://primeminister.kz/ru/news/reviews/iskusstvennyy-intellekt-i-cifrovye-fabriki-kak-vnedryayutsya-elementy-industrii-4-0-na-kazahstanskih-predpriyatiyah [in Russian].

Hallin, A., Lindell, E., Jonsson, B., & Uhlin, A. (2022). Digital transformation and power relations. Interpretative repertoires of digitalization in the Swedish steel industry. *Scandinavian Journal of Management, 38(1),* 101183. https://doi.org/10.1016/j.scaman.2021.101183

Jeske, T., Würfels, M., & Lennings, F. (2021). Development of Digitalization in Production Industry – Impact on Productivity, Management and Human Work. Proceedings of the 2nd International Conference on Industry 4.0 and Smart Manufacturing (ISM 2020). *Procedia Computer Science, 180,* 371–380. https://doi.org/10.1016/j.procs.2021.01.358

Karpovich, O.G., Karipov, B.N., & Nogmova, A.Sh. (2020). Razvitie tsifrovoi yekonomiki Kazakhstana. Problemy postsovetskogo prostranstva [Development of the digital economy of Kazakhstan. Problems of the post-soviet area]. *Post-Soviet Issues, 7(4),* 485–494 [in Russian]. https://doi.org/10.24975/2313-8920-2020-7-4-485-494

Li, H., &Yang, C. (2021). Digital Transformation of Manufacturing Enterprises. *Procedia Computer Science, 187,* 24–29. https://doi.org/10.1016/j.procs.2021.04.029

Mussina, K.P., Mamrayeva, D.G., & Lemanowicz, M. (2020). Digitalization in the tourism industry of Kazakhstan. *Bulletin of the Karaganda University. Economy Series, 3(99*), 64–72.

Napravleniia gosudarstvennoi programmy «Tsifrovoi Kazakhstan» (Digital Kazakhstan) po tsifrovizatsii Kazakhstana [Directions of the state program "Digital Kazakhstan" for the digitalization of Kazakhstan. Retrieved from https://digitalkz.kz/napravleniya-programmy/ [in Russian].

Perno, M., Hvam, L. & Haug, A. (2022). Implementation of digital twins in the process industry: A systematic literature review of enablers and barriers. *Computers in Industry, 134,* 103558. https://doi.org/10.1016/j.compind.2021.103558

Qian, F., Zhong, W., & Du, W. (2017). Fundamental Theories and Key Technologies for Smart and Optimal Manufacturing in the Process Industry. *Engineering, 3(2),* 154-160, https://doi.org/10.1016/J.ENG.2017.02.011

Rekomendatsii po resheniiu problem s primeneniem tsifrovykh proektov (reshenii) i po povysheniiu effektivnosti raboty predpriiatii. AO «Kazakhstanskii tsentr industrii i eksporta «Qazindustry» (2020). [Recommendations for solving problems using digital projects (solutions) and for improving of the enterprises efficiency. JSC "Kazakhstan center of industry and export "Qazindustry"]. Nur-Sultan, 67 [in Russian].

Tashenova, L., Babkin, A., Mamrayeva, D., & Babkin, I. (2020). Method for Evaluating the Digital Potential of a Backbone Innovative Active Industrial Cluster. *International Journal of Technology, 11(8),* 1499–1508. https://doi.org/10.14716/ijtech.v11i8.4537

Tashenova, L.V., Babkin, A.V., & Mamrayeva, D.G., (2019). Digital transformation of industrial production in the context of Industry 4.0. *Bulletin of the Karaganda University. Economy Series, 4(96*), 154–162.

Turkyilmaz, A., Dikhanbayeva, D., Suleiman, Zh., Shaikholla, S., & Shehab, E. (2021). Industry 4.0: Challenges and opportunities for Kazakhstan SMEs. *Procedia CIRP, 96,* 213–218. https://doi.org/10.1016/j.procir.2021.01.077

Vukadinovic, V., Majstorovic, V., Zivkovic, J., Stojadinovic, S., & Djurdjanovic, D. (2021). Digital Manufacturing as a basis for the development of the Industry 4.0 model. *Procedia CIRP, 104,* 1867–1872. https://doi.org/10.1016/j.procir.2021.11.315.

Zhandybaev, K. (2019). Mirovye trendy tsifrovizatsii: ikh primenenie v promyshlennosti Kazakhstana [Global digitalization trends: their application in the industry of Kazakhstan]. *Obzorno-analiticheskii portal «Strategy – 2050. kz» – Review-analytical portal Strategy2050.kz.* Retrieved from https://strategy2050.kz/ru/news/52760/ [in Russian].

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Қазақстан Республикасындағы өнеркәсіпті цифрландыру

Аңдатпа

Мақсаты: Технологиялық трансформация жағдайында экономикалық дамудың негізгі факторы ретінде Қазақстан Республикасының өнеркәсіп секторындағы цифрландыру үрдістерін зерттеу.

Әдісі: Зерттеу барысында мазмұнды талдау әдісі қолданылды, ол зерттелетін ғылыми мәселелерге қатысты мәліметтер жиынтығын кеңінен талдауға мүмкіндік береді; талдау нәтижелерін жан–жақты көрсетуге мүмкіндік берген материалдарды жүйелеу; графикалық интерпретация әдісі, оның негізінде «Индустрия 4.0» компоненттері, сондай-ақ SIMP технологиялық платформасының жұмыс істеу ерекшеліктері ұсынылған.

Қорытынды: Мақалада Қазақстанның өнеркәсіп секторын диджитализациялаудың негізгі бағыттары талданған. Өнеркәсіптік кәсіпорындарда цифрлық құралдарды енгізу факторлары қарастырылды, Төртінші өнеркәсіптік революция шеңберінде өнеркәсіптік өндірістің цифрлық трансформациясының негізгі компоненттері айқындалды.

Тұжырымдама: Осы ғылыми мақала аясында жүргізілген талдау Индустрия 4.0 элементтерін енгізу өнеркәсіптік кәсіпорындарға өндірістік процестерді жетілдіруге, уақытты едәуір қысқартуға және тиімділікті арттыруға, сонымен қатар жеке тұтынушылардың сұраныстарына бағытталған өнімдерді жасауға мүмкіндік беретінін көрсетті. Цифрлық трансформацияның маңызды факторы мемлекеттік бағдарламаларды іске асыру аясында да, кәсіпорындардың бір–бірімен өзара ынтымақтастығы арқылы да компаниялар алатын қолдау болып табылады. Авторлардың зерттеуі цифрландырудың қазіргі заманғы модернизацияның «сәнді» құралы ғана емес, бәсекелестік артықшылықтарға қол жеткізудің тиімді әдісі екенін тағы бір рет растайды.

Кілт сөздер: цифрландыру, цифрлық экономика, Индустрия 4.0, өнеркәсіптік кәсіпорындар, роботтандыру, жасанды интеллект, өндіріс, блокчейн технологиясы, үлкен сандар (BigData).

Д.Г. Мамраева, А.Б. Токсамбаева, Л.В. Ташенова

Цифровизация промышленности в Республике Казахстан

Аннотация

Цель: Исследовать тенденции цифровизации в промышленном секторе Республики Казахстан как ключевой фактор экономического развития в условиях технологической трансформации.

Методы: В ходе исследования были использованы методы контент-анализа, позволивший емко проанализировать массив данных, касающийся исследуемой научной проблематики; систематизации материалов, давший возможность представить результаты анализа комплексно; и графической интерпретации, на основе которого были представлены компоненты «Индустрии 4.0», а также особенности функционирования технологической платформы SIMP.

Результаты: В статье проанализированы ключевые направления диджитализации промышленного сектора Казахстана. Рассмотрены факторы внедрения цифровых иструментов на промышленных предприятиях, определены ключевые составляющие цифровой трансформации промышленного производства в рамках Четвертой промышленной революции.

Выводы: Анализ, проведенный в рамках данной научной статьи, показал, что внедрение элементов Индустрии 4.0. позволяет промышленным предприятиям совершенствовать производственные процессы, в значительной мере сокращая время и повышая эффективность, а также создавать продукты, ориентированные на запросы отдельно взятых потребителей. Немаловажным фактором цифровой трансформации выступает поддержка, получаемая компаниями как в рамках реализации государственных программ, так и посредством взаимной кооперации предпритий друг с другом. Исследование еще раз подтверждает, что цифровизация – не просто «модный» инструмент соврменной модернизации, а эффективный способ получения конкурентных преимуществ.

Ключевые слова: цифровизация, цифровая экономика, Индустрия 4.0, промышленные предприятия, роботизация, искусственный интеллект, производство, технология блокчейн, большие числа (BigData).

References

Babkin A. A Structural Functional Model for Managing the Digital Potential of a Strategic Innovatively Active Industrial Cluster / A. Babkin, L. Tashenova, D. Mamrayeva, T. Andreeva // International Journal of Technology. — 2021. — No. 12(7). — P. 1359–1368.

Babkin A. Digital platforms for industrial clusters and enterprises: Essence and structure / A. Babkin, L. Tashenova, D. Mamrayeva, G. Makhmudova // ACM International Conference Proceeding Series. — 2020. — P. 3444486.

Babkin A. Analyzing the trends in the digital economy and the factors of industrial clustering / A. Babkin, L. Tashenova, O. Smirnova, D. Burkaltseva // ACM International Conference Proceeding Series. — 2020. — P. 3444516.

Blichfeldt H. Performance effects of digital technology adoption and product & service innovation — a process-industry perspective / H. Blichfeldt, R. Faullant // Technovation. — 2021. — No. 105. — P. 102275.

Chirumalla K. Building digitally-enabled process innovation in the process industries: A dynamic capabilities approach / K. Chirumalla // Technovation. — 2021. — No. 105. — P. 102256.

Hallin A. Digital transformation and power relations. Interpretative repertoires of digitalization in the Swedish steel industry / A. Hallin, E. Lindell, B. Jonsson, A. Uhlin // Scandinavian Journal of Management. — 2022. — No. 38(1). — P. 101183.

Jeske T. Development of Digitalization in Production Industry — Impact on Productivity, Management and Human Work / T. Jeske, M. Würfels, F. Lennings // Proceedings of the 2nd International Conference on Industry 4.0 and Smart Manufacturing (ISM 2020). Procedia Computer Science. — 2021. — No. 180. — P. 371–380.

Li H. Digital Transformation of Manufacturing Enterprises / H. Li, C. Yang // Procedia Computer Science. — 2021. — No. 187. — P. 24–29.

Mussina K.P. Digitalization in the tourism industry of Kazakhstan / K.P. Mussina, D.G. Mamrayeva, M. Lemanowicz // Bulletin of the Karaganda University. Economy Series. — 2020. — No. 3(99). — P. 64–72.

Perno M. Implementation of digital twins in the process industry: A systematic literature review of enablers and barriers / M. Perno, L. Hvam, A. Haug // Computers in Industry. — 2022. — No. 134. — P. 103558.

Qian F. Fundamental Theories and Key Technologies for Smart and Optimal Manufacturing in the Process Industry / F. Qian, W. Zhong, W. Du // Engineering. — 2017. — No. 3(2). — P. 154–160.

Tashenova L. Method for Evaluating the Digital Potential of a Backbone Innovative Active Industrial Cluster / L. Tashenova, A. Babkin, D. Mamrayeva, I. Babkin // International Journal of Technology. — 2020. — No. 11(8). — P. 1499–1508.

Tashenova L.V. Digital transformation of industrial production in the context of Industry 4.0. / L.V. Tashenova, A.V. Babkin, D.G. Mamrayeva // Bulletin of the Karaganda University. Economy Series. — 2019. — No. 4 (96). — P. 154–162.

Turkyilmaz A. Industry 4.0: Challenges and opportunities for Kazakhstan SMEs / A. Turkyilmaz, D. Dikhanbayeva, Zh. Suleiman, S. Shaikholla, E. Shehab // Procedia CIRP. — 2021. — No. 96. — P. 213–218.

Vukadinovic V. Digital Manufacturing as a basis for the development of the Industry 4.0 model / V. Vukadinovic, V. Majstorovic, J. Zivkovic, S.Stojadinovic, D. Djurdjanovic // Procedia CIRP. –2021. — No. 104. — P. 1867–1872.

Абдикаримова К.А. О цифровизации промышленности Казахстана / К.А. Абдикаримова // Научный вестник: Финансы, банки, инвестиции. — 2018. — № 1. — С. 167–174.

Аубакирова Г.М. Цифровизация промышленных предприятий Казахстана: потенциальные возможности и перспективы / Г.М. Аубакирова, Ф.М. Исатаева, А.С. Куатова // Вопросы инновационной экономики. — 2020. — № 10(4). — С. 2251–2268.

Аубакирова Г.М. Цифровизация промышленности Казахстана: факторы, тенденции, перспективы / Г.М. Аубакирова, Ф.М. Исатаева // Экономика, предпринимательство и право. — 2021. — Т. 11. — № 1. — С. 51–68.

Автономный кластерный фонд «Парк инновационных технологий». Цифровизация промышленности. Retrieved from https://techgarden.kz/about_fund

Баймухамедов М.Ф. Перспективы развития цифровизации и роботизации в промышленной сфере Казахстана / М.Ф. Баймухамедов, А.А. Жикеев, А.С. Боранбаев // Актуальные научные исследования в современном мире. — 2021. — Вып. 8. — № 3(76). — С. 110–113.

Есымханова З.К. Развитие цифровой трансформации в глобальной экономике / З.К. Есымханова, Ж.Д. Даулетханова, Б.А. Баймамыров // Материалы IX Междунар. науч.-практ. конф. «Глобальные проблемы модернизации национальной экономики». — 2020. — Тамбов: Изд-во: Изд. дом «Державинский», 160–166.

Жандыбаев К. Мировые тренды цифровизации: их применение в промышленности Казахстана / К. Жандыбаев //Обзорно-аналитический портал Strategy – 2050.kz. — 2019. Retrieved from https://strategy2050.kz/ru/news/52760/

Искусственный интеллект и цифровые фабрики: как внедряются элементы Индустрии 4.0 на казахстанских предприятиях. — 2019. Retrieved from https://primeminister.kz/ru/news/reviews/iskusstvennyy-intellekt-i-cifrovye-fabriki-kak-vnedryayutsya-elementy-industrii-4–0-na-kazahstanskih-predpriyatiyah

Карпович О.Г. Развитие цифровой экономики Казахстана. Проблемы постсоветского пространства / О.Г. Карпович, Б.Н. Карипов, А.Ш. Ногмова // Post-Soviet Issues. — 2020. — № 7(4). — С. 485–494.

Направления государственной программы «Цифровой Казахстан» (Digital Kazakhstan) по цифровизации Казахстана. Retrieved from https://digitalkz.kz/napravleniya-programmy/

Рекомендации по решению проблем с применением цифровых проектов (решений) и по повышению эффективности работы предприятий. АО «Казахстанский центр индустрии и экспорта «Qazindustry». — Нур-Султан, 2020. — 67 с.