Digitalization of industry in Russia and Kazakhstan: the Best Practices

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Abstract. The current transformation of the economy, caused by the proactive implementation of the main provisions of Industry 4.0, has largely been a critical factor for the digitalization of industries of Russia and Kazakhstan. Every year, there is an increase in projects in industrial production, described by high digital potential, primarily because of the use of various information and communication technologies, and secondly, due to companies' desire to ensure high-level competitiveness in both national and foreign markets. *This scientific article aims to study* the best practices in the digital transformation of industrial enterprises in Russia and Kazakhstan. *The following methods were applied*: methods of analysis, graphical interpretation, systematization, and content analysis, which made it possible to achieve the objective and implement the tasks provided for by the study. *The article discusses* general areas of digital transformation of industry in Russia and Kazakhstan, with a focus on government programs aimed at supporting initiatives in this field the companies-suppliers of I.T. services for the industrial sector and the main areas of their activities are studied Specific features of digital solutions offered by the companies for enterprises engaged in their activities in the field of production (virtualization and robotization of production cycles, telemetry, industrial analytics, predictive analytics and building of digital production models, cloud solutions) are given.

Keywords: Digital economy; Digital factories; Digital platforms; Digital solutions; Digital transformation of industry

1. Introduction

Digital transformations taking place in the current economic situation due to the active formation of digital economies in different countries and regions of the world have largely predetermined features of industrial development. At present, the active introduction and use of various information and communication technologies allow companies to form unique competitive advantages.

Over recent years, the scientific literature has formed a pool of articles devoted to the problem under consideration. Thus, a number of authors especially highlight aspects

related to changes in enterprise management in the digital economy (Bencsik, 2020), assessment of the impact of digitalization of industrial production on the overall economic development of the country (Zagloel et al., 2021; Rojko et al., 2020; Gnezdova et al., 2019).

Other researchers, in turn, focus on issues related to the assessment of the digital potential not of individual industrial enterprises but off complex integrated industrial structures and systems (Babkin et al., 2020a; Babkin et al., 2019), system-forming innovation-active industrial clusters (Babkin et al., 2020b).

Another pool of papers is dedicated to the role of innovative programs (including regional ones) in the sustainable development of an industrial enterprise in the context of globalization and large-scale digital transformation of various industries and services (Burova et al., 2021; Nikolova et al., 2017a; Nikolova et al., 2017b; Rodionov & Rudskaya, 2017).

In scientific articles, a significant emphasis is placed on the features of the functioning of smart factories (Coumans, 2018), their adaptation to specific production (depending on the algorithms used), as well as on opportunities for using smart technologies in the course of constructing smart cities (Berawi, 2022). It is also important to note that many studies highlight aspects of industrial robotics (Sobolev, 2022; Barbosa et al., 2020). and the need to use digital twins to reduce costs and accelerate information processing and management decision-making (De Prada et al., 2022; Hyre et al., 2022; Mylonas et al., 2021; Schmitt et al., 2020; Parri et al., 2018). Considering the reviewed scientific directions, including those widely represented in scientometric databases, one can conclude that the relevance of the theme of the scientific article presented is beyond doubt.

*This scientific article aim*s to study *the best practices (examples of industrial enterprises implementing digital solutions as well as the best examples of companies creating digital products for the industry).* In the digital transformation of industrial enterprises in Russia and Kazakhstan (after this referred to as R.F. and R.K., respectively). *The main tasks are defined as follows:* reviewing government and departmental programs regulating aspects of the formation and development of digital economies in R.F. and R.K., identifying key areas and target indicators of industrial digitalization in these countries; researching the best practices in the digital transformation of industrial production in Russia and Kazakhstan, identifying the leading companies that are key software suppliers for industrial enterprises of R.F.; conducting a content analysis of I.T. companies' websites, to describe the set and nature of digital solutions for industry; studying the institutional component of industrial transformations in R.K.; defining future areas for researching, with specific features of the scientific problem under consideration to be taken into account.

2. Methods

In the course of the research, the following general scientific and specialized methods were used: *the method of analysis* for studying main trends in the digital transformation of the R.F. and R.K. industries; *the method of graphical interpretation* for visualizing trends and relationships existing in the objects and phenomena under consideration (especially when highlighting structural components of government programs for building and developing digital economies); *the method of systematization*, for concluding the studied scientific problems, applying careful consideration of digitalization aspects to the R.F. and R.K. industrial sectors; *the method of content analysis*, for exploring the information array presented at official websites of industrial enterprises, directly or indirectly related to the issues of digitalization.
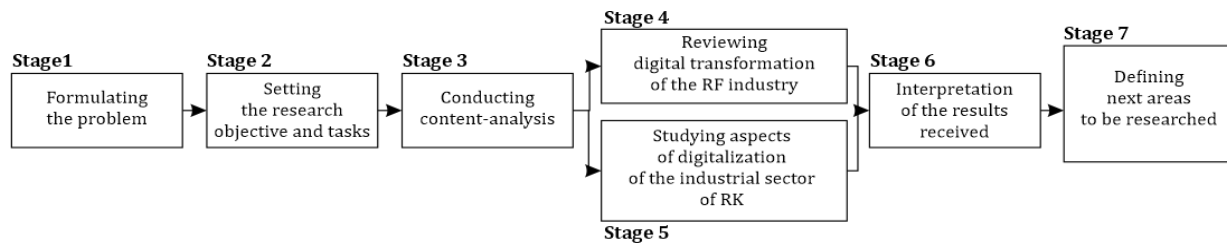
Note: developed by the authors
Figure 1 Stages of the study

So, according to Figure 1, the general structure of the study includes seven key stages, starting from the moment of identification of the problem (related to the study of the most successful practices of digital transformation of industrial enterprises in R.F. and R.K.). Setting the objective and the tasks of the work, and ending with analyzing features of industrial digitalization in Russia and Kazakhstan, with subsequent separation of future research areas in the framework of scientific problems considered.

3.   Results and Discussion

The dynamic formation of digital economies has become the priority area for many countries, including R.F. and R.K., the basis for the development of which was global transformations in the field of industrial production. Determined by introducing and using various information and communication technologies, as well as understanding the role of digital tools for accelerating all processes in the organization, strengthening the significance of international business integration, simplifying production chains of creating the final product with high added value, forming competitive advantages in domestic and foreign markets. *The best practices* for implementing various digital solutions by industrial enterprises in Russia and Kazakhstan are considered in the example of individual industries and companies/universities that create and implement digital solutions for industry.

3.1. Digital Transformation of Russian Industry

Aspects related to industrial digitalization in the R.F. territory can be found in the following regulatory documents reflecting key target indicators, legal, regulatory norms, and rules, responsible persons, as well as the description of events purposed at implementing main tasks in the field of digital transformation of industrial production:

1. National Program "Digital Economy of the Russian Federation" (approved by the Presidential Council for Strategic Development and National Projects, dated June 4, 2019, No. 7);

2. the departmental project "Digital Industry" (developed by the Ministry of Industry and Trade of Russia), the main areas of which are the following: .creating a regulatory environment for the digital transformation of industry; creation, integration, and development of platforms for the Governmental Information System of Industry (GISP); the digital transformation of manufacturing industries (Digital Energy, 2022).

According to experts, by 2030, the demand of the manufacturing industry for various information and communication technologies will have amounted to about 587.5 billion rubles (currently, it is about 41.5 billion rubles) (Rudycheva, 2021a), which will largely determine Russian IT companies' activity in the elaboration of respective digital products.

Table 1 shows Russia's five largest providers of I.T. services, data analysis solutions and B.I. solutions (including those for the industrial sector) in 2020. It is important to note that most of them provide the full range of I.T. services, mainly located in Moscow. The leaders in the context of the categories under consideration are Lanit, GlowByte, and Digital Economy League, respectively.

Table 1 TOP 5 largest providers of I.T. services, data analysis solutions, and B.I. solutions in Russia in 2020

Company name	Revenue, thousand rubles	City
TOP 5 largest I.T. service providers		
Lanit	92,271,563	Moscow
Croc	21,079,193	Moscow
T1 Group (formerly Technoserv)	18,131,113	Moscow
Jet Infosystems	17,439,001	Moscow
Digital Economy League	16,772,000	Moscow
TOP 5 largest providers of data analysis solutions		
GlowByte	6,961,000	Moscow
Digital Economy League	6,690,459	Moscow
Croc	1,752,816	Moscow
Parma TG	1,383,389	Moscow
Korus Consulting	944,406	Saint Petersburg
TOP 5 largest suppliers of B.I. solutions		
Digital Economy League	6,690,500	Moscow
Croc	1,752,800	Moscow
Parma TG	1,383,400	Moscow
Korus Consulting Group	944,400	Saint Petersburg
RDTECH	885,200	Moscow

Note: compiled by the authors with the use of materials from information portals cnews.ru and tadviser.ru (Tadviser, 2022; CNews Analytics, 2021; Cnews, 2021).

Table 2 reflects key areas of activity and features of digital products developed by leading companies in the Russian IT service market presented above.

It can be noted that I.T. companies mainly offer the following digital products: cloud solutions, virtualization, and robotization of production cycles, telemetry, industrial analytics, predictive analytics, and building of digital production models. It should also be noted that many companies offer services for developing customized information systems based on the customer's requirements, specific features of the products they produce, and the enterprise's organizational structure.

Table 2 Activities of companies providing I.T. services, data analysis solutions, and B.I. solutions in the industrial sector

Company name	Digital Solutions for Industry
RDTECH	Electronic archive, technology consulting services, intelligent corporate security center, development of the customized information system, regulatory and information management systems, development of corporate portals.
Korus Consulting Group	Production planning, SNLP, lifecycle management, MRO, Tool data management, IOT, robotics, ERP, equipment monitoring, automated tool management, and management service processes (based on the HUBEX IT platform).
RDTECH	Electronic archive, technology consulting services, intelligent corporate security center, development of the customized information system, regulatory and information management systems, development of corporate portals.
Croc	Computing infrastructure, software development, network solutions, business analytics, content, and document management. Information security, implementation of Russian ERP systems, cloud services, industrial analytics based on Big Data etc.

Company name	Digital Solutions for Industry
Digital Economy League	Cloud solutions and virtualization (including those based on VMware, Microsoft, IBM, BMC, and Oracle), B.I. and Big Data, Data Mining, application integration, load testing, custom software development, ERP, ECM systems, CPM, management consulting.
GlowByte	Business Intelligence, Advanced Analytics, Risk Management & Compliance, Customer Experience, Operational CRM, and Process Intelligence. Analytics for Industry, Customer Analytics and Marketing Automation, Financial Intelligence, Corporate Data warehouses, and Retail Solutions.
Group T1 (formerly Technoserv)	Cold supply systems (cold centers, precision air conditioning), modular data centers, consulting on planning and development of I.T. infrastructure, hyper-convergent infrastructure, workplace virtualization. Automation of Enterprise and I.T. Service Management processes, predictive analytics, forecast of technical condition of equipment, digital production model, control of production processes, intelligent building, etc.
Jet Infosystems	Video Analytics, telemetry (IIOT), digital labor protection laboratory, optimization of technological processes (based on machine learning), etc.
Note: compiled with the use of materials from the companies' official websites.	

Table 3 shows the largest in Russia suppliers of I.T. solutions directly for the industrial sector in 2020; among them are Softline Group, Croc, Jet Infosystems, X-Holding, and Lanit.

Table 3 Main suppliers of digital solutions for industrial enterprises in 2020

Company name	Revenue, thousand rubles	City
Softline Group	13,327,268	Moscow, London
Croc	6,225,081	Moscow
Jet Infosystems	3,412,265	Moscow
X-Holding	3,267,313	Moscow
Lanit	2,812,184	Moscow
Note: compiled by the authors with the use of materials from the information portal cnews.ru (Rudycheva, 2021b).		

The total revenue of the presented above companies from the supply of I.T. solutions for industry in 2020 amounted to 29,044,111 thousand rubles which is 23.5 % more than the same indicator in 2019. This confirms the increase in demand from industrial enterprises for ICT tools (mainly ERP, PLM, MES, virtual testing, simulation modeling, solutions for end-to-end integration and automation and digitalization of industrial safety) as well as their awareness of the role of introducing digitalization elements in various aspects of business activities of industrial structures for ensuring the necessary level of competitiveness, and creating competitive advantages.

Table 4 shows examples of Russian companies to have implemented various digital solutions in their activities.

Table 4 Examples of Russian industrial companies developing and implementing digital technologies

No.	Company name	Region	Nature of digital technology
1	N.L. Dukhov All-Russian Research Institute of Automation (VNIIA)	Moscow	The Prism System is the product for digital control of all processes in small-scale and serial production.
2	Peter the Great Saint Petersburg State Polytechnic University	Saint Petersburg	"Factory of the Future" is a project on minimizing the time of digital design, based on total mathematical modeling and optimization technologies (the Time to Market principle)
3	KAMAZ PJSC	Moscow, Kazan, Naberezhnye Chelny	"Digital Kamaz" is a large-scale project on modernizing production and updating the product line by applying the new K5 platform (for example, KAMAZ-54901)
4	Moscow Refinery Plant	Moscow	Digital twins of the catalytic cracking gasoline hydrotreating unit
5	Omsk Refinery Plant	Omsk	Primary oil refining units
6	United Engine Corporation	Moscow	3D printing units of large-sized parts for industrial gas turbine engines
7	Sibur	Moscow	Augmented reality systems and life cycle management of finished products
8	NLMK Group	Moscow	BIM technologies in construction and reconstruction
9	Tikhvin Railway Car Building Plant	Tikhvin	80 industrial robots for welding, painting parts, etc.
10	Rosatom National Corporation	Moscow	1. Smart Helmets (personal protective equipment with the built-in situational controller); 2. Information modeling technology; 3. Automated decision-making systems based on artificial intelligence and Big Data technology; 4. Introduction of uniform information security requirements; 5. Inspection of enterprises in virtual reality; 6. Cross-platform software, etc.
11	SAKHALIN ENERGY	Yuzhno-Sakhalinsk	Digital Workplace Twins

Note: compiled by the authors with the use of materials from the companies' official websites.

It should be noted that, according to Dell Technologies' review, in 2020, about 85 % of Russian enterprises "accelerated implementation of digital transformation programs."

3.2. Digital transformation of industry in Kazakhstan

On December 12, 2017, Resolution of the Government of the Republic of Kazakhstan No. 827 approved the State Program "Digital Kazakhstan" (for 2018–2022), the objective of which was: "Accelerating the republic economy development pace and improving the population's life quality through the use of digital technologies in the medium term, as well as creating conditions for the R.K. economy transition to the fundamentally new trajectory of development, ensuring the creation of future digital economy in the long term" (Egov.kz, 2022). The Program included five key areas: 1. digitalization of economic sectors (including the industrial sector); 2. transition to the digital state; 3. implementation of the digital Silk Road; 4. development of human capital; 5. creation of the innovation ecosystem (Digital Kazakhstan, 2022).

Thus, according to the Program, key areas of digitalization of the country's industry are implementation projects execution: "Digital mines" (at NAC Kazatomprom JSC); "Digital deposits" (mainly in the oil and gas industry; moreover, the first project was successfully implemented in 2015, on the basis of EmbaMunaiGas JSC in the Atrau Region); "Model digital factories" (at seven large enterprises: Khimfarm JSC, Kentau Transformer Plant JSC,

Eurasian Foods JSC, AK Altynalmas JSC, Karlskrona LLP, Almaty Fan Plant LLP, Bal Textile LLP), totally 49 projects for the overall amount of investment of 10.4 billion tenges (about 0.022 billion U.S. dollars) (National Bank of Kazakhstan, 2022). According to the data posted at the portal uchet.kz, as of July 13, 2021, 25 projects worth 4.7 billion tenges (about 0.01 billion U.S. dollars) were completed (Uchet.kz, 2021).

In the context of the applied aspect, the experience of executing the Digital Mine program in the territory of AK Altynalmas JSC, which implements its activities in the Almaty Region, is interesting; this is an enterprise of full geological, mining, and gold processing cycle. Mining is carried out at nine country deposits (Altynalmas JSC, 2022); the number of employees is 9,500 people; the car fleet is 120 units of mining equipment. The company also actively introduces and implements the "Mine to Mill" technology (integrated mining optimization strategy). Key areas of implementation of the Digital Mine program at AK Altynalmas JSC are automation of maintenance and repairs of stationary and self-propelled equipment (1. formation of process flowchart for equipment; 2. transition to the "Equipment Reliability Management" method; 3. implementation of the tool for improving MRO planning quality and optimizing resources for MRO), automation of the gold recovery factory (1. cloud-based Big Data analytics system based on artificial intelligence; 2. implementation of the Production Process Management System (MES)), automation of the mining and geological complex (1. implementation of advanced solutions in the field of geological exploration and geology; 2. implementation of shift-daily planning of mining operations; 3. automatic collection and online display of information on the implementation of the mining plan) (Altynalmas, 2022).

In general, even in 2018, the following implemented measures in the field of industrial digitalization became the "quick" start of the Program (State Program "Digital Kazakhstan", 2022): ERG: Improving the mining sector efficiency and developing the "Intellectual Quarry" program; Kazzinc LLP: implementation of ERP resource planning information system; implementation of the "Intelligent deposit" technology at the enterprises of Kazgermunaigas JSC; establishment of the Institute of Industrial Automation and Digitalization (on the base of Satbayev University, Almaty); Ust-Kamenogorsk Titanium-Magnesium Industrial Complex JSC: the production balances formation and calculation system (the East Kazakhstan Region); starting up seven digital model factories; commissioning the "Digital Mine," I.E.; the pilot project of the national industrial Internet platform has been developed; Kazzinc LLP: "New Metallurgical Balance" and implementation of the unified production database.

It is important to note that, according to the action plan for the implementation of the Program, in the section "Digitalization of economic sectors" (Task No. 1 "Digitalization of industry and electric power industry") *for 2022, the following are assigned as target indicators:* increasing the share of subsoil users' project documents in the information system of the competent authority in the field of hydrocarbons up to 100%; increasing the share of oil and gas companies using IIoT solutions (Industrial Internet of Things – online oil metering devices) and integrated with the information system of the competent authority in the field of oil up to 95%; increasing the share of large- and medium-sized enterprises using digital technologies up to 11%; increasing the share of sets of local automation systems to prevent disruption of the stability of the power system (LAPNU) connected to the Centralized ECA System (TSSPA) up to 100%.

By Resolution of the Government of the Republic of Kazakhstan dated May 17, 2022 No. 311, Resolution of the Government of the Republic of Kazakhstan dated December 12, 2017 No. 827 "On approval of the State Program "Digital Kazakhstan" has lost its validity, though key results obtained during its implementation, according to the analysis. are of

great importance for further digitalizing economic sectors, including industry.

In 2021, Kazakhstan ranked 61 out of 130 countries in the Network Readiness Index ranking, scoring 52.17 points. The country shows the highest indicators in the "People" component (54th place), 52nd place in the "Business" sub-component, reflecting the continued ICT implementation by enterprises; slightly not-so-high indicators for "Individuals" and "Government" – 61st place in both these sub-components. In the indicator related to improving the pace of new technologies implementation, R.K. ranks 84th, while in terms of expenses on computer software, it ranks 114th.

For supporting key areas of digital transformation, shaping the digital ecosystem, creating breakthrough I.T. companies, attracting talented ICT specialists, and solving Tech tasks for various business sectors, the Astana Hub technopark is successfully operating in Kazakhstan, including the following regional development programs: incubation of startup projects in the region (13 cities), development of regional partners (15 cities), events of regional Community managers (129 events), cooperation with the I.T. hub "Terricon Valley" (26 startup projects), Regional/Online Incubation, Regional Agents. Also, on September 28–29, 2022, the International Forum on Digital Technologies "Digital Bridge 2022" was held in Astana, where issues of digital transformation of Kazakhstan's economic sectors were discussed in detail, including panel sessions and Keynote speeches of those related to the digitalization of industrial production: "Unified Digital Ecosystem: advantages and challenges", "Robotics: areas and ways of application," "5G on Silk Road", "Digital transformation of Tengizchevroil: investing in people, business and technology", "From the Internet of Things to the Internet of Everything: drivers of implementation of the 4th Industrial Revolution", "Digital ecosystems: innovations or must-have leaders", "Transformation of the oil industry by the example of Karachaganak Petroleum Operating B.V. New areas", "Development of the web3.0 ecosystem and blockchain technologies". Events of this kind are the driver for developing the digital economy and digitalization of the country's industry, no doubt about it.

The issues related to the qualitative assessment of digital transformation of industrial enterprises remain *debatable*, in particular: what indicators/set of indicators should measure it, and what effect on all business processes of the company. It should have how to affect aspects of forming competitive advantages in the active development of digital economies. In the scientific literature and practice, there is no *single methodology / common scientific* approach to conducting research of this kind, so, in this regard, this issue remains open as before.

4. Conclusions

Volatility This research made it possible to identify areas of digital industrial transformation by the example of a number of large enterprises *(best practices)* operating both in the territory of the Russian Federation and in the Republic of Kazakhstan. In general, it can be noted that the industrial sector of both countries is focused on the active implementation of various ICT tools, while overall modernization of the industry is closely linked to key objectives of state and departmental programs for the development of digital economies. Further research areas of the authors will be related to the study of specific features of the functioning of cyber-physical systems and cross-platform solutions in the activities of complex integrated structures – industrial clusters.

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