

Development of Industry on the Basis of its Digitalization

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ABSTRACT

The purpose of the article is to detect the features of Russian industrial digitalization practices, that determine the specifics of domestic tactics for the implementation of digital technologies into the economy. The digitalization of the economy has a stimulating effect on all spheres of society. The article is dedicated to disclosing the essence of digital transformation of industry, which became the basis for building economic knowledge, measuring economic results when implementing end-to-end technologies. The paper presents the experience of foreign countries in the digitalization of the economy, including industry. The features and directions of digitalization in China, as well as in Germany and other countries of the European Union, are revealed. The main programs for the development of the digital industry in the world and in the Russian Federation are considered. Within the framework of scientific technical initiatives, the directions of development of the high-tech market TechNet are presented.

Keywords: *digital economy, digital transformation, innovative industry development, end-to-end technologies, digital model, foreign digitalization experience, industry digitalization*

1. INTRODUCTION

Many countries around the world were involved in the process of rebuilding the industry through digital transformation. Digital transformation is the process of integrating innovative (disruptive) technologies into all aspects of business activity, requiring fundamental changes in technology, culture, operations, and principles of creating new products and services in order to be successful in the new digital economy. In different countries, at different times, different programs, related to the support and development of certain solutions for the development of the digital industry, were launched.

Germany is the world leader in the implementation of the transition to a new production model. The German Industry 4.0 program is the most famous government initiative in the field of technological development and industry re-equipment [11]. In actual practice, Industry 4.0 is one of 10 projects to improve the competitiveness of German industry under the High-Tech Strategy 2020 Action Plan.

2. METHODOLOGY OF THE STUDY

Comparison of Russian and foreign experience in implementing digital technologies into industry allows to identify the strengths and weaknesses of the approaches, used to organize production. The demands of the modern period form the need to revise the frameworks of the current industrial policy for its digitalization. Analysis of the available foreign experience made it possible to identify possible options for applying the knowledge of the

digitalization process in the domestic economy and to predict the further development of the digital model of industry organization.

Methods of comparative and factor analysis, mental modeling, inductive and deductive approaches were used to comprehensively study of the digitalization of industry. The methodological basis for studying the digitalization of industrial technologies was the results of studies by Russian and foreign scientists. As a result of the analysis of foreign and Russian ways of digitalization of industry, the author assumes the presence of features of the model for the implementation of digital technologies in the Russian Federation.

3. RESULTS

The key task within Industry 4.0 is the transition to the use of cyber-physical systems - a set of new technologies, that allow combining real-life physical processes with their digital models through the use of appropriate information and communication technologies. According to opinion of German analysts, it is the development of new digital technologies, that makes it possible to realize the convergence of the virtual and physical world, that is the main way to ensure leadership in the modern digital world [1].

The successful implementation of the Industry 4.0 program will ensure the solution of the economic problems of the German industry. In particular, this refers to increasing the competitiveness of German manufacturers in conditions, where Germany is inferior to developing countries in terms of labor costs and production capacity.

The application of new technologies and the creation of a modern production infrastructure on their basis will ensure the optimal production of more high-tech and science-intensive products, that meet consumer requirements. Industry 4.0 is not solely limited to supporting the development of modern digital technologies and creating a cyber-physical ecosystem of a manufacturing enterprise on their basis. This also refers to forming general regulations and standards to let German industrialists digitally transform their production capacities.

Along with Germany, other countries of the European Union joined the process of innovative development and digital transformation of their own industries. The development of advanced production in the EU is reflected in a number of programs and various initiatives. Within the framework of the European Union funding program Horizon 2020, various programs are being implemented, in particular Industrial Leadership, aimed at modernizing production and increasing the competitiveness of European products in the world market. Within its framework, a set of measures is planned to introduce advanced production technologies at the production sites of industrial companies [2].

One more example of a global initiative, that unites the entire European Union, is the "Factory of Future Partnership" program. The program implies partnership interaction between public and private market representatives in order to create unified technological solutions, the integration of which will propel industrial production to the next level. This partnership covers all production spheres and attracts both public and private market participants in order to develop and implement:

- Advanced manufacturing technologies;
- Self-adjusting "smart" equipment;
- Automated control and planning systems for factories;
- Mobile factory systems;
- Systems of customer-oriented production.

The development of new technological solutions and new models of production organization is a potential source of knowledge and technologies of the "Know-How" level, providing a global advantage and competitiveness.

For this reason, all the world's industrial leaders have joined the race to develop advanced production technologies.

In some sort, the American Advanced Manufacturing Partnership initiative served as a response to the German Industry 4.0 program [3].

American and German approaches agree on the need to combine physically flowing production processes and virtual management, modeling and control systems. The differences relate to the approach to the implementation of the set tasks. According to the American initiative, the main obstacle to the rapid development of both technologies and models of their integration into the real industrial sector is the existence of a gap between the stages of fundamental study (funded by the state) and the development of innovative products (funded by industrial companies). Главным средством преодоления данного

разрыва, являются «Институты производственных инноваций» (Institute of Manufacturing Innovation, IPI). IPIs are public-private partnerships with parallel funding, the main purpose of which is to bring together all parties, interested in the development of a particular party technology. In general, IPI specializes in a particular disruptive technology and provides collaboration between researchers, investors, manufacturers and end users of that technology. To date, about 15 IPIs have been formed in the USA. The best known IPI is "America Makes" for additive technologies.

The Advanced Manufacturing Partnership program is part of a comprehensive process to develop the digital excellence of American industry. It should be understood, that the development and, often, the functioning of modern breakthrough technologies is largely based on the computing capabilities of modern computers. The "High-End Computing Revitalization Act", initiated by the Ministry of Energy in 2004, was aimed at solving the problem of creating sufficient computing capacities.

It was the development of supercomputer technology and the opening of supercomputer centers with a huge productive resource, that served as a qualitative foundation for the accelerated development of modern digital technologies.

China has a strong developing economy and today is the world leader in many industries. However, the high dependence on foreign technologies and foreign highly qualified personnel does not allow the Chinese industry to compete in the field of high-tech production of science-intensive products with high added value. The 10-year program for the development of Chinese industry "Made in China 2025" is aimed at increasing competitiveness in high-tech industries [4]. This program has become most relevant in recent years in connection with the trade war between China and the United States.

Reducing scientific and technological dependence on other countries is ensured by solving 9 priority tasks:

- Stimulation of innovative activity in industry;
- Harmonization of technologies and industry;
- Strengthening the industrial base;
- Development of Chinese brands;
- Implementation of "green" technologies in production;
- Restructuring of the industrial sector;
- development of service-oriented industry and production services;
- Internationalization of production;
- Breakthrough in 10 key industry sectors.
- The key industries are:
- Power industry;
- Agricultural equipment;
- New materials;
- Energy-saving systems and transport systems using alternative fuels;
- Robotics and numerically controlled systems;
- Information technology;
- Aerospace industry;
- Railway machinery and equipment;

- Construction of high-tech ships and marine equipment;
- Medicine and medical technologies.

Advances in these fields should increase the share of its own products in China's domestic markets. However, China's industrial development program has more global goals. Upon completion of the first phase by 2025, subsequent development is aimed at securing global leadership and increasing the share of Chinese producers in the global market of high-tech industries.

Other Asian countries, such as Japan, are also associated with the development of advanced production and modern digital technologies. However, these countries have a higher scientific and technological premise and today are world leaders in the field of digital technologies.

Japan is of particular interest in this context. Like other developed countries, Japan is using modern achievements of science and technology to transform the existing production capacities, with the aim of forming a digital industry. However, the Japanese government and representatives of big business (the national business federation "Keidanren") consider the attraction of digital technologies in the context of the development of the whole society. Modern digital solutions are considered as a universal tool for solving modern problems of Japanese society:

- reduction and aging of working population;
- The decrease in the global competitiveness of production;
- The need to update the infrastructure;
- Ecological problems;
- Shortage of natural resources;
- Issues of counteraction to natural disasters.

The concept of changing the socio-economic formats of Japanese society was named "Society 5.0" [5]. This concept is aimed not only at solving the above problems, but also at the formation of a superintelligent society, capable of using modern information technologies and harmoniously coexisting in the digital age. New technologies are designed to optimize the resources of not just one individual person, but society as a whole, through the integration of physical and cyber spaces. However, such a transformation causes significant concerns on the part of society itself. As a result, one of the main tasks of the government is to put across its vision of the advantages of the modern digital world. In addition to this obstacle, there are four more "walls": the wall of the ministry and departments; the legislative system; technologies as well as human resources.

Thus, the transformation of industry is impossible without the transformation of all spheres of life and activities of the state.

The key industrial digitalization programs in the Russian Federation are:

"Strategy for scientific and technological development of the Russian Federation until 2035". [6] This program forms the goals and objectives of the scientific and technological development of the country, and also determines the main directions and priorities of state policy in this field. Within the framework of this program,

for the first time, such a term was formulated as "big challenges" - significant risks and problems, facing the society, economy, and government of the Russian Federation. Cope with these problems is possible largely due to the development of science and technology.

The "big challenges" include:

1. Raw material dependence and the digital revolution.
2. Population aging and new diseases.
3. Depletion of natural resources and environmental degradation.
4. Food safety.
5. Generation and conservation of energy.
6. Threats to national security.
7. Development of the country's territory, the World Ocean, the Arctic, and the Antarctic.

• National Program "Digital economy" [7]. This is a large national project, launched in the Russian Federation and covering many different directions. By 2024, the state intends to carry out a comprehensive digital transformation of the economy and social sphere of Russia.

To this goal, it is planned to develop a legal framework, regulating the use of digital technologies, modernize the country's digital infrastructure, implement digital practices in all key spheres of the economy and public administration, and also organize training for personnel with relevant digital competencies. It should be noted, that within the framework of this program, many federal projects of various directions are being developed. In particular, the federal project for the development of digital technologies is highlighted. The goal of this federal project is to create a support system for search, applied studies in the digital economy, ensuring technological independence in the areas of end-to-end digital technologies, that are globally competitive, and national security. Within the framework of the federal project, a list of "end-to-end" technologies, the development of which attention is paid, is also provided. Within the framework of this project, nine "end-to-end" technologies are identified for the development of each of which the so-called Competence Centers of the National technology initiative (NTI Centers) were formed.

The NTI Competence Center is a structural subdivision, created on the basis of a university or a scientific organization, which carries out the integrated development of "end-to-end" technologies through:

1. Translation of the results of fundamental science into engineering applications. This implies the adaptation of fundamental scientific studies and ideas into applied technological solutions in the interests of certain industrial partners.
2. Technological transfer through cooperation with industrial partners. NTI centers contribute to the formation of communications and interactions between organizations, associated with the development of scientific and technological premise and industrial representatives, interested in such a result.
3. Training leaders in the development of new technologies through the implementation of educational programs. NTI centers create and implement appropriate educational programs with the aim of training specialists,

who can successfully realize their potential in the digital economy conditions.

- National technology initiative (NTI) [8]. This initiative is a long-term comprehensive program to create conditions for ensuring the global technological leadership of the Russian Federation by 2035 by “growing national champions” for the high-tech markets of the future. The proposal on the need to modernize Russian industry in accordance with the new technological order and the challenges, that will await Russia in solving the problems of state security and improving the quality of life of people in the next 10-15 years, was disclosed by the President of the Russian Federation V.V. Putin in his Address to the Federal Assembly on December 4, 2014. Analysis of world experience and current trends in the development of technological solutions made it possible to form a development strategy, supervised by the Agency for Strategic Initiatives (ASI) and the Russian Venture Company (RVC).

NTI is initially built as a broad coalition action, involving the formation of project teams, made from technology entrepreneurs, representatives of leading universities and research centers, large business associations of Russia, development institutions, expert and professional communities, as well as interested executive authorities.

The function of the leader is assigned to the domestic high-tech business, companies with the "NTI gene". In addition, NTI, being a national program, does not deny the need for international cooperation, but, on the contrary, supports this direction of work. Cooperation with international partners is the key to the success of domestic high-tech companies in the world of global technologies [9].

The graphic interpretation of a certain logic of the formation of interaction between all participants in the NTI is called the Matrix of the National technology initiative (NTI Matrix).

The NTI matrix is formed according to the principle of a spiral: we are talking about the development of new markets in the Russian Federation, based on breakthrough technologies, the development of which can be attracted by a minimum - sufficient density of talent, for the development of which support tools are oriented or created, that work in a service model.

The main goal of the program is the formation of fundamentally new "markets of the future" and "growing" of "national champions" in these markets. NTI markets are promising sectors of the world industry, which will potentially be formed in 15 - 20 years and meet the following criteria:

- The market will become significant and remarkable on a global scale. We are talking about the volume of the market - more than \$ 100 billion by 2035.
- The market will potentially have a network nature, which is reflected in the presence of "Net" in the name.
- The market is preferably orientated on the needs of people as end users (B2C priority over B2B).

- The market is important for the Russian Federation in terms of meeting the country's basic needs and security.

- Within the market, there are conditions for achieving competitive advantages and occupying a significant market share.

Today, within the framework of NTI, 12 key directions are identified ("high-tech NTI markets"), which, in accordance with analysts' forecasts, will be the most relevant on a global scale as of 2035. A working group, formed within each market, ensures the development of a development strategy for the chosen direction and the implementation of this strategy by attracting intellectual, material and other resources. The following NTI markets are distinguished:

- AutoNet is a market for the development of modern land vehicles, as well as related services and systems, implemented on the basis of intelligent platforms, networks and infrastructure in the logistics of people and things.

- AeroNet is a market for distributed systems for unmanned aerial vehicles.

- MariNet is a market for intelligent systems of management of maritime transport and technologies for the development of the world's oceans.

- NeuroNet is a market for human-machine communication tools, based on advanced developments in neurotechnologies, that increase the productivity of human-machine systems, the performance of psycho and mental processes.

- HealthNet is a market for personalized medical services and medicines, that provide an increase in life span, as well as new effective means of preventing and treating various diseases.

- FoodNet is a market for the production and sale of nutrients and final types of food products.

- EnergyNet is a distributed energy market, that includes both the creation of flexible distribution networks and modern digital platforms for supplier-consumer interaction.

- SafeNet is a market for the security of networks and computer technologies, aimed at protecting personal and confidential data in the process of storage and any use.

- FashionNet is a market of small-scale / piece production of personalized clothing and accessories, with the involvement of modern technologies at all stages of production and sale of manufactured products.

- MediaNet is a market for communication and information exchange between people, organizations, and the mass media.

- EduNet is an education market, based on network and platform principles.

The technology market - TechNet deserves special attention [10]. The above listed 11 NTI markets are largely based on a number of breakthrough technologies, called "end-to-end technologies".

End-to-end technologies are key scientific and technical directions, that have the most significant influence on the development of markets. These technologies simultaneously cover several trends or industries. With the

goal of developing Russia in accordance with global technological trends and increasing the competitiveness of Russian industry, special attention is paid to one of the most important "end-to-end technologies" - advanced manufacturing technologies.

The high-tech market TechNet is focused on the development of this "end-to-end technology".

TechNet is a cross-market and cross-industry direction, that provides technological support for the development of NTI markets and high-tech industries through the development of advanced production technologies, including the following "subtechnologies": digital design and modeling, new materials, additive technologies, CNC-technologies and hybrid technologies, robotics, enterprise management information systems, Smart Big Data and the industrial Internet of Things.

However, none of the single advanced manufacturing technologies can provide long-term competitive advantage in the marketplace. Such an advantage can only be provided by systems of integrated technological solutions, that provide, in the shortest possible time, the design and production of globally competitive products of a new generation - "the Factory of Future" (FoF).

4. CONCLUSION

The constant severization of requirements for the quality and characteristics of final products, as well as the process of globalization, stiffer competition. The improvement of technologies leads to the fact, that technological processes in industrial productions and final products are becoming more complex and diversified. The demand for a maximum consideration of individual customer requirements is increasing. There is a need for mass customization and even personalization of products when the product is manufactured for a specific customer. However, at the same time, competition requires bringing products to the market faster and faster, and this, in turn, requires the acceleration of production processes.

The digital development model assumes not only a total digital transformation of the economy into a "digital economy" and high-tech industry into a "digital industry", but also taking into account the triad of requirements of modern global markets, related to the reduction of decision-making time (Time-to-Decision, T2D), a significant reduction in the time of execution/implementation of projects (Time-to-Execution, T2E) and a significant reduction in the time to bring products to the market (Time-to-Market, T2M), where the market means the global market.

Digital data is becoming a key production factor. Their analysis allows to significantly increase the efficiency of various types of production, technologies, equipment, etc. [12].

The digital industry is a modern high-tech industry with fundamentally new approaches to the development of new products, based on a multi-level matrix of targets and resource constraints, digital automation platforms and intelligent assistant systems, designed to develop digital

twins, develop virtual benches and test ranges, and perform virtual tests. All this provides a significant reduction in the volume of field tests and a reduction in the time and cost of new product launch. A total restructuring of the process of development, production and service of products is taking place.

REFERENCES

- [1] German Standardization Roadmap: Industry 4.0. Version 3, DKE Deutsche Kommission Elektrotechnik - March, 2018.
- [2] Horizon 2020: European Commission, 2020. <https://ec.europa.eu/programmes/horizon2020/en>
- [3] A National Advanced Manufacturing Portal. <http://www.manufacturing.gov/>
- [4] Made in China 2025. Institute for Security & Development Policy, 2018. <http://isdpeu/content/uploads/2018/06/Made-in-China-Backgrounder.pdf>
- [5] Society 5.0. Science and Technology Policy, Council for Science, Technology and Innovation, Cabinet Office, Government of Japan.
- [6] Strategy of scientific and technological development of the Russian Federation, 2016.
- [7] National Program "Digital Economy of the Russian Federation", Government of Russia - Electron. portal - <http://government.ru/rugovclassifier/614/events/>
- [8] National Technology Initiative. <https://nti2035.ru/>
- [9] National Technology Initiative. Agency for Strategic Initiatives. <https://asi.ru/nti/>
- [10] Association "Technet", Infrastructure center "Technet". <https://technet-nti.ru/>
- [11] N.V. Vasilenkova, Global trends in the development of the digital industry, 64th International Scientific Conference of Astrakhan State Technical University, 2020, 306 p.
- [12] N.V. Vasilenkova, Modern technologies of industrial management in Russia, Recent Trends in Science and Technology Management, 2 (2020) 41-45.