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Industry 4.0 Development Prospects and Introduction Readiness into Russian Enterprises

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Abstract. Today the competitiveness of the Russian economy is closely dependent on the successful introduction of new digital technologies into the domestic industry. In the study, the authors analysed features of the industrial revolution in Russia and other countries. It was discovered that the industrial Internet is currently underutilized in the Russian market. However, one of its notable characteristics is the dominance of the industrial segment in the Russian Internet of Things, which indicates promising development prospects for the industrial Internet technology in Russia. The authors also analysed readiness of Russian enterprises to introduce Industry 4.0 technologies. Although the enterprises clearly expressed their readiness to implement digital technologies, there are some objective difficulties that set back the process. The main obstacles that prevent the integration of the industrial Internet into the Russian industry are insufficient flexibility of enterprises, a lack of developed digital business models of companies, a shortage of skilled personnel, and limited funding. In the conclusion, the authors set some objectives that need to be addressed in order to facilitate the development of the industrial Internet in Russia based on the findings of the study.

1. Introduction

In the recent decades the world economy has entered the active development stage of the fourth industrial revolution. As today many countries compete in the implementation of Industry 4.0 technologies, it is especially vital to consider introducing a digital technology platform into Russian industries. More advanced industrial Internet projects will result in increased productivity of the industry, which in turn will significantly benefit the world and the Russian economies [1]. As it was reported at the World Economic Forum in Davos, technological developments in the area of cyber physical systems, in particular of the Internet of Things, cloud and quantum computations, the Big Data, biotechnologies, autonomous robots, virtual and augmented realities, 3D modelling and 3D printing, can bring more than \$30 trillion to the world economy in the next 10 years [2].

The term Industry 4.0 was first publicly used in 2011. Since then it has been used to describe a widespread application of information and communication technologies in industrial production. Once it is efficiently incorporated into an industrial enterprise, the industrial Internet introduces innovative cyber physical approaches in production organisation, maintenance and management. However, this term often gets misinterpreted as only referring to technological aspects, but in reality, it also requires changes in a company's organizational structure and culture. The ultimate goal is to become a constantly developing and flexible company that is always ready to quickly adapt to a changing environment.



Recent years saw effective introduction of the industrial Internet, which is as a component and the most significant development pathway of the industrial revolution, into Russian industrial enterprises as well [3]. Many major projects have been successfully launched. Moreover, a platform for further development of the industrial Internet is being designed. Although these examples demonstrate a clearly successful pathway of the industrial Internet in Russia, there are still some obstacles that prevent its complete implementation into industry [4]. The primary one is a low level of readiness of Russian enterprises to digitalize their production processes by introducing industrial Internet technologies. The purpose of the study is to analyse readiness of Russian enterprises to implement the key principles of the Industry 4.0 programme, and to set primary objectives that need to be addressed in order to facilitate the development of the industrial Internet in Russia. The named purpose requires the following steps:

- 1) the study of the international experience in the Industry 4.0 integration,
- 2) assessment of the current state of the industrial Internet in Russian enterprises,
- 3) an analysis of factors of the Russian economy that hinder integration of industrial Internet projects,
- 4) an analysis of readiness of Russian enterprises for digitalization and introduction of industrial Internet projects,
- 5) setting objectives that could facilitate development of the industrial Internet in Russia.

2. Theory

The theoretical basis of the study was works of some leading contemporary Russian and foreign scientists with theoretical and practical expertise in development of the industrial revolution and its integration into economies of many countries, including Russia. Their works address issues of the emergence of the industrial revolution, its possible development pathways and impact on the economy and the social life. Some works focus on some general issues of the modern industrial revolution [5, 6, 7]. Some study the impact of the Internet of Things on industrial production [8, 9]. Others examine the actual implementation of the Internet of Things into industrial enterprises [10]. In their works, scientists estimate the impact of the industrial Internet on competitiveness of various production sectors [11, 12], and describe some principles of working with the Big Data with the use of Internet technologies [13]. The impact of intelligent technologies on the social and psychological and the economic spheres is studied as well [14]. However, it should be noted that the contemporary literature does not provide a comprehensive analysis on features of the industrial Internet and its development in the Russian economy. The present paper aims to cover the gap as it focuses on estimating the current state and some development prospects of the Industry 4.0 concept in Russian enterprises.

When studying possible development pathways of the industrial revolution in theory and practice, particular attention should be given to the international experience in the Industry 4.0 integration and the results of international forums and conferences dedicated to the Industry 4.0 development. The concept of the fourth industrial revolution called Industry 4.0 was presented for the first time at the Hannover Fair in 2011. It was introduced as the integration of cyber physical systems into production processes [15]. In 2011 the USA launched the Cloud Computing Strategy program [16] aimed at realisation of modern technological ideas in order to create smart industrial production. In 2010 the EU introduced the Digital Agenda for Europe program [17]. In 2016 the Eurasian Economic Commission presented its digital industry development program called Digital Market and Industrial Digitalization: Questions and Answers. In 2015 the Internet Plus concept was announced in China. It comprised the most successful initiatives of the world's leading countries on introduction of Internet technologies into industrial and financial sectors, medical system and agriculture.

As projected by the McKinsey Global Institute, the Industrial Internet of Things may be contributing about 11% of the global GDP to the global economy by 2025. In addition, by 2025 its impact on the average annual GDP growth rate is estimated to be ranging from \$3.9 trillion to \$11.1 trillion based on pessimistic and optimistic projections respectively [7]. The statistics show the extensive use of the industrial Internet around the world. Analysts at Ericsson believe that globally by

2021 of 28 billion devices connected to the Internet about 16 billion will be related to the Internet of Things.

Therefore, based on the international experience in the Industry 4.0 implementation, it can be concluded that the integration of modern technologies into industry is currently at its active stage. It is recommended to introduce a new digital technology platform into the domestic industry to ensure competitiveness of the Russian economy. The relevance of the research implies methods of assessing enterprises' readiness to implement the industrial Internet technologies and primary objectives facilitating the digitalization of production processes in Russian enterprises.

3. Research Methods

The study was based on works by leading Russian and foreign scientists on statistics, financial and economic analyses and modern information technologies of data storage and processing. The current state of the Industry 4.0 implementation in Russian enterprises was estimated with the use of the comprehensive economic and statistical analysis of the Russian industry. Its present development trends were described with methods of mathematical statistics and expert evaluation. The study was based on data taken from the state statistical reporting.

Readiness of Russian enterprises to introduce Industry 4.0 technologies was determined via the Acatech Industry 4.0 Maturity Index developed by the German Academy of Science and Engineering [18]. The method is used to assess the current level of Industry 4.0 readiness of industrial enterprises and detect those spheres that require further action. It allows enterprises to systematically identify their weaknesses and capabilities and establish an individual Industry 4.0 implementation plan appropriate for their business strategies based on its results. The Acatech Industry 4.0 Maturity Index helps to determine the current stage of an enterprise in their transformation into a constantly developing and flexible company. An enterprise is assessed on the basis of its technological, organizational and cultural aspects with emphasis on its business processes. When applying the method, a company is required to strategically choose some particular advantages that need to be achieved, determine business priorities and establish a plan of appropriate actions. The final result is identification of a company's main failures and difficulties in the Industry 4.0 realisation and a proposed course of action with recommendations on its comprehensive digital transformation strategy development. Figure 1 shows the method application process.

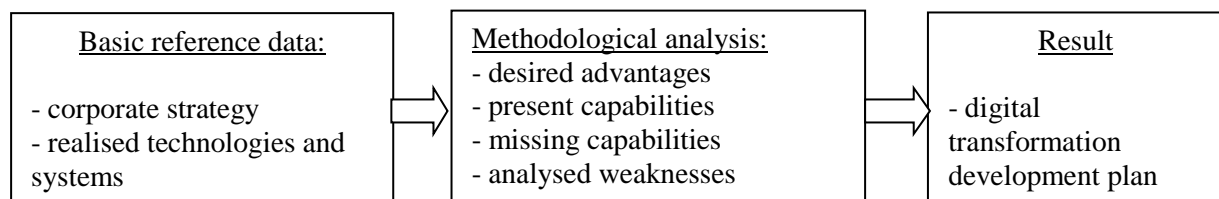


Figure 1. Analysis of an enterprise's digital transformation maturity index.

This method allows enterprises to run a comprehensive analysis to determine a range of guiding principles that demonstrate which characteristics need to be developed for successful introduction of Industry 4.0 projects. In the study, this method was applied on the basis of survey answers given by directors of domestic companies in various economic sectors throughout the country.

4. Findings and Discussion

Firstly, some characteristics of the industrial Internet introduction in Russia were addressed. A comprehensive analysis of the state statistical reporting with methods of mathematical statistics showed that Russia is currently at an early stage of the industrial Internet introduction. However, the industrial segment dominates on the Russian Internet of Things. In 2016 its share was 64%, while the cross-industrial segment had 20%, and the state and the consumer segments had about 8% each [19]. It

indicates promising development prospects for the industrial Internet technology in Russia. It should also be noted that the industrial Internet introduction into Russian enterprises significantly differs according to a region. The analysis of the development rate of the Russian industrial Internet of Things showed that in 2017 there were 17.9 million devices, which indicated the increase in their number by 42% compared to 2016. By 2021 the overall number of devices connected to the Internet of Things is estimated to reach 79.5 million and by 2026 - 164.7 million. Widespread introduction of the industrial Internet can result in an increase in the global GDP by \$10-15 trillion in 20 years [20].

Russian enterprises that are planning to utilize industrial Internet projects have already begun to establish a digital model of their production business process primarily focusing on efficient data management. Elimination of digital gaps in a production process is exactly one of the prospects for the industrial Internet. Rostelecom is one of the leading Russian companies in this area, as it also acts as an engineering centre for a digital support of a product life cycle. The company is currently developing an industrial Internet platform. Their research is based on the analysis of the most effective solutions of developed countries adapted to the Russian market. Rostelecom also facilitated the establishment of the National Association of the Industrial Internet Market Participants. Among public and government organisations currently working on an industrial Internet development strategy in Russia, the Ministry of Industry and Trade of the Russian Federation can be mentioned, as it is preparing a road map for the Internet of Things development with the assistance of the Internet Initiatives Development Fund. However, organizational and legal aspects of implementation of innovation-oriented production processes as part of the information and communication technologies development have not been thoroughly determined yet.

The analysis of Russian enterprises' readiness to introduce Industry 4.0 projects based on the Acatech Industry 4.0 Maturity Index (Figure 1) showed that although the enterprises clearly expressed their readiness to implement digital technologies, there are some objective difficulties that hinder their introduction into Russian enterprises. Results of the survey which involved domestic companies' directors in various economic sectors throughout the country conducted in mid-2018 displayed the following [21]:

- 32% of the enterprises confirmed their readiness to introduce the Internet of Things technologies into their production processes.
- 11% of the enterprises have already introduced the Internet of Things technologies into their production processes.
- 57% of the enterprises do not use the Internet of Things technologies.

Industry 4.0 Maturity Index results and statistical studies of development trends and prospects of particular enterprises, industries and industry groups were used in an analysis of factors of the Russian economy that prevent integration of industrial Internet projects and setting primary objectives that can facilitate development of the industrial Internet in Russia.

The analysis also showed that currently it is mostly utilized in automated data collection systems at industrial facilities, for example, in mechanical engineering, the energy and the mining industries. Machine-to-machine communication is being developed mostly by transportation companies that efficiently apply navigation systems. Positive trends include the market share growth of companies incorporating information management systems in their production. Between 2013 and 2018 their market share increased from 25% to 30%. These systems are primarily integrated into the communication industry, the chemical industry, the electrical equipment production and metallurgy.

The methodological analysis of enterprises' readiness for digital transformations with emphasis on SWOT analysis of enterprises revealed some factors that set back industrial Internet integration into production processes in Russia.

Internal factors include:

- insufficient flexibility that does not allow for real-time changes in the company;

- poor business models development in the company;
- a shortage of qualified personnel with expertise in modern technologies;
- limited funding.

External factors include:

- low awareness of technologies and their poor accessibility;
- insufficient legal framework on IT technologies;
- understudied information protection and security measures in dealing with data;
- mindset and bureaucracy.

Therefore, ensuring accessibility and security of modern Big Data processing technologies, cloud and quantum computations, smart devices usage, robotics and computerized management systems is of a high priority for businesses and the state; its successful realisation will lead to the situation when a higher number of Russian enterprises will join the industrial Internet system.

Based on the findings of the research described above, some objectives that can facilitate the development of the industrial Internet in Russia were set. These objectives are the following:

1. development of an accessible Internet of Things platform for collection, storage and processing of data;
2. establishment of information and telecommunication infrastructure to ensure technological accessibility of new Internet technologies,
3. establishment and development of enterprises, a business model of which allows for the Internet of Things integration,
4. establishment of a domestic market for connected devices that may interact with the Internet of Things platform,
5. public or public and private funding of industrial Internet projects implementation, support for pilot projects,
6. support for domestic developers of high-technology products and for research on AI, information management systems and networking,
7. modification of the education system and training in IT technologies,
8. establishment of the legal framework to support the development of new technologies, ensure their legality and protect information.

5. Conclusion

The analysis of statistical data showed that the industrial Internet is currently underutilized in the Russian market. One of the notable characteristics of the Russian Internet of Things is the dominance of the industrial segment. It indicates promising development prospects for the industrial Internet technology in Russia. The analysis of Russian enterprises' readiness to introduce Industry 4.0 projects based on the survey among domestic companies' directors in various economic sectors throughout the country showed that although the enterprises clearly expressed their readiness to implement digital technologies, there are some objective difficulties that set back their introduction. In particular, the main obstacles that prevent the integration of the industrial Internet into the Russian industry were found to be insufficient flexibility of enterprises, a lack of developed digital business models, a shortage of skilled personnel, and limited funding. External factors included low awareness about technologies and their poor accessibility, insufficient legal framework on IT technologies, and understudied information protection and security measures in dealing with data. Establishment of the common digital technology platform in Russia, development of information and telecommunication infrastructure to ensure technological accessibility of new Internet technologies, as well as realization of the objectives proposed in the conclusion will result in successful implementation of industrial Internet of Things projects in the Russian economy.

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