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Russian Industrial Sector Development in the Context of New Technological Revolution*

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Abstract. The rapid spread of new technologies in all areas of human activity leads to rapid and profound changes in the structure of industrial production, global markets and the economic and social sphere. Modern developed countries seek growth sources on the basis of scientific and technological potential emerging in new information, digital and industrial technologies. Their development results in new technological revolution and accelerated productivity growth. In this regard, scientific understanding of organizational and methodological problems to form a technological basis for Russian economy growth in the context of global transformation of the world labor division system under the influence of large-scale introduction of innovative technologies of the fourth industrial revolution will develop a paradigm and methodological tools for further implementation and successful realization of digital economy in the country, focused on improving industrial production efficiency through the use of new technologies. The purpose of this article is to study trends in formation and identification of problems to develop the Russian industrial sector in the context of new technological revolution. The paper generalizes theoretical foundations of the essence of innovative reforms in the economy in the fourth industrial revolution; analyses a state and trends of scientific and technological development of the country's industrial sector, estimates a degree of readiness of its transition to digital economy; reveals functional possibilities of improving quality characteristics of the industrial sector; and determines directions of its state regulation in the conditions of digital transformation.

Key words: new technological revolution, digital economy, industrial sector development.

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Introduction. In recent decades, the world is rapidly moving to a new type of economy, with the main development tool being digital technologies. At the present stage of development, digital technologies are the main factor in technological changes, the most important condition for the competitiveness of both individual enterprises and countries. They ensure the restructure of all economic and production processes, significantly increase productivity, improving the quality and reducing the cost of goods and services.

By bringing collection, aggregation and exchange of accumulated information to a fundamentally different quality level with minimal role and degree of human participation, new technologies are becoming drivers of the fourth industrial revolution characterized by the merge of technologies and blurred boundaries between the digital and industrial sphere.

In the context of the fourth industrial revolution, industrialized countries have set themselves large-scale structural reindustrialization objectives, considering digital technologies as an accelerator of growth in world production performance. By 2025, the share of industry in GDP of OECD countries should be 20% of GDP against the current 15% in the EU and 12% in the US.

The status of Russia's high-tech sector of the economy is defined as catching up. This is confirmed by the opinion of the vast majority of researchers, experts and politicians who point to low competitiveness of domestic industry due to technological backwardness [1].

In this regard, the scientific understanding of organizational and methodological foundations of the introduction of technologies of the fourth industrial revolution will ensure successful implementation of the digital economy focused on improving the efficiency of industrial production. This represents the purpose of the presented paper.

The following objectives are aimed at achieving this purpose:

1) study the theoretical basics of innovative reforms in the economy in the fourth industrial revolution;

2) analyze the state and trends in scientific and technological development of the Russian industrial sector, assess the degree of readiness for the transition to the digital economy of the region and determine the functionality to improve its quality characteristics amid the transition;

3) determine the areas of state regulation of the Russian industrial sector amid digital transformation.

Theoretical aspects of the research. The current changes in the world have a significant impact on Russia's development. In the first half of the 21st century, in addition to "major challenges" such as exhaustion of traditional resources and their reduced management efficiency, population reduction and population ageing, lagging behind industrialized countries in life expectancy, Russia faces specific challenges, one of which is the participation in the new technological revolution [2]. This process is complicated by the introduction of sectoral sanctions by the EU and the US in 2014, which revealed a number of areas where Russia is not yet able to compete. The decline in world oil prices in 2015, in turn, not only increased the systemic economic crisis, but also raised the issue of Russia's need for radical diversification of the national economy which still largely depends on energy exports: in 2016, fuel and energy products accounted for 62% of all Russian exports to foreign countries.

One of the possible ways to solve these problems, as well as to respond to the challenges the Russian economy is currently facing is to

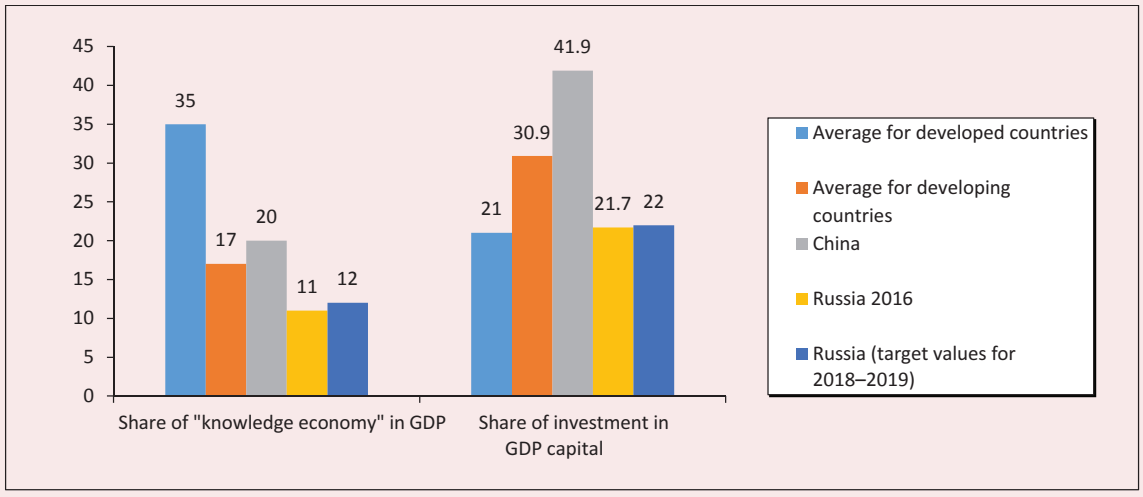
include Russia in the new technological revolution. However, we should understand that Russia's situation with the large-scale technological and industrial modernization differs from similar processes in countries that already implement similar programs [3].

The main drivers of the new economy are intangible assets, cooperation of innovation participants, company's cognitive abilities and human abilities. It is these components of competitiveness in the global markets of new goods and services that need target support. A human and a cognitive subsystem and related industries make up the "knowledge economy" [4]. In countries leading in new technologies, this understanding is reflected in the structural investment policy covering the branches of "knowledge economy" and basic industrial sectors (*Fig. 1*).

The negative trends in Russia's development of knowledge economy and the national economy as a whole can be overcome by shifting towards a new model of economic growth through the introduction of new advanced technologies that significantly increase productivity. At the same time, the country significantly lags in a number of scientific and technological indicators, which should be the subject of state policy aimed at addressing the problems of new industrialization. Within the framework of this policy, it is necessary to set clear goals, objectives, structural and technological priorities, form appropriate tools and support mechanisms for their successful implementation [5].

Note that the development of global industrialization (mid-18–19th century) was accompanied by rapidly growing productive forces [6]. The transition of the economy to industrial production was facilitated by the first industrial revolution, which ensured the transition from manual to machine labor. It is traditionally linked with the invention of a steam engine in the 17th century. The second industrial revolution (20th century) was connected with electrification and helped organize belt-line production of cars at first, and

Figure 1. Share of "knowledge economy" and fixed capital investment, % of GDP



Source: Nikonova A. The potential and tools of growth of innovative industries in the process of formation of a new way of economy: a system approach. *Economist*, 2018, no. 10, pp. 20–39.

later – of many other goods. At the beginning of the 21st century, economic progress was ensured through the achievements of the third industrial revolution, which is based on the shift towards renewable energy, the introduction of computers, and industrial automation.

J. Rifkin identified five principles or pillars on which the third industrial revolution is based: 1) shifting to renewable energy; 2) transforming the building stock of into micro-power plants; 3) deploying hydrogen; 4) using Internet technology; 5) producing electric vehicles [6]. Consequently, it can be noted that the features of the third industrial revolution are not yet observed globally and their important property is lack of synchronicity of distribution.

However, many researchers believe that the world is on the threshold of the fourth industrial revolution, involving the introduction of cyber-physical systems in production (Industry 4.0).

According to the German economist K. Schwab, a fundamental difference of the fourth industrial revolution is the synergy effect that arises from the merge of different technologies: computer, information, nano-technology, bio-technology, etc. Another feature may be the blurring boundaries between the physical, digital (information) and biological (including human) world. The main features of the fourth industrial revolution are the "ubiquitous" mobile Internet, miniature production devices, artificial intelligence, and learning machines [7].

To date, the most developed countries are shifting from industrial to information society, forming Industry 4.0, which characterizes the organization of production processes based on network interaction of technologies and devices in the value added chain, and implies continuous communication at all levels. According to Klaus Schwab, Chairman of the World Economic Forum in Davos, the fourth industrial revolution is characterized by technological breakthroughs in artificial intelligence, robotics, the Internet of things (IoT), self-driving cars, 3D printing, nano-technology, bio-technology, materials science, energy storage and quantum computing.

Analysis of the current state of research in this area has shown that the global industrial strategy reveals a fundamental innovation – the development of information and communication technologies is no longer considered as one of the goals of growth and development, but as a source of systemic transformation of the entire industry and the economy as a whole. A clear illustration of the widespread digital technology in many areas of the modern society is rapidly growing capitalization of IT companies. In recent years, IT companies rank firs in the list of the most expensive companies in terms of capitalization. A similar pattern is observed among expensive brands in the world. The top 10 most valuable brands according to Forbes includes five IT companies represented by Apple, Google, Microsoft, Facebook, and IBM.

At this stage of industrial development, electronics, computer, information and Internet technologies cover the entire economy, ensuring horizontal and vertical integration of all business processes. The introduction of network interaction between machines, buildings and information systems changes the "paradigm" of technological development and forms a new digital economy [8, 9].

According to the study, nowadays there is no common understanding of the phenomenon "digital economy" in the world. Many researchers agree that the very concept of "digital economy" appeared in the 1990s. The ideology of the concept under study in 1995 was outlined by Nicholas Negroponte. The American computer scientist described

digital economy in the form of the following metaphor: "the transition from the movement of atoms to the movement of bits".

A number of researchers understand digital economy as an area of economy in which processes of production, distribution, exchange and consumption operate on the basis of digital technologies. Others consider the concept from the philosophical and conceptual point of view, considering digital economy as a new socio-cultural and economic reality, a new civilization based on the use of binary codes and the result of a new digital product and capital, and in the future – new relations, augmented reality (transformation of nature and industrial relations, changes in their subject-object focus, according to K. Schwab – the transformation of mankind) [7, 10].

The definition of digital economy is reviewed in the Strategy for the information society development in Russia for 2017–2030, published in December 2016, where digital economy is referred to as activities with the key factors being data in digital form [11].

Note that the interpretation of the terms "the fourth industrial revolution" and "digital economy", the definition of their relations is ambiguous in the works of foreign and domestic experts. In this article we consider digital economy and its technologies as the basis for the fourth industrial revolution.

It is known that the set of technologies characteristic of a certain level of production development represents a technological mode. This term was introduced by Russian economists D.S. Lvov and S.Yu. Glazyev. According to S.Yu. Glazyev, the scientific and technological progress triggers a transition from lower to higher, progressive modes [12]. Each of these modes covers a closed reproduction cycle from mineral extraction and training to non-production consumption. This thesis is supported by C. Perez, who argues that the new techno-economic paradigm is developing in the process of diffusion of new technologies, which leads to their multiplicative impact on the economy, changing the socio-institutional structures [13].

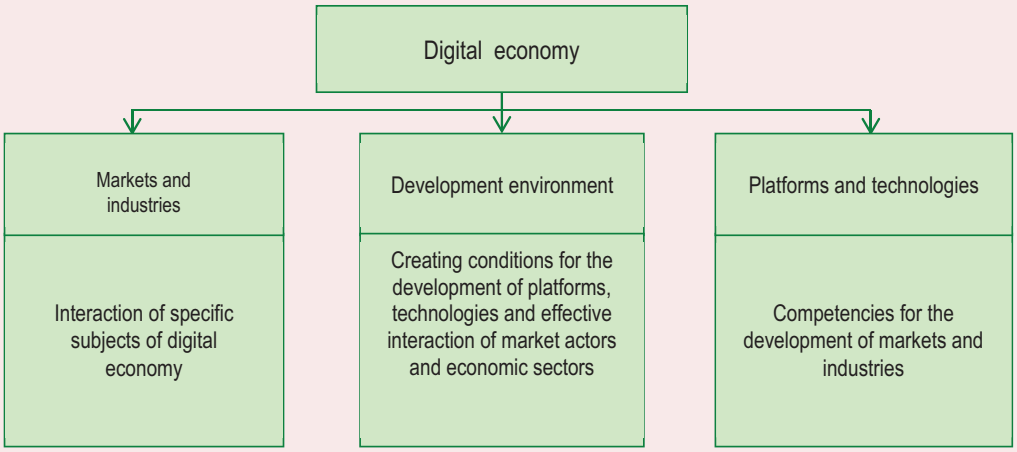
Thus, it is possible to define the techno-economic paradigm as a set of the most successful and profitable practices that exist amid the need to choose the primary material, methods and technologies within organizational structures, business models and strategies. These mutually compatible principles and criteria are developed through using new technologies, overcoming obstacles and finding the most appropriate procedures, established practices and structures. Thus, digital economy as a new form of economic activity of the society and socio-economic relations within it is a response to the changes occurring in the world during the transition from one state to another, from the fifth to the sixth technological mode. It is this form that will become the basis for maintaining and increasing the countries' pace of socio-economic development.

The modern digital economy is formed as a result of close interaction of three levels (*Fig. 2*).

Digital economy is based on the most promising technologies, which, according to researchers [14, 15], will have the most significant impact on various fields of activity in all world countries: artificial intelligence, augmented reality, VR, unmanned aerial vehicles, block chain, Internet of things, 3D printing, robotics, etc.

In the framework of digital economy, the world is moving to a different – technogenic – civilization, with a decisive role of constant search and application of new technologies in its development: not only production, but also technologies of social communication and social management. In fact, it should be about

Figure 2. Levels of interaction of digital economy



the development of a country in a completely different economic environment, the environment of the so-called digital transformation, whose characteristics are the following:

– prevalence of information exchange over the exchange of physical objects in economic activity;

– knowledge (intellectual capital) rather than money (financial capital) becomes the predominant economic resource and instrument of power);

– the Internet is becoming the predominant means of mass communication;

– a network organization, rather than a hierarchy, is the prevailing organizational structure;

– self-organization (as a bottom-up management) and evolution, which sets changes from simple to complex, becomes the predominant development methodology;

– the prevailing level of information exchange is global, rather than regional or local [16].

Thus, a review of research in this area helps conclude that the change of the paradigm of economic development, the transition to a new technological revolution and the formation of digital economy is becoming extremely important for Russia.

Description of research methods. The methodological framework of the study lies in a comprehensive analysis of the development of Russia's industrial complex in the context of the new industrial revolution and economic development, focused on the introduction of digital and information technologies, serving as a technological framework for Russia's economic growth.

The logic of the study is based on analysis of two factors which we consider basic for a successful transition to a new model of technological development – the achievement of a high level of scientific and technological development of the industrial sector of economy and the implementation of effective state policy aimed at improving the mechanisms of development of Russia's industrial sector amid the new industrial revolution.

In order to identify the effect of digital technologies on the industrial sector, determine the directions of its transformation, we form an empirical framework covering the indicators of innovative economic development, as well as indicators of the real economy development.

The information framework of the study is the research of domestic and foreign economists in the field of scientific, technological and innovative development, regional economy, public administration; of researchers engaged in studying industrial and technological development, formation and implementation of the industrial policy in their correlation with the socio-economic modernization in the new industrial revolution.

Moreover, we conducted a sociological questionnaire survey into the level of scientific and technological development of the industrial sector and its readiness for the transition to information and communication technologies in the fourth industrial revolution. The sample consisted of 50 respondents who are heads of industrial enterprises in the Vologda Oblast. The in-depth research was conducted using this region as a basis since the region is industrially developed, and because it is a typical Russian region characterized by negative trends inherent in innovation and scientific and technological development. The sociological survey made it possible to assess the scale, nature and level of development of the fourth industrial revolution, as well as the emerging trends that cannot be estimated solely by quantitative indicators.

The combination of these methods made it possible to create a framework for proposals on the implementation of effective state policy aimed at improving the mechanisms of Russia's industrial development amid the new industrial revolution.

The main research results. The peculiarity of the modern world economic development is the construction of the economy based mainly on generation, dissemination and use of knowledge by world's leading countries. According to expert estimates, in recent years the vast majority of GDP growth (up to 90%) in developed countries has been generated by new knowledge-intensive products resulting from the commercialization of research and development (R&D). For Russia, the transition from an exports-commodity to an innovative type of development is also the main goal of the state policy in science and technology, a necessary prerequisite for economic modernization to ultimately ensure the competitiveness of domestic production. Therefore, the development of science and innovation, investment in intellectual capital are important components of success in achieving sustainable economic growth.

The objective of innovative development of Russia's economy is very large-scale due to its significant technological lag behind developed countries. Thus, according to the integrated Global Innovation Index[1], which, on the one hand, characterizes the opportunities for change, on the other – the final results of innovation, Russia occupies a middle position, being behind developed European countries and the United States (*Tab. 1*).

Currently, world's developed countries are undergoing active processes of new industrialization, involving the revival and further development of the real economy based on most advanced technologies.

In Russia, the digital agenda initiative in industry has become possible thanks to the implementation of similar initiatives by Western countries (*Tab. 2*).

Thus, these data suggest that global competition in the markets of production technologies is increasing. In order to maintain the direction of the fourth industrial revolution,

[1] The Global Innovation Index is compiled by Cornell University, INSEAD business school and the World Intellectual Property Organization. This index contains detailed data on the innovation activity of 126 countries and territories of the world, including 80 parameters of innovative development, including an overview of the political situation, the situation in education, the level of infrastructure and business development.

Table 1. Comparison of results of scientific and technological development of Russia and leading countries by Global Innovation ranking in 2017

Country (rank in the Global Innovation ranking)	Domestic costs of education ,% of GDP	Domestic costs of R&D, % of GDP	Patents received abroad (Patent Cooperation Treaty)	Income from technology exports and payments for technology imports, mln dollars	Researchers per 10,000 employed in the economy, people
Switzerland (1)	5.07	2.97	4115	21086.8/24404.3	55
The UK (5)	5.75	1.71	5282	49174.8/27223.0	84
Sweden (2)	7.72	3.28	3925	20922.8/11547.7	106
Finland (8)	7.16	2.93	1815	10749.9/8005.8	159
The Netherlands (3)	5.61	2.01	4218	39985.8/29427.8	62
The USA (4)	4.94	2.80	81492	113057.0/77286.0	95
Germany (9)	4.94	2.88	18008	61110.3/53079.5	81
Japan (14)	3.77	3.49	42459	29887.2/5197.0	102
China (22)	4.76	2.09	25539	n/a	17
Russia (45)	3.86	1.13	890	688.5/2043.2	65

Sources: https://www.wipo.int/edocs/pubdocs/en/wipo_pub_gii_2017.pdf; *Human Development Report 2015. Mobility and Communication Technical notes*; *Scientific indicators: 2015.* Statistics book. Moscow: NIU VShE. Pp. 394, 365.

Table 2. Foreign experience in state programs in Industry 4.0 [14]

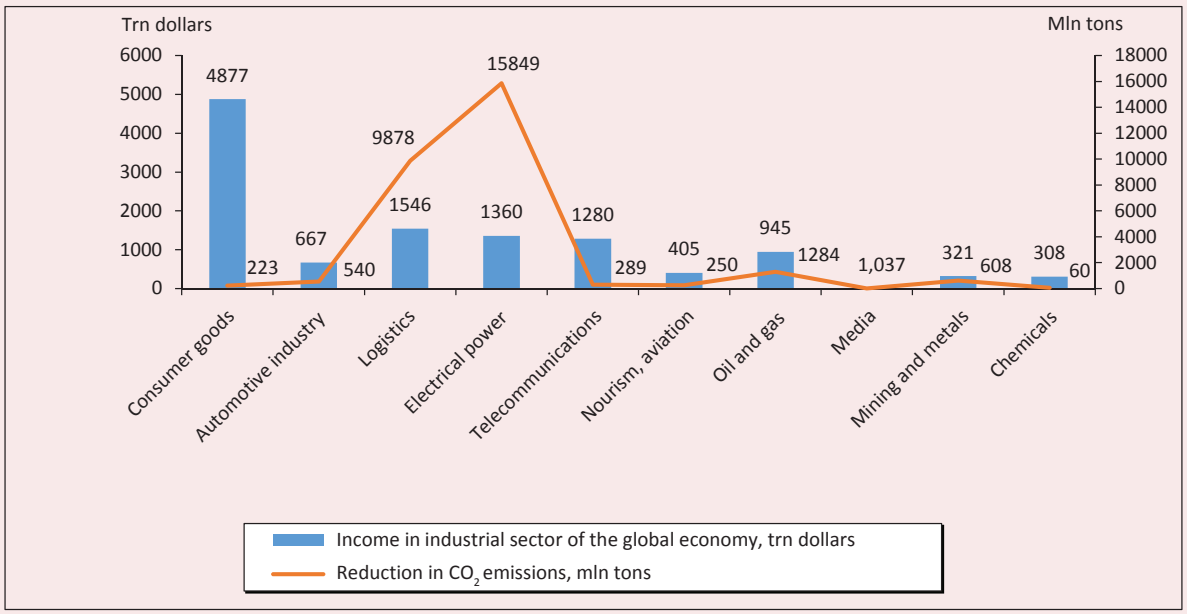
No.	Countries	Features of the program in Industry 4.0.
1.	European Union	In 2010, *the Digital Europe initiative* was adopted, aimed at the development of the Internet economy. The full implementation of this digital agenda will lead to a 5% increase in European GDP, or € 1,500 per capita, through increased investment in ICT, improved skills, creation of opportunities for innovation in the public sector and the reform of the basic conditions for the Internet economy. In April 2016, the European Commission presented the project "Digital market – digitalization of industry: questions and answers".
2.	Germany	In 2011, the *Industry 4.0 strategy* was adopted based on the concepts of the Internet of things and the industrial Internet. According to the forecasts of PwC audit and consulting company, German industrialists will invest 40 billion euros annually in industrial Internet technologies, which will help Germany fully switch to *Internet production* by 2030.
3.	China	In 2015, the concept of *Internet +* was adopted, which included the best initiatives of the world's leading countries: Internet + Manufacturing, Internet + Finance, Internet + Medicine, Internet + Government, Internet + Agriculture.
4.	The USA	In 2009, the *Cloud strategy initiative* was developed, aimed at creating smart industrial production, shops, cities and transport systems, grid technologies in the energy sector, as well as solving the problems of social interaction, e-Commerce, monitoring of supply chains of goods (including global logistics flows).

leading industrial countries are developing an appropriate industrial policy, which is reflected in programs to increase scientific, technological and industrial potential, improve innovation systems, upgrade the technological framework, primarily in manufacturing, as well as the accelerated development of high-tech industries.

At the World Weconomic Forum in 2015, the Digital Transformation Initiative (DTI) was adopted. In 2015–2016, the project focused on six sectors (logistics, media, consumer goods, electricity, automotive industry and healthcare), as well as four cross-themes (digital consumption, Digital Enterprise, social impact and management platforms).

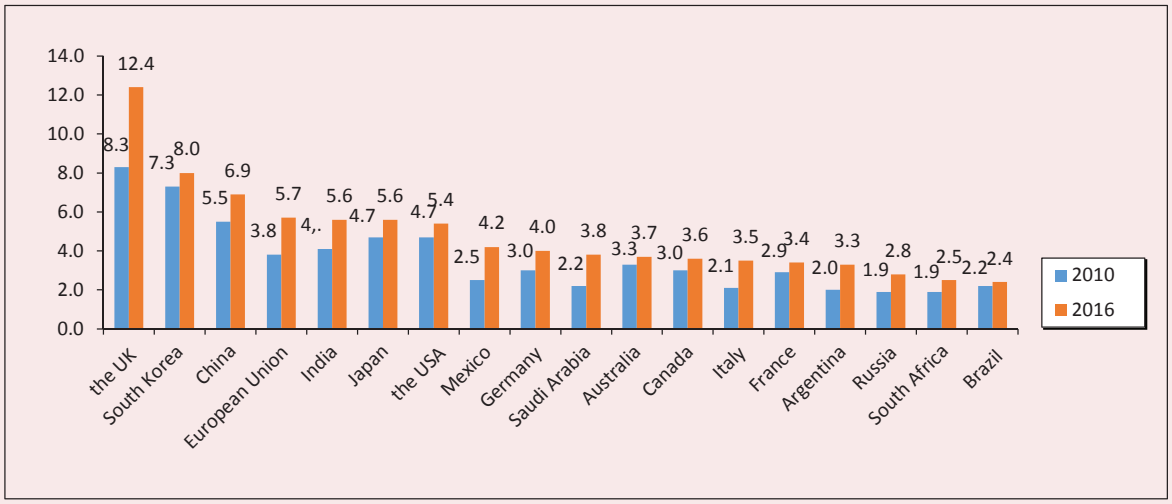
According to the participants of the Forum, industrial and public digitalization over the next decade will bring more than 30 trillion U.S. dollars (*Fig. 3*) [8]. The development of domestic economy is carried out according to a similar scenario typical for most world countries. One of the indicators demonstrating the degree of the socio-economic digitalization

Figure 3. Contribution of industry digitalization to economy



Source: *Analysis of world experience in the development of industry and approaches to digital transformation of industry of the EAEU member-States (information and analytical report of the Eurasian Economic Commission)*. Available at: http://www.eurasiancommission.org/ru/act/prom_i_ agroprom/dep_prom/SiteAssets/Forms/AllItems.aspx

Figure 4. Share of digital economy in GDP in G20 countries*



* The contribution of digital economy to the country's economy is measured by digital GDP. Quantifying the size of digital economy is difficult due to differences in approaches to measuring it. Thus, according to BCG, the level of digitalization of the country's economy is calculated through the e-Intensity index as a weighted average of three sub-indices: infrastructure development, online spending, user activity. The infrastructure development sub-index shows the degree of infrastructure development and the availability and quality of Internet access (both fixed and mobile). The Online spending sub-index includes spending on online retail and advertising. The User Activity sub-index is calculated as the weighted average of sub-indices of a lower level: companies; activity, consumer activity and activity of public institutions. All sub-indices are formed from weighted average of values from the underlying multiple parameters.

Source: *Russia online? Catch up can not be left behind: report*. The Boston Consulting Group. June, 2016.

in the country is the share of digital economy in GDP. According to Boston Consulting group (BCG) international analytical agency, in recent years world's developed countries have demonstrated a significant increase in the share of digital economy in GDP (*Fig. 4*).

The largest share of digital economy in GDP among G20 countries is in the UK, which during 2010–2016 increased the value of this indicator to 12.5%. In Russia, the share of digital economy in GDP in 2016 was almost 3%, and it increased by 0.9% over the period. However, the increase in this indicator is associated with the interest of large Russian companies in new information and digital technologies. Analysis of Internet resources and official websites of enterprises operating in different sectors of the Russian economy shows that large business is focused mainly on production management information systems (SAP-, EAM-, ERP-systems), on the transformation of the business model based on digital technologies. Nevertheless, in terms of the share of digital economy in GDP, Russia continues to lag behind the leaders of digitalization 3–4 times [17].

According to the study, innovation stagnation characteristic of the Russian economy is manifested in the fact that mass redistribution of resources in favor of progressive technological structures has not yet occurred. A steady technological lag in the industrial sector has been established. Backward production for objective reasons cannot demand high-level innovations, so they do not appear [12]. At the same time, the 3rd and 4th technological modes prevailing in the Russian industry have reached the limits of economic growth accompanied by a drop in profitability in traditional production.

This situation is confirmed by statistics on the indicators of growth in the physical volume of GRP, return on assets, return on sales and value of volume of innovative goods, works and services calculated as a whole in Russia (*Tab. 3*).

The performance of GRP growth and profitability of organizations indicates a downward trend in indicators for the period under review. According to official statistics, the share of innovative goods in the total volume of shipped goods has not exceeded 10% over the past decades on a national scale, while in the regional context there is a significant spread in the value of the indicator (from 0.1 to 28.4%).

In developed economies, the main motive for launching a new industrial and technological policy aimed at stimulating the transition to the fourth industrial revolution was the need to overcome the slowdown in productivity growth.

Russia has not yet been able to achieve stable growth in labor productivity: this is particularly clear in recent years, where periods of productivity growth and periods of decline in this indicator took turns (*Tab. 4*).

Thus, Russia faces a difficult challenge: it is necessary to ensure a steady increase in labor productivity and at the same time – to reach its maximum growth rates to fully realize the potential of the national economy.

Table 3. Performance of GRP indicators, profitability of organizations in Russia as a whole for 2000–2016

Indicator	2000	2005	2010	2012	2014	2015	2016
GRP index, increase, %	10.6	7.6	4.6	3.1	1.3	-0.6	0.8
Return on assets, %	7.6	8.8	6.7	6.1	2.5	3.9	4.9
Return on sales, %	18.9	13.5	10	8.6	7.3	8.1	8.7
Volume of innovative goods, works and services, %	4.4	5.0	4.8	8	8.7	7.9	8.4
Source: *Russia in figures. 2017: statistics book*. Rosstat. Moscow, 2017. 511 p.							

Table 4. Performance of labor productivity across countries (GDP output for PPP per employed, U.S. dollars)

Country	Year								
	2000	2005	2010	2011	2012	2013	2014	2015	2015 to 2000,%
The USA	41	52	62	63	64	65	66	67	203.0
France	40	48	58	60	61	63	64	65	203.1
Germany	38	48	57	59	61	63	64	65	203.1
The UK	36	45	47	48	48	49	50	52	179.3
Japan	27	34	37	38	41	42	41	42	190.9
Russia	8	13	23	24	25	24	26	25	by 3.5 times

Source: *New technological revolution: challenges and opportunities for Russia: expert-analytical report*. Moscow, 2017. 136 p.

One of the main conditions for increasing productivity is the technological modernization of production, including the improvement of the existing equipment, as well as putting into operation new equipment, introduction of complex automation, etc.

This conclusion is confirmed by the results of a study conducted in February 2017 by the Center for Strategic Development together with the Ministry of Industry and Trade of Russia, Center for Industry Development, and Agency for Technological Development: almost 84% of the surveyed leaders of Russian industrial enterprises consider increasing the technological level the key to increasing labor productivity.

At the system level, technological modernization should be reflected in increased capital investment, which is not currently observed in Russia (*Fig. 5*): according to Rosstat, the depreciation of fixed assets in manufacturing from increased steadily (46% against 50%, respectively) during 2008–2016.

Russia is currently lagging behind in other key indicators of the new technological revolution. The main issues include the low activity of industrial companies in implementing innovations. Only 8% of enterprises are engaged in development and implementation of innovations in Russia (*Fig. 6*). In European countries, the share of such organizations is much higher: 82% in Germany (2015), 63% in Finland, 60% in France [1].

Another challenge is to reduce the complexity of economic exports, i.e. to reduce the

Figure 5. Degree of depreciation of fixed assets in manufacturing in Russia, % [26]

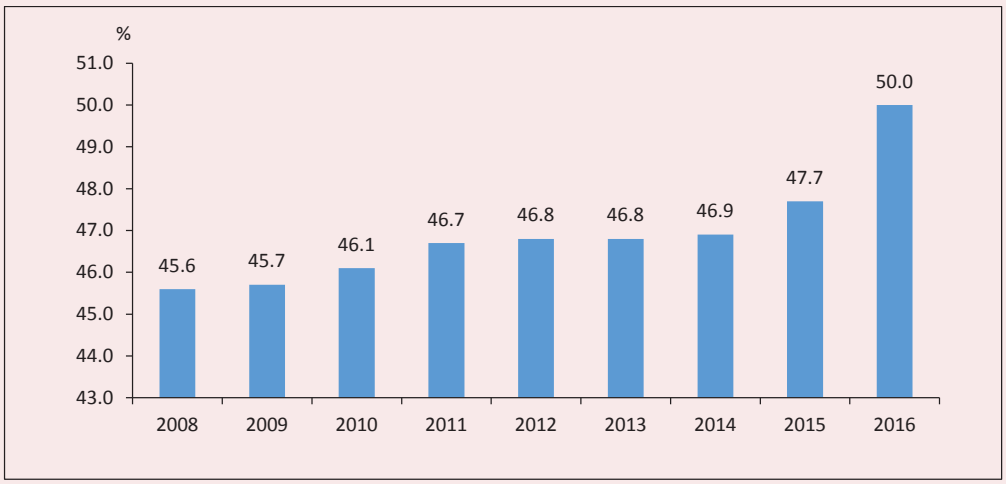
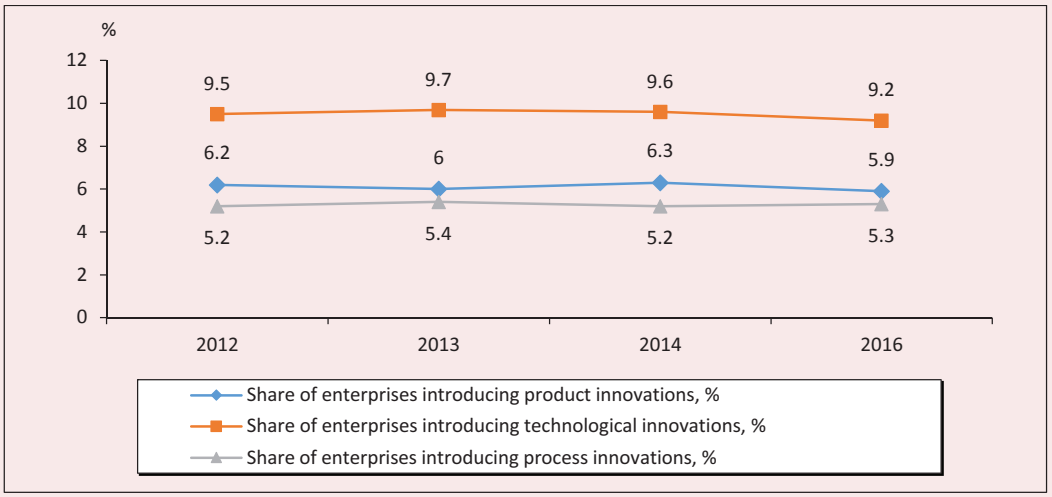


Figure 6. Innovation activity of industrial enterprises in Russia



Source: *Science and innovation*. Moscow: Rosstat. Available at:http://www.gks.EN/wps/wcm /connect/rosstat_main/rosstat/ru/statistics/science_and_innovations/science/#

diversification of the country's products. In recent decades, there has been a shift in the structure of Russian exports towards products of low complexity (82%). At the same time, exports of Russian manufacturing products remain at a relatively low level. As a result, the share of exports of Russian high-tech products in the world is much smaller than that of highly developed countries (*Tab. 5*).

Russia's lag behind the leading countries in the development of advanced technologies underlying the new industrial revolution is also critical. According to Rosstat, at the end of 2016, the amount of developed advanced production technologies amounted to 1,534 units, of which new ones for Russia – 1,342, and fundamentally new ones – 192 units. At the same time, the amount of advanced production technologies used in the whole country was much higher – 232,338 units [1].

Moreover, the gap between Russia and the leading countries of the new technological revolution in the number of registered patents in areas such as robotics, new materials, additive

Table 5. Exports of high-tech products in total exports in Russia and world's countries, %

Country	Year							2016 to 2010,%
	2010	2011	2012	2013	2014	2015	2016	
France	24.9	23.7	25.4	25.9	26.1	26.8	26.7	1.8
China	27.5	25.8	26.3	27.0	25.4	25.6	25.2	-2.3
The UK	21.0	21.4	21.7	21.9	20.6	20.8	21.8	0.8
Austria	11.9	11.7	12.8	13.7	13.9	13.4	17.5	5.6
Germany	15.3	15.0	16.0	16.1	16.0	16.7	16.9	1.6
Hungary	24.1	22.7	18.1	16.3	13.7	–	14.0	-10.1
Russia	9.1	8.0	8.4	10.0	11.5	13.8	10.7	1.6
Finland	10.9	9.3	8.5	7.2	7.9	8.7	8.4	-2.5
Spain	6.4	6.5	7.0	7.7	7.0	7.1	7.0	0.6
Source: compiled using data from the World Bank. Available at: https://data.worldbank.org/indicator/TX.VAL.TECH.MF.ZS								

technologies, industrial Internet of things, etc. remains significant. The gap is measured in times, which affects the development of relevant new markets. Thus, according to the All-Russian Scientific Research Institute of Aviation Materials, the share of Russia in the world market of additive technologies in 2016 amounted to about 1.7%. In general, about 1.10% of GDP (2015) is spent annually on R&D in the country. This figure is quite different from the indicators of the leading countries of the technological revolution (3–4% of GDP). Russia also lags behind in other key indicators of the new technological revolution: for example, in 2015, the volume of high-tech exports in China was $554.3 bln, in Germany – $185.6; in the USA – $153.5; in South Korea – $126.5, and in Russia – only $9.7 billion dollars. Russia lags behind the leading countries 5–6 times in the share of organizations engaged in technological innovations. In the international ranking of information and communication infrastructure development (Networked Readiness Index, 2016/2017) our country ranks only 41st [1].

Thus, the main problems are the low level of activity of industrial enterprises in the implementation of innovation, the reducing diversification of products produced in the country, Russia's lagging behind the leading countries in terms of development of advanced technologies and low rates of economy digitalization and platformization.

In general, the comparative analysis of the values of main indicators of the new technological revolution is presented in *Table 6*.

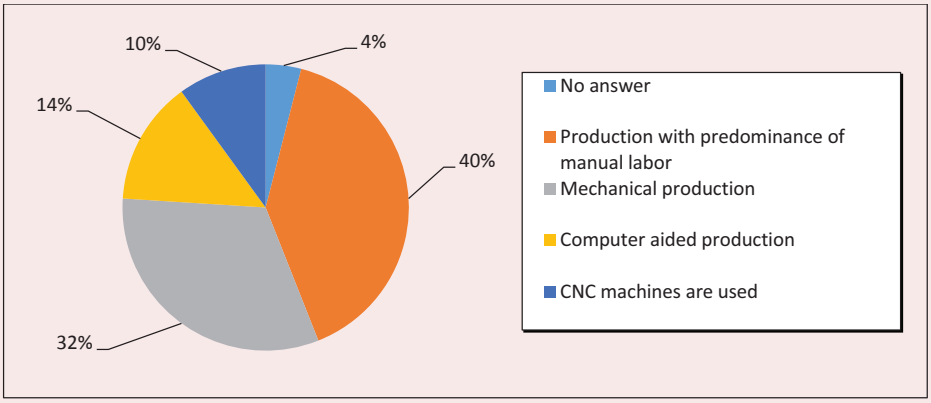
In order to assess the enterprises' readiness for the development of industry based on digital

Table 6. Comparative analysis of Russia's position on certain indicators of new technological revolution [43]

No.	Indicator	Russia	Leading countries
1.	Number of platform companies (2015)	3	China – 64, the USA – 63, the UK –9
2.	Volume of high-tech exports, billion U.S. dollars (2015)	9.7	China – 554,3, Germany –185.6, the USA –153.5, South Korea – 126.5
3.	Labor efficiency, U.S. dollars per person-hour (2015)	25.9	Average labor productivity by OECD countries – 50.8, including in: the USA – 68.3; France– 67.6; Germany –66,6
4.	Share of organizations carrying out technological innovations, % (2014)	8.8	Germany – 55, Sweden– 45.2, Finland–44.6, the Netherlands – 44.5
5.	Share of high-speed broadband network subscribers in the total number of fixed broadband network subscribers (2015), %	58	South Korea – 100, Israel – 97, the UK – 87, Australia – 72, the USA – 67
6.	Share of Internet sales in total retail sales (2015), %	4	The USA – 20, the UK – 20, France –15, Spain – 15, Italy – 9
7.	Costs of R&D (2015), % of GDP	1.10	South Korea – 4.23%, Germany – 2.93%, the USA – 2.79%, China – 2.07%, the UK – 1.70%
8.	Number of patents granted (applicant's country of origin) (2015), units	24 998	China – 279,501; the USA – 257,108; South Korea –109,107; Germany – 86,849; the UK –21,503
9.	Rank in the Global Innovation Development Index (2017)	45	Switzerland – 1; Sweden – 2; the Neterlands –3; the USA – 4; Germany – 9; South Korea –11; Japan – 14; China – 22
10.	Rank in the Global Manufacturing Competitiveness Index (2016)	32	China –1; the USA – 2; Germany –3; Japan –4; South Korea – 5; the UK – 6
11.	Rank in the Networked Readiness Index, 2016/2017)	41	Singapore – 1; Finland – 2; Sweden – 3; Norway – 4; the USA – 5; the UK – 8; Japan – 10; Germany – 15; China – 59

Sources: 1. *Global Platform Survey*, The Center for Global Enterprise, 2015; 2. World Bank; 3. OECD; 4. Rosstat, Eurostat; 5. International Digital Economy and Society Index (I-DESI) 2016; 6. RVC, NIU VShE, I-DESI 2016; 7. EOCD; 8. WIPO; 9. Global Innovation Index (GII) 2016; 10. Deloitte Global Manufacturing Competitiveness Index 2016; 11. WEF.

Figure 7. Distribution of respondents' answers to question "How can you characterize production according to the proposed list of criteria?", % of respondents



Source: survey data on readiness of enterprises in the Vologda Oblast to develop industries based on digital technologies. Vologda Research Center of RAS, 2018.

Table 7. Distribution of respondents' answers to question "How do you assess the use of digital technologies at your enterprise?", % of respondents

Option	%
Studying the possibilities of how this can be used	40.0
Do not use (never considered such a possibility)	36.0
No answer	0.0
Just started using	12.0
Several projects have been implemented	6.0
Planning to use (we have studied various possibilities and are preparing a pilot project)	6.0
Source: survey data on the readiness of enterprises in the Vologda Oblast to develop industry based on digital technologies. Vologda Research Center of RAS, 2018.	

technologies, the Vologda Research Center of RAS conducted a survey among heads of leading industrial enterprises of the region[2].

The monitoring results demonstrate that the majority of enterprises in the Vologda Oblast are dominated by manual labor production (40%), about 32% of respondents said that their enterprise is fully mechanical. However, only 14% of enterprises in the region have computer aided production, and 10% of enterprises use CNC machines (*Fig. 7*).

According to the survey, 36% of industrial enterprises do not use digital technologies in the production process (*Tab. 7*). Only 6% of surveyed enterprises have implemented several projects in digitalization, 6% are preparing a project, and 40% are studying the possibilities of using digital technologies.

In general, industrial enterprises in the region (54%) do not have plans to develop and implement digital technologies, 22% of respondents say that they do not see the need for them. In most cases, enterprises in the region use IOT technologies. The main barrier that complicates the use of digital technologies is the high cost of digital projects (54%); about 40% of respondents note lack of qualified personnel; 26% – draw attention to insufficient experience

[2] The sample totaled 50 industrial enterprises of the Vologda Oblast. The sampling error was no more than 5%.

in using digital technologies.

Amid unfavorable geopolitical situation, toughened competition, extremely low rates of economic growth, Russia faces the issue of increasing economic power through activating the technological factor. The consequence of delaying the transition to a new development model will be the country's further lag in terms of productivity and, thus, competitiveness. There is no doubt that Russia should develop within the framework of the global trend – new industrialization [18].

However, current trends are not optimistic. The competitiveness of most of Russia's production facilities remains low. This is largely due to insufficient funding: the gap between the real need for financial resources to re-equip the backward material and technological production basis is growing, it is estimated at 30–50% (2011–2015) [19].

The current situation requires increased investment in those types of activities that determine the transition to a new technological mode. Ultimately, it is investment that must become the source of a new level of economic development. However, despite the growing federal budget spending on high-tech science-intensive production, such investment has almost did not help modernize and create innovative reserves for the future due to dispersion of funds, high costs of the costly Russian economy, miscalculations in the structural policy.

Analysts estimate the degree of Russia's technological readiness for innovation at the level of 57th position in the ranking[3], which is only thanks to active access to the Internet [20]. The backward material base at the level of III–IV mode interferes with modern technology. According to some estimates, the share of VI mode technologies in Russia is close to zero, V – about 10% only in the knowledge-intensive sector (aerospace and defense industry); more than 50% of technologies belong to the IV mode; 30% – to the III mode, while in developed countries the technological structure of economy is fundamentally different. For example, in the USA – VI mode comprises about 5% of productive forces, V – 60%, IV – 20%, III – 15% [21].

Russia also lags far behind in mastering the achievements of modern scientific and technological progress. This conclusion is based on the country's low share in the world's high-tech markets, which is estimated at 0.3–0.5%, a high degree of dependence of industrial production on imports, reaching 80–90% in some economic sectors [22]. The backward technological basis makes it impossible to increase labor efficiency and reach high rates of industrial growth, as well as to compete successfully in the world markets. As a result, over the years of market transformations, the Russian industrial sector has seriously decreased, while the process of deindustrialization was most critical in technology-intensive industries.

From this layout it becomes clear that the issue of transferring the industry to the platform of digital technologies is becoming important for the Russian economy.

Proposals. Thus, despite the high potential for technological transition in various economic sectors, especially in terms of digitalization of economic and social processes, the negative performance demonstrated by the Russian economy does not ensure effective joining to global trends set by the new technological revolution.

The development of Russian production in the context of transition to the digital economy

[3] *The Global Competitiveness Report 2017–2018*. Geneva: World Economic Forum. 2017. P. 249.

in the near future will require to address issues related to productive inclusion in the new technological revolution in order to implement a structural step in the economy, radical technological modernization of traditional sectors of the Russian economy, support for suppliers of technological solutions for the industrial sector, training for a qualitatively new industry and facilitating the transition to a new organization of business processes at industrial enterprises. The implementation of this course coincides with the general global trend – new industrialization, which determines the main content of the industrial policy of world's developed countries. Given the current structure of the Russian economy, the current level of development of the national innovation system, we can conclude that the country's transition to a qualitatively new economic, industrial and technological paradigm will depend on coordinated implementation of measures in a number of areas [23].

It is impossible to achieve progress in addressing this issue without the development and implementation of an appropriate state industrial policy. It should ensure the formation of balanced proportions in the economy through the development and implementation of a set of measures of state regulation at the macro-, meso- and micro-level. These measures should be aimed at restructuring and large-scale technological modernization of the economy, presented in the form of step-by-step objectives, based on global trends and internal features of economic management.

The most important objective of the state industrial policy is to determine priorities in forming a promising industrial structure of the national economic complex, capable of generating new growth sources. The choice of structural priorities is important as it will form the basic requirements for the quantity and quality of the necessary resources for their development – labor, technology, investment, as well as requirements for the institutional environment.

The choice of structural priorities should be preceded by a thorough inventory of the industrial complex with a number of factors taken into account: promising commodity markets for national producers, potential, the growing competitiveness of various industrial sectors, provision with strategic goods, the social importance of certain sectors of industry, the available scientific and technological reserves, etc.

Having a fairly capacious market and claiming to be one of the subjects of the global economy, Russia cannot specialize in a narrow range of industries and technologies, especially in the context of the worsening geopolitical situation. Russia can only maintain its subjectivity by forming a diversified, technologically independent and competitive economy focused on the development of industries of different technological modes that address different problems. The industries of a future wave should guarantee independence and self-sufficiency in the future, the industries of the current wave provide basic infrastructure and technological support to the economy, while old industries are the main source of employment.

In this context, two groups of structural priorities should be formed within the framework of industrial policy. The first group should be focused on advanced development of industrial potential, ensuring Russia's competitiveness in fundamentally new technological areas. Today, Russia has the opportunity to integrate into global value added chains in shipbuilding, nuclear power, aerospace, ICT. However, it is necessary that centers of profit and system integration

gradually moved to the territory of Russia. And this requires close attention to the new technologies of Industry 4.0, opening up new opportunities for the development of the industrial sector and forming new promising markets. Thus, the potential effect of using mobile Internet by 2025 may be close to 10 trillion dollars; of automation of mental labor – more than 6 trillion dollars; of robotics – more than 4 trillion dollars [24].

The second group of priorities should ensure large-scale technological modernization of the most important economic sectors – their re-equipment and dynamic development, overcoming technological backwardness and import dependence on foreign manufacturers of equipment, including by building their reproduction chains.

It is particularly relevant to link the structural priorities of industrial policy with the main directions of the scientific and technological policy, to implement which it is necessary to form a technological vector of development of the Russian economy based on visualizing the future of the country, its promising sectoral structure, the technological state of the main economic sectors, and the objectives of the socio-economic development.

Such a vector should be based on a long-term qualitative forecast of scientific and technological development and disclosed in the framework of key objectives of the strategy of scientific and technological development, followed by the development of specific programs and projects. The scientific and technological priorities specified in the Strategy should outline the directions of structural and technological modernization, whose practical implementation will form the core of industrial production based on new promising technologies.

In 2017, the country developed and adopted the program "Digital economy" (which in 2019 was transformed into the national project "Digital economy"), in which the main emphasis is put on addressing the problems of information technology development and the creation of digital platforms. At the same time, the problems of "industry digitalization" and introduction of advanced production technologies remained almost out of the developers' sight.

Thus, within the framework of Russia's transition to a new development model, the formation of its strategic technological vector should become an integral part of domestic industrial policy. In fact, the principle of unity of science, technology, innovation and industrial policy should be adopted, on the basis of which the developed countries are achieving success in addressing the problems of new industrialization, in improving the global competitiveness of national economies.

Conclusion. To develop the Russian industrial complex it is required in the near future to address issues related to country's productive inclusion in the new technological revolution in order to take a structural step in the economy; to radical technological modernization of traditional sectors of the Russian economy; support for suppliers of technological solutions for the industrial sector and transition to a new organization of business processes at industrial enterprises. The implementation of this course coincides with the general global trend – new industrialization, which determines the main content of the industrial policy in developed countries. Given the current structure of the Russian economy and the current level of development of the national innovation system, we can conclude that the country's transition to a qualitatively new economic, industrial and technological paradigm will depend on coordinated implementation of measures in a number of areas. These include the technological

modernization of traditional sectors of the Russian economy, the development of new high-tech sectors and ensuring the country's entry into new markets, the restart of the R&D management system, the reorganization of development institutions, as well as the end-to-end "digitalization" of the real economy.

The research novelty of the study lies in the development of methodological approaches to detecting innovative transformations of Russia's industrial sector in the context of the fourth industrial revolution and economic development, focused on the introduction of digital technologies in production, serving as a technological basis for the economic growth of the Russian economy. The research results can be used for analytical, predictive studies of regional and national macro-systems performance, for developing recommendations for creating prerequisites for economic growth amid the transition to a new technological revolution. This will improve the quality of economic policy.

In our opinion, further stages of the research should be: 1) assessing the innovative development of the Russian economy amid global competition and formation of high-tech science-intensive production; 2) identifying directions of organizational and technological transformations in the Russian economy amid global competition and development of digital economy; 3) developing the mechanism of state regulation of innovative development of the regional economy based on the transition to digital economy.

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