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Digital Economy and Industry 4.0: Russia's Development Trends

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Abstract

Being in the transformation stage, from post-industrial to digital, the digitalization process is characterized by advanced information, telecommunication, and production technologies such as cloud services, mobile devices, virtual and augmented reality, the Internet of Things, geolocation, user authentication, 3D printing, robotics, artificial intelligence technologies, metadata analysis, personalization for the client's profile. Within the conceptual framework of informatization of the economy, when information became the fifth factor's production, along with labor, land, capital, entrepreneurial abilities; and the economy digitalization - a stage based on the use of the Web-4.0 technology platform. The economic transformation is expressed in the digitization of physical assets and their integration into the digital ecosystem, together with business partners involved in the goods and services creation. The digital economy marks the transition to the sixth technological order and Industry 4.0; is the fourth industrial revolution result; and involves the digital ecosystems creation, where, with the stakeholders' help, collective network competencies should be formed. The article discusses the main trends in the digital economy development, the transformation problems, and offers solutions.

Disciplinary: Digital Economy (Digital Transformation), Industrial Revolution.

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1 Introduction

The transition from the introduction of digital technologies to the integrated construction of an international digital ecosystem requires new approaches and changes. This trend reflects the

need for effective cross-border interaction of all participants in the digitalization process: government authorities, business, educational institutions, industrial enterprises and financial structures.

Industry 4.0 is not just a change in a new way of life, not just a communications digitalization between enterprises with each other and with authorities, not just the automation's work processes and the replacement of the human resource with software. This is a change in the state activity principles and business building, mentality and consciousness transformation.

In this regard, the study aims to analyze the trends of digitalization in industry and society, caused by the formation and the digital economy development and Industry 4.0, to study and generalize the experience of the practical implementation of these approaches and concepts, as well as modern high-tech technologies in an unstable external environment. To improve the efficiency of the economy, it is necessary to restructure it on the various tools and mechanisms basis, including the industrial, cluster and infrastructure policies transformation.

2 Methodology

The Russian scientists' works are devoted to the problems of socio-economic and scientific-technological economy and industry development. The Industry 4.0 issues (a concept element of the Fourth Industrial Revolution), digital production are dealt with. The world experience of transition to the digital economy is described in the domestic scientists' works [1].

The basis for the formation of the "digital economy" and "Industry 4.0" concepts is the operational conceptual apparatus creation, intended to serve as the basis for creating a relevant phenomenon and processes system and the necessary regulatory framework. In international practice, there is still no unified approach to their definition.

2.1 Digital Economy

Digitalization is not only technology and a product but rather an approach to using digital resources to transform an organization's work [2]. It involves redefining technologies and business processes to improve the work environment for employees, interact with customers and other participants in the modern distributed enterprise [3,4].

Digitalization involves the information translation into digital form. Digital transmission for information data encoded in discrete signal pulses. In the USA, digitalization is seen as the path to an information society, further globalization and transnationalization of information communications throughout the planet. In Europe and other countries, there is a different viewpoint on digitalization, associated with the protection of terrestrial broadcasting as a means for preserving national and local characteristics and interests through their own media [5].

In 1995, American computer scientist Nicholas Negroponte (University of Massachusetts) coined the term "digital economy". Last year, World Bank issued a report on the digital economy state in the world (the report entitled "Digital Dividends"). However, the content of this concept is still vague.

Recalling the definition for the usual "analogous" economy, this is the economic activity for society, as well as the totality' relations that develop in the system of production, distribution, exchange and consumption. The use of a computer, the Internet, mobile phones can already be considered "consumption", in this case, the digital economy can be represented as that economic relations part that is mediated by the Internet, cellular communications, ICT [6].

In most foreign sources, the digital economy emphasizes on technologies and the changes associated with their use in the ways of interaction between economic agents. The definition for the digital economy is often substituted by listing the directions for its influence on the economy and social sphere [7,8,9].

The approaches to defining the digital economy

- It is a global network of economic and social activities that are supported by platforms such as the Internet and mobile and sensor networks;

- As a new way for an economy based on knowledge and digital technologies, within which new digital skills and opportunities are formed in society, business and the state;

- A complex structure consisting of several levels/layers, interconnected by an almost infinite and constantly growing number of nodes;

- Digital markets that facilitate the goods and services trading through e-commerce on the Internet;

- an economy capable of providing high-quality ICT infrastructure and mobilizing ICT capabilities for the benefit of consumers, businesses and governments;

- An economic activity form that emerges from the billions for examples of networking between people, businesses, devices, data and processes. The digital economy is based on hyper-connectivity, i.e. the growing interconnectedness of people, organizations and machines, driven by the Internet, mobile technology and the Internet Things;

- An economy in which, thanks to the digital technologies development, there is an increase in labor productivity, competitiveness for companies, a decrease in production costs, the new jobs creation, a decrease in poverty and social inequality.

In Russia, the key formulations of the digital economy are

- a new technological generation economy (the Russian Federation President Message to the Federal Assembly of December 1, 2016);

- business activities in which digital data is a key factor in production; processing large volumes of these data and using the results of their analysis in comparison with management traditional forms can significantly increase the production various types efficiency, equipment, storage, sale, delivery of goods and services (Strategy for the Information Society Development of the Russian Federation for 2017-2030).

The digital economy development, as a phenomenon, happened due to a change in the technological order. This statement allows us to talk about a new level of science and innovation development [10].

2.2 Industry 4.0

The fourth industrial revolution represents a new level of organization for production and management of the value chain throughout the product's entire life cycle. It is positioned as a massive introduction of robotization and digital control technologies, which will significantly increase production efficiency. Industry 4.0 is globalization and universalization of the "distributed" principles if production and access to information and finance. The importance of automation and control systems is increasing as the current Fourth Revolution.

One's characteristics of the information society will be a very high speed for decision making. Valuable scientific knowledge, its dissemination, as well as design work automation and the production process will acquire a new qualitative embodiment. The emergence of the fourth wave of the industrial revolution was made possible by the rapid development of technology and the Internet penetration into every person's life.

Based on the very Industry 4.0 concept, this stage is associated with economic cyclical development. Spiral Dynamics is a theory that describes humanity's development stages and the individual. It is based on the theory of psychology professor Claire Graves and was originally intended for a management audience. In short, the main idea of the theory is that human nature manifests itself in a progressive movement from one balanced state to another. At the moment, 7 stages have been identified (Figure 1).

Reactive or infrared stage: One hundred thousand years ago, people lived in small groups of people several tens. There was no responsibilities division and no hierarchy within the group - everyone was engaged in gathering. The leader was not needed.

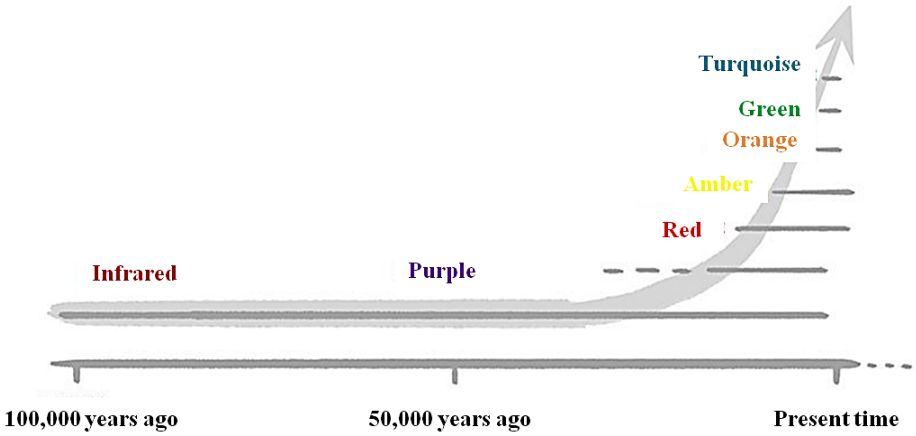

Figure 1: The spiral dynamics stages of human development

Magic or purple stage: Fifteen thousand years ago, humans went from tiny family groups to tribes of up to hundreds each. People attributed everything that happened around them to magical powers. Bad weather is spirits punishment for bad deeds. In the tribes, intermediaries between spirits and people appeared - shamans or leaders. They made decisions and could use rituals to rid a

person of the spirit's wrath. Shamans had some power degree, but there was still no organization at this stage - shamans were not responsible for the labor division in the tribe.

Impulsive or red stage: Ten thousand years ago, tribes began to fight with each other. The leaders appeared - the group leaders. The defeated and captured enemies became slaves, they were entrusted with duties that the members of the victorious tribe did not want to fulfill. This is how the first labor appeared division. The strongest was chosen as the leader. If he showed weakness for a moment, he was immediately overthrown. The organization was built impulsively according to the principle: "I am stronger than you - I will take your food. If you resist, I will kill you".

The organizations' red stage still exists and is built around the leader: in prisons - a thief in law, in war - a commander, in mafia structures - a gang leader.

Conformist or amber stage: States and civilizations began to appear six thousand years ago. The amber worldview is static: there are immutable laws; things are divided into right and wrong. During the lesson, children should sit at their desks - this is not discussed. Whoever gets up without permission is punished. The employees of the amber organization strictly follow the orders without asking unnecessary questions. Despite the conservatism of amber companies, it was in them that planning originated and stable organizational structures arose. Typical amber organizations are the Catholic Church and the army. Strict subordination is emphasized by the uniform: you will never confuse a bishop with a priest, and a general with a private.

Competitive or orange stage: Orange organizations emerged during the Renaissance, gained strength two centuries ago, and after World War II dominated the Western world. From the orange point of view, everyone has the right to achieve any goal: a janitor can become a CEO; a beggar can become a millionaire. The main thing is to win the competition: both internal and external between employees. The company's goal is profit.

The structure has a clear hierarchy. Planning and implementation of plans are separate: thinking occurs at the top, execution at the bottom. Decisions are made by the manager, transferred down to another level, and as a result, the task reaches the lower-level performer. The company has internal rules set.

With a rigid structure, innovation is encouraged at this stage; personal responsibility and career growth are encouraged. The measure of success is material well-being. Most large international companies are still orange: Nike, Philip Maurice, and Coca-Cola.

Pluralistic or green stage: Green organizations first made themselves knew at the turn of the 19th and 20th centuries. Back then, people tried to fight the inequality that arose after the Industrial Revolution, and in the 1960s they built communes. Green organizations are sensitive to feelings and respect the view of different points. People strive for justice, equality, harmony, good neighborliness and consensus. For green organizations, personal relationships within the group are more valuable than the result, and the benefits for the planet and humanity are more important than personal benefits.

The most successful green company is Southwest Airlines, helping clients get to the right place at the lowest possible cost. The airline's ground employees are creative in solving passenger problems. Green companies were claiming the place of the future company. But they failed - such organizations cannot exist in their pure form. Personal relationships within the team have become higher than the company's goals - to defeat competitors. This is how the first turquoise (emerald) organizations appeared.

Turquoise (Emerald) organizations have taken the best from orange and green. From the orange got the desire to compete with outside companies, from the green - the desire to be a team.

The main feature of the future organization is self-government. But not in a perverted concept, when workers stand on their heads. This self-government is controlled. In self-governing teams, the leader is not a Cerberus, but a mentor. He does not supervise the work but teaches and gives recommendations. Instead of planning and budgeting, turquoise (emerald) teams practice in-house consulting in which the entire team participates.

Despite the significant research presence, there is currently no single methodology for managing the breakthrough development of the digital economy. This is a significant barrier and hinders the conditions creation for ensuring national security, technological independence, and global competitiveness for the Russian economy.

3 Results

In recent years, other models transformation wave business and social activity have been unfolding, caused by the emergence of new generation digital technologies, which, due to the influence scale and depth, have received the name "end-to-end" - artificial intelligence, robotics, the things Internet, wireless communication technologies and several others.

Their implementation, according to experts, can increase labor productivity in companies by 40%. Shortly, it is the effective use of new digital technologies that will determine the international competitiveness of both individual companies and entire countries that form the infrastructure and legal environment for digitalization.

Industry 4.0 poses one's the main challenges to the exponential growth in the quantity, relationships quality and diversity between organizations, citizens and socio-economic systems, accompanied by leaping dynamics in the transactions number and volumes of data circulating and leading to a more complex and synchronized integration of “all with all”, the consequences which are not yet fully understood. Such transformations require new skills and competencies from people, a willingness to use new technologies in everyday life. Of particular importance is the formation of educational programs that meet global trends and personalized learning paths that can provide "digital literacy".

The economic transformation determines the number of digitalization negative consequences, including the traditional markets disappearance, the replacement of some professions with automated systems, the cybercrime growth, the vulnerability for human rights in

the digital space, threats to the safety of digital user data, and a trust low level in the digital environment. The solution to these problems is seen in the digital economy regulation.

The accelerated adoption of digital technologies in the economy and the social sphere is an ambitious goal that is being successfully implemented in only a very few leading countries. It is achievable only if some essential conditions are met.

Firstly, business and the social sphere must be ready for digital transformation, development strategies must mature and take shape, implying a radical change in the ways for organizing and conducting activities through the planned intensive introduction of digital technologies, which are in demand by organizations and promising stakeholders a return on their own funds' investment.

Secondly, the country should have a relatively mature technology supply sector, which, if it does not claim to be an international leader, is at least capable of a quick transfer and adaptation of foreign technological solutions and a rapid increase in the scale of its own activities. Thirdly, the population's demand for digital technologies should constantly grow, since it is the needs and capabilities of consumers that ultimately determine the adequate demand for digital technologies from organizations, primarily in the B2C field.

Moderately favorable conditions have developed in terms of the technological proposal for the successful solution of these tasks. Thus, the ICT sector is one's the most dynamically developing segments of the Russian economy. For the period 2010-2017, it grew by 17%, almost twice the GDP growth.

The sector's share in GDP is 2.7%. However, in most developed countries, the ICT sector plays a more important role - its share in the added value of the business sector in OECD countries is 1.6 times higher than in Russia (5.4% and 3.4%, respectively). Our country lags behind the leaders of the technological proposal - Korea, Sweden, Finland in this indicator by 2-3 times.

The fastest-growing segment for the ICT sector is the information technology industry. Since 2010, its gross value added in comparable prices has doubled, including by 12% since 2016. The share of domestic software in the cost of purchasing software in government bodies and social security institutions is gradually growing (in 2017 - 66.9%), although in organizations it reached only 23.4%. The Russian manufacturers' positions in the foreign market are being strengthened. In 2017, the export of ICT goods and services increased by a quarter, including information services - by 34%, computer - by 28%. For the first time since 2009, the foreign trade balance for computer services turned out to be positive: in 2017, exports exceeded imports by 0.5%.

At the same time, Russian companies - developers and manufacturers of equipment and software are not yet among the world leaders in the main areas of the economy and social sphere digitalization. A relatively compact segment of export-oriented IT companies that are competitive in foreign markets has grown in Russia, but they cover only certain niches and are often embedded in global value chains controlled by foreign corporations.

Since 2019, a multiple increases in budget expenditures for the development of end-to-end digital technologies is planned: for the period up to 2024, 282 billion rubles will be allocated from

the federal budget for these purposes; state support is growing within the framework of the National Technology Initiative and other - more “traditional” - scientific measures, technical and innovation policy (programs: the Education and Science Ministry of Russia, the Industry and Trade Ministry of Russia, development institutions). It should be borne in mind that such a large-scale financial intervention for the state in the highly competitive field of ICT can distort the market behavior of companies and reduce the investments quality. A sharp jump in budget spending creates the risks of an unjustified increase in support for already existing technological solutions and "weak" projects in the face of a breakthrough development shortage.

In addition, due to the lack of Russian reserves, such significant budgetary investments in technology development create the falling risk into the "trap" for overestimated expectations, when even large-scale funding and preferences will not lead to the formation of a high-quality and massive supply for Russian digital technologies in a short time. Reducing the resource dispersal risk is possible only through high-quality management in the development and implementation for digital technologies based on the promising demand for business and the population.

The demand for digital technologies is generally showing positive dynamics. The household’s digital development level is already in line with current trends. The number of fixed broadband Internet users increased 1.8 times compared to 2011 and amounted to 30.9 million subscribers in 2017, mobile - 1.7 times, to 117.4 million subscribers. For the period 2010–2017 the households share with access to the Internet increased 1.6 times to 76.3%. 72.6% of households have broadband Internet. The gap in Internet access for urban and rural residents is decreasing: in 2013 it was 1.5 times (72.8 and 49.5% of households, respectively), in 2017 - 1.2 times (79.5 and 66.5%). The Internet spread among the population is accompanied by an increase in the intensity for its use: the share of the most active (daily) Internet users over the past 8 years has grown by 2.3 times, reaching 60.6% in 2017.

Russian organizations have widely mastered basic and relatively simple digital technologies, but only a few have carried out deep automation and restructured business processes for advanced digital technologies. Today 83% of Russian organizations already use broadband Internet, 63% have mastered electronic data exchange technologies. At the same time, the shares for organizations that have mastered more complex technologies are several times lower: cloud services - 23%, ERP systems - 12.2%, RFID technologies - 5%.

The digitalization of manufacturing enterprises remains at a low level. While abroad a tendency has already formed to move from using individual solutions to the implementation of unified knowledge management systems, technologies and competencies - digital platforms, in Russia the concept of transition to "Industry 4.0" is still being discussed.

The use of computer engineering and virtual modeling technologies, additive technologies, the industrial Internet, mechatronics and robotics has not yet received a significant distribution. As a result, domestic industrial products are inferior to leading foreign competitors in price and quality terms, as well as terms of bringing finished products to the market. Russian industrial

systems, as a rule, do not allow for customization' production, as well as the ability to quickly respond to market changes.

In order to stimulate the citizens and organizations demand digital technologies, it is important not to be limited to measures of direct financial support, public procurement of digital technologies and “manual” management typical for the project management model (federal and departmental projects have been chosen as the main instruments for achieving the national goal). By themselves, apart from a favorable institutional environment, they will not bring a multiplier effect and are unlikely to be able to provide wide coverage of private companies, stimulate massive growth in demand for digital technologies and volumes of extra-budgetary investments, especially in the context of many years of innovative activity stagnation' enterprises.

International comparisons based on a factors combination demonstrate Russia's promising positions in key indicators of development and implementation for digital technologies. Thus, according to the rating of the World Economic Forum, in 2018 Russia was ranked 43rd among 140 countries, including in the direction for "Penetration of information and communication technologies" - 25th, which is provided primarily due to a significant share of users mobile phones among the population and the widespread use of fiber-optic Internet (Figure 2).

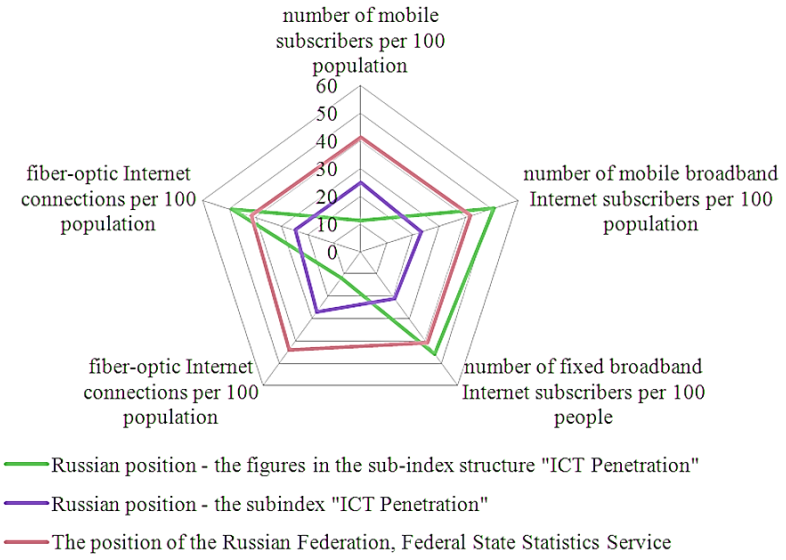

Figure 2: Sub-Index "ICT Penetration" of the Russia Global Competitiveness Index in 2018

Russia is consistently in the top 50 of all major international digital development ratings. However, in 2014–2018. Russia's positions in the number of them decreased: according to the e-government development index EGDI - from 27th to 35th place, the ICT development index IDI - from 41st to 43rd. At the same time, Russia ranked 10th in 2018 in the GCI global cybersecurity index.

In terms of business digitalization, Russia lags far behind the leading countries. This is evidenced by the HSE ISSEK Index of Business Digitalization, which measures the companies adaptation speed to digital transformation and characterizes the use of broadband Internet, cloud services, RFID technologies, ERP systems, as well as the involvement of the business sector in e-commerce. The value of the business digitalization index in Russia is 28 points. In terms of the

digital technologies penetration level in the business sector, Russia is next to Bulgaria, Hungary and Romania. Finland is the leader (50 points), followed by Belgium (47), Denmark (46), the Republic of Korea (45). The use intensity in Russia of certain technologies taken into account in the calculation of the Index is distinguished by serious differentiation (Figure 3).

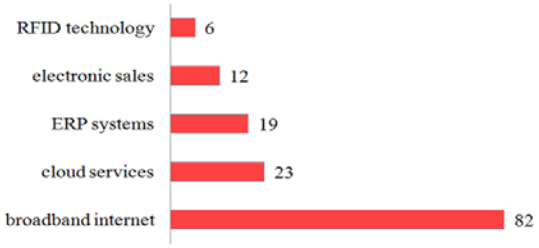

Figure 3: The use intensity of certain technologies in Russia,% for organizations in the business sector.

The gap between the Russian indicators and similar data for Finland varies in the range from 9 to 43 pp: the minimum gap was recorded in such areas as electronic sales (9 pp) and the use of RFID technologies (17), the maximum - in regarding cloud services (43).

Although the introduction of digital technologies over the past decades in many countries, including Russia, has acquired the status of a "traditional" development direction, both at the state and corporate levels, the modern stage, characterized by the formation of the so-called digital economy, gives rise to fundamentally new technological, organizational and managerial challenges. At the same time, operational definitions of new key concepts have not yet emerged, not to mention a full-fledged regulatory framework and regulatory mechanisms, which, of course, hinders the development of the digital economy and the realizing possibility the positive effects associated with it.

One of the main conditions for making large-scale public investments in the digital technologies introduction is to assess the contribution of relevant measures to economic growth in terms of cost-benefit ratio. Regardless of the economic development scenario, guarantees for sufficient return on such investments are required to justify the feasibility of their implementation.

The digital technologies introduction is one of the economic growth key drivers. Products and services of the ICT sector already occupy a significant share in the cost structure of the Russian economy sectors. In some industries (mechanical engineering, chemical industry), the spending intensity on products of the ICT sector corresponds to the level of the United States and even exceeds it in science, education, health care, financial sector and transportation. However, in such sectors as trade and the timber industry complex, which are large in terms of their share in Russia's GDP, and in certain sectors of the service sector, significantly lower values of the intensity of ICT spending are observed. In mechanical engineering, in recent years, the costs level for ICT (relative to output) is about 8%, which is comparable to the transport costs of the sector. In general, the intensity of spending on ICT products in Russia lags slightly behind the US level (2.46% versus 3.08%). To a large extent, the lag of certain segments of the Russian economy in terms for digitalization is due to low investment in digital infrastructure (software, electronic component base, etc.), which in Russia (1.46% of GDP) is much inferior to the American level (2.80 % of GDP).

Under the conditions of sanctions, more expensive imported technologies are slowly being replaced by domestic ones, which slow down the pace for digital infrastructure modernization.

The digitalization of industries leads to a change in the demand for production factors. Under the influence of digital technologies and related new business models, not only individual sectors are being transformed, but also the entire structure of the economy and intersectoral interactions. HSE ISSEK calculations show that in the baseline scenario under moderately favorable macroeconomic and institutional conditions (first of all, the outstripping growth for investment activity in all sectors of the Russian economy and the achievement of the maximum effects of scientific and technological development), digitalization can significantly increase factor productivity as industries and the service sector (Table 1).

Table 1: Average annual values for the additional contribution of growth factors to the added value of economy sectors as a digitalization result for the period 2019-2030.

Economy sectors	Performance Contribution (TFP), %	Capital contribution, %	Labor contribution, %	Total, %
Financial sector	0.92	1.20	0.93	3.04
Transport	1.29	1.20	0.55	3.03
Construction	0.98	1.02	0.88	2.88
Education	1.00	1.20	0.57	2.77
Chemical industry	1.64	1.40	-0.43	2.61
Mechanical engineering	1.52	1.48	-0.46	2.54
Other services	0.93	0.79	0.24	1.95
Health care	0.81	0.58	0.25	1.65
Light industry	1.02	0.96	-0.65	1.32
Power engineering	0.32	0.83	0.04	1.19
Trade	0.60	0.36	0.04	1.00
Agroindustrial complex	0.78	0.69	-0.56	0.91
Public administration	0.58	0.24	-0.40	0.41
Timber industry complex	0.31	0.14	-0.53	-0.08
Metallurgy	0.25	0.10	-0.55	-0.21
Mining	0.08	0.04	-0.46	-0.35

The greatest effect of digitalization can be achieved in the knowledge-intensive sectors of the service sector and high-tech industries, the efficiency of which can grow at a faster pace than other sectors' economy. Digitalization will require not only an increase in investment in digital technologies but also a radical modernization for the infrastructure of almost all sectors of the economy (except the mining sector, where this process has already largely taken place), which will ensure high growth rates for the capital factor contribution to added value.

In a number' sectors, the inflow of highly qualified personnel will not be able to compensate for the release of low-qualified personnel, which will lead to a negative contribution of the labor factor to the growth rates of certain sectors' economy.

According to our estimates, by 2030, GDP growth will be more than half associated with digitalization (1.47% of 2.75% of annual GDP growth), primarily as a result of increased efficiency and competitiveness of all sectors' economy. Some additional effects will provide the information industry growth (Figure 4).

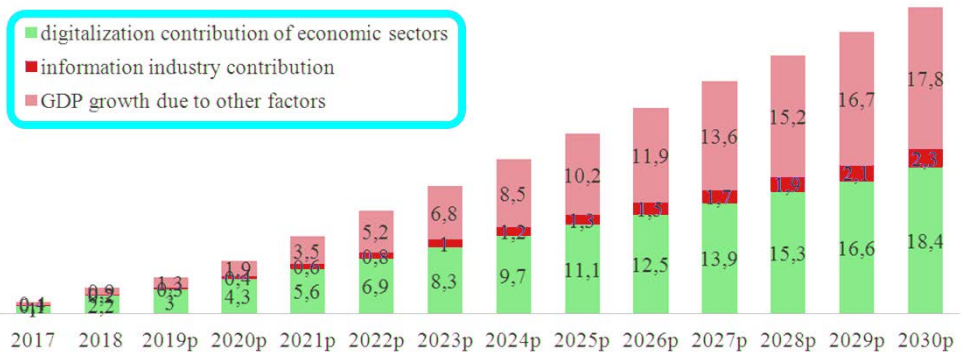

Figure 4: Assessment of the contribution' digitalization to GDP growth as a cumulative total (base case) (%)

With accelerated socio-economic development (4.35% of GDP growth per year), growth due to digitalization should already be more than 2% annually (Figure 5).

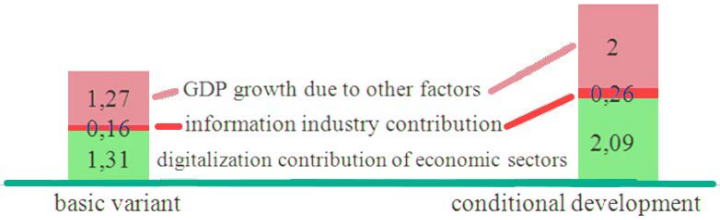

Figure 5: Estimates of the digitalization contribution to GDP growth (average annual growth rates for the period from 2019 to 2030 under two options for economic development) (%)

The maximum economic effects can be achieved with a dramatic increase in productivity and investment activity in the economic sectors.

Thus, in the long term, digitalization can become a significant structural factor of economic growth under various scenarios for Russian economic development.

4 Conclusion

The trends analysis in the digitalization process made it possible to identify a number' negative consequences, including the disappearance of traditional markets, the replacement of some professions with automated systems, cybercrime growth, the vulnerability of human rights in the digital space, threats to digital user data, and a low trust level in the digital environment. For the solution in the digital economy regulation, it is necessary to develop strategies that imply a radical change in the ways of organizing and conducting activities due to the planned intensive introduction of digital technologies, which are in demand by organizations and promising stakeholders a return on investing their own funds. Forming a sector of technological offers, capable of fast transfer and adaptation for foreign technological solutions and a rapid increase in the scale of its own activities, Russia needs to develop public demand for digital technologies, primarily in the B2C field.

The study showed that for the successful solution of these tasks, moderately favorable conditions have developed in terms' the technological proposal. The ICT sector is the most dynamically developing segment for the Russian economy. For 2010-2017, it grew by 17%, almost double the growth of GDP. In the long term, digitalization can become a significant structural factor of economic growth under various scenarios for Russian economic development.

5 Availability of Data and Material

Data can be made available by contacting the corresponding author.

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