Technique Of Complex Measurement Of The Level Of Digital Development And Its Impact On The National Economy

Tatyana Kuzovkova, Dmitriy Tkachenko
MTUCI
Moscow, Russia
tkuzovkova@me.com, chiker17@yandex.ua

Abstract–**The reasons for changes in the indicators of the information society, the criteria for the depth of penetration and the scale of ICT use in the economy and society, the transformation of indicators of the digital development of the Russian economy and the need to use complex methods are revealed. The results of a integrated assessment of the development of the Russian digital economy in terms of accessibility of broadband access and the degree of use of the Internet by regions, cloud technologies in business by type of activity and the development of a multiple regression model of gross domestic product from ICT application factors are presented.**

I. Introduction

Digitalization of the production of goods and services through the introduction of digital platforms, the industrial Internet of things and cloud technologies has a global impact of information resources and information and communication technologies (ICT) on the entire socio-economic space that contributes to the growth not only of internal, but also of external efficiency of investments in digital technologies. The high speed of distribution and the wide possibilities of using digital technologies in various areas of social and production activities, the scale of digitalization processes dictate the need to measure their impact on the development of the national economy based on statistical methods. [7-9]. The rest of the paper is structured as follows: the synergistic nature of digital development efficiency, transformation of digital economy development indicators, the results of the evaluation of the development of the digital economy by main indicators, modeling the contribution of digital development in Russia's economic growth and, finally, conclusion.

II. The Sinergistic Nature of Digital Development Efficiency

At the modern stage of development of civilization, knowledge, information, technologies are acquiring a primary role, the share of information products and electronic services is growing, global network structures, business models and markets for electronic products and services are being created, virtual and cloud technologies, digital platforms, electronic social and production networks, new branches of the digital economy are emerging: e-commerce, banking, marketing, industrial Internet [10-11].

In the digital economy, the role of the Internet, infocommunication and digital technologies and platforms in business is constantly growing [12]. The creation of virtual corporations consisting of several business partners, combining their production resources and capital for the implementation of the production process of goods and services [13], greatly increase the external effects of investment and functioning. The development of digital technologies and network information and communication infrastructure in a large area allows the creation of multiple services for consumers, integrated business systems, lower prices for digital devices and service, i.e. contributes to a synergistic socio-economic effect [3-5].

The synergistic social and economic effect of digital technologies and platforms, as well as infocommunications in general, is due to: first, the economic effect of the scale of production and consumption of infocommunication services, secondly, the social effect of the impact of infocommunication services and technologies on the quality of production and social life [4], [6], [10], [13].

Well-known dynamic methods of cost evaluation of the effectiveness of investment and information technology are not well suited for measuring the synergistic efficiency of introducing digital platforms and operating a business based on it [5], [13], [14]. It is necessary to apply complex methods of measuring the results of digital development at the national level, based on the integration of the results of digital development by a set of significant indicators, measuring the external socio-economic efficiency of ICT use and modeling the contribution of digital technologies to the growth of the national economy.

III. Transformation of Digital Economy Development Indicators

In the course of digital development and accumulation of data on the results of digitalization, indicators and criteria for the development of the information society, indicators of the depth and extent of the use of digital technologies in the economy and society are constantly changing [1], [2], [9]. In the early stages of the development of the digital economy industry, the criteria for the scale of ICT distribution, the volume of information resources, the development of markets for goods and services of an electronic nature were important. At subsequent stages, the results of ICT penetration into all

spheres of the economy and people's livelihoods, the intensity of the digitalization process, assessed by the progressiveness of the structure of GDP, production and resources, changes in the nature of work, the emergence of new sources of human well-being, equalization of regional and social development in terms of accessibility and utilization of digital networks, technologies and resources become more important.

So, in just 2 years, the system of indicators of the digital economy of Russia has doubled and substantive estimates of indicators have drastically changed. In 2016, the digital economy indicators included: ICT sector, ICT infrastructure, content and media sector, international conparisons, ICT use in organizations, ICT use in households and among population. And in 2018, the indicators of the digital economy were as follows: Russia in international rankings, ICT research and development, personnel of the digital economy, ICT, telecommunications, content and mass media sectors, population in the digital reality, digital technology in business, digitalisation of the social area, electronic government, information security, technological trends in the field of digital economy, and the main indicators of the development of the digital economy in the regions of the Russian
Federation.

The system of indicators of statistics of the information society in Russia [6, p. 295] included six groups of indicators covering the activities of the ICT sector, ICT infrastructure, content and media sectors, the use of ICT in organizations of the national economy, households and among population, as well as international comparisons for countries around the world.

The system of indicators of statistics of the digital economy covers the main indicators of the digital development of Russia and its place in international ratings; indicators characterizing ICT research and development; personnel of the digital economy; the activities of the ICT, telecommunications, content and mass media sectors. In addition, it reflects the demand for digital technologies by the population and in business; the results of the digitization of the social area and public administration; the state of information security and technological trends, as well as indicators of the development of the digital economy in the regions of Russia.

IV. The results of the evaluation of the development of the digital economy by main indicators

For a comprehensive description of the development of the digital economy of the Russian Federation, one can use the methods of comparative analysis: regional, structural, rating. On the basis of the main indicators of the development of the digital economy in the regions (federal districts) of Russia, [2] we will conduct a comparative analysis of the accessibility of subscribers with broadband Internet access and the degree of its use by the population and business (Table I) and a rating analysis of the position of the regions by these indicators (Table II).

TABLE 1. Availability of broadband Internet access for subscribers and households and the degree of its use in 2017, part 1

Name of the Federal District	Subscribers of broadband Internet, individuals per 100 people		Percentage of households with broadband Internet, %
	fixed	portable	
Central	24,6	92,8	74,2
Northwestern	29,4	78,5	74,9
Southern	16,6	73,2	74,5
North Caucasian	7,5	65,7	69,3
Volga (Privolzhsky)	21,7	71,4	71,7
Ural	24,0	76,9	73,6
Siberian	18,9	75,0	67,3
Far Eastern	18,2	86,6	73,5
Russian Federation	*20,9*	*79,2*	*72,6*

TABLE I. Availability of broadband Internet access for subscribers and households and the degree of its use in 2017, part 2

Name of the Federal District	Percentage of the population using the Internet, in total population, %			Percentage of organizations using the Internet, %	
	aged 15-74 years	for orders of goods, services	for obtaining public services	broadband	«cloud» services
Central	86,2	33,5	71,3	85,6	23,2
Northwestern	85,6	33,6	56,0	86,8	22,5
Southern	83,9	28,8	64,3	73,9	19,0
North Caucasian	81,8	15,6	53,0	79,5	19,4
Volga (Privolzhsky)	82,0	26,4	67,2	79,3	17,7
Ural	83,4	33,7	58,9	80,3	21,1
Siberian	80,7	24,5	59,6	75,0	19,6
Far Eastern	83,0	28,8	56,5	78,0	20,3
Russian Federation	*83,7*	*29,1*	*64,3*	*80,5*	*20,5*

The data in Table I, by region and national average, shows not only the level of accessibility of subscribers and households for broadband access to the Internet and the degree of its use by the population and business, but also the size of variation in indicators by federal districts. Regarding the main indicators of digital development: the number of mobile broadband access to the Internet per 100 inhabitants, the percentage of households with broadband access to the Internet, the percentage of the population and organizations in the business sector using the Internet in total, the regions of Russia differ slightly from each other. But in terms of the number of fixed broadband subscribers per 100 inhabitants (from 7.5 to 29.4) and the percentage of the population using the Internet for ordering goods and services, including government services, the regions have significant variation (respectively, from 15.6% to 33.7% and from 53% to 71.3%).

TABLE II. RATINGS OF FEDERAL DISTRICTS IN TERMS OF INDICATORS OF ACCESSIBILITY OF BROADBAND INTERNET ACCESS FOR SUBSCRIBERS AND HOUSEHOLDS AND THE DEGREE OF ITS USE IN 2017, PART 1

Name of the Federal District	Subscribers of broadband Internet, individuals per 100 people		Percentage of households with broadband Internet, %
	fixed	portable	
Central	1	1	3
Northwestern	2	3	1
Southern	7	6	2
North Caucasian	8	8	7
Volga (Privolzhsky)	4	7	6
Ural	3	4	4
Siberian	5	5	8
Far Eastern	6	2	5
Russian Federation	1	1	3

TABLE II. RATINGS OF FEDERAL DISTRICTS IN TERMS OF INDICATORS OF ACCESSIBILITY OF BROADBAND INTERNET ACCESS FOR SUBSCRIBERS AND HOUSEHOLDS AND THE DEGREE OF ITS USE IN 2017, PART 2

Name of the Federal District	Percentage of the population using the Internet, in total population, %			Percentage of organizations using the Internet, %	
	aged 15-74 years	for orders of goods, services	for obtaining public services	broadband	«cloud» services
Central	1	3	1	2	1
Northwestern	2	2	7	1	2
Southern	3	4	3	8	7
North Caucasian	7	8	8	4	6
Volga (Privolzhsky)	6	6	2	5	8
Ural	4	1	5	3	3
Siberian	8	7	4	7	5
Far Eastern	5	5	6	6	4
Russian Federation	1	3	1	2	1

Rating assessments of individual federal districts of the Russian Federation based on rankings (Table II) provide a clear picture of their position. The established ratings of federal districts based on the ranking of the maximum value of the indicator show an objective position on the digital development map, the presence of a significant lag in the digital development of the economy and social sphere of the Southern, North Caucasian, Far Eastern and Siberian federal districts, which is explained by the low level of socio-economic development of these regions. To eliminate the imbalances in the digital development of Russia, state support of these regions is necessary to ensure a unified digital space.

The development of the digital economy is based on innovative digital technologies, including distributed data processing technologies, in which computer resources and facilities are provided to the user as an Internet service ("cloud" services); neurotechnology and artificial intelligence; intelligent systems that use a combination of big data analytics, cloud computing, connections between machines and the Internet of things for work and study; production technologies, including cyber-physical systems, sensor technologies, 3D printing, computer engineering, robotics, qualitatively other production resources (nanotechnologies and new materials), etc.

To assess the use of digital technologies in organizations of various types of activities, relative indicators of the proportion of organizations using digital technologies are used, in the total number of organizations in the business sector, in percentage (Table III) [2].

TABLE III. ASSESSMENT OF THE INTENSITY OF APPLICATION OF VARIOUS DIGITAL TECHNOLOGIES IN THE BUSINESS SECTOR

Name of activities	Broadband Internet	«Cloud» services	RFID - technologies	ERP - systems	Electronic sales
Mining operations	88,8	17,7	10,3	24,5	7,3
Manufacturing activities	91,3	23,2	8,7	22,1	19,3
Production and distribution of electricity, gas and water	80,1	16,2	4,4	13,3	9,4
Construction	85,0	21,6	5,6	8,1	9,7
Wholesale and retail trade; repair of vehicles, motorcycles, household goods and personal items	91,6	25,7	7,8	32,6	21,3
Hotels and restaurants	75,3	27,5	7,5	12,2	17,9
Transport	72,9	16,5	6,2	14,4	9,8
Communication	89,9	31,2	8,9	33,6	24,8
Operations with real estate, rental and provision of services	69,9	16,9	3,2	7,3	5,1
Business sector - total	***80,5***	***20,5***	***5,8***	***17,3***	***12,6***

An analysis of the degree of use of digital technologies by type of economic activity shows that all types of digital technologies are more intensively used in construction, wholesale and retail trade and communication, and there is a lag in the use of digital technologies in other types of business. In terms of the use of digital technologies in all types of businesses, the following are distinguished: broadband Internet – 80,5%; «cloud» services – the average level is 20,5%; ERP-systems – 17,3% and electronic sales using special forms posted on a website or on an extranet using automated data exchange between organizations (EDI-systems) – 12,6%.

V. MODELING THE CONTRIBUTION OF DIGITAL DEVELOPMENT IN RUSSIA'S ECONOMIC GROWTH

For a comprehensive measurement of the development of infocommunications in the conditions of digital transformation of the economy and society, one can also use the statistical apparatus of correlation and regression analysis in the

presence of a sufficient number of units in the aggregate and factors [7],[9].

Statistical records of a number of ICT development indicators in economic activity and society over a 10 year period [1] allowed us to investigate the relationship between the degree of ICT use and the growth of gross value added (GVA) [12]. Analysis of the nature of changes in GVA and indicators of the degree of use of ICT in production and among population in the conditions of the formation of the information society shows a very clear direct correlation (Fig. 1).

The resulting GVA multiple regression equation from ICT development indicators is:

$$Y = -170.7633 + 4,5023\,X_1 + 3,6025\,X_2 + 0,3427\,X_3 - 2,2179\,X_4,$$

where Y – gross value added; X_1 – percentage of organizations using the Internet (%); X_2 - percentage of organizations having a website (%); X_3 - percentage of households with Internet access (%); X_4 - percentage of the population using the Internet (%).

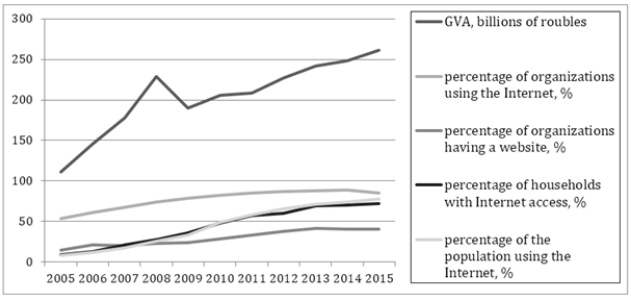

Fig. 1. The dynamics of the main indicators of ICT application and GVA over a ten-year period

Coefficient of multiple correlation R = 0,938, coefficient of determination R^2 = 0,881, approximation error at significance level α = 0.01 is equal to 5,43%, which indicates a fairly high degree of reliability of the model. The values of beta coefficients by factors (x_1 = 1,264; x_2 = 0,765; x_3 = 0,178; x_4 = -1,282.) indicate, firstly, the higher significance of ICT use indicators in economic activity, namely: the share of organizations using the Internet and having a website, and secondly, insufficient use of the Internet in households.

The transformation of the indicators of the digital economy towards the depth of ICT penetration into the business and the use of ICT by the population provided the basis for modeling GDP from factor signs. Figure 2 clearly shows a direct link between GDP and 4 relative ICT application indicators: by the population using the Internet to order goods and services, by business organizations in terms of the use of broadband Internet and cloud services, the use of software that prevents unauthorized access of malicious programs in organizations.

The analysis of the dependence of GDP on ICT application factors yielded the following multiple regression equation:

$$Y = -34,4827 - 0,09179\,X_1 + 1,0468\,X_2 + 1,274\,X_3 + 0,2002\,X_4,$$

where Y – gross domestic product; X_1 – percentage of the population using the Internet to order goods and services; X_2 – percentage of business organizations using broadband Internet; X_3 – percentage of organizations using software and hardware that prevent unauthorized access of malicious programs; X_4 – percentage of organizations using cloud services in the business sector.

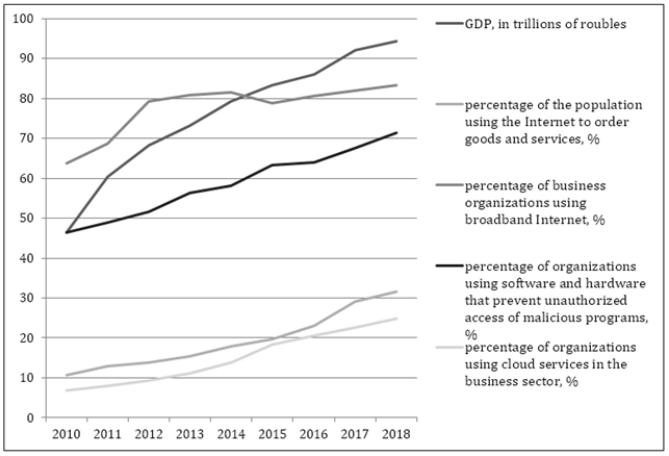

Fig. 2. Dynamics of the main indicators of the digital economy and GDP in the Russian Federation for the period 2010-2018

It follows from the equation that the percentage of the population using the Internet to order goods and services does not directly affect GDP, and the other three factors have a direct positive effect on the economic development of Russia. The statistical significance of the equation is verified using the coefficient of determination and the Fisher criterion. R^2= $0,9918^2$ = 0,9836, which indicates a high degree of reliability of the model.

By the maximum coefficient β_3 = 0,548 we conclude that the percentage of organizations using software and hardware that prevent unauthorized access of malicious programs has the greatest effect on GDP. This is due to the fact that reliable data protection using software and hardware prevents leakage of important financial information and money by cybercriminals and competitors. Thus, investments in information security can significantly enhance the stability of the company and its competitiveness.

The use of broadband Internet and cloud services in business also contributes to the economic growth of the Russian economy. This is because cloud services allow us to better store and manage data. Cloud services have such advantages as: high probability of saving data even in case of hardware failures, the client pays only for the place in the storage that he actually uses, but not for renting the server, all the resources of which he can not use, the client does not need to engage in the acquisition, support and maintenance of its own infrastructure for storing data, which ultimately reduces the overall production costs; all procedures for backing up and

preserving the integrity of data are performed by the provider of the "cloud" center, which does not involve the client in this process. Thus, companies and enterprises save on costs associated with data storage and focus more on the production of goods and services.

CONCLUSION

The results of a comprehensive assessment of the development of the digital economy of Russia in terms of accessibility of broadband access and the degree of use of the Internet by region, the use of cloud technologies in business by activity and the development of a multiple regression model of gross domestic product from ICT application factors not only quantify the digital development processes in Russia, but they also confirm the expediency of applying complex analytical and statistical methods for measuring synergy the efficacy of digital development. In contrast to the well-known methods of measuring the economic efficiency of IT projects and business automation at the corporate level, the proposed methodology is macroeconomic and socioeconomic in nature and is designed to solve government problems of analyzing and forecasting more efficient use of ICT and digital technologies, implementing the program of the country's digital development and building an information society.

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