Transformation of Criteria and Indicators of Digital Development of Economy and Information Society

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***Abstract*—The reasons for the transformation of criteria and indicators of digital development of the economy and the information society are revealed, an assessment of a number of countries, including the Russian Federation, on international indices of digital development, e-government development and ICT is made, a system of indicators of the digital economy of Russia is shown and a rationale for the evolution of criteria and indicators of digital development of economy and society is given, taking into account the stages of scientific and technological progress of infocommunications.**

I. INTRODUCTION

The process of digital development of the economy and society is a dynamic and structurally developing process occurring in all sectors of the economy and affecting the system of management, production and consumption of various goods and services, as well as social life. Measuring the scale of the digital development of the economy and society, the directions and intensity of the application of information and communication technologies (ICT) is becoming increasingly important for determining the strategy of movement towards the information society and the global development of the digital economy.

The ongoing processes of digitalization of the economy and society are characterized by an in-depth and all-pervading nature with many effects and consequences. So the use of ICT not only increases labor productivity and contribution to economic growth, but also changes the way people work, communicate and interact with each other, their learning and entertainment. This dictates the need for continuous improvement of the system, methods of recording and analyzing indicators that adequately reflect the state of digital development, including the "digital divide" between countries and regions, the coverage of all sectors of the economy and society within the country, the industrial Internet of things.

II. INTERNATIONAL SYSTEM OF INDICATORS OF THE DEVELOPMENT OF THE DIGITAL ECONOMY AND THE MOVE TO THE INFORMATION SOCIETY

Due to the high dynamism of scientific and technological progress (STP) of infocommunication, quantum and nano technologies, the presence of a special catalytic effect of the mutual influence of the scientific and technological development of infocommunications and all sectors of the economy and society, Russian and international organizations have to constantly revise the methodological tools, methods of collecting, processing and analyzing indicators of digital development, and the use of ICT and the movement to the information society [1], [5], [8], [10], [11].

The activity of the processes of informatization, digitalization (electronization) of the economy and the widespread introduction of ICT creates the basis for the movement of all countries of the world to the information society, the distinguishing features of which are the increasing role of information and knowledge in society; increase in the share of information and communication technologies, products and services in gross domestic product; formation of a global information space providing free access to world information resources, effective information and electronic interaction of people [7], [8].

The need for accurate and comparable statistical data characterizing the state and development of infocommunications, ICT accessibility and the extent of ICT use in the business sector, government bodies, in the social sphere, in households and the population are causing close attention to the organization of statistical observation of current processes.

At the beginning of the XXI century, the United Nations Commission for the Development of Science and Technology with the participation of the International Telecommunication Union (ITU) developed an enlarged system of indicators for assessing the state and development of informatization and the movement of countries to the information society [1, C. 199], which included three blocks:

1 block - indicators of the state of subjects and objects of informatization, the state of the infrastructure and the industry of informatization, the markets of information and communication services, equipment and technologies, as well as the user environment;

2 block - indicators of the development and advancement of the country to the information society, determining the development and progressiveness of the infocommunication infrastructure, the intensity of use of infocommunication networks and technologies, the country's position on the trajectory of movement towards the information society;

3 block - conditions and factors of the socio-economic environment, reflecting the socio-economic, regulatory and legal conditions for the implementation of the informatization process and the orientation of the state's strategy on the development and propagation of ICT or other priorities.

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The enlarged system of indicators concerned both the list of indicators of the state and development of the infocommunication infrastructure, the nature of the movement towards the information society and the impact of infocommunication development on the economy and society, as well as the methods of their measurement, comparisons by countries and regions [1], [9].

Key positions in the development of statistical standards in the field of measuring the state of infocommunications, accessibility and the extent of ICT use in the economy and society are occupied by the Organization for Economic Cooperation and Development (OECD), the Statistical Office of the European Union (Eurostat) and ITU. The main international documents that define standards and recommendations on statistical observation in the field of ICT and are applied in Russia: OECD Guide to Measuring the Information Society (2011), Eurostat Information Society Methodological Guideline (2012), ITU Handbook on measuring household access to ICTs and the extent of its use (2009), main ICT indicators (2010).

The OECD Information Society Indicators Working Group was established at the end of the 20th century with the goal of developing common definitions and data collection methods for measuring various aspects of the information society, information economy, and electronic commerce. The Eurostat working group develops standard definitions and concepts for information society statistics, statistical tools for measuring ICT use in organizations and households. In order to increase the international comparability of information society development indicators, the Partnership, which includes 10 international and regional organizations (except for the above: UNCTAD, UNESCO, ECLAC, ESCAP, ESCWA, ECA and the World Bank), in 2010 developed a list of basic ICT indicators, including 53 indicators in six areas of formation of the information society (Fig. 1).

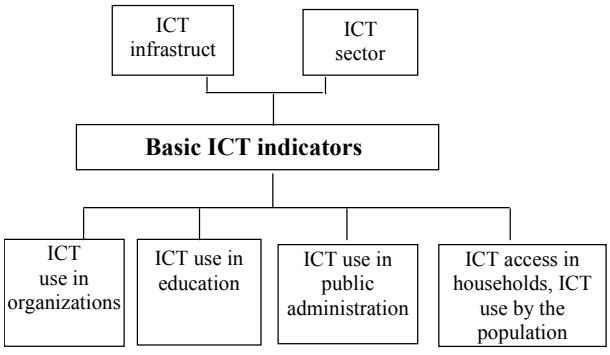

Fig. 1. "Basic ICT Indicators" of the International Partnership on Measuring ICT in Research Areas

Further improvement of the system of indicators of the information society is due both to the dynamic development of STP, the deep penetration of ICT into the production of goods and services, the life of society, and the development of qualitatively new methodological approaches to the study of these processes and the provision of reliable international comparisons [1, 3-6, 10-13].

In the international system of indicators for measuring the process of moving countries to the information society, an important place is occupied by international composite indices of readiness for network society, e-readiness, digital opportunities and e-government development, etc., which are indicators of the development of the information society [1, p. 204-209]. Each of the indices is composite and consists of a number of sub-indices and other parameters.

The modern international system of indicators of the development of the digital economy and the movement towards the information society is presented in Fig. 2 [2], [14-17]. In the international system of indicators, an important place is occupied by indicators of the digital economy, which include: global cybersecurity index; ICT development indices, e-government indices, readiness of countries for a networked society indices, characterizing the development of infrastructure and ICT demand for socio-economic development; as well as the international digital economy index, which measures the progress of countries in the development of the digital economy and society by the following components: connectedness, human capital, Internet use, integration of digital technologies, digital public services [3]. Using these indices, one can assess not only the trends of the development of the digital economy and the information society, but also the scale of the "digital divide" between countries.

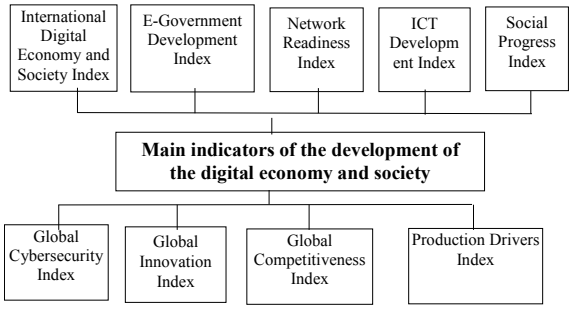

Fig. 2. International System of Indicators of the Development of the Digital Economy and the Move to the Information Society

III. CHARACTERISTICS OF THE INTERNATIONAL DEVELOPMENT OF THE DIGITAL ECONOMY

The characteristic of the development of the digital economy in a number of countries based on a number of international composite indices presented in Tables I-III shows the country's position in the overall rating of the composite index of the digital economy, e-government development and ICT development.

TABLE I. INTERNATIONAL COMPOSITE INDEX OF DIGITAL ECONOMY IN SOCIETY IN 2017 FOR A NUMBER OF COUNTRIES

States	Index of the digital economy in society	Including subindexes				
		Connectedness	Human capital	Internet use	Integration of digital technology	Digital government services
Iceland	0,66	0,69	0,66	0,61	0,73	0,58
Repub-	0,64	0,81	0,75	0,29	0,47	0,73

lic of Korea						
Norway	0,63	0,70	0,65	0,45	0,66	0,63
New Zealand	0,63	0,62	0,59	0,44	0,79	0,65
Japan	0,62	0,71	0,66	0,22	0,67	0,71
USA	0,62	0,62	0,56	0,37	0,68	0,79
Canada	0,59	0,63	0,62	0,42	0,58	0,67
Russia	0,47	0,50	0,63	0,32	0,43	0,36
Turkey	0,41	0,39	0,39	0,35	0,39	0,38
EU-28 countries	0,54	0,54	0,61	0,38	0,55	0,47

* Data of report «International Digital Economy and Society Index (I-DESI)"

The calculations of the digital economy index in society and its components (subindexes) are made by the European Commission Directorate General for Communications Networks, Content and Technology in accordance with the methodology of the European Digital Economy and Society Index (DESI) [14].

Progress in the development of the digital economy is observed in 11 countries of the world whose index exceeds the EU average (0,54). Russia takes its rightful place in the ranking of countries of the world (0,47), which is close to the average value.

The results of the evaluation of e-government development (e-GRI index) in 192 countries of the world in 2016 showed that the top ten included: Great Britain (0,92), Australia (0,91), Korea (0,89), Singapore, Finland (0,88), Sweden, Netherlands (0,87), New Zealand (0,86), Denmark, France (0,85). The highest value of the components of e-government development (1,0) is occupied by the United Kingdom in the sub-index “Development of online state servers”, Australia – in the sub-index “Telecommunication ICT infrastructure”. Russia (0,72) ranks 35th in the world ranking [16].

TABLE II. INTERNATIONAL COMPOSITE INDEXES OF E-GOVERNMENT DEVELOPMENT IN A NUMBER OF COUNTRIES FOR 2016*DATA OF ANALYTICAL REPORT UN DESA “UN E-GOVERNMENT SURVEY 2016” AND REPORT E-GOVERNMENT IN SUPPORT OF SUSTAINABLE DEVELOPMENT

States	E-Government Development Index		Including subindexes	
			Development of online government servers	
	Place in the ranking	Value	Rank	Value
Great Britain	1	0,9193	1	1,0
Australia	2	0,9143	2	0,9783
Republic of Korea	3	0,8915	5	0,9420
Singapo-re	4	0,8828	3	0,9710
Finland	5	0,8817	5	0,9420
France	10	0,8456	5	0,9420
Russia	35	0,7215	37	0,7319
Poland	36	0,7211	45	0,7029
Croatia	37	0,7262	33	0,7464

States	Including subindexes	
	Telecommunication ICT infrastructure	Human capital development
	Rank	Value	Rank	Value
Great Britain	6	0,9402	7	0,8177
Australia	1	1,0	12	0,7646
Republic of Korea	18	0,8795	2	0,8530
Singapo-re	34	0,8360	3	0,8414
Finland	4	0,9440	13	0,7590
France	30	0,8445	15	0,7502
Russia	37	0,8234	38	0,6091
Poland	22	0,8747	44	0,5857
Croatia	44	0,8050	41	0,5974

For comparing the development of information and communication infrastructure, the introduction of digital technologies, the preparation and use of ICT in the countries of the world, ITU assesses ICT development indices (Table III) [15].

TABLE III. INTERNATIONAL COMPOSITE ICT DEVELOPMENT INDEXES FOR A NUMBER OF COUNTRIES IN 2017

States	ICT Development Index		Including subindexes	
			Access to ICT	
	Place in the ranking	Value	Rank	Value
Iceland	1	8,98	2	9,38
Republic of Korea	2	8,85	7	8,85
Switzerland	3	8,74	8	8,85
Denmark	4	8,71	14	8,39
Great Britain	5	8,65	4	9,15
Japan	10	8,43	9	8,80
Russia	45	7,07	50	7,23
Slovakia	46	7,06	51	7,22
Italy	47	7,04	47	7,33

States	Including subindexes			
	ICT use		Practical ICT Utilization	
	Rank	Value	Rank	Value
Iceland	5	8,70	9	8,75
Republic of Korea	4	8,71	2	9,15
Switzerland	2	8,88	31	8,21
Denmark	1	8,94	6	8,87
Great Britain	7	8,38	33	8,17
Japan	11	8,15	30	8,22
Russia	51	6,13	13	8,62
Slovakia	36	6,67	50	7,54
Italy	42	6,35	43	7,86

* The data of the ITU Report "Measuring the Information Society Report 2017"

In 2017, the ranking of countries in terms of ICT development was headed by Iceland (8,98), followed by Korea (8,85), Switzerland (8,74). In addition to them, the top ten countries in terms of ICT development include: Denmark, Great Britain, Hong Kong (China), the Netherlands, Norway, Luxembourg and Japan. Russia ranks 45th in the ICT Development Rating (7,07) with a high level of the Practical ICT Utilization Sub-Index (8,62) - 13th in the rating for this

component of the ICT Index. ICT development levels across countries vary widely: from 8,98 to 0,96 points. At the same time, the following trend is noticeable: developed countries hardly change their place in the ranking of countries, while the range of variations in the level of ICT development does not decrease, indicating a widening gap between developed and developing countries and the problem of moving towards a harmonious information society.

Conducting the rating analysis of international digital development indices reveals opportunities of each country to improve the efficiency of the digital economy, the development of ICT, electronization of management, business and society. Thus, the evaluation of Russia's place in the ratings of the countries of the world according to digital development indices resulted in the adaptation of the Russian statistics to the current processes and the activation of the information society development strategy until 2030 based on the implementation of 12 national programs of the Digital Economy of the Russian Federation.

IV. Adaptation of Russian Statistics on the Development of the Digital Economy to International Requirements

Considered international systems of indicators of digital development of the economy and society dictate the need for systemic adaptation of Russian statistics. Since 2011, the Federal State Statistics Service of Russia and the Institute of Statistical Studies and Economics of Knowledge of the HSE have conducted a special statistical survey of economic and social activities and published a statistical compilation "Information Society Indicators", since 2016 - "Indicators of the digital economy" according to the system of indicators presented in Fig. 3 [3], [4].

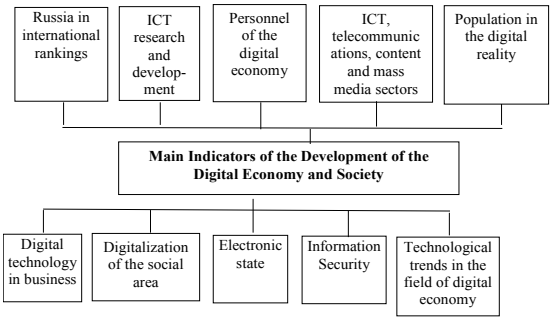

Fig. 3. The system of indicators of statistics of the digital economy of Russia

Statistics of the digital economy and the information society is the newest direction of the Russian socio-economic statistics, aimed at studying all aspects of activities related both to the digital development of the economy and society, business models and the integration of digital platforms, and their application in the economy, social area, public and private life. If the system of indicators of the information society statistics [9, p. 295] included six groups of indicators covering the activities of the ICT sector, ICT infrastructure, the content and media sectors, the use of ICT in organizations of the national economy, in households and by population, as well as international comparisons of countries of the world, the system of indicators of statistics of the digital economy has doubled the list of indicators and their integrated groups [2].

The system of indicators of statistics of the digital economy in the Russian Federation covers the indicators of the development of the digital economy of the country and its place in international ratings; indicators characterizing ICT research and development; personnel of the digital economy; activities in 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 sphere and public administration; state of information security and technological trends, as well as indicators of the development of the digital economy in the regions of Russia.

V. Justification of the Natural Evolution of Digital Development Indicators

For systematization of changes in measurement objects and a system of indicators of movement to the information society over the past 50 years, we used the key principle of forming the stages of scientific and technological progress based on the identification of fundamentally new generations of information and communication equipment and technologies [7, p. 51-53]. Since the development of infocommunications is closely interconnected with macroeconomic development due to the infrastructural role and manifestation of the catalytic effect of innovative ICT development [7, p. 76-78; 93-95], we used the stages of the scientific and technical development of infocommunications (Table IV) to establish the regularity of change, expand the list and content of digital development indicators.

TABLE IV. Evolution of the System of Indicators of the Development of Info-Communications, Digital Development of the Economy and the Information Society

Stages	Objects of measurement and name of indicators
Stage №1 1955-1975 ***Integration of communica-teons and computers***	The state and development of networks and communications; informational technology, hardware and software Availability (density) of communications; personal computers
Stage №2 1975-1990 ***Convergen-ce of Communi-cations and Informatics***	State and development of the industry of informatization, market of ICS and ICT Provision of society with communications and information technology Availability of communications, Internet, information resources Criteria of readiness for the information society in conjunction with the level of socio-economic development of the country Legal support of ICT activities
Stage №3 1990-2005 ***Informatiza-tion, infocommu-nications***	The state and development of the industry, subjects and objects of informatization, including the user environment The level of use of communications, ICT, the Internet in the economy, management and social area E-Readiness Criteria Government regulation and ICT development strategy ICT business climate and human capital
Stage №4 2005-2020	Information orientation of public policy strategy Broadband access to infocommunications and the Internet

Formation of the information society	The effectiveness of the use of ICT in the economy and social area The degree of involvement of the state, business and population in the electronic space Share of GDP created using ICT and electronic environment Criteria for belonging to the information society and indicators of the digital economy Evaluation of the positive and negative effects of informatization
Stage №5 2021-2040 ***Digital Economics of the Information Society***	Internet access, digital skills and competencies of each inhabitant of the planet Earth and the degree of its use The degree of application of digital technologies, cloud services and other nano technologies in business and social area The share of industrial production and the digital economy in GDP The degree of digitalization of organizations of business, government and social area The optimal combination of positive and negative effects of informatization in production and society Criteria for a harmonious information society and social progress

Systematization of changes in measurement objects and a system of indicators of movement to the information society over the past 50 years, taking into account the scientific and technical development of infocommunications, has made it possible to establish a logical sequence of changes and expanding the list and content of indicators (Table IV). The results of the systematization of the indicators indicate the presence of an evolution in the methodological support for the formation of a global information space directly related to the stages of the STP of infocommunications, the digitalization processes of the economy and society [1, 9]. Taking into account the current world and domestic changes in the development of the digital economy and movement towards the information society, allowed the authors to adjust the previously developed system of indicators of the fifth stage [9, p. 299], reflecting the processes of digitization of the economy and social life.

This process is characterized by the following:

first, the evolution of the system of indicators of information and digital development, consisting in transferring priorities from the area of ensuring the availability of communication networks and the Internet to users, the development of information and communication infrastructure, taking into account the STP systems and information transmission and processing technologies, to the field of measurement the depth of penetration into production and the society and the results of the manifestation of the effects of the use of ICT and digital technologies in government, education, culture, business, etc.;

secondly, the development of a system of evaluating the effectiveness and consequences of the spread of ICT in various sectors of the economy and society, as well as the parameters of the formation of the digital economy and the movement towards the information society, taking into account social progress, the use of ICT by organizations of all types of economic and social activities, by all groups of people;

thirdly, development and improvement of the methodology for calculating complex indicators of infocommunication development, statistical monitoring in accordance with the requirements of completeness, reliability and trustworthiness of accounting, ensuring international comparability of the results of digital development of the economy and society.

The evolution of the system of indicators of infocommunication and digital development consists in transferring priorities from the field of ensuring the availability of communication networks and the Internet for users, developing the infocommunication infrastructure taking into account STP systems and technologies for transmitting and processing information to the field of measuring the depth of penetration into production and society and evaluating the results of application of ICT and digital technologies in public administration, education, culture, business, etc.

The natural development of a system for evaluating the effectiveness and impact of ICT use in various sectors of the economy and society dictates the need to:

develop the qualitative methods for assessing the synergistic socio-economic efficiency of ICT, digital platforms and applications, taking into account the positive and negative effects of the use of ICT in the management, business and among all groups of the population [3], [6];

develop methods for measuring the multiplicative external efficiency of the development of infocommunications, innovations of infocommunication companies, showing the real result of investing infocommunication projects in other sectors of the economy and society [5], [11];

improve the methodology of integrated assessment of the digital development of the economy and society based on integrated methods and the use of expert methods and selective statistical observation in Russian and international statistics.

VI. Conclusion

The development of a system of indicators of digital development is aimed at assessing the business climate and the eco-system of the digital economy, the quality of human capital, including information literacy, the degree of readiness for electronic development. A further step in the development of indicators is to measure the socio-economic efficiency of the use of ICT in the production, management, education and society systems, as well as to focus research on the social consequences of digitalization in shaping a harmonious personality in society.

The widespread use of ICT and the Internet in production and society, access to the Internet for every inhabitant of planet Earth ensures the formation of a harmonious information society in which state, social, educational, medical and other services are carried out in electronic format, a significant proportion of goods and services are produced in an electronic environment, the positive and negative effects of digitalization are optimally combined and contribute to the formation of a harmonious social personality.

A special feature of statistical monitoring, evaluation, analysis of the state and development of the digital economy and the information society is the lack of statistical reporting on most indicators, so it is necessary to use a sampling method, conduct one-time surveys of the demand for digital technologies in the economic and social spheres, their use, taking into account changes in business models and consumption models of service packages.

A significant breakthrough in the use of ICT and artificial intelligence, the emergence of large open data arrays require restructuring of the statistical system in the direction of digital transformation and integration of various types of accounting, coordinated and intelligent management of large volumes of information and application of new analytics tools for decision-making, eliminating duplication of information based on the transition from the collection of primary reporting to the collection of primary information.

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