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DIGITAL INEQUALITY OF RUSSIAN REGIONS

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Abstract

Digitalisation processes are sources of the active growth of national economies. They provide competitive advantages and protect national priorities in the long and short term. Their pace is rapidly accelerating, as new ways of collecting, processing and transmitting big data are emerging based on the 'digital traces' left by information during its use. This leads to the need to develop tools for the qualitative assessment of digital transformation processes to justify management decisions and improve project management. Therefore, the purpose of this article is to develop theoretical and methodological provisions and practical recommendations for assessing trends in the processes of digitalisation to subsequently conduct an interregional analysis, identify the causes of digital inequality and find ways for their elimination based on general and particular scientific methods: comparative and statistical analysis, methods of comprehensive assessment and ranking of statistical information reflecting the efficiency of digitalisation processes. The authors developed their own approach to assessing the efficiency of digital transformation processes at the regional level. A distinctive feature of the methodology proposed is the inclusion of indicators that reflect the development of the digital infrastructure, use of digital technology, personnel availability and innovation activity, which are integrated into three indices and eventually form an additive model for the comprehensive assessment of the digitalisation processes taking place in the region. This methodological approach was tested to assess the digital transformation processes taking place in the regions in the Central Federal District of Russia. The regions were grouped according to the level of their digital development. The results of the study allowed us to identify six groups of regions and draw the conclusion that there is a problem of digital inequality despite similar economic conditions and potential. To improve the methodological tools, we suggest using methods of expert evaluation and introducing significance ranks for the selected indices. This is the basis for improving regional strategies, adjusting the targets of regional projects carried out within the Digital Economy Programme and searching for options for effective interaction between all parties operating in the digital ecosystem so that the economy and its competitiveness could grow.

Keywords: region, digital inequality, digital transformation, digital technology, digital development, digitalisation

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ЦИФРОВОЕ НЕРАВЕНСТВО РОССИЙСКИХ РЕГИОНОВ

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Аннотация

Процессы цифровизации представляют собой источники активного роста экономик стран, обеспечивают их конкурентные преимущества и защиту национальных приоритетов в позиции, как долгосрочной, так и краткосрочной перспективы. Темпы ее стремительно ускоряются, так как появляются новое способы сбора, обработки и передачи больших данных на основе «цифровых следов», которые оставляет информация при ее использовании. Это приводит к необходимости разработки инструментария качественной оценки процессов цифровой трансформации для обоснования управленческих решений и совершенствования проектного менеджмента. Поэтому целью данной статья является разработка теоретико-методологических положений и практических рекомендаций по оценке тенденций процессов цифровизации с целью последующего проведения межрегионального анализа для выявления причин цифрового неравенства и поиска резервов их устранения. На основе общенаучных методов, частных научных методов: сравнительного, статистического анализа, методов комплексной и рейтинговой оценки и статистической информации, отражающей результативность процессов цифровизации, разработан авторский подход к оценке эффективности процессов цифровой трансформации на региональном уровне. Отличительной особенностью предлагаемой методики является учет показателей, отражающих развитие цифровой инфраструктуры и использование цифровых технологий, кадровое обеспечение, инновационную активность, которые интегрируются в три индекса и в итоге формируют аддитивную модель комплексной оценки процессов цифровизации региона. В результате апробации разработанного методического подхода была проведена оценка процессам цифровой трансформации регионов, входящих в состав Центрального федерального округа России, а в последствии выделены группы регионов по уровню цифрового развития. Результаты исследования позволили выделить шесть групп регионов, что позволило сделать вывод о существующей проблеме цифрового неравенства при схожих условиях хозяйствования и имеющемся потенциале.

Ключевые слова: регион, цифровое неравенство, цифровая трансформация, цифровые технологии, цифровое развитие, цифровизация

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1. Introduction

On the one hand, the active processes of digital transformation occurring over the last 20 years around the world stimulate the growth of economies in various countries, but on the other hand, bring the problem of digital inequality to a new level, making it common for individual countries, regions and sectors. This means that some countries are increasingly lagging behind due to the immaturity of their digital infrastructure and a myriad of problems caused by many demographic, political, social, economic, technological and environmental factors.

In the context of global development, every country faces the challenge of digital inequality, which can be removed either in a natural way or by drawing on substantial external resources. However, for an adequate assessment of the possibilities for reducing digital inequality, one must have a suitable set of methodical and methodological tools, since the result of digitalisation processes should be considered as various effects rather than as total investments. For this reason, if elements such as the current level of digital inequality, the amounts of financial resources allocated for digitalisation processes and the effects obtained are compared with each other, can provide opportunities for improving federal and regional programmes, changing the strategic development priorities, and, consequently, systematising the resources for increasing competitiveness and reducing the differentiation of digital development.

The matters of reducing the digital divide correlate with the matters of adequate assessment of its acceptable level, the problems of preserving human capital and using it efficiently, the development of an information society and digital infrastructure, insurance of digital maturity and improvement of the general state policy, all of which can help to reduce the influence of various barriers on the way to digital transformation.

Since the late 1990s, many works have touched upon the problem of growing digital inequality. In particular, Attewell1, Norris2, DiMaggio, Hargittai3, Van Deursen and Van Dijk4 discuss unequal access to knowledge, the possibilities of knowledge using via the Internet, the technologies and specifics of their application due to the social stratification of society, etc.

The digital divide is a complex and dynamic phenomenon, while social stratification, which is observed in unequal access to the Internet, is blamed by Safiullin and Moiseeva is its underlying cause (Safiullin, 2019).

Scientific interest in the problems of the digital development of society has led to the emergence of a theory of three levels of the digital divide, including the following major components:

1) The level of access to the Internet and Information Computer Technology (ICT);

2) The level of digital competence of the users and their digital literacy;

3) The level of social advantages the users obtain if digital technology is used properly and to a sufficient extent in their professional and private lives (Gladkova, 2019).

The concept of the digital divide makes us look for an interdisciplinary approach to reducing this issue. In their studies, an increasing number of researchers and experts stop to associate the problems of the digital divide with geographic factors, but instead focus on social aspects. In particular, Hargittai points out that one of the causes of the digital divide is that users have quite different competences in

[1]Attewell, P., 2001. The first and second digital divides. Sociology of Education. 74, 252–259.
[2]Norris, P., 2001. The Digital Divide: Civic Engagement, Information Poverty, and the Internet Worldwide. Cambridge, UK: Cambridge University Press.
[3]DiMaggio, P., Hargittai, E., 2001. From the ‘digital divide’ to ‘digital in-equality’: Studying Internet use as penetration increases. Princeton University. Working papers series. Available at: https://www.princeton.edu/~artspol/work-pap/WP15%20-%20DiMaggio%2BHargittai.pdf (
[4]Van Deursen, A., Van Dijk, J., 2014. The digital divide shifts to differences in usage. New Media and Society. 16, 507–526. DOI: https://doi.org/10.1177/1461444813487959

working in a digital environment.5

Scientific research more and more frequently discusses the fact that in the case of equal access to digital technologies, well-developed digital infrastructure and connections in a digital ecosystem, a different effect, performance and social advantages can be reached. All of this is considered in the works by Ragnedda (2018), Einav, Levin.6, Varian7, Haber, Stornetta8, Golovina, Polyanin, Adamenko, Khegay and Schepinin (2020).

The causes of digital inequality cannot be investigated without researching how the tools of Industry 4.0 (Big Data, Internet of Things, machine learning, artificial intelligence, etc.) affect the level of socio-economic development of individual countries and regions in terms of access to modern end-to-end technologies and their use for improving the standard and quality of living. These important aspects are discussed in the studies by researchers such as Babkin, Burkaltseva, Kosten (2017) Vorobyev, Pshenichnicov, Tyulin (2017), Barefoot, Curtis, Jolliff, Nicholson, Omonhundro (2018), Bukht and Heeks (2017).

One controversial issue is the choice of a system of indicators for making quantitative comparisons within the world community, individual countries, regions, sectors and entities based on widely available statistics. When selected, the indicators must ensure the possibility of evaluating various groups of factors that influence the mechanism of economic management, as well as forms and methods for regulating digitalisation processes (Norman9, Mulgan10, Brynjolfsson, McAfee, Spence11).

Russia saw the beginning of active digitalisation processes in 2017, when the most important laws and regulations were introduced, laying the foundation for the digital transformation of the economy (Digital Economy of the Russian Federation Program, 2017–2030 Strategy for Developing Information Society in the Russian Federation). This was the time when some federal measures were taken and President Putin emphasized the need for developing the potential of breakthrough technologies, tools for storing and protecting big amounts of information and practical introduction of smart solutions for better efficiency and competitiveness of economic entities at various levels.

According to research conducted by McKinsey, an international consulting company, Russia's projections about the contribution of digitalisation to the Gross Domestic Product (GDP) of the country by 2025 do not look that optimistic. The growth in the Russian GDP will amount to 4.1–8.9 trillion rubles, which is equal to 19–34% of the planned figures. The analytical report prepared by the experts says that to triple the share of the digital economy in Russia from 3.2 trillion rubles in 2015 to 9.6 trillion in 2025, the average yearly growth rate must be maintained at the level of 12%, which was observed in 2010–2015. This is equal to an increase in the share of the digital economy up to 8–10% of the GDP, which is inherent in the countries leading the world market.12

One of Russia's strategic short-term goals is to ensure that it is one of the world's leading economic systems, which is hardly possible without reducing the range of digital inequality and finding additional tools for achieving competitiveness.

There is a need for a comprehensive assessment of the digitalisation processes taking place in regional economic systems. The results obtained can be the basis for improving the programmes of digital development in the country, aimed at reducing the differences in digital development between various

[5]Hargittai, E., 2002. Second Level Digital Divide: Differences in People's Online Skills. First Monday. 7, 4. Available at: https://firstmonday.org/article/view/942/864 (accessed: 17.06.2019)
[6]Einav, L., Levin, J., 2014. Economics in the age of big data, Science346, pp. 715–721.
[7]Varian, H.R., 2014. Big data: new tricks for econometrics. Journal of Economic Perspectives. 28, 8.
[8]Haber, S., Stornetta, S., 1991. How to time stamp digital document. Lecture Notes in Computer Science. 537, 437–455.
[9]Norman, A.C., 1993. Information Society: An Economic Theory of Discovery, Invention and Innovation. Boston, Kluwer Academic Publishers, 120.
[10]Mulgan, G.J., 1991. Communications and Control: Networks and New Economies of Communication. Oxford, Polity, 19.
[11]Brynjolfsson, E., McAfee, E., Spence, M., 2014. New world order. Labor, capital, and ideas in the power law economy. Foreign Affair. 93.
[12]McKinsey report. URL: https://www.mckinsey.com/russia/our-insights/ru-ru. (accessed: 18.03.2021).

regions. They can also be used to analyse the contribution of every individual region to the achievement of the target indicators, according to the federal digital economy project. Thus, the problem of digital inequality in the Russian regions calls for extensive theoretical research, scientific evidence and more sophisticated tools for developing practical solutions.

2. Literature review

Digitalisation processes penetrating the global socio-economic environment make the development trajectories of economic systems evolve. These processes contribute to the transformation of public administration and the adaptation of business models towards the challenges the digital economy faces today. This leads to a modification of the traditional forms of relationships and their principles, a transformation of behavioural strategies and, despite obvious advantages, the problem of digital inequality.

To study the problems of inequality in various social groups, territories and countries in terms of digital technology tools, as early as 1997, the UNO coined a new term—information poverty. It includes a few characteristics: financial, technical, educational, preparatory, cultural, demographic and linguistic.13

In the early 2000s, the Organization for Economic Cooperation and Development coined the term 'digital divide', which refers to 'the gap between individuals, households, businesses and geographic areas at different socio-economic levels with regard both to their opportunities to access information and communication technologies (ICT) and to their use of the Internet for a wide variety of activities'14.

Starting from the 2000s, matters concerning the evaluation of global digital inequality were considered primarily in terms of the geographic aspect and in relation to the unequal access to the Internet and digital technologies. This was the basis for referring countries to either being informationally rich or informationally poor.

Further research into the problem of digital inequality was based on a simulation of numerous factors that correlate strategy and policy at all levels of management. For example, 2001 witnessed the appearance of the 'income – infrastructure – human capital – policy' model. The calculations made with this model show that the key factors of the digital divide are the level of income, the quality of regulation and the competitiveness of the telecommunication market.

The differences in the level of economic, social and political development of individual countries, as well as the state policy, are some of the most important premises for them being essentially differentiated in terms of the availability of up-to-date ICT and digital tools used by the people, as noted by Ragnedda and Muschert in their study.15

The digital divide as a form of digital inequality can be assessed in a comprehensive way based on an analysis of technological, social and economic aspects. The existing approaches to studying these problems vary in terms of the determinants they rely on for evaluating, to a certain degree, the digitalisation processes occurring in the society and the end-to-end digital technologies being used.

For example, the Intelligence Unit of *the Economist* considers the Internet coverage in 100 countries, as it is an essential condition of digitalisation. The Inclusive Internet Index suggested for calculation includes the production of four sub-indices: availability, affordability, relevance and readiness16.

The International Telecommunication Union suggests that the development characteristics of the ICT infrastructure and demand for ICT be used as the resulting indicators of digital transformation. The

[13]Digital inequality. Science and life [Electronic resource]. URL: http://www.nkj.ru/archive/ articles/6053/ (accessed: 30.03.2021)

[14]Understanding the digital divide. OECD. 2001. URL: http://www.oecd.org/internet/ieconomy/1888451.pdf (Date of retrieval: 30.03.2021).

[15]Ragnedda, M., Muschert, G.W., (eds.) 2013. The Digital Divide: The Internet and Social Inequality in International Perspective. New York, NY: Routledge.

[16]The Inclusive Internet Index 2020, https://theinclusiveinternet.eiu. com/explore/countries/performance.

ICT Development Index includes the calculation of 11 indicators grouped into subsystems: ICT access, ICT use and ICT skills17.

In terms of the evaluation of the obligations imposed on the International Telecommunication Union (ITU) member states, the Global Cybersecurity Index considers the processes of digitalisation. When calculating its integrated indicator, the ITU considers five sub-indices: legal aspects of cybersecurity (legal), technical aspects of cybersecurity (technical), organisational aspects of cybersecurity (organisational), the skills of a country to build a cybersecurity system (capacity building) and international cooperation in the field of cybersecurity (cooperation)18.

The opportunities of various countries for carrying on e-commerce in the business-to-customer segment underlie an approach suggested by United Nations Conference on Trade and Development, (UNCTAD) via the B2C E-Commerce Index. The comprehensive assessment uses an integrated indicator obtained from the average mean of four indicators: the share of individuals using the Internet, the share of individuals aged 15 or older having a bank account, the number of secure internet servers per 1 million people and the integrated index 'UPU Postal Reliability Score'19.

The methodological approach of the European Commission implies calculating 31 indicators that are grouped into five areas: communications (landline broadband access, mobile broadband access, speed of the Internet and cost), human capital (basic skills and communications, long-term opportunities), use of the Internet (content, communications and transactions), integration of digital technology (e-business and e-commerce) and public digital services (e-government). The result of the comprehensive assessment is the Digital Economy and Society Index20.

Bhaskara Chakravorty and Ravi Shankara Chaturvedi, researchers from the Fletcher School at Tufts University, suggested using the Digital Evolution Index to assess the maturity of the digital economy, given a country's involvement in international digital trade. The specifics of their approach is that the final indicator is calculated based on the analysis of trends in 170 indicators, which are systematised into four sub-indices: supply conditions, demand conditions, institutional environment, innovation and change. The results of their studies in 60 countries worldwide allowed them to make up a map called the 'Digital Planet' and define four trajectory zones: Watch Out countries, Break Out countries, Stand Out countries, and Stall Out countries21.

The Network Readiness Index (NRI), developed by the Portulans Institute and the World Information Technology and Services Alliance (WITSA), can be used to evaluate the development of digital technology and its impact on the economic growth of a country. It includes 62 indicators. Each indicator refers to a certain group of sub-indices: technology, people, governance and impact, whose comprehensive assessment is made based on the arithmetic mean22.

The International Institute for Management Development (IMD) compiles the World Digital Competitiveness Ranking, which is based on evaluating the countries in terms of the intensity of development and practical use of digital technology, leading to the transformation of public administration, business models and society. The final index, which is used for ranking the countries, consists of three sub-indices: knowledge, technology and future readiness. Fifty-one analytical indicators were used to calculate them23. The Institute for Information Society Development and the Ministry of Communications and

[17]Measuring the Information Society Report 2017 http://www.itu.int/en/ITU-D/Statistics/Documents/publications/misr2017/MISR2017_Volume1.pdf.

[18]'Global Cybersecurity Index (CGI) 2018': https://www.itu.int/dms_pub/ itu-d/opb/str/D-STR-GCI.01-2018-PDF-E.pdf

[19]https://unctad.org/en/PublicationsLibrary/tn_unctad_ict4d14_en.pdf.

[20]The Digital Economy and Society Index (DESI). Final Report. European Commission. https:// ec.europa.eu/digital-single-market/en/desi

[21]'Global Cybersecurity Index (CGI) 2018'. https://www.itu.int/dms_pub/ itu-d/opb/str/D-STR-GCI.01-2018-PDF-E.pdf

[22]https://networkreadinessindex.org/wpcontent/uploads/2020/03/The-Network-Readiness-Index-2019-Newversion-March-2020-2.pdf

[23]https://www.imd.org/wcc/world-competitivenesscenter-rankings/world-digital-competitiveness-rankings-2019/

Mass Media24 elaborated a methodology for forming the rankings of the constituent entities of the Russian Federation. It is based on an integral index measuring the development of the information society (including 15 sub-indices) and can be used for a comprehensive assessment of the factors affecting the evolution of the information society and the use of ICT for development.

The Center for Digital Technology Competence (Rosatom State Corporation), together with experts from research organisations, universities and businesses, suggested its own way to assess the digital divide in economic sectors that are analysed from the perspective of digital technologies used by enterprises according to OECD standards and are distinguished by the classifier of the types of economic activity. The methodological tools are based on the principle of a Russian doll; the total number of indicators used depends on the level of assessment. The method of distances from the reference values is used as a basis, and the procedure for normalising the initial data is applied in the calculations.25.

Stepanova, Ukhanova, Grigorishchin and Yakhyaev proposed an approach to differentiating the constituent entities of the Russian Federation based on two integral indices that consider the digital activity of the population, organisations and the digitalisation of the state: the Digitalization Index of the region (Id), which defines the digital activity of the subjects of an ecosystem, and the Digitalization Conditions Index of the region (Idc), based on which the digital ecosystems of Russian regions are evaluated. A matrix analysis based on the k-maximum method represents a procedure for reducing a given number of observations to several groups with similar characteristics. Since the indicators selected for evaluating digital ecosystems are stimulating indicators (the higher their value, the better), then the maximum value of the x variable (indicator) acts as k (Maksimova, 2019).

Based on the adapted ICT Development Index (IDI), Karyshev built his own statistical method for evaluating digital inequality26. The calculations rely on three blocks of indicators, while the resulting index and sub-indices are measured using an arithmetical mean formula, whose weights are determined based on the implicit logic of the experts in each case:

1 block: Core indicators of the use of ICT by businesses (12 indicators)

2 block: Core indicators for the ICT sector (2 indicators)

3 block: Core indicators on trade in ICT goods.

Gladkova, Garifullin and Ragnedda Massimo built their methodological approach on the three-levelled theory of digital inequality. According to the authors, the theory allows for more detailed studies of the digital divide, as it investigates the social prerequisites for digital inequality. A system of indicators is suggested in the context of each level.

For example, the first level of digital inequality characterises the following indicators: data on the total number of internet users (broadband, mobile Internet), the number of internet subscribers, the number of households having access to the Internet, the degree of internet coverage, mobile radiotelephone (cellular) communication coverage, the average internet access cost, the average internet connection speed, and the type and quantity of devices with internet connection.

The indicators determining the qualitative characteristic of the second level of digital inequality are as follows: the data on digital literacy/the level of digital competencies/users' skills, the level of internet openness of the region (applicable to Russia), the data on the motivation to use the Internet and ICT, given the users' socio-demographic characteristics, the practice of using the Internet, etc.

The indicators measuring the third level of digital inequality include data on the benefits of the

[24]Methodology for assessing the advancement of the information society in the constituent entities of the Russian Federation/ The Institute for Development of Information Society; Ministry of Communications and Mass Media. https://d-russia.ru/wp-content/uploads/2016/04/methodika_otsenka_io.pdf

[25]The National Index of Digital Economy Development: Pilot implementation. Public Corporation 'Rosatom', 2018.

[26]Karyshev, M.Yu., 2011. The statistical method for measuring the digital economy: searching for an integral indicator. Accounting and statistics. 4, 74–82.

Internet and ICT, expressed, among other things, in the dynamics and specifics of the online services that are used, their adaptation to user requests, the work of e-government, various opportunities for users' professional self-realisation, etc. (Gladkova, 2019).

A special feature of the approach proposed by Safiullina, Abdukaeva and Elshina is the possibility of identifying indicators according to the profiles of federal (regional) projects. To perform calculations, the entire array of the source information must be divided into five groups of sub-indices: personnel and education (three calculated indicators), research competencies and technical capacities (three calculated indicators), information infrastructure (seven calculated indicators), information security (two calculated indicators) and legal regulation (analysis of information from websites). The index method of analytical information aggregation and ordering is used, with the initial data normalised (Kuzovkova, 2019).

A complex system of integral, generalising and partial indicators that take into account the maturity of the economy and society was proposed by Kuzovkova, Salyutina and Kukharenko (Dobrinskaya, 2019). In particular, the researchers highlighted an integral indicator of digital development at the stage of digitalization of operational and business processes, as well as management, production and consumption systems and structures; an integral indicator of digital development at the stage of digital transformation of the economy and society, and an integral indicator of digital development at the stage of formation of a single national digital space. The state of digital development is evaluated by objects and their rankings are compiled based on normalised values of private indicators, given the significance of individual and consolidated indicators.

The authors substantiated seven sub-indices and their weights, which can be used together with an additive model to obtain the resulting value of the Digitalisation Index for each constituent entity of the Russian Federation (RF):

1. Regulatory control and administrative indicators of digitalisation

2. Skilled personnel and training programmes

3. Availability and formation of research competencies and technological capacities, including the level of research and development

4. Information infrastructure

5. Information security

6. Economic indicators of digitalisation

7. Social effect from digitalisation.

According to the results of the calculations, two main causes of the digital divide were identified. They are the inequality in technological opportunities and insufficient digital skills and competencies27.

As seen, each of the approaches to assessing the level of digital development of economic systems differs from the others in terms of the assessment indicators, description of individual effects from digital technologies, and characteristics of institutional aspects.

After analysing the foreign and national methodological approaches to assessing the level of digital transformation and finding ways to reduce the digital divide, it can be concluded that they can be used to a very limited extent, given the conditions in the Russian Federation. This is caused by the following circumstances:

- Today, the single bank of statistical information supported by Rosstat contains no information for carrying out research that details or draws objective conclusions about the current situation.

[27]Digital Life of Russian Regions. What Does Digital Breakthrough Depend on? https://iems.skolkovo.ru/downloads/documents/SKOLKOVO_IEMS/Research_Reports/SKOLKOVO_IEMS_Research_Digital_life_of_russian_regions_2020-06-09_ru.pdf

- There are still discussions about which indicators should be prioritised.

- There is no clear separation of the indicators that characterise the trends of the digital economy and its efficiency in certain industries, sectors and levels of the economy.

- The dynamic processes of digitalisation and changes in the global market transform the requirements for legal regulation, digital infrastructure, cybersecurity, digital government and digital technologies. All of this calls for prompt adjustments in the methodological approaches for making adequate qualitative and quantitative assessments.

- Most of the methodologies proposed exclude the possibility of analysing and monitoring the indicators that are used, since the periods for providing economic systems by these constituent entities vary greatly.

- Additional studies into the characteristics of the regions must be conducted to consider the entire data provided. This implies that a separate system of indicators should be used for individual regions and should consider their development and potential.

- Due to the high labour intensity of the calculations, some indicators are 'morally' outdated and cannot fully reflect real digital transformation processes.

- The foreign methodological approaches do not consider the special features of individual countries, in particular, innovative, financial, investment potential and other components, as well as the most important social characteristics that lead to significant differentiation in the use of ICT.

- The existing national approaches to assessing the efficiency of the digital economy do not consider the indicators that reflect the possibilities of having highly qualified personnel and the innovative activity of the region, which, we believe, cannot be excluded from the integral assessment.

- Modern sources of information lack any common understanding of the terminology that characterises the digitalisation processes, which leads to different interpretations of the concepts and inconsistency in the systems of indicators that characterise them. This is typical of different levels of administration in various aspects.

3. Materials and methods

This study relies on a system approach, methods of ranking scores, expert evaluation, comprehensive assessment, comparison, standardization of indicators, induction and deduction and statistical analysis of data. The source information included statistics from official publications and the Rosstat website, data on trends in the digitalisation processes in the country and its individual regions from the 'Digital Russia' website28, and the reports of the Analytical Center for the Government of the Russian Federation.

The digital differentiation of Russian regions is the result of inconsistent socio-economic policy and the uncertain contours of strategic development. Each region independently determines the priority areas of end-to-end digital technologies and the opportunities for them being used, given the state of the digital infrastructure and its developmental prospects.

For example, according to the 2019 data of the Analytical Center for the Government of the Russian Federation, 80% of all regions (altogether there were 79 respondent regions) called Big Data and wireless communication technologies their top priority (Figure 1)29.

Considering the digital initiatives implemented in sectors, three leading segments should be distinguished: healthcare, comfortable urban environment and personnel for the digital economy (Figure 2).

[28]https://d-russia.ru/

[29]The Current Development of Projects in the Digital Economy in the Russian Regions. Analytical report. https://ac.gov.ru/archive/files/publication/a/23243.pdf (accessed: 16.03.2021).

The current situation in the regions is caused by numerous circumstances that influence the practical implementation of the projects aimed at the digitalisation of the economy, the use of end-to-end digital technologies and the state of the digital ecosystem, which creates the digital divide (Figure 3).

Obviously, the lack of qualified personnel capable of tackling the problems in digitalisation, plus the imperfect current legislation, are among the key factors hindering the digital transformation processes in the regions.

Moreover, these aspects are identical for almost all regions. Only three out of 70 constituent entities gave a positive answer about the absence of problems in the digitalisation projects they are implementing.

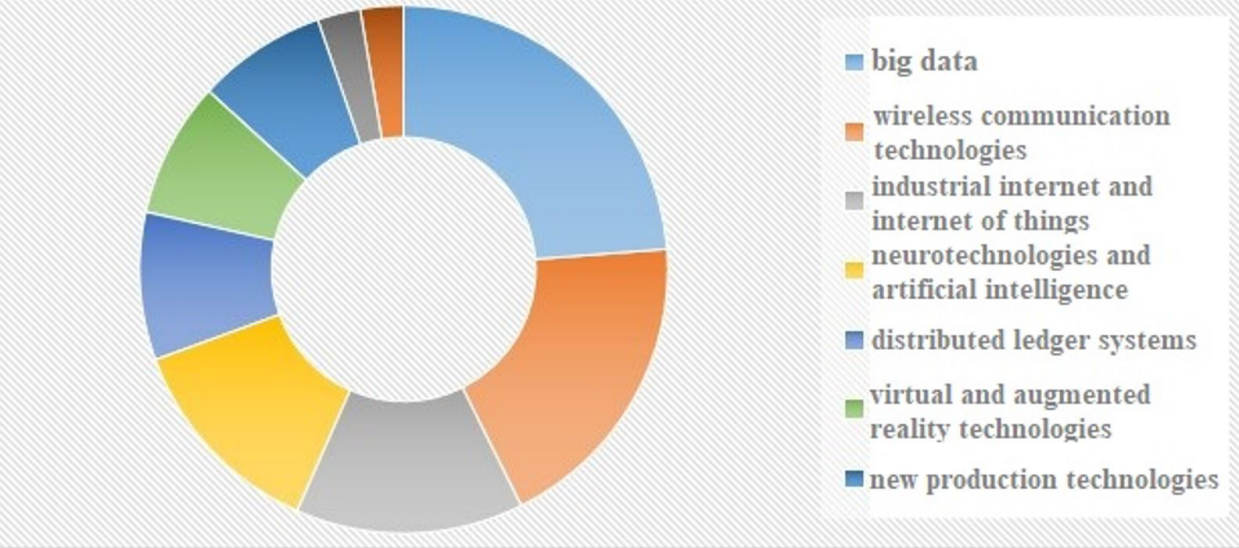

Figure 1. Priority end-to-end digital technologies in the regions of Russia according to 2019 data (Source: Analytical center for the results of a survey of regional executive authorities [ROIV]).

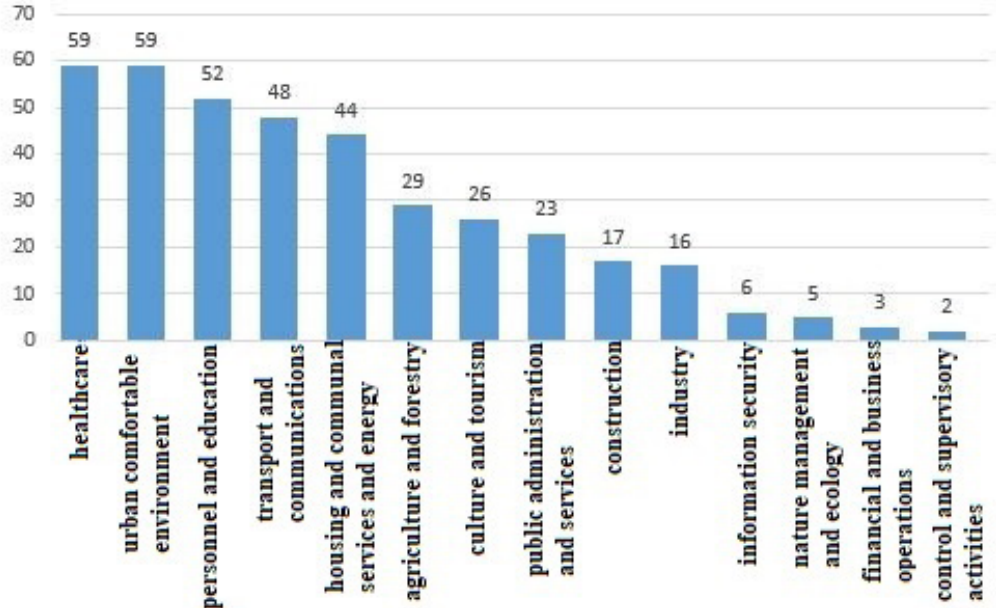

Figure 2. Priority sectors of digital transformation in the regions of Russia (according to 2019 data (Source: Analytical center for the results of a survey of regional executive authorities [ROIV]).

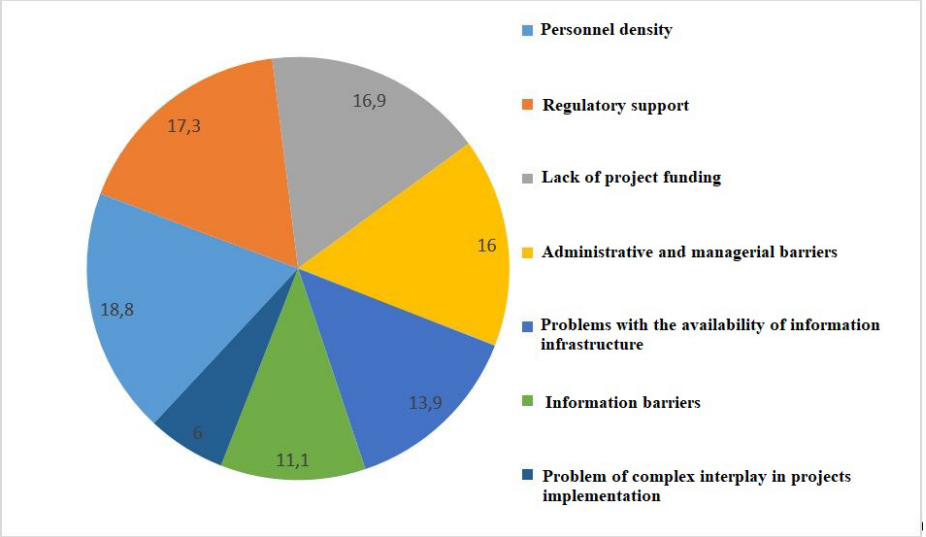

Figure 3. The structure of barriers to the digital transformation processes in the Russian regions, %, according to a survey of 70 regions for 2019. (Source: Analytical center for the results of a survey of regional executive authorities [ROIV])

Due to the above circumstances, a separate group of indicators had to be formed to analyse the current state of this problem and the possibility of its resolution within a region. Also, the experts' opinion was that the low level of digital culture is a significant barrier to the introduction of end-to-end digital technologies in different economic sectors and industries.

The digital transformation of Russian regions depends primarily on the ICT sector. Therefore, when a set of indicators is chosen for assessing the efficiency of digital transformation processes and identifying the digital divide, this group is the most important. This is because the digital divide can be reduced in the regions in case there are comprehensive programmes for developing information networks, improving the quality and access to digital services, introducing modern digital platforms and services, enhancing the functionality of the e-government, etc.

Active digital transformation processes mean that innovative activity increases due to fundamental and applied research and the growing number of personnel involved in research and development. As a result, there is a rise in the quantities of products, work and digital services, which is a qualitative characteristic and requires, in our opinion, special consideration (Ragnedda, 2018).

Thus, we propose an original approach to assessing digital transformation processes through an integrated criterion, which considers the current state of the digital infrastructure, personnel potential and innovative development. Figure 4 illustrates the decomposition of the algorithm presented.

We believe that the assessment mechanism can be used to control the digital transformation process in a region because of various changes aimed at reducing the digital divide and developing ways to increase digital activity.

The comprehensive assessment of the digitalisation processes in a regional economy (Kdt) can be represented as an additive dependence:

$$Kdt = IDI + Idp + Iia; \quad (1)$$

where IDI is the Digital Infrastructure and Technology Index;

Idp is the Personnel for Digital Economy Index;

Iia is the Innovative Activity Index.

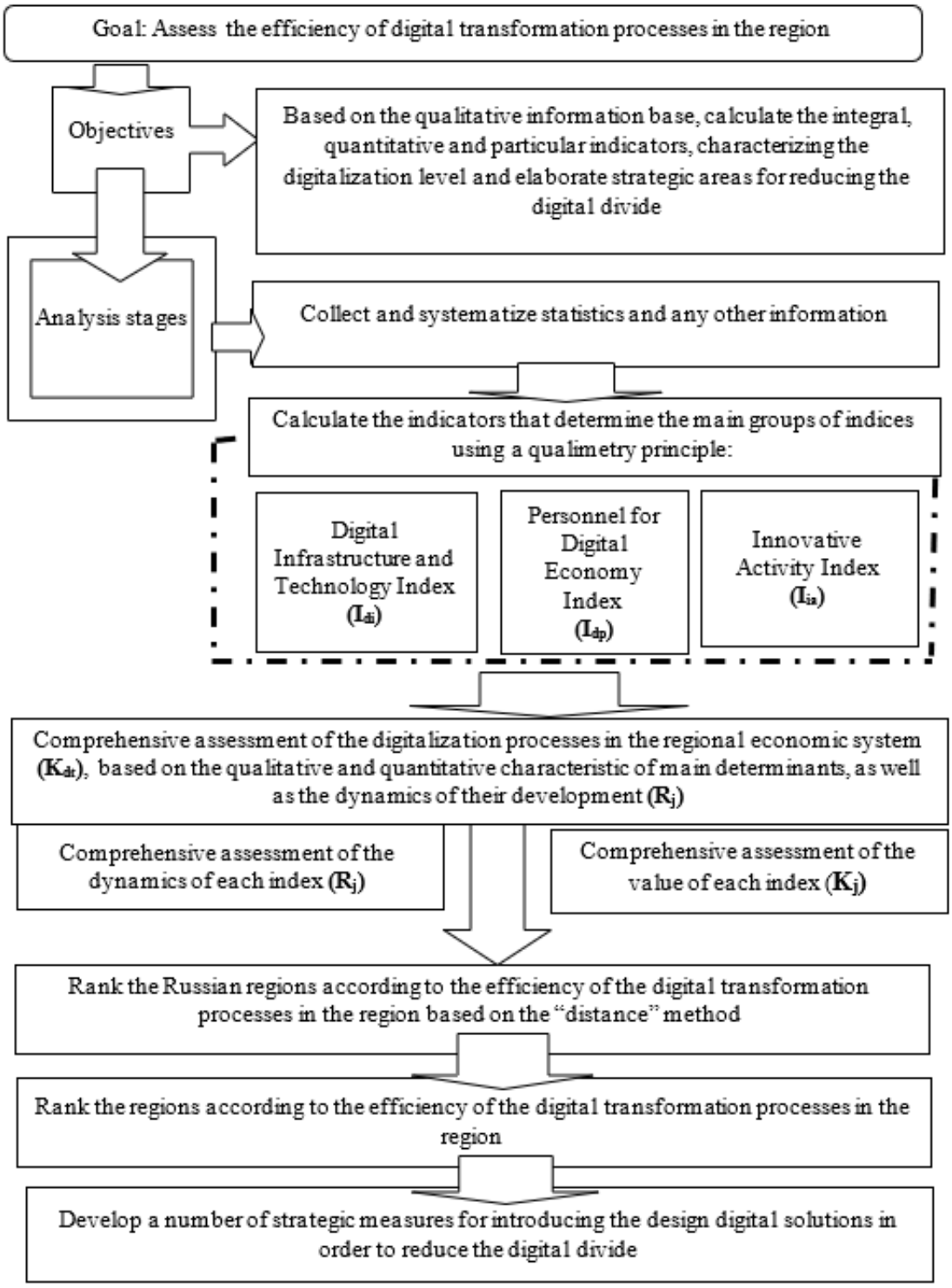

Figure 4. The authors' approach to comprehensively assessing the efficiency of the digital transformation of a regional economic entity

Table 1 shows the system of qualitative and quantitative indicators to be calculated. It can be used to assess the level of digital inequality in the regions and to find reserves for reducing the imbalance in digital development.

Table 1. System of indicators for assessing the determinants that characterise the digital transformation of the regional economic system

Index	System of indicators for assessing the digital development determinants (F)
Digital Infrastructure and Technology Index (I_{DI})	Labour productivity in the economic sectors, %
	Share of digital products in the GRP, %
	Maturity of the regulatory framework for digital transformation solutions, %
	Level of digital competencies in the regional centres, %
	Implemented digitalization cases, units
	Share of the purchased (leased) national software in the total purchases, %
	Subscribers to the broadband landline Internet per 100 people, units
	Subscribers to the broadband mobile Internet per 100 people, units
	Share of households with access to the broadband Internet in the total number of households, %
	Share of organisations using the Internet in the total number, %
	Share of organisations using the broadband Internet in the total number, %
	Share of organisations that have a website, %
	Number of personal computers per 100 employees, units
	Number of personal computers with access to the Internet per 100 employees, units
	Share of organisations using special software total, %
	Share of organisations using special software for scientific research, %
	Share of organisations using special software for designing, %
	Share of organisations using special software for automated production control and / or managing some technical means and technological processes, %
	Share of organisations using special software for tackling organisational, managerial and economic problems, %
	Share of organisations using special software for financial settlements in electronic form, %
	Share of organisations using special software for providing access to databases through global information networks, including the Internet, %
	Share of organisations using special software for training programs, %
	Share of organisations using CRM, ERP, SCM systems, %
	Share of organisations using special software for electronic legal reference systems, %
	Share of organizations using software, %
	Share of organizations using local computer networks, %
	Share of organisations using electronic document management systems, %
	Share of organisations using electronic data exchange between their own and external information systems, according to exchange formats, %
	Share of households with a personal computer, %
	Share of the population using the Internet

Personnel for Digital Economy Index (I_{dp})	Number of students enrolled in training programs for skilled workers, employees, thousand people, including those in IT programmes
	Skilled workers and employees, thousand people, including in graduates from IT programmes, people
	Number of students enrolled in Bachelor's, Specialist's, and Master's programs, thousand people, - Including those in IT programmes
	Enrollment in bachelor's, specialists, master's programs—total, thousand people, including those in IT programmes
	Graduation of bachelor's, specialists, master's, thousand people, including those in IT programs
	Number of graduate students, people, including in IT areas of training
	Number of PhD students, people, including in IT programs
	Population who received a personal digital certificate
	Number of teaching staff who received digital skills in AVE programs
	Number of employees in various economic sectors who received digital skills under AVE programs
	Highly qualified personnel in the digital sector of the economy, %
	Cybersecurity specialists, %
	Educational institutions teaching digital competencies, %
Innovative Activity Index (I_{ia})	Innovative goods, work, services, million rubles
	Research and development organisations, units
	Number of personnel involved in research and development, people
	Internal research and development costs, million rubles
	Internal fundamental research costs, million rubles
	Internal applied research costs, million rubles
	Issued patents for inventions, units
	Created advanced production technologies, units
	Issued patents for utility models, units
	Innovative activity of organisations, %
	Costs of innovative activities in organisations as a percentage of the total goods, work, services
	Innovative goods as a percentage of the total goods, work, services, million rubles

As you can see, the list of indicators in the table illustrates the qualitative processes of digitalization and is grouped into three system-forming blocks, which are logically interconnected and, in our opinion, fully reflect the current development trends.

In contrast to the above approaches to assessing the processes of the digital divide, the system of indicators we propose has the following strengths:

- It considers the innovation block, which is not considered by researchers and practitioners and is not included in any of the approaches to evaluating digitalization. As you know, digitalization processes cannot be actively implemented without an increase in the level of innovative activity.

- It has three most important indicators in the 'Digital Infrastructure and Technology' block of the three most important indicators that reflect the digital initiatives of regional development: level of digital competencies in the regional centres, %; implemented digitalization cases, units; share of purchased

(leased) national software in total purchases, %.

- The structure of the 'Personnel for the Digital Economy' block includes indicators that show to what extent digital competencies are developed. It is an important condition for activating digitalization processes and achieving the planned effect: the number of teaching staff who have received digital skills in the programmes of further vocational education and the number of workers in various sectors of the economy who have received digital skills in the programmes of further vocational education.

- The differentiation of indicators by three indices makes it possible to use the methods of factor analysis to determine the effect of various determinants on the level of digital inequality.

- The system of the proposed indicators is based on official information presented in statistical compilations and analytical studies.

- The list of indicators can be reduced to meet the objectives of analytical research.

Since the calculations include heterogeneous indicators, the qualitative assessment is obtained using a traditional normalising procedure, which implies that all the determinants are divided into two groups—simulating indicators and de-simulating indicators. The further calculation algorithm suggests that various methods of comprehensive assessment are used (Figure 6).

4. Results

To test the methodological approach suggested by the authors, many of the quantitative and qualitative indicators were calculated using statistics on the regions that are constituents of the Central Federal District of the Russian Federation30. The period of study is 2018–2019. Table 2 shows the estimated data by indices and a comprehensive assessment of the digital transformation levels of the analysed population of the regions.

Table 2. Results of calculations of the integral indicator and the components of the determinants of digital transformation of the regions of the Central Federal District of the Russian Federation

Constituent Entities of the Central Federal District	2018			2019			2018	2019
	I_{DI}	I_{dp}	I_{ia}	I_{DI}	I_{dp}	I_{ia}	K_{dt}	K_{dt}
Belgorod region	0.3822	0.1730	0.3141	0.3915	0.1970	0.2946	0.869	0.883
Bryansk region	0.3214	0.0922	0.1422	0.3445	0.1070	0.1318	0.556	0.583
Vladimir region	0.3251	0.0615	0.1203	0.3450	0.0712	0.1182	0.507	0.534
Voronezh region	0.3861	0.1496	0.3274	0.3972	0.1512	0.3215	0.863	0.870
Ivanovo region	0.3945	0.0349	0.1237	0.4060	0.0496	0.1105	0.553	0.566
Kaluga region	0.4368	0.0583	0.3144	0.4429	0.0850	0.3128	0.810	0.841
Kostroma region	0.2295	0.0644	0.1378	0.2396	0.0733	0.1262	0.432	0.439
Kursk region	0.2815	0.1134	0.3214	0.3048	0.1297	0.3195	0.7163	0.754
Lipetsk region	0.2463	0.1007	0.2855	0.2844	0.1189	0.2792	0.734	0.761
Moscow region	0.3918	0.1540	0.3246	0.4244	0.1619	0.3177	0.870	0.904
Oryol region	0.2522	0.0722	0.1722	0.2603	0.0899	0.1640	0.4966	0.514
Ryazan Oblast	0.2916	0.0461	0.1834	0.3071	0.0531	0.1752	0.521	0.575
Smolensk region	0.3041	0.0582	0.2861	0.3261	0.0674	0.2722	0.648	0.666
Tambov region	0.3678	0.1022	0.3298	0.3937	0.1188	0.3210	0.799	0.834
Tver region	0.2145	0.0763	0.1477	0.2263	0.0901	0.1350	0.439	0.451

[30]Russian Regions. 2020 Socio-Economic Indicators. https://gks.ru/bgd/regl/b20_14p/Main.htm (accessed 16.03.2021)

Tula region	0.2586	0.0807	0.2331	0.2657	0.08110	0.2243	0.5724	0.571
Yaroslavl region	0.2897	0.0530	0.2538	0.3014	0.0690	0.2402	0.60	0.611
Moscow	0.4376	0.1583	0.3314	0.4413	0.16663	0.3245	0.927	0.932

Source: Calculated by the authors based on statistics of Rosstat

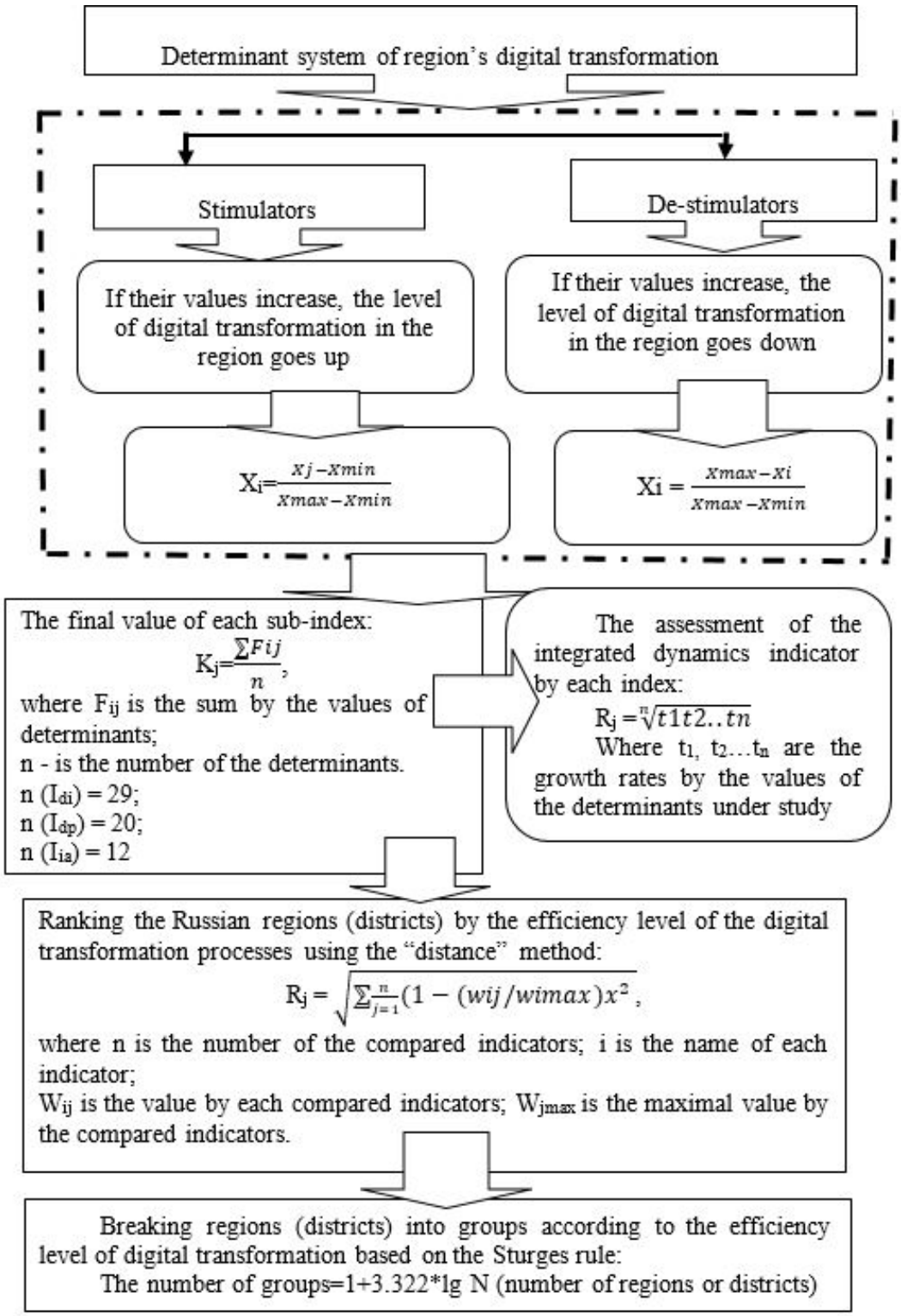

Figure 5. Methodological approach to a comprehensive assessment of the determinants characterising the digital transformation of regional economic systems for evaluating the level of the digital divide

As we can see from the table, the integrated indicator of the digital transformation within each of the regions we are considering tends to grow compared to the level of 2018. However, it occurs only

due to the increasing values of 'Digital Infrastructure and Technology' and 'Personnel for Digital Economy'. This situation is due to the financing of the measures taken within the national projects and aimed at reaching the target indicators. It should also be noted that the value of the Innovative Activity Index tends to decline, which is a factor impeding active processes of digital transformation in regional economic systems and calls for special attention and support measures, as it is one of the major causes of the digital divide. At the same time, we should not forget that the quality state of the regional innovation system is an intensive factor affecting the development of the national economy (Ragnedda, 2018).

The research should break up regions by group according to their level of digital transformation. Then it will be possible to identify the causes of the digital divide and adjust the strategies for digital development of the regions. We grouped the regions using the Sturges rule31.

Based on the results of the calculations and assessments, six groups of regions were identified given the level of digital development based on the design value ranges (Table 3).

Table 3. Groups of regions of the Central Federal District of the Russian Federation by the efficiency level of digital transformation processes

Groups of Regions	Design value ranges		Regions	Level
I	0.436	0.537	Kostroma region Oryol region Tver region	Outsider regions
II	0.537	0.635	Bryansk region Vladimir region Ivanovo region Ryazan region Tula region Yaroslavl region	The initial level of development of digitalisation processes
III	0.635	0.733	Smolensk region	The average level of development of digitalisation processes
IV	0.733	0.831	Kursk region Lipetsk region	Active regions
V	0.831	0.929	Belgorod region Voronezh region Kaluga region Tambov region	Advanced regions
VI	0.929	1.0	Moscow region Moscow	Leading regions

As you can see, Moscow and the Moscow region are the leading regions. Their distinctive feature is active digitalisation processes in all spheres of life. Numerous pilot projects that were launched clearly demonstrate the possibilities of improving the quality and standard of living of the people.

The group of advanced regions includes Belgorod, Voronezh, Tambov and Kaluga regions. This is because regional government bodies pay a lot of attention to the development of the IT sector and building effective chains of interaction between the participants in the digital ecosystem, which opens up new opportunities and prospects.

The calculations show that the Kursk and Lipetsk regions are active regions. The digital transformation processes have affected all sectors of the economy, strategic documents have been adopted for implementing digital development, and educational institutions in the regions are actively involved in

[31]Sedler, M.I., Sedler, M.X., 2013. Statistical Methods in Quality Management: Course book. /St. Petersburg State Polytechnic University.

training workers for the digital economy, which is done, in particular, through additional educational programmes funded by the federal budget.

Among the regions with an average level of development of digitalisation processes is the Smolensk region. The digital infrastructure in the region is relatively developed; most people prefer using an electronic mechanism for obtaining services, and there are up-to-date educational programmes for working in the digital environment.

The fourth group was the most numerous among the ones presented. It includes six regions—Bryansk, Vladimir, Ivanovo, Ryazan, Tula and Yaroslavl. The basic level of digitalisation processes in these regions can be explained by the fact that these digitalisation processes are slow in the entire economic system. That is, digitalisation processes occur only in certain sectors, for example in healthcare or in the transport sector. No clear mechanism has yet been provided for interaction between educational institutions and regional government bodies in terms of training highly qualified workers, developing digital infrastructure and expanding cluster forms of interaction. Regional projects must be improved and accommodated with the target figures of the strategy for the socio-economic development of the regions.

Based on the calculation results, the Kostroma, Oryol and Tver regions are categorized as outsider regions. The slow pace of digitalisation is caused by the lack of a sufficient number of regional digital transformation cases, the low level of initiatives for industrial digitalisation, and the absence of experience in creating cluster structures in the IT sector, even though the regions have the appropriate resource potential to do so.

All of the above implies that there is a problem of differentiation of the digital development of regional economic systems and the plans and programmes for the strategic development of territories have to be adjusted so that the consequences of the current situation can be mitigated and new points of economic growth can be found.

4. Discussion

The tools proposed by the authors for assessing the level of digital transformation can be used to measure the performance of regional government bodies in terms of achieving the target indicators of regional projects under the National Digital Economy Program. For instance, the results achieved in the interregional analysis of similar operating conditions can be used to systematise the strengths and weaknesses of the digital solutions being implemented. They can also help in developing a set of measures to eliminate threats and enhance initiatives, which ultimately implies that the vector of the strategic development of the territory is adjusted accordingly.

The following conclusions were made after carrying out a comparative analysis of the results obtained from the study of the approach proposed by the authors, given the methodology for assessing the digital development of regions and identifying the causes of the digital divide.

According to the results of the Digital Russia Index32, calculated based on public information, events and their citations, the final ranking represents the sum of the score and the ranking of the regions by the level of their digital development, as well as a comparison of the districts of the Russian Federation. In contrast to the tools proposed by the authors, one of the ‘bottlenecks’ of this approach is the predominant use of expert evaluations rather than official statistics, which leads to several distortions. The approach does not consider opportunities for a comparative assessment in the context of constituent entities that are parts of districts, which seems inappropriate. Moreover, the ranking does not take into account the innovative activity of the regions, even though innovations are the most important tool of digital transformation and these elements cannot be considered in isolation from each other.

For example, the ranking “Digital Life of Russian Regions” prepared by a team of researchers from the SKOLKOVO Moscow School of Management33, is based on the use of a model built by

[32]https://d-russia.ru/vyshla-polnaya-versiya-rejtinga-regionov-po-urovnyu-razvitiya-tsifrovizatsii-tsifrovaya-rossiya.html
[33]https://iems.skolkovo.ru/downloads/documents/SKOLKOVO_IEMS/Research_Reports/SKOLKOVO_IEMS_Research_

Dasgupta and his colleagues and regions are ranked depending on the state of factors that affect the level of secondary digitalisation and cause digital divide. The factors are broken down into three groups: (1) income level, (2) human capital and (3) the region's digitalisation policy. They are considered in relation to the region's transportation system, financial sector, healthcare, media, education and administration. In our opinion, the approach we propose is much broader, as it can be used for evaluating innovative activity as well as for considering a large list of indicators that characterise the potential for developing personnel for the digital economy. For example, this ranking considers the entire educational system with just two system indicators—total higher educational institutions and educational institutions that use distance-learning technologies. Thus, it is impossible to fully analyse people's readiness to acquire digital skills. Moreover, the 'Administration' block is analysed only by learning about whether people are registered on Gosulsugi (public services portal) and does not consider the most important areas for the development of e-government, which are covered in our methodology.

The results of the analysis of the Digital Economy Development Index calculated by Rosatom Corporation34 are based on a set of indicators systematised into groups of factors: state policy and regulation, human capital, research and development and innovations, business environment, information security, digital economy, digital infrastructure, digital government, digital healthcare, digital business, digital citizens, competitiveness and economic growth, new business models and organisation of activities. Thus, all the characteristics of digital transformation processes can be considered on a large scale. On the other hand, it should be noted that it may be difficult to calculate many of these indicators due to their inaccessibility to interested users. Therefore, the system of indicators we propose makes it unnecessary to specify digital development indicators in such detail, allowing us to obtain an objective assessment and determine groups of regions according to similar characteristics of their digital transformation.

The undoubted advantage of the methodological approach we propose is that it relies on a system of indicators calculated using open-source data, which makes the calculations and decision-making more efficient. Also, a distinctive feature of our approach is that the data can be visualized using the simplest means of information processing, and integrated indices can be projected. Also, the proposed system of indicators is resistant to dynamic digitalisation processes, and the assessment tools themselves can be enhanced with expert evaluation methods to rank indices by significance. To do so, an expert community must be involved, since the conditions, factors and goals of a particular region can affect the significance of each index.

5. Conclusion

The results of the digital development goals depend on the active processes of digital transformation in certain regions, industries and economic sectors. They lean on the potential available, the digital transformation strategy and initiative decisions, which take the form of the readiness of regional government to put concrete digital solutions into life. This requires a clear prioritisation of regional development based on a detailed analysis of the key socio-economic indicators and forecasted trends (Alexandrova, 2019).

The active digitalisation processes taking place in regional economic systems contribute to their qualitative transformation and help the development trajectory change towards ensuring competitive advantages. The digital potential of the region and the initiatives of businesses and government can create new opportunities, not just inside the region. They can facilitate the opening of international markets, which is one of Russia's strategic priorities.

The level of digital transformation in regions should be assessed primarily to obtain reliable and objective information about various aspects of the region's digital transformation. Therefore, the methodological approach we propose includes three major components—the Digital Infrastructure and Development Index, the Personnel for Digital Economy Index, and the Innovation Activity Index—which are aggregated with 61 analytical indicators.

Digital_life_of_russian_re

[34]National Digital Economy Development Index: Pilot Implementation. Moscow, Rosatom State Corporation, 2018.

Approbating the algorithm based on statistics about the regions of the Central Federal District of the Russian Federation, we managed to obtain a comprehensive assessment of the digital transformation processes. We used the Sturges rule to distinguish regions by their level of digital transformation, based on specific characteristics and certain indicators achieved by regional economic systems.

Following the results of an analytical study of the Russian regions included in the Central Federal District, six groups of regions were found according to their levels of digital development:

Outsider regions (Kostroma, Oryol and Tver regions);

Regions with a basic level of digitalisation processes (most of the regions in the Central Federal District—the Bryansk, Vladimir, Ivanovo, Ryazan, Tula and Yaroslavl regions);

The Smolensk region has an average level of digitalisation;

The Kursk and Lipetsk Regions are regions with active digitalisation processes;

The advanced regions are Belgorod, Voronezh, Kaluga and Tambov regions;

The Moscow region and Moscow are the leading regions.

The data obtained are the basis for adopting a set of measures aimed at taking strategic actions in the field of project management and digitalisation of the regions and improving the tools currently used for assessing the achievement of the target indicators included in the federal projects. In particular, action plans must be developed to reduce the level of digital differentiation in these regions. Among other things, much attention should be paid to the quality of the digital environment, the availability of up-to-date digital services and platforms for citizens, educating people on digital skills, making people more mobile, providing them with access to the elements of the digital infrastructure, and creating conditions for more intense innovative activities to increase the level of implemented digital solutions.

Thus, the level of development of the digital ecosystems in the regions can be assessed in a reliable and accurate way only if the algorithm used for the assessment takes into account not just the individual characteristics of these systems but also their full content, including the subjects of digitalisation of the economy and society, environmental conditions, territorial features, information technology, scientific and innovative advances, and the availability of infrastructure.

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