The comprehensive analysis of digitalisation indices and cross-cutting digital technologies metrics for assessing the digitalisation of the economy

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Abstract. The article examines the comparative analytical validity of two approaches to assess the digitalisation of the economy in terms of the international composite indices of digital development and metrics based on the level of dissemination of cross-cutting digital technologies. Nowadays, index systems, including DESI, NRI, EGDI, and IDI mainly consider the infrastructural, institutional, and social conditions of digital transformation. However, there are some limitations of their implementation in the real sector of the economy. It ensures the relevance of the research. Therefore, the purpose of the research is to compare the effectiveness of index- and technology-based approaches to digitalisation of the economy. The methodological basis of the research includes systematic, comparative, criterion, and index analysis. To unify international index systems, we used the author's method of unified composite digitalisation index (UCDI) based on the aggregation of DESI, NRI, EGDI, and IDI indicators. To assess the technological issue of digitalisation, we use the comprehensive analysis of cross-cutting digital technologies. It resulted in the comparable analytical model including artificial intelligence, quantum technologies, robotics, additive manufacturing, DLT, 5G/6G, and AR/VR. According to the research, unified composite digitalisation index (UCDI) reflects institutional and infrastructural maturity more efficiently. Indeed, cross-cutting digital technologies-based approach identifies differences in technological specialisation and digital transformation of the economies. For instance, China demonstrates a higher position in terms of cross-cutting digital technologies parameters compared to a number of countries leading in traditional digital indexes. At the same time, there is a gap between the level of the digital environment and the level of technological implementation in Russia. Hence, cross-cutting digital technologies metrics have a higher analytical sensitivity in assessing the technological component of digitalisation of the economy. Therefore, those promising in terms of the scientific research and strategic planning.

Keywords: digitalisation of the economy; cross-cutting digital technologies; composite indexes; unified composite index of digitalisation; digital transformation

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Introduction

The digital platforms, artificial intelligence, big data, the industrial Internet of Things, robotics, and other cross-cutting digital technologies (CCDT) form qualitatively new architecture of economic development. It includes traditional factors complemented by technological intensity, information processing speed, and economic systems ability to adapt rapidly.

Therefore, importance of methodically correct assessment of digitalisation of the economy is increasing. However, international digital development indexes, including DESI, NRI, EGDI, and IDI are primarily focused on measuring the infrastructural, institutional, and social prerequisites for digital transformation.

Despite their high analytical value, they reflect to a limited extent the depth of implementation of advanced digital solutions in the real sector and the actual level of technological transformation of the economy.

It forms a methodological gap between assessing the conditions of digitalisation and estimating the results. In this regard, there is a need to develop a comprehensive analytical approach that combines the advantages of composite indexes and a system of metrics based on the level of CCDT distribution. This approach allows us to assess both digital and technological maturity of the economy and intensity the introduction of digital solutions.

The scientific problem of the research is an insufficient ability of existing digitalisation indices to identify real differences between countries in terms of the level of technological implementation, the structure of digital transformation, and the degree of economic involvement in the new technological order. In this regard, comparative analysis of traditional digitalisation indices by CCDT was implemented to form a valid model for economy digitalisation assessment.

The object of the research is approaches to economy digitalisation assessment based on composite indices of digital development and CCDT. The subject of the study is the effectiveness of composite digitalisation indexes and CCDT metrics.

The purpose of the study is to consider the analytical effectiveness of index-based and CCDT-based approaches to assess economy digitalisation based on CCDT combined analysis and the author's method of a single composite index of digitalisation.

Within the framework of achieving the research goal, the following tasks were considered:

- to analyse CCDT as a relevant basis for assessing the technological aspect of digitalisation of the economy;
- to develop and apply a method of CCDT combined analysis to introduce CCDT metrics into a comparable analytical model;
- to study the structure, methodological features, and analytical capabilities of current international composite digitalisation indexes;
- to develop and apply the author's method of unified composite digitalisation index (UCDI) for the unification and comparison of global index systems;
- to conduct a comprehensive comparative analysis of CCDT and UCDI;
- to identify the comparative advantages, limitations, and analytical effectiveness of the studied approaches to assess the digitalisation of the economy.

The application of systematic, comparative, structural-functional, criterion, correlation, and index approaches ensure the methodological basis of the research. It allows us to compare the analytical viability of various methodologies for economy digitalisation assessment in terms of infrastructural, institutional, and technological parameters of digital transformation.

The key element of the research is comprehensive CCDT metrics analysis included heterogeneous indicators of analytical framework. Its methodological structure is based on three levels of assessment: conditions, implementation, and results. It consistently records the presence of a basic digital environment, the degree of actual technological implementation, and its final economic impact. This approach provides an opportunity to assess economy digital readiness and its technological transformation.

The second methodological research tool is the author's method of the Unified Composite Digitalisation Index (UCDI) to unify and compare international index systems. It allows us to unify heterogeneous composite indexes of digital development to a single measurement scale through normalisation, subsequent aggregation, and calculation of the average integral indicator. It provides a comparable basis for analysing the digitalisation of the economy in infrastructural, institutional, and social conditions.

To verify an analytical validity of the studied approaches, comparative and correlation analysis were used. They compare CCDT and UCDI, assess their relationship with the key macroeconomic results of digital transformation. All named above identify differences in the structure of data obtained and determine the methods to assess the aspects of technological and economic digitalisation.

Main part

Analysis of CCDT effectiveness

CCDT includes neurotechnology and artificial intelligence (AI) systems, quantum technologies, advanced manufacturing technologies (3D printing, additive technologies), robotics and sensor systems, distributed ledger technologies (DLT, blockchain), new generation wireless communication technologies (5G/6G), augmented and virtual reality (AR/VR). Their effectiveness analysis requires a comparable framework of indicators to assess the technological base, institutional, and social conditions.

The methodological structure of CCDT approach involves the three levels of analysis:

Level 1 (assessment of conditions): the fundamental conditions of digital development are fixed, including the communication infrastructure, the availability of digital services, the level of digital competencies, the maturity of government regulation, and the overall degree of network readiness. The level correlates with existing international indexes such as DESI, NRI, EGDI, or IDI, and largely reproduces their logic. However, it is a basic factor of CCDT in the economy impossible[1] [1].

Level 2 (implementation assessment): the technological core of digital transformation includes an assessment and implementation of CCDT in key industries. Mainly, it focuses on assessment of technological solutions integration degree: industrial implementation of AI, robotisation of production processes, industrial Internet of Things penetration, digital twins use, the intensity of big data use, the prevalence of cloud-based infrastructure and other components of CCDT. This level of methodology allows ones to assess real implementation of technologies in the new technological order [7; 13].

Level 3 (assessment of results): reflects the overall effectiveness of digital transformation and focuses on evaluation of economic, structural, and social effects of CCDT. It provides an assessment of real changes in the economy and society. The key indicators are the growth of labour productivity, the contribution of the digital sector to GDP, the expansion of high-tech exports, increased innovation activity, the transformation of employment structure and quality of life. This level determines the actual impact of digitalisation, including its impact on economic growth, competitiveness, and structural modernisation. However, the effect of digital transformation is non-linear and depends on the institutional environment, the industry structure, and the level of human capital development. The third level verifies the effectiveness of digitalisation, assesses technological implementations transformed into measurable socio-economic results[2] [5; 11].

The proposed structure forms a methodologically holistic approach to assess the digitalisation of the economy. It also combines a traditional macroeconomic and institutional framework with technologies. Its main advantage is ability to reflect the real processes of digital transformation. Unlike classical indexes focused on the availability of technology and the maturity of government digital policy, the presented methodology for CCDT metrics analysis captures technological practices in the economy, measures the degree of their industrial and sectoral penetration, and provides more accurate technological forecasts. Moreover, the methodology has a high analytical sensitivity to identify technological gaps in specific industries. It makes it particularly relevant in research on technological development and in the strategic planning system. The presented framework is a CCDT combined analysis: first – to verify the availability of basic conditions; second – the actual use of technologies; third – contribution to economic development. The scientific literature emphasizes the value of multi-level assessments. For instance, the National Research Centre of Russia considers indices of 'readiness', 'use' and 'impact' of technologies. Indeed, it similar to the presented research model[3] [8; 12].

However, this approach has significant limitations. Firstly, CCDI monitoring requires industry statistics [7; 11]. Moreover, CCDT indicators are not standardised and are not included in international databases.

[1] *Skolkovo Institute of Science and Technology. (2019). Methodology for calculating the "Digital Russia" index of the subjects of the Russian Federation. 2018. Source: https://finance.skolkovo.ru/downloads/documents/FinChair/Research_Reports/SKOLKOVO_Digital_Russia_Methodology_2019-04_ru.pdf (accessed on 04.03.2026).*

[2] *OECD. (2019). Measuring the Digital Transformation: A Roadmap for the Future. Paris: OECD Publishing. DOI: 10.1787/9789264311992-en*

[3] *Institute of Information Society Development. (2023). The index of readiness of priority sectors of the economy of the Russian Federation for the introduction of artificial intelligence Analiticheskiy otchet. Source: https://iis.ru/2024/03/28/aireadinessindex2023 (accessed on 01.03.2026).*

Therefore, it difficult to compare countries. CCDT development has a high dynamic, and technological cycles of updating occur faster than official statistics occurs. It ensures a discrepancy between the actual changes and the available data, forming time lags and distorting current estimates. A significant methodological challenge is the separation of technological maturity from the fundamental conditions of digitalisation. As in some cases, infrastructural security can show a low depth of technological implementation, and relatively weak institutional conditions. On the contrary, it can correlate with individual technological breakthroughs. The high heterogeneity of CCDT is an equally significant limitation in various economic sectors. The introduction of AI, robotics, and quantum technologies in industry, transportation, the financial sector, or the public administration system requires special nonstandard indicators. This limits a formation of aggregated unified international digitalisation CCDT based index and implies the combination of macroeconomic, industry and technological metrics [2; 4; 9; 14].

Table 1 shows a comparison of the level of leading countries' economies and China and Russia economies in terms of 7 basic CCDT, 2022-2024. Indeed, this demonstrates fundamentally different technological profiles that are not revealed existing composite digital development indices.

Indeed, the leading countries of the EU and the USA have higher degree of AI and big data analysis implementations in the business sector: the share of organisations using AI is on average 35-50%. China demonstrates higher values of 40-55% in a number of industries. It correlates with large-scale government and corporate investments in algorithmic solutions, industrial AI, and intelligent platforms. In Russia, this indicator does not exceed 10-15%. It indicates an early stage of AI technologies in the real sector of the economy[4,5,6].

Quantum technologies are of special interest. According to the cumulative index, including patent activity, government funding, and research centres, the leading countries are estimated at 80-90%, and China – 90-100%. Russia, despite the general technological lag in most CCDT, demonstrates a comparatively higher position in this area of 60-65 points. It indicates the preservation of scientific groundwork with limited commercialisation of results[7].

Additive manufacturing technologies are also differentiated. In the leading countries, the share of enterprises using 3D printing in production reaches 20-25%; in China 25-30%, primarily in the mechanical engineering, aerospace, and defence-industrial complexes. In Russia, additive technologies are used in 3-5% of enterprises. It shows a low degree of their technological integration into industry[8].

The most contrasting differences are in robotics and sensor systems. The density of industrial robots in the leading countries of the EU and the USA is 280-350 units per 10,000 people employed in the manufacturing industry; in China – 320-400 units. In Russia, the density of robotics is 20-30 units. These differences are hard to be reflected by aggregated digital indexes. Indeed, they are of key importance for assessing industrial digitalisation[9,10].

The leading countries and China demonstrate moderate growth in the distributed registries and blockchain technologies. The share of organisations using DLT solutions is 10-15% and 15-20%, respectively,

[4] *OECD. (2026). AI use by individuals surges across the OECD as adoption by firms continues to expand. Retrieved from https://www.oecd.org/en/about/news/announcements/2026/01/ai-use-by-individuals-surges-across-the-oecd-as-adoption-by-firms-continues-to-expand.html (accessed: 15.02.2026).*

[5] *OECD. (2025). The Adoption of Artificial Intelligence in Firms. Paris: OECD Publishing. Source: https://www.oecd.org/en/publications/the-adoption-of-artificial-intelligence-in-firms_f9ef33c3-en.html (accessed on 04.02.2026).*

[6] *Stanford Institute for Human-Centered Artificial Intelligence. (2025). AI Index Report 2025. Source: https://hai.stanford.edu/ai-index/2025-ai-index-report (accessed on 12.03.2026).*

[7] *World Economic Forum. (2022). Quantum Technologies: Transforming the Future of Science and Industry. Geneva: Press Release. Source: https://www.weforum.org/reports/quantum-technologies/ (accessed on 17.03.2026).*

[8] *Wohlers Associates. (2024). Wohlers Report 2024: Additive Manufacturing and 3D Printing State of the Industry. Fort Collins. Source: https://wohlersassociates.com/product/wr2024/ (accessed on 02.03.2026).*

[9] *International Federation of Robotics. (2024). World Robotics Report 2024. Source: https://ifr.org/worldrobotics (accessed on 03.09.2026).*

[10] *Reuters. (2024). China overtakes Germany in industrial use of robots, says report. Source: https://www.reuters.com/technology/china-overtakes-germany-industrial-use-robots-says-report-2024-11-20/ (accessed on 22.02.2026).*

with a concentration in the financial sector, logistics, and cross-border operations. In Russia, this indicator is 5-7%. It reflects both institutional constraints and the limited scale of corporate implementations[11].

Next-generation wireless communication technologies (5G/6G) are one of the key points of divergence between CCDT approach and composite indexes. In the leading countries, the industrial use of 5G covers 20-30% of large enterprises; in China – 30-40%, including the use of private networks on industrial sites. In Russia, the industrial use of 5G remains is below 10%. However, there is a relatively high level of telecommunications infrastructure development in the consumer segment[12].

The same is for virtual and augmented reality technologies. In the leading countries, AR/VR is actively used in industry, engineering design, and education, covering 15-20% of organizations; in China – 20-25%. In Russia, these technologies are used by 3-5%. It reflects their fragmented implementation[13].

Table 1 – The leading countries, China and Russia in terms of digitalisation of the economy and 7 main cross-cutting digital technologies

Country / Group of countries	AI share in business, %	Quantum Technologies (index)	Additive technologies, %	Robot density (units/10 thousand)	DLT / blockchain, %	5G/6G industrial use, %	AR/VR, %
Leading countries Asia/EU/USA	35-50	80-90	20-25	280-350	10-15	20-30	15-20
China	40-55	90-100	25-30	320-400	15-20	30-40	20-25
Russia	10-15	60-65	3-5	20-30	5-7	<10	3-5

Source: Authors

Analysis of economic digitalisation effectiveness indices

To compare CCDT metrics and digitalisation indices and assess the level of economy digitalisation, we used the author's method of unified composite digitalisation index (UCDI). It as an aggregated indicator integrating the calculation results of the four most widespread and methodologically recognised international digital development indices: The Digital Economy and Society Index (DESI), the Network Readiness Index (NRI), the E-Government Development Index (EGDI), and the Information and Communication Technology Development Index (IDI). The choice of the presented indices is determined by their methodological features, assessment of consistency, orientation of indicators, high prevalence in scientific research, stability of methodology, regularity of updating the statistical base and coverage of key aspects of digitalisation of the economy and society[14] [3; 7; 10].

The Digital Economy and Society Index (DESI). The index annually assesses the digital productivity and dynamics of the European Union countries in key areas of digital transformation. In 2025, DESI is a dashboard aligned with the Digital Decade KPIs targets and covers five basic dimensions: Connectivity (infrastructure), Human capital (digital skills and personnel), Use of the Internet (broadband Internet access), Business digital integration (digital technology integration in business), and Digital public services. DESI 2025 is presented in Table 2 and uses more than 30 indicators, including the KPIs of the digital decade. It serves as a tool for comparing and monitoring the progress of EU member states. The index assesses both the infrastructural and institutional aspects of digitalisation[15].

[11] *Deloitte. (2023). Global Blockchain Survey 2023. Source: https://www2.deloitte.com (accessed on 05.02.2026).*
[12] *GSMA. (2024). The Mobile Economy 2024. Source: https://www.gsma.com/mobileeconomy (accessed on 10.03.2026).*
[13] *PwC. (2019). Seeing is believing: How VR and AR will transform business and the economy. London: Press Release. Source: https://www.pwc.com/gx/en/industries/technology/publications/economic-impact-of-vr-ar.html (accessed on 02.04.2026).*
[14] *European Commission. (2025). Digital Decade 2025: DESI methodological note. – Brussels: European Commission. Source: https://digital-strategy.ec.europa.eu/en/library/digital-decade-2025-desi-methodological-note (accessed on 07.03.2026).*
[15] *European Commission. (2025). Digital Decade 2025: DESI methodological note. – Brussels: European Commission. Source: https://digital-strategy.ec.europa.eu/en/library/digital-decade-2025-desi-methodological-note (accessed on 07.03.2026).*

Table 2 – Weighted average coefficient of the leading countries, DESI 2025

Rank	Country	Total DESI Score
1	Finland	77.6
2	Denmark	76.5
3	Netherlands	74.0
4	Malta	74.0
5	Sweden	71.9

Source: European Commission, 2025[16]

According to the analysis of leading countries component profiles shows, the main drivers of the overall result in Finland, Denmark, the Netherlands, Malta, and Sweden are as follows:

- high coverage of high-bandwidth fixed and mobile broadband networks (almost total coverage of FTTH/5G-capable networks);
- high level of basic and advanced digital skills;
- widespread adoption of digital business processes (e-commerce, cloud services, automation);
- advanced digital government services (e-ID, online registration, data exchange between departments).

These are confirmed by the DESI sectional breakdown and national reports. More than 77% of Finnish citizens believe that digitalisation makes their lives easier. It increases the willingness of the population to accept electronic services and contributes to the growth of digital public services (socio-behavioural effect).

DESI covers only EU member states (in the expanded version, some neighbouring partners through adapted methods). Therefore, there is no the Russian Federation DESI rating. For comparable international positioning, is necessary to use the ITU ICT Development Index (IDI) and other global indexes (World Bank, OECD, Eurostat, etc.).

Methodological features of DESI:

Limited geography: DESI is focused on the EU; non-EU countries are either not included or can be represented through adapted 'international' versions (I-DESI). It complicates direct interpretation.

Incompleteness and variance of data: there are no recent national data for a number of 2025 indicators; in DESI, those are considered and estimated/extrapolated. It reduces the accuracy of interannual comparisons for individual sub-components.

Consistency with Digital Decade KPIs: In 2025, DESI was revised and aligned with the KPIs of the digital decade; it shows the inclusion of indicators directly related to the EU goals for 2030 (gigabit networks availability, IT specialists share, and the digital intensity of business). The synchronisation enhances the political relevance of the index. However, it complicates direct comparability with previous issues without retrospective normalisation.

The composition of the indicators: DESI focuses on institutional and political institutions of digitalisation (e-government, EU digital goals). Indeed, global indexes consider an access and infrastructure (connectivity, affordability). Consequently, DESI includes 'political and institutional' component of digitalisation.

Relevance and frequency of updates: individual DESI components are reviewed and updated irregularly (some KPIs have publication delays). It is relevant in terms of the index for operational evaluation.

Assessment of DESI's viability. DESI is a methodologically valid tool for screening the level of digital transformation within institutional aspects the EU (digital public services, digital policy, business practices). However, inter-regional and global DESI comparisons require complementarity with methodologically compatible global indicators (ITU IDI) for network access and quality parameters, industry-specific SST indicators (e-health, e-education, digital industry) to assess the sector transformation. To include DESI in CCDT we implement an institutional component of the composite index and the weighting coefficients of EU countries and other economies).

[16] *European Commission. (2025). Digital Decade 2025: DESI methodological note. – Brussels: European Commission. Source: https://digital-strategy.ec.europa.eu/en/library/digital-decade-2025-desi-methodological-note (accessed on 07.03.2026).*

Network Readiness Index (NRI). The index assesses countries 'network readiness' for the use of digital technologies and covers four basic criteria: Technology (the level of digital and technological infrastructure), People (human capital, digital skills and the willingness of the population and businesses to use technology), Governance (quality of regulation, institutional environment, trust and cyber-security) and Impact (economic and social effects of digitalisation). The model includes a multi-level hierarchy of 58 indicators; individual indicators are systematically updated between releases. The NRI is presented in Table 3 and covers about 133 economies. It is a global comparison tool, additionally focusing on the role of digital public-private partnerships (DPPPs)[17].

Table 3 – Weighted average coefficient of the leading countries, NRI 2024

Rank	Country	Total EGDI Score
1	USA	78.96
2	Singapore	76.94
3	Finland	75.76
4	Sweden	74.99
5	South Korea	74.85
…	…	…
17	China	68.70
…	…	…
41	Russia	55.74

Source: Portulans Institute, 2024[18]

The analysis of leading countries component profiles shows the following:

- the high level of technological base development, the quality of the digital infrastructure, the scale of investments in software and cloud solutions, the intensity of scientific activity in AI and robotics;
- advanced digital literacy and an effective education and training system ensuring sustainable reproduction of human capital for the digital economy;
- mature institutional practices, including quality regulation, high level of trust, and advanced digital government services;
- a pronounced economic effect of digitalisation, development of domestic digital services market, and the competitiveness of ICT services exports.

The report highlights the United States, Singapore, and a group of European countries as the most representative profiles. The United States occupies a leading position primarily due to the Technology component. It shows the sustainable advantage in the development of digital infrastructure, software solutions, and technological entrepreneurship. Singapore demonstrates one of the most balanced profiles. Its high result is ensured by a close link between digital business, public administration, and institutional coordination. The stability of the final positions is typical for European countries, due to consistent digitalisation policies, high predictability of regulation, and consistency of infrastructural and social components.

China has a high technological advantage with less strong institutional parameters. The country strongest positions are in the Access area. It is estimated as 91.77. Moreover, it shows the extremely high level of digital infrastructure coverage, including FTTH development, network bandwidth, and international Internet traffic. Additionally, China ranks 1st in the AI scientific publications indicator, and 3rd in the Robot density indicator. It shows high intensity of scientific and technological development and industrial implementation of advanced solutions. At the same time, according to the second-order Governance indicator, China ranks 88th with a score of 62.11. It shows a relatively weaker position in ICT regulation, data protection, and institutional

[17] *Portulans Institute. (2024). Network Readiness Index 2024. Washington: Press Release. Source: https://networkreadinessindex.org/nri-2024-edition-press-release/ (accessed on 17.02.2026).*

[18] *Portulans Institute. (2024). Network Readiness Index 2024. Washington: Press Release. Source: https://networkreadinessindex.org/nri-2024-edition-press-release/ (accessed on 17.02.2026).*

trust. Therefore, the Chinese profile of NRI reflects the advanced development of the technological circuit in the presence of restrictions from the regulatory environment.

The Russian Federation NRI profile 2024 is a combination of relatively strong infrastructural parameters and weaker positions in technologically promising areas. The highest results are Access (30th place; 76.47) and Inclusion (40th place; 73.47). It shows a high level of digital accessibility and engagement. According to the People index, Russia has a relatively stable position (22nd place; 54.58). It shows an acceptable level of human capital in terms of country network readiness. However, there is a lag in Future technologies – Russia ranks only 104th with an estimate of 24.23. It shows a weak investment and technological base in terms of promising digital solutions. There is an internal imbalance in the Governance component: at relatively high values of digital trust, Regulatory indicators are low (112th place; 52.66). It limits the institutional effectiveness of digital transformation. Methodological features of NRI:

Variability of indicators: Indicator replacements/corrections occur between NRI releases (several replacements and adjustments were recorded in 2024). It complicates long-term dynamics without initial structural post-calibration.

Aggregation of different types of measurements: NRI combines technological, institutional, and socio-economic indicators; direct aggregation eliminates important industry signals. For instance, breakthrough CCDT in certain sectors are not presented in the overall index).

Different relevance of indicators for countries with different economic structures: the weight of individual subgroups (for example, Future technologies versus Access) correlate differently with the national economic structure. It requires adaptive weighting.

Sensitivity to institutional policies and shocks: the index shows political and institutional decisions (regulation, trust). Therefore, it can respond quickly to regulatory changes, but slowly to real technological shifts in industries.

Assessment of NRI viability. NRI is a global network readiness indicator with the advantage of a wide geographic sample and a multidimensional model. To assess CCDT effectiveness, we should: apply NRI as a macro-institutional, systemic component of a composite metric (reflecting the ecosystem's readiness to implement DDCT); combine it with sectoral indicators (industry level: e-health, e-education, level of industrial digitalisation, etc.); compensate the loss of detail in the aggregate index; retrospectively monitor changes in the composition of NRI indicators; normalise/post-calibrate time series; consider JRC methodology audit (external verification) to interpret the results and make policy conclusions.

The e-Government Development Index (EGDI). The index assesses development of e-government and the ability of government institutions to use digital technologies to provide public services to citizens and businesses. The EGDI is developed by the United Nations Department of Economic and Social Affairs (UN DESA) and is a part of the regular UN E-Government Survey report. In 2024, the EGDI considers 193 UN member states and is used as a global tool for comparing the maturity of digital governance. In the current methodological version, the index aggregates three basic components: the Online Service Index (the level of development and maturity of electronic public services), the Telecommunication Infrastructure Index (the state and accessibility of telecommunications infrastructure), and the Human Capital Index (human capital, including the level of education and digital literacy). The EGDI assesses institutional and infrastructural aspects of public administration digitalisation.

According to the E-Government Survey 2024 (Table 4) the global average EGDI value is 0.64; China ranks 35th place with a score of 0.8718; the Russian Federation ranks 43rd with a score of 0.8533[19].

Table 4 – Weighted average coefficient of the leading countries, EGDI 2024

Rank	Country	Total EGDI Score
1	Denmark	0.9847
2	Estonia	0.9727
3	Singapore	0.9691

[19] *United Nations Department of Economic and Social Affairs. (2024). United Nations E-Government Survey 2024: Accelerating*

Rank	Country	Total EGDI Score
4	South Korea	0.9679
5	Iceland	0.9671
…	…	…
35	China	0.8718
…	…	…
43	Russia	0.8533

Source: United Nations Department of Economic and Social Affairs, 2024[20]

The analysis of component profiles shows the key factors of EGDI overall result for the leading countries. They are as follows:

- high level of maturity of digital government services, including CCDT (birth-to-business, life events), active services and interagency data exchange (OSI);
- fixed and mobile broadband, high network bandwidth, and availability of next-generation mobile Internet (TII);
- a high level of digital and general skills of the population, provided by a well-developed education and continuous training (HCI) system.

The leading countries have well-developed infrastructure and human capital. They enhance the benefits of digital public services directly reflected in the values of OSI. For example, in Denmark and Finland, the share of users of electronic government services exceeds 90%; the digital channels are dominant in the interaction of citizens and businesses with the government. It ensures their stable position in the top of the EGDI rating.

China has a high component asymmetry. The country is demonstrating high TII values due to the large-scale deployment of fiber-optic networks and mobile infrastructure, significant progress in the digitalisation of basic public services. At the same time, the relative lag in HCI and institutional aspects of digital governance limits the final position in the ranking. It indicates structural imbalances between technological access and the quality of electronic services.

The Russian Federation has high EGDI values, formed due to the developed segment of public services (Gosuslugi portal, digital registries, electronic payments. It shows the growth of OSI's competitive performance in recent years (2022 – 0,8319; 2024 – 0,8533). However, the limitations are the heterogeneity of the telecommunications infrastructure by region and restrained dynamics of HCI. It reduces the scaling effect of digital services. Therefore, the Russian EGDI profile indicates the advanced development of the applied level of the digital state in the presence of structural constraints from the infrastructural and personnel components [3].

Methodological limitations of EGDI:

Institutional focus: EGDI has the institutional level of digital government (services, policy, infrastructure), but does not fully cover the depth of the digital transformation of the economy (sectoral aspects, private sector ICT).

Data time lags: the methodology is revised every few editions. It complicates comparison of cycles (changes in OSI sub-components, revision of HCI and TII).

Aggregation of components: the EGDI indicator is aggregated; countries with the same EGDI may have very different quality of one of the components (for example, strong infrastructure, but weak 'electronic engagement' of citizens).

Digital Transformation for Sustainable Development. New York: United Nations. Source: https://desapublications.un.org/publications/united-nations-e-government-survey-2024 (accessed on 12.02.2026).

[20] *United Nations Department of Economic and Social Affairs. (2024). United Nations E-Government Survey 2024: Accelerating Digital Transformation for Sustainable Development. New York: United Nations. Source: https://desapublications.un.org/publications/united-nations-e-government-survey-2024 (accessed on 12.02.2026).*

Assessment of EGDI viability. EGDI can serve as an institutional and infrastructural foundation for analysing digitalisation in terms of CCDT. Therefore, combining EGDI with indicators shows innovation maturity (for example, AI, digitalisation of industries) as part of CCDT metrics. The use of EGDI in terms of the component values (OSI, TII, HCI) and the updated methodology of 2024, allows ones to adjust the index weight in the composite ranking of CCDI assessments depending on the region and country profile. The EGDI is a reliable tool for assessing the progress of digitalisation of the public sector and can be used as a component of IT infrastructure assessment within the framework of integrated indices of economy digitalisation. For a comprehensive assessment, we integrate EGDI with DESI and ITU IDI to cover both institutional, infrastructural, and industry-specific aspects of digitalisation.

Information and Communication Technology Development Index (IDI). The index provides a comprehensive assessment of the level of development and dissemination of information and communication technologies in national economies. It is developed by the International Telecommunication Union (ITU) as a tool for international comparison of countries digital development. The structure of the index includes three basic dimensions: Access (access to ICT infrastructure and communication services), Use (intensity and scale of ICT use by the population and organisations), and Skills (human capital and educational prerequisites for digitalisation). The index covers more than 170 countries and is used to monitor the digital divide, assess the dynamics of ICT development, and compare infrastructural and socio-human aspects of economy digitalisation. A sample of statistical data from the ITU 2025 study is presented in Table 5[21].

Table 5 – Weighted average coefficient of the leading countries, ITU 2025

Rank	Country	Total DESI Score
1	Saudi Arabia	99.2
2	Finland	98.7
3	Estonia	98.5
4	Kuwait	98.4
5	Qatar	98.4
…	…	…
37	Russia	92.3
…	…	…
43	Russia	0.8533

Source: International Telecommunication Union, 2025[22]

According to the analysis of leading countries component profiles, the main drivers of the overall result are as follows:

- a total coverage of fixed and mobile broadband networks (FTTH, LTE/5G), high bandwidth and availability of international Internet traffic;
- intensive use of ICT by the population and businesses, high levels of Internet activity, mobile broadband traffic, and digital services;
- a high level of human capital, secondary and higher education enrolment, digital and cognitive skills.

The leading countries access ICT infrastructure and communication services is 40-45%. It confirms the critical role of telecommunications infrastructure as the foundation of digitalisation.

China demonstrates high Access rates; the country is the world leader in the number of mobile broadband Internet connections and the scale of fiber-optic infrastructure (90%). It shows the extensive nature of ICT infrastructure and economies the development. At the same time, China's position is weaker in terms of Use and especially Skills. It shows a structural imbalance between technological coverage and the

[21] *International Telecommunication Union. (2025). Measuring Digital Development: ICT Development Index 2025. Source: https://www.itu.int/itu-d/reports/statistics/idi2025 (accessed on 12.03.2026).*

[22] *International Telecommunication Union. (2025). Measuring Digital Development: ICT Development Index 2025. Source: https://www.itu.int/itu-d/reports/statistics/idi2025 (accessed on 12.03.2026).*

quality of human capital.

According to ITU IDI 2025, Russia shows strong performance in the Access component (mobile and fixed-line coverage exceeds 95% for the urban population), moderate performance in Use (about 70% of the adult population actively uses the Internet and online services), and the Skills component is limited by the low prevalence of advanced digital competencies and insufficient population digital training. Therefore, Russia has a high level of ICT development, but is inferior to the leading countries in terms of usage and skills.

Methodological features

Focus on the basic digital infrastructure: the IDI, being developed by ITU, is focused on measuring the level of ICT development and captures primarily access, use, and skills. It ensures high comparability, but limits institutional and sectoral aspects of economy digital transformation.

Structure and aggregation of indicators: the index aggregates three blocks (access, use, skills); they consider the proxy indicators (educational coverage, literacy). It reduces the accuracy of assessing real digital competencies and their compliance with the requirements of the digital economy.

Limited relevance for leading countries: the index loses its discriminating ability between economies with advanced digital ecosystems. It requires its use in combination with more institutionally and technologically sensitive indexes.

Assessment of IDI viability. IDI is a reliable tool for global assessment of economy digitalisation in terms of comparing infrastructure, digital usage, and skills of the population. To integrate IDI with CCDI it is necessary to use IDI as a basic component of the global digitalisation index, complementing DESI for the analysis of institutional and managerial aspects. The combined use of IDI and DESI provides a complete understanding of the digital development of countries with different economic, political, and institutional characteristics.

Table 6 shows the results of the comprehensive analysis.

Table 6 – A brief description of the indices for economy digitalisation assessment

Index	Structure	Direction	Limitations
DESI EU	Connectivity; Human Capital; Use of Internet; Business Digital Integration; Digital Public Services	Infrastructural, Institutional, Social	Focus only on EU countries; low sensitivity to breakthrough technologies (quantum technologies, AR/VR, DLT); Relevance and frequency of updates
NRI Global (134 countries)	Technology; People; Governance; Impact	Technological, Institutional, Socio-economic	Variability of the set of indicators, Aggregation of different types of measurements, Sensitivity to institutional policies and shocks
EGDI Global (UN)	Online Services; Telecom Infrastructure; Human Capital	Service, Infrastructural, Institutional and managerial	Institutional direction, Time lags of data, Aggregation of components

Index	Structure	Direction	Limitations
IDI Global (ITU)	Access; Use; Skills	Technological, Infrastructural	Focus on basic digital infrastructure; structure and aggregation of indicators; limited relevance for leading countries

Source: Authors

A method for comparing the consistency of approaches to assess economy digitalisation

A comparison of the consistency of approaches to assess economy digitalisation is shown in Figure 1. Methodically, UCDI was formed by normalising the final values of each of the four indices to a single scale from 0 to 100, followed by averaging. To ensure comparability, linear normalisation was used for the maximum and minimum of the sample of countries included in the analysis. The final ECIC value was calculated as an unweighted average of the normalised DESI, NRI, EGDI, and IDI indicators. It allows us to avoid subjectively overestimating the significance of individual components and maintain the neutral aggregating nature of the index.

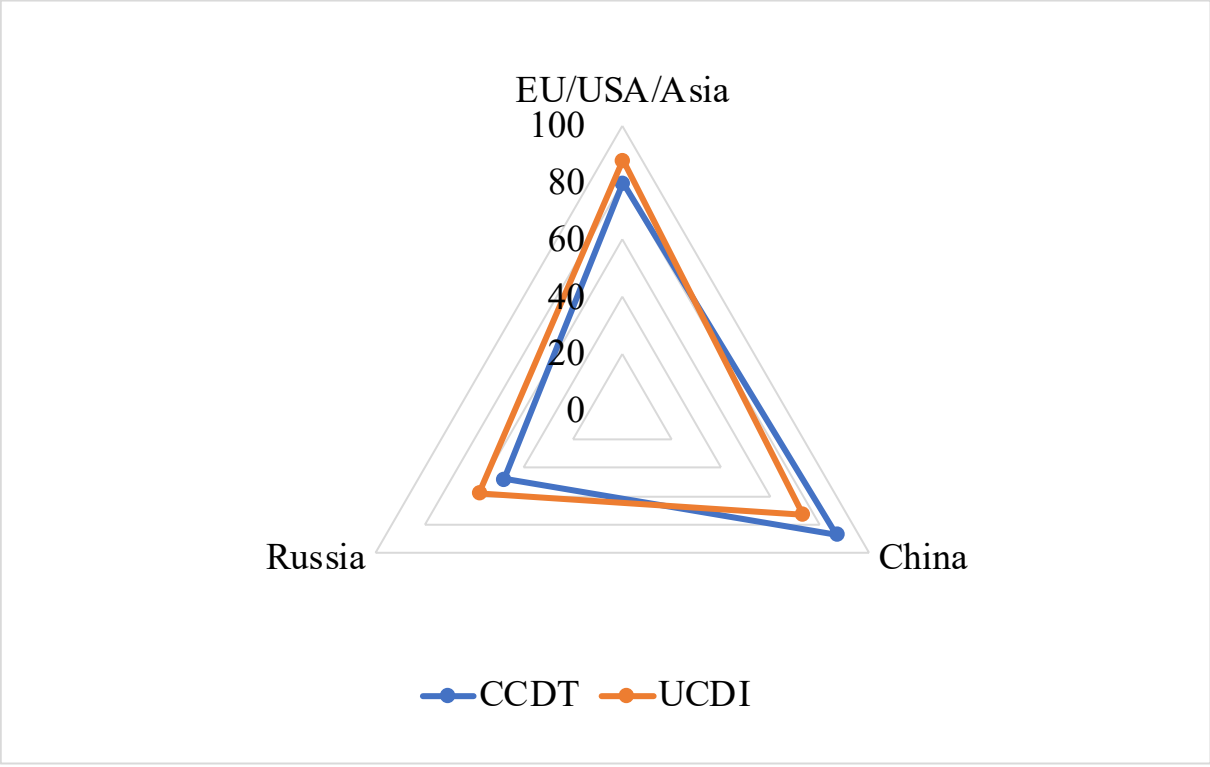

Figure 1. A method for comparing the consistency of approaches to assess economy digitalisation
Source: Authors

UCDI data shows a neutralised condition of digitalisation. The gap between the leading countries and China in terms of UCDI is 15-20 percentage points, despite fundamental differences in technological specialisation. Russia ranks relatively low. It is interpreted as a general low level of digital development.

CCDT index forms a differentiated picture. In terms of CCDT, China is 5-10 percentage points ahead of most of the leading countries in the EU and the USA due to the high density of robotics, the scale of AI adoption, and the industrial use of 5G. At the same time, the lower positions of UCDI are due to technological rather than institutional and social components dominant in CCDT approach.

Russia demonstrates a structural gap between the digital environment and technological digitalisation. The single composite index records a lag of 25-30 percentage points; CCDT assessment shows a qualitative difference: the values of indicators are 5-10 times lower than those of the leading countries; for robotics

and 5G – 10-15 times lower. Therefore, Russia's digitalisation is primarily service-infrastructural rather than technologically-productive.

The second method of comparing the consistency of approaches to assess economy digitalisation is to analyse the correlation of the obtained indicators with key macroeconomic results. The correlation analysis allows us to assess the degree of connection with digital transformation economic effects. Within the framework of the research, labour productivity, measured by GDP per employee, the share of high-tech and knowledge-intensive industries in gross value added, the volume of exports of high-tech products, the growth rate of the manufacturing industry was used as effective indicators. For comparability of calculations, averaged data for 2024 were used. It which made it possible to minimise cyclical fluctuations and identify stable dependencies.

According to the results of the correlation analysis, UCDI has a moderate relationship with economic results. The correlation coefficients between the values of the UCDI and labour productivity indicators for a sample of countries, including technological leaders, China and Russia, are in the range of 0.40-0.55. Similar values were obtained when comparing the share of high-tech value added and exports of high-tech products. Therefore, traditional indexes are more appropriate in terms of assessment the digital environment and institutional conditions.

CCDT aggregated significantly higher correlate with economic results. The correlation coefficient between CCDT the CT index and labour productivity exceeds 0.70; in some samples it is 0.75-0.78. A comparison with the share of high-tech industries in gross value added shows a correlation at the level of 0.72-0.76. It shows a close relationship between the intensity of CCDT introduction and the structural modernisation of the economy. A similar relationship was found for exports of high-tech product – the correlation coefficients exceed 0.65; composite indices does not exceed 0.50.

Correlation analysis is of particular importance when considering some countries. In China, high values of CCDT indicators are combined with steady growth in labour productivity in the manufacturing industry and an increase in the share of high-tech exports. It confirms the role of robotics, AI, and 5G industrial networks as key drivers of economic growth. In Russia, the moderate values of UCDI are accompanied by a weak correlation with the dynamics of productivity and high-tech value added; low CCDT indicators show the limited economic effect of digitalisation.

Conclusion

The existing composite digitalisation indices and metrics of CCDT show different levels and aspects of economy digital transformation. As a result, they have different analytical consistency. To ensure the correct comparison of these approaches, two complementary methodological tools were used in this research. As a result, a comprehensive CCDT metrics analysis combines the heterogeneous indicators to a single analytical framework. The author's UCDI ensures the unification of international index systems.

The proposed UCDI is a generalised indicator of the institutional and infrastructural maturity of the digital economy. It allows ones to compare the level of digital readiness and digital inclusion of countries. However, when analysing the technological structure of digitalisation and the factors of long-term economic growth, UCDI demonstrates limited analytical sensitivity. It requires to supplement it with CCDT indexes and indicators.

According to the comparative and correlation analysis, CCDI reflects the actual scale of key technologies introduction, the degree of their integration into industry, and countries scientific and technological potential. However, UCDI mainly considers countries institutional and infrastructural characteristics. This confirms the analytical advantage of using CCDT in assessing of economy digitalisation, scientific research, and strategic planning. It is especially evident when comparing the leading countries, China and Russia in terms of technological differences in AI, robotics, high-speed Internet, additive and other technologies.

According to the statistical calculations, CCDT in assessing of economy digitalisation has a fundamental analytical advantage over existing composite indexes:

- it provides a higher discriminating ability between countries with different technological specialisations;

- identifies real technology leaders;
- captures the structural depth of digitalisation and its contribution to productivity and industrial development;
- moreover, it is especially effective for analysing developing countries, where the digital infrastructure may be relatively developed with weak implementation of key technologies.

Therefore, UCDI is an effective tool for assessing the institutional and infrastructural maturity of the digital environment. However, CCDT is more effective to assess the technological depth of economy digitalisation. The scientific significance of the research concerns with substantiating of analyses integration. The practical significance includes the implementation of proposed approach for strategic diagnostics of digital development, identifying technological gaps and digital policy priorities.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

AUTHOR'S CONTRIBUTIONS

Elena E. Irodova – conceptualization; supervision.
Alexey M. Sokolov – writing – original draft.

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