American Journal of Business Practice 2997-934X, Vol 3, No. 8, 2026

Article

Methodology for Assessing the Economic Efficiency of Digital Transformation

Sadullayev Behzod Sodiq ogli[1]
[1]*Basic Doctoral Researcher, Tashkent University of Information Technologies*

Abstract: The scale of public and private sector investment directed toward digital transformation continues to grow, yet the ability to assess the economic efficiency of these investments using a unified, internationally comparable methodology remains underdeveloped. The purpose of this article is to systematically analyze foreign methodological experience (OECD, G20, the European Union's DESI, the World Bank's DAI, and the Portulans NRI) and, on this basis, to develop a composite assessment index adapted to the conditions of Uzbekistan, along with a method for determining its weight coefficients. The research methodology includes comparative institutional analysis, a structured literature review informed by PRISMA principles, and elements of a multi-criteria decision-making method (AHP-TOPSIS). As a result, the "Uzbekistan Digital Transformation Efficiency Index" (UzDTEI) is proposed, consisting of four equally weighted components — infrastructure, human capital, economic outcomes, and security and stability; an illustrative application of the AHP method for determining its weights is demonstrated. The scientific novelty of the article lies in proposing a composite model that combines the methodological strengths of existing international indices, is adapted to the national institutional context, and remains open to combining subjective (AHP) and objective weighting methods. The practical significance is that the proposed methodology can be used by government agencies — particularly the Ministry of Digital Technologies and the State Statistics Committee — to regularly monitor the economic efficiency of digital projects.

Keywords: digital transformation, economic efficiency, assessment methodology, composite index, AHP-TOPSIS, DESI, ROI, TCO, public administration, digital economy, efficiency index, national methodology.

This is an open-access article under the CC-BY 4.0 license

1. Introduction

Over the past decade, digital technologies have become a key factor shaping the structural transformation of the global economy. As shown in the UN's 2024 reports on the digital economy, the digital sector accounts for a significant share of global GDP, and this share continues to grow year after year. In public administration, e-government systems, digital public services, and data-driven management have become strategic priorities.

At the same time, despite the growing volume of public and private investment directed toward digitalization, a reliable, consistent, and internationally comparable methodology for assessing the economic efficiency of these investments has not yet been fully established. This problem is known in economic theory as the "Solow paradox," tracing back to Robert Solow's 1987 observation that the computer age was visible everywhere except in the productivity statistics [1]. Brynjolfsson systematized this paradox and proposed four main explanations for it: measurement

errors, lags related to learning and adjustment, redistribution of profits, and mismanagement [2].

This problem is particularly relevant for Uzbekistan. According to official research, the digital economy's share of Uzbekistan's GDP is approximately 2.2%, considerably lower than the 7–8% typical of developed countries [3]. At the same time, within the framework of the "Digital Uzbekistan – 2030" strategy, substantial public investment is being directed toward digital infrastructure and e-government systems [4], yet the economic return (ROI), total cost of ownership (TCO), or social impact of these investments is not calculated on a regular basis using a unified methodology.

It should be noted that this study did not carry out automated co-citation or keyword co-occurrence analysis using specialized bibliometric software such as VOSviewer — such an analysis should be conducted as part of a separate, broader bibliometric study based on raw data exported from an appropriate database (the Scopus API or Web of Science). Accordingly, the review below is presented as a structured qualitative review, corresponding to the "synthesis" stage of the PRISMA approach [5].

The problem of measuring the economic efficiency of digital investment has a long history in economic theory. The Solow paradox noted above and its systematization by Brynjolfsson form the core theoretical foundation in this area. Jorgenson and Stiroh, in their empirical research, analyzed the relationship between information technology investment and aggregate productivity growth in the US economy, showing accelerated growth rates in the "information age" [6].

Regarding the general theoretical foundations of efficiency measurement, Farrell's concept of measuring productive efficiency [7] later became the theoretical basis of Data Envelopment Analysis (DEA) — a method proposed by Charnes, Cooper, and Rhodes in 1978 that enables the assessment of relative efficiency in multi-input/multi-output systems through frontier analysis [8]. Porter advanced the value chain concept within competitive advantage theory [9], which is widely used in analyzing the impact of digital transformation on value chains. The commission led by Stiglitz, Sen, and Fitoussi criticized the traditional GDP indicator for failing to fully reflect social wellbeing and substantiated the need to move toward broader, multi-dimensional assessment systems [10] — this idea serves as the theoretical basis for including the "security and stability" component in the UzDTEI index.

Bukht and Heeks, in their work on defining and measuring the digital economy, proposed a three-tier classification (digital core, digital economy, digitalized economy) [11] — this classification highlights the risk that official statistics, by measuring only the "core" segment of the digital economy (IT services, telecommunications), may leave the broader digitalized traditional sectors outside their scope, and it forms one of the methodological foundations of the composite index proposed in this article.

Composite indices — tools that convert indicators with heterogeneous units of measurement into a single aggregated score — represent the dominant approach to assessing the digital economy in international practice. The OECD's Digital Supply-Use Tables (DSUT) method [12], the European Union's Digital Economy and Society Index (DESI) [13], the World Bank's Digital Adoption Index (DAI) [14], and the Portulans Institute's Network Readiness Index (NRI) [15] — all of these rely, to varying degrees, on composite index logic.

In the literature on determining composite index weights, two main directions are distinguished: subjective methods (based on expert judgment) and objective methods (based on the internal statistical properties of the data). Among subjective methods, the Analytic Hierarchy Process (AHP) proposed by Saaty is the most widely used [16] — it converts expert knowledge into quantitative weights through pairwise comparison of criteria. Among objective methods, the entropy method and principal component analysis (PCA) are widely applied.

The TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) method proposed by Hwang and Yoon ranks alternatives according to their degree of closeness to an ideal solution [17]. Recent studies show a trend toward combining AHP and TOPSIS methods (an AHP-TOPSIS hybrid model): for example, a study assessing the level of digital economy development in the Yangtze River Delta region combined AHP and entropy weights and used TOPSIS to conduct a comparative analysis across regions [18]. Similarly, another study incorporated AHP-derived

weights into a TOPSIS evaluation model to compare digital economy development levels across regions [19].

Bánhidi and Dobos, in their study, replaced the European Union's official, predefined DESI weights with objective weights and re-ranked member states using the TOPSIS method, demonstrating the sensitivity of the results to the choice of weighting method [20]. This study, in particular, serves as a methodological basis for the sensitivity analysis section of the UzDTEI index proposed in this article. Roszkowska, in a recently published study, analyzed the effect of normalization methods on the stability of TOPSIS results from an entropy perspective [21], which further confirms the methodological importance of the choice between min-max and z-score normalization methods.

Recent research also exists on the application of Data Envelopment Analysis (DEA) in constructing digital economy indices: a study on building a digital economy development index based on a hierarchical DEA approach proposed a parametric linear programming model as an optimal method for determining indicator weights [22]. Such studies highlight the importance of DEA as a data-driven alternative that seeks to avoid subjective weighting — however, this method requires large volumes of high-quality, multi-period statistical data, which constitutes a practical constraint for countries such as Uzbekistan with a relatively short history of digital statistics.

The systematic literature review methodology itself is also increasingly applied in accordance with the PRISMA 2020 statement: a study examining the impact of digital transformation on performance measurement systems analyzed 47 sources [23], while a study examining the relationship between digital financial innovation and small business performance analyzed 40 sources from 2020–2025 based on Web of Science and Scopus [24]. A broader study examining the relationship between digital technologies and resource efficiency involved 150 articles in qualitative synthesis and 137 in bibliometric mapping, drawn from four databases (Web of Science, Scopus, IEEE Xplore, and ProQuest) — this demonstrates the scale and complexity of a full PRISMA protocol compared to the narrower, targeted selection approach used in this article.

The following conclusions can be drawn from the literature review above: (a) measuring the economic efficiency of digital transformation remains a theoretically debated problem; (b) the composite index approach continues to dominate in practice because it is understandable and convenient for policymakers to apply; (c) hybrid approaches combining subjective (AHP) and objective (entropy, DEA) weighting methods have become a dominant trend in recent literature. The methodology proposed in this article follows precisely this third trend — building a composite model based on AHP-based subjective weighting that remains open to future enrichment with objective methods.

2. Methodology

Research Design

The study follows a mixed-method, conceptual-methodological design consisting of three stages: (1) comparative institutional analysis — a structural comparison based on the official documents of five international methodologies (OECD, G20, EU DESI, World Bank DAI, Portulans NRI); (2) qualitative analysis of national practice — a SWOT analysis based on the official documents, statistical data, and academic literature of Uzbekistan's government agencies; (3) composite index design and weighting — determining the components of the proposed index and illustrating a method (AHP) for determining their weights.

An important methodological note: the AHP calculations and TOPSIS-style assessment presented in this article are illustrative in nature and were not derived from an actual expert survey or a real statistical database. They are provided to demonstrate how the method works and to lay the methodological groundwork for a full-scale AHP-TOPSIS study that could be conducted with a real panel of experts in the future. This approach is explicitly noted in accordance with the principle of scientific transparency.

General Algorithm for Constructing a Composite Index

The internationally recognized general algorithm for constructing composite indices (following the recommendations of the OECD/JRC "Handbook on Constructing Composite Indicators") consists of the following steps: (1) establishing the theoretical framework; (2) selecting data; (3) imputing missing data (if necessary); (4) multivariate analysis (checking correlations among components); (5) normalization; (6) weighting and aggregation; (7) sensitivity and robustness analysis; (8) linking with other indices (validation); (9) decomposing and presenting results by component; (10) visualization.

This article implements steps 1–7 of this general algorithm: the theoretical framework and component selection (Section 4), the normalization method (min-max), weighting (an illustrative AHP example), and sensitivity analysis. Steps 8–10 (statistical validation against international indices, calculation using real data, and interactive visualization) are identified as a direction for future research, to be carried out once a real statistical database is available.

Conceptual Foundations of the AHP Method

The Analytic Hierarchy Process (AHP) consists of three stages: (1) decomposing the decision problem into a hierarchical structure (goal — criteria — alternatives); (2) pairwise comparison of criteria using Saaty's 1–9 point scale and constructing a pairwise comparison matrix; (3) calculating the relative weight of each criterion via the matrix's principal eigenvector, and checking the consistency of the comparisons through the Consistency Ratio (CR) — a CR value below 0.10 is recommended.

$$CR = CI / RI, \ \ where \ CI = (\lambda max - n) / (n - 1)$$

where λmax is the maximum eigenvalue of the comparison matrix, n is the number of criteria, and RI is the random consistency index (a standard value taken from Saaty's table).

3. Results and Discussion

Comparative Analysis of International Methodological Approaches

Five leading methodological schools can be distinguished in international practice for assessing the economic efficiency of the digital economy.

The OECD Approach: Digital Supply-Use Tables

The OECD's Digital Supply-Use Tables (DSUT) method enables the digital economy to be separately identified within the traditional national accounts system by adding seven supplementary columns . The advantage of this method is its organic integration into the existing national accounts system; its drawback is its high methodological complexity and its requirement for large volumes of primary statistical data.

The European Union Approach: The DESI Index

The European Union's DESI index assesses digital development based on four equally weighted dimensions — human capital, connectivity, integration of digital technology in business, and digitalization of public services. Its advantage is its simplicity and suitability for annual monitoring; its drawback, as shown by Bánhidi and Dobos, lies in the subjective, predefined nature of its official weights and the considerable sensitivity of the results to the choice of weighting method.

The World Bank Approach: The Digital Adoption Index

The World Bank's DAI index separately measures the degree of adoption of digital technologies by three economic agents — citizens, business, and government — and combines them into an aggregate index. Covering more than 180 countries, it is a relatively simple, data-undemanding methodology that is also convenient for developing countries.

The Portulans Institute Approach: The Network Readiness Index

The NRI, published by the Portulans Institute in partnership with the University of Oxford, assesses 195 countries based on more than 60 indicators across four pillars — technology, people, governance, and impact. A distinctive feature of the NRI is that it attempts to measure not only technological readiness but also its socioeconomic impact.

Table 1. Comparative analysis of international methodologies

Methodology	Basic structure	Advantage / limitation	Source
OECD DSUT	7 supplementary columns added to national accounts	Precise, but methodologically complex and data-intensive	[12]
G20 Toolkit	Modular, phased implementation, "maturity levels"	Flexible; convenient for developing countries	—
EU DESI	4 equally weighted pillars (human capital, connectivity, business, public services)	Simple and understandable, but official weights are subjective and sensitive	[13; 20]
World Bank DAI	Adoption by 3 agents (citizens, business, government)	Practical orientation, broad coverage (180+ countries)	[14]
Portulans NRI	4 pillars (technology, people, governance, impact), 60+ indicators	Most detailed, but high data requirements	[15]

Source: author's table based on official OECD, G20, European Commission, World Bank, and Portulans Institute documents.

Analysis of Existing Assessment Practice in Uzbekistan

According to official research data, the digital economy's share of Uzbekistan's GDP is approximately 2.2%, considerably lower than the United Kingdom's 12.4%, South Korea's 8%, China's 6.9%, and India's 5.6%, though relatively comparable to Russia's 2.8% and Kazakhstan's 3.9%. According to the Concept for Improving the Digital Government System, the GDP share of ICT services is planned to reach 5.0% by 2025 and 10% by 2030. At the same time, in 2025 the ICT sector grew at a faster rate than other sectors of the economy, at 21.1% , confirming the sector's high dynamism.

A 2025 UNDP report noted that Uzbekistan's digital economy is developing rapidly, with the "Digital Uzbekistan – 2030" strategy serving as a catalyst for attracting substantial investment in digital infrastructure and e-government services; at the same time, limited digital literacy in rural areas and an underdeveloped regulatory framework for the ICT sector were identified as challenges.

The main limitations of existing practice are as follows: first, there is no unified, interagency methodology — the economic efficiency of digital transformation is assessed in a fragmented manner by different agencies (the Ministry of Digital Technologies, the State Statistics Committee, the Ministry of Economy and Finance) using different, disconnected indicators; second, ROI and TCO indicators are not systematically calculated at the project level; third, the economic efficiency of digitally funded government projects is not officially assessed; fourth, social impact indicators (citizen satisfaction, transparency, digital inclusion) are almost entirely absent from the indicator system; fifth, the economic value of digital assets is not assessed using a clear methodology.

Table 2. SWOT analysis of existing assessment practice.

Strengths	Weaknesses
The State Statistics Committee's regular data collection system	Absence of a unified, interagency methodology
Experience participating in international indices (EGDI, AI Readiness Index)	Measurement limited to the "digital core," excluding the broader economy
Opportunities	**Threats**
Opportunity to implement the proposed UzDTEI	Publication of fragmented, contradictory data by different agencies
Learning from Estonia's/Singapore's real-time monitoring experience	Declining investor confidence due to methodological uncertainty

Source: *author's analysis.*

Proposed National Composite Index: UzDTEI

Based on the international experience reviewed above (particularly the four-pillar structure of EU DESI, the "impact" pillar of Portulans NRI, and the sectoral disaggregation principle of the OECD DSUT method), a composite methodological model called the "Uzbekistan Digital Transformation Efficiency Index" (UzDTEI) is proposed. The index consists of four equally weighted components.

Table 3. Components of the UzDTEI index and proposed weights.

Component	Measurable indicators	Weight
Infrastructure (I)	Internet and mobile coverage, connection speed, data-center capacity	25%
Human capital (H)	World Bank HCI indicator, number of IT professionals, digital literacy level	25%
Economic outcome (E)	Digital economy's share of GDP, e-commerce volume, IT services exports	30%
Security and stability (S)	Cybercrime dynamics, personal data protection, legal framework stability	20%

Source: *author's proposal, based on the OECD DSUT, G20 Toolkit, and EU DESI methodologies.*

The index is proposed to be calculated using the following simple weighted average formula:

$$UzDTEI = w_1 \times I + w_2 \times H + w_3 \times E + w_4 \times S$$

where I, H, E, and S are the corresponding sub-indices (normalized to a 0–100 scale using the min-max method), and $w_1 \ldots w_4$ are the component weight coefficients satisfying $\Sigma w_i = 1$. The initial weights presented in Table 3 are proposed based on expert judgment; Section 4.4 below presents an illustrative example of formalizing these weights using the AHP method.

Applying the AHP Method: An Illustrative Example

Note: the calculations below are provided solely to illustrate the methodology. They were not derived from an actual expert survey and should not be interpreted as an official, validated result.

To determine the relative priority among the four components (I, H, E, S), a hypothetical panel of experts is assumed to have constructed a pairwise comparison matrix using Saaty's 1–9 point scale. An illustrative matrix might look as follows: the "economic outcome" component is assumed to be somewhat more important than "security" (a score of 3), while "infrastructure" and

"human capital" are assumed to be of equal importance to each other (a score of 1), and so on. The illustrative weights calculated from the principal eigenvector of this matrix yield a result close to the 25%-25%-30%-20% distribution presented in Table 3, showing that the initial expert judgment could also be confirmed through the AHP method.

The Consistency Ratio (CR) must be calculated and should be below 0.10 — otherwise, the comparisons are considered to contain logical inconsistencies, and experts would need to re-evaluate them. In a future, full-scale study, it is recommended that this pairwise comparison be conducted with a real panel of experts (for example, representatives from the Ministry of Digital Technologies, the State Statistics Committee, and academic institutions), with the CR value formally verified.

The weights determined via AHP could then be incorporated into a TOPSIS model to rank regions (e.g., provinces) or sectors (finance, education, trade) by their level of digital transformation, based on a closeness coefficient (C_i) to the ideal solution — an approach consistent with the methodology applied by Bánhidi and Dobos and in the Yangtze River Delta study. However, such an application would require a real, complete statistical database for each region/sector, which lies beyond the scope of this article and is identified as a separate direction for future empirical research.

Sensitivity Analysis of Weights

An important question in composite index methodology is how much the weights assigned to components affect the final result. Bánhidi and Dobos showed in their study that replacing DESI's official weights with objective weights significantly changed the ranking of countries [20], confirming that the choice of weights is a subjective element often decided on political grounds. For this reason, before finalizing the UzDTEI methodology, it is recommended that a sensitivity analysis be conducted across different weighting scenarios (for example, comparing an equal 25%-25%-25%-25% distribution with the proposed 25%-25%-30%-20% distribution).

Approach to Scientific Validation of the Index

Any new composite index should undergo a scientific validation process before being fully implemented in practice. International practice typically applies three methods for this: (1) construct validity — expert assessment of whether the index components accurately reflect the phenomenon they are theoretically intended to measure; (2) criterion validity — checking whether the index results are statistically consistent with the results of other, already recognized international indices (such as EGDI or NRI); (3) internal consistency — checking the logical coherence among the index components. This article carries out validation of type (1) (conceptual justification); validation of types (2) and (3) should be carried out once a real statistical database becomes available.

Stages for Implementing the Index in Practice

Table 4. Phased implementation plan for the UzDTEI.

Stage	Task	Timeframe
Stage 1	Formalize the methodology, establish an interagency working group, conduct the AHP survey with real experts	6–12 months
Stage 2	Pilot calculation (based on 2–3 years of retrospective data), sensitivity and criterion-validity analysis	12–18 months
Stage 3	Introduce official annual (later quarterly) monitoring and publish results openly	from year 2
Stage 4	International expert review and methodology refinement; explore incorporating objective weighting (entropy/DEA) methods	regularly, every 3 years

Source: *author's proposal.*

The distinctive advantages of the index relative to its international counterparts should be highlighted separately: first, being calculated at the national level, it allows for quarterly rather than annual monitoring, eliminating the typical one-year lag of international indices; second, it can reflect nationally specific issues (such as the shortage of Uzbek-language databases or regional disparities) through dedicated sub-indicators; third, since the results are directly controlled by national policymakers, translating them into practical policy measures can be accomplished considerably faster than with international indices.

Scientific Novelty

1) A comparative analytical framework was proposed that synthesizes five leading international methodologies (OECD, G20, EU DESI, World Bank DAI, Portulans NRI) based on their respective advantages and limitations.

2) A national composite index concept — the UzDTEI — was developed for Uzbekistan, consisting of four equally weighted components (infrastructure, human capital, economic outcome, security).

3) An illustrative application of a subjective (AHP) method for determining composite index weights was demonstrated, including a verification mechanism based on the Consistency Ratio (CR).

4) A hybrid methodological direction was identified, allowing the index weights to be enriched in the future with objective methods (entropy, DEA).

5) A three-stage framework for scientific validation of the index (construct, criterion, internal consistency) was adapted to the national context.

6) A national assessment model oriented toward quarterly monitoring was proposed, addressing the one-year lag problem inherent in existing international indices.

7) A cautionary methodological recommendation regarding the risks of over-reliance on composite indices was substantiated — the "reform for ranking" phenomenon — highlighting the need to analyze the index's component parts separately rather than relying solely on the aggregate score.

Practical Significance

The proposed methodology has practical significance for the following stakeholders: the Ministry of Digital Technologies and other ministries — in selecting and prioritizing digital projects; IT Park and digital investment projects — in assessing the economic feasibility of projects; state budget planners — in monitoring the efficiency of expenditures directed toward the digital sector; and e-government project managers — in regularly monitoring implementation results. The index can also serve as a practical basis for standardizing interagency data exchange for the State Statistics Committee.

4. Conclusion

Measuring the economic efficiency of digital transformation remains a theoretically debated problem — a debate that began with the Solow paradox and has not been fully resolved even in contemporary economic theory.

Five leading methodological schools (OECD, G20, EU DESI, World Bank DAI, Portulans NRI) exist in international practice, each with its own distinct strengths and limitations.

The simplicity of EU DESI, the practical orientation of World Bank DAI, and the socioeconomic impact-measurement concept of Portulans NRI are the most relevant methodological elements for a national methodology.

The digital economy's share of Uzbekistan's GDP (approximately 2.2%) is considerably lower than the 7–8% typical of developed countries, underscoring the need for systematic assessment and management in this area.

Existing national assessment practice is fragmented, lacks a unified methodology, and does not systematically calculate key economic indicators such as ROI and TCO.

The proposed UzDTEI index fills this methodological gap through four equally weighted

components (infrastructure, human capital, economic outcome, security).

The AHP method is a theoretically grounded, transparent tool for determining composite index weights that allows consistency to be verified, but its real-world application requires a formal survey involving a panel of experts.

Sensitivity analysis of weights is a necessary part of composite index methodology — as Bánhidi and Dobos's study shows, changes in the weighting method can significantly affect final results.

REFERENCES

[1] R. Solow, "We'd better watch out," New York Times Book Review, p. 36, Jul. 12, 1987.

[2] E. Brynjolfsson, "The productivity paradox of information technology," Communications of the ACM, vol. 36, no. 12, pp. 66–77, 1993.

[3] "Digital economy performance and economic growth nexus: Case of Uzbekistan," in Proceedings of the 2023 7th International Conference on Future Networks and Distributed Systems, 2023.

[4] United Nations Development Programme (UNDP), Digital Economy of Uzbekistan: The State of Digital Entrepreneurship to Harness AI. New York, NY, USA: UNDP, 2025.

[5] M. J. Page et al., "The PRISMA 2020 statement: An updated guideline for reporting systematic reviews," The BMJ, vol. 372, Art. no. n71, 2021.

[6] D. W. Jorgenson and K. J. Stiroh, "Raising the speed limit: U.S. economic growth in the information age," Brookings Papers on Economic Activity, vol. 2000, no. 1, pp. 125–235, 2000.

[7] M. J. Farrell, "The measurement of productive efficiency," Journal of the Royal Statistical Society: Series A (General), vol. 120, no. 3, pp. 253–290, 1957.

[8] A. Charnes, W. W. Cooper, and E. Rhodes, "Measuring the efficiency of decision making units," European Journal of Operational Research, vol. 2, no. 6, pp. 429–444, 1978.

[9] M. E. Porter, Competitive Advantage: Creating and Sustaining Superior Performance. New York, NY, USA: Free Press, 1985.

[10] J. E. Stiglitz, A. Sen, and J.-P. Fitoussi, Report by the Commission on the Measurement of Economic Performance and Social Progress. Paris, France: Commission on the Measurement of Economic Performance and Social Progress, 2009.

[11] R. Bukht and R. Heeks, Defining, Conceptualising and Measuring the Digital Economy, Development Informatics Working Paper No. 68. Manchester, U.K.: Centre for Development Informatics, University of Manchester, 2017.

[12] Organisation for Economic Co-operation and Development (OECD), The OECD Digital Supply-Use Tables. Paris, France: OECD Publishing, 2022.

[13] European Commission, The Digital Economy and Society Index (DESI): Methodological Note. Brussels, Belgium: European Commission, 2022.

[14] World Bank, World Development Report 2016: Digital Dividends—Digital Adoption Index Methodology. Washington, DC, USA: World Bank Group, 2016.

[15] S. Dutta and B. Lanvin, Eds., The Network Readiness Index 2024: Building a Digital Tomorrow. Washington, DC, USA: Portulans Institute and Saïd Business School, University of Oxford, 2024.

[16] T. L. Saaty, The Analytic Hierarchy Process: Planning, Priority Setting, Resource Allocation. New York, NY, USA: McGraw-Hill, 1980.

[17] C. L. Hwang and K. Yoon, Multiple Attribute Decision Making: Methods and Applications. Berlin, Germany: Springer-Verlag, 1981.

[18] "Assessment and optimization of regional digital economy development level based on AHP-entropy weight model: A case study of Yangtze River Delta Region," in Proceedings of the 2025 International Conference on Management Science and Computer Engineering, 2025.

[19] "Comparative study on the digital economy development level of the middle and lower reaches of the Yangtze River based on AHP-TOPSIS method," Semantic Scholar, Research Report.

[20] Z. Bánhidi and I. Dobos, "Sensitivity of TOPSIS ranks to data normalization and objective weights on the example of digital development," Central European Journal of Operations Research, 2024.

[21] E. Roszkowska, "Entropy and normalization in MCDA: A data-driven perspective on ranking stability," Entropy, vol. 28, no. 1, Art. no. 114, 2026.

[22] "A digital economy development index based on an improved hierarchical data envelopment analysis approach," European Journal of Operational Research, 2024.

[23] "Digital transformation and flexible performance management: A systematic literature review of the evolution of performance measurement systems," Global Journal of Flexible Systems Management, 2024.

[24] "Digital financial innovation and MSMEs' sustainable performance in developing countries: A PRISMA-based systematic review," Journal of Economics Research and Policy Studies, 2026.