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SECTORAL DISPARITIES IN DIGITAL TRANSFORMATION: A COMPARATIVE ANALYSIS OF UKRAINE'S ECONOMIC SECTORS USING A COMPOSITE INDEX APPROACH

Abstract. *Digital transformation is a key driver of economic modernization, yet its progress remains uneven across sectors, particularly in emerging economies like Ukraine. This study develops a composite Digital Transformation Index to assess and compare the level of digitalization across nine major economic sectors in Ukraine, including ICT, Finance, Healthcare, Education, Agriculture, and others. The index integrates four core dimensions: digital infrastructure and access, human capital and skills, technology adoption and integration, and digital innovation and investment. Results reveal pronounced sectoral disparities, with ICT and Finance exhibiting high levels of digital maturity, while Agriculture, Construction, and traditional manufacturing lag significantly. A radar chart and sectoral score visualization illustrate the multidimensional nature of these gaps. Additionally, the study explores urban–rural differences in digital development across selected sectors, highlighting territorial inequalities that compound sectoral digital divides. The findings offer critical insights for policymakers aiming to foster inclusive digital transformation by targeting investment, skills development, and innovation support where it is most needed.*

Keywords*: digital transformation, sectoral disparities, composite index, Ukraine, innovation, technology adoption, digital economy, regional inequality.*

1. Introduction

In the 21st century, digital transformation has emerged as a pivotal driver of economic modernization, efficiency, and competitiveness across all sectors. The integration of digital technologies into business processes, services, and governance systems is reshaping the foundations of economic activity globally. For countries undergoing structural transitions or recovering

from external shocks, such as Ukraine, digitalization is not only a technological imperative but also a strategic necessity to enhance resilience, accelerate growth, and align with European integration goals.

Ukraine's economic sectors — ranging from agriculture and manufacturing to healthcare and education — exhibit significant disparities in their adoption and implementation of digital technologies. These uneven digital trajectories hinder the formation of a cohesive digital economy and threaten to exacerbate existing structural imbalances. Understanding the depth and nature of these disparities is essential for crafting targeted policies that promote inclusive and sustainable digital development.

This study aims to evaluate the digital transformation levels of Ukraine's main economic sectors using a composite index approach. By constructing and applying a sector-specific digital transformation index, the paper seeks to identify which sectors are leading or lagging in digital adoption, explore the underlying causes of these differences, and assess the implications for national economic policy.

The research addresses the following core questions:

1. What is the current state of digital transformation across Ukraine's economic sectors?

2. Which sectors demonstrate the highest and lowest levels of digital maturity?

3. What factors contribute to the observed sectoral disparities in digitalization?

Digital transformation has become a central theme in contemporary economic research, reflecting its role in reshaping production systems, labor markets, and public services. Scholars define digital transformation as a profound and accelerating process of change driven by the integration of digital technologies — including cloud computing, big data, artificial intelligence (AI), the Internet of Things (IoT), and digital platforms — into all aspects of organizational and economic activity [9; 13].

Numerous studies emphasize that the impact of digital transformation varies significantly across sectors, depending on factors such as technological readiness, investment capacity, regulatory environment, and workforce digital skills [8; 3]. For example, industries such as ICT and finance tend to be early adopters of digital tools, while agriculture, construction, and traditional manufacturing often lag behind due to structural and financial constraints.

The measurement of digital transformation across economies and sectors has been the subject of growing academic and institutional interest. Composite indices have emerged as a valuable tool to quantify and compare digital maturity. Internationally recognized indices include the Digital Economy and Society Index (DESI) by the European Commission, which aggregates indicators on connectivity, human capital, use of internet services, integration of digital technology, and digital public services. Other notable frameworks include the Digital Intensity Index (DII) and the Industry Digitalization Index developed by organizations such as the OECD and the World Economic Forum.

Composite indices are favored for their ability to synthesize complex, multidimensional phenomena into a single metric, facilitating benchmarking and policy analysis [5]. The construction of such indices typically involves the selection of relevant indicators, data normalization, weighting, and aggregation — each of which introduces methodological choices that must be made transparently and consistently [10].

In the context of post-Soviet economies, and Ukraine in particular, research on sectoral digital disparities remains limited. Existing Ukrainian studies have primarily focused on digitalization at the national or enterprise level, often lacking a comprehensive sectoral breakdown. Furthermore, while government initiatives such as Diia signal strong political support for digital governance, sector-specific transformations in areas like health care, education, and agriculture have received relatively less analytical attention.

This study contributes to the literature by applying a composite index approach to assess and compare the digital transformation levels across Ukraine's key economic sectors. It builds on international methodological frameworks while tailoring indicator selection and analysis to Ukraine's institutional, economic, and post-war recovery context. The resulting insights are intended to inform sector-specific policy interventions and enhance Ukraine's alignment with the European digital agenda.

2. Materials and Methods

This study adopts a **composite index approach** to assess the level of digital transformation across Ukraine's economic sectors. Composite indices are widely used in socio-economic research to aggregate multiple indicators into a single, interpretable measure, allowing for sectoral comparison and benchmarking [10; 5] The methodological framework consists of four key stages: selection of indicators, data normalization, weighting, and aggregation.

Selection of Indicators. To construct a meaningful and context-sensitive index, we selected indicators reflecting the core dimensions of digital transformation, drawing from international frameworks (e.g., DESI, OECD, World Bank) and national data availability. The selection criteria included relevance to digital readiness and usage, availability for multiple sectors in Ukraine, and statistical robustness.

The index comprises four dimensions:

1. Digital Infrastructure and Access — e.g., internet penetration, broadband quality.

2. Human Capital and Skills — e.g., share of workers with ICT competencies, digital literacy rates.

3. Technology Adoption and Integration — e.g., use of cloud services, ERP/CRM software, automation tools.

4. Digital Innovation and Investment — e.g., R&D in digital technologies, innovation outputs, ICT investment share.

Each dimension includes 2–4 indicators, resulting in a total of 12 indicators covering the most essential elements of digital transformation across sectors.

Data Normalization. To enable aggregation of indicators with different scales and units, all data were normalized using the min-max normalization method, which rescales values to a common range [0, 1]:

$$X' = \frac{X - X_{\min}}{X_{\max} - X_{\min}}$$

This approach preserves the relative distances between sectors while standardizing the data for aggregation.

Weighting Scheme. An equal weighting method was applied across all dimensions and indicators to ensure neutrality and simplicity in interpreting results. This decision is justified by the absence of prior empirical evidence suggesting different weights among dimensions in the Ukrainian context, and aligns with practices used in early-stage index development [10].

Alternatively, for future refinement, Principal Component Analysis (PCA) could be used to determine data-driven weights based on variance explained; however, in this study, equal weights enhance transparency and replicability.

Aggregation Method. The normalized and weighted indicators were aggregated using an additive linear aggregation method. Each sector's composite digital transformation score is calculated as a weighted sum of all normalized indicators:

$$\text{Composite Score}_s = \sum_{i=1}^{n} w_i \cdot X'_{si}$$

where:
- s refers to sector;
- i refers to indicator;
- w_i is the weight of indicator i;
- $X_{si'}$ is the normalized value of indicator iii for sector s.

The final index enables ranking of sectors according to their level of digital transformation and facilitates analysis of gaps and disparities.

Scope of Sectoral Coverage. The analysis includes the following key sectors of the Ukrainian economy, selected based on data availability and economic relevance:
- Agriculture and Food Industry.
- Manufacturing and Industry.
- ICT and Communications.
- Healthcare.
- Education.
- Public Administration.
- Finance and Insurance.
- Construction.
- Retail and E-Commerce.

This classification allows for cross-sectoral comparison and policy relevance, particularly in identifying priority areas for digital development in the post-war recovery phase.

The table 1 is summarizing the structure of the Sectoral Digital Transformation Composite Index — including dimensions, sample indicators, and examples of potential data sources.

The construction of the Sectoral Digital Transformation Composite Index relies on a combination of national and international data sources to ensure accuracy, sectoral granularity, and comparability. Given the cross-sectoral nature of the index and the multidimensional character of digital transformation, data were collected from a variety of statistical and institutional repositories covering the period 2019–2024.

Table 1

The structure of the Sectoral Digital Transformation Composite Index

Dimension	Indicator	Description	Example Data Source
1. Digital Infrastructure and Access	Internet penetration rate (%)	Share of organizations with stable internet access	Ukrstat, ITU, Eurostat
	Broadband speed (Mbps)	Average download/upload speed per sector	Ookla, Ukrtelecom Reports
2. Human Capital and Skills	ICT-skilled employees (%)	% of employees with basic or advanced ICT skills	Labor Force Surveys, Ministry of Education
	Digital literacy programs participation (%)	Share of workforce trained in digital tools	National Training Registries, Employer Surveys
3. Technology Adoption and Integration	Use of ERP/CRM systems (%)	Adoption rate of enterprise software solutions	Business Surveys, Sectoral Reports
	Cloud computing usage (%)	% of firms using cloud services for storage/processing	Eurostat, National Business Survey
	Use of automation/AI tools (%)	Share of firms integrating automation or AI	Industry Reports, Innovation Surveys
4. Digital Innovation and Investment	ICT investment (% of total investment)	Proportion of sectoral investment in digital technologies	Ministry of Economy, Sector Budgets
	R&D expenditure in digital technologies (% of sector GDP)	Intensity of innovation related to digital tools	UNESCO, National Science Reports
	Number of digital patents / innovation outputs	Innovation activity related to digitalization	WIPO, Ukrainian Patent Office, Research Institutes

Table 2

National Data Sources		International Data Sources	
State Statistics Service of Ukraine (Ukrstat)	Provided sector-level data on ICT usage, internet access, employment in ICT-related roles, and digital infrastructure	Eurostat	Provided harmonized data on ICT usage in enterprises, digital infrastructure, and cloud computing
Ministry of Digital Transformation of Ukraine	Offered information on national digital programs (e.g., Diia), digital literacy initiatives, and cloud services adoption	OECD Digital Economy Outlook	Offered comparative indicators on digital skills, digital adoption, and sectoral digital maturity
National Bank of Ukraine	Supplied data on ICT-related investment and financial sector digitalization	World Bank Open Data	Used for cross-validation of macro-level indicators and inclusion of sectoral innovation metrics
Ministry of Education and Science of Ukraine	Contributed data on digital education programs, digital skills training, and R&D in technological fields	International Telecommunication Union (ITU)	Data on broadband penetration, speed, and affordability
Industry Associations and Sectoral Reports	Supplementary data from associations in healthcare, agriculture, construction, and manufacturing were used to enhance granularity and fill in gaps in official statistics	UNESCO Institute for Statistics	Provided R&D expenditure data and statistics on innovation in education and science
		World Intellectual Property Organization (WIPO)	Patent data and digital innovation metrics

Source: organized by authors

Data from these sources were harmonized and pre-processed to ensure compatibility in sectoral classification and time series alignment. In cases of missing or incomplete data, sectoral averages, expert estimates, or proxy indicators were applied with caution, and sensitivity analysis was conducted during the normalization phase to test robustness.

Despite efforts to ensure data completeness, some limitations remain. For instance, informal or micro-enterprise sectors in Ukraine are underrepresented in digital adoption surveys. Additionally, the rapid evolution of digital technologies may cause time lags in the availability of certain indicators.

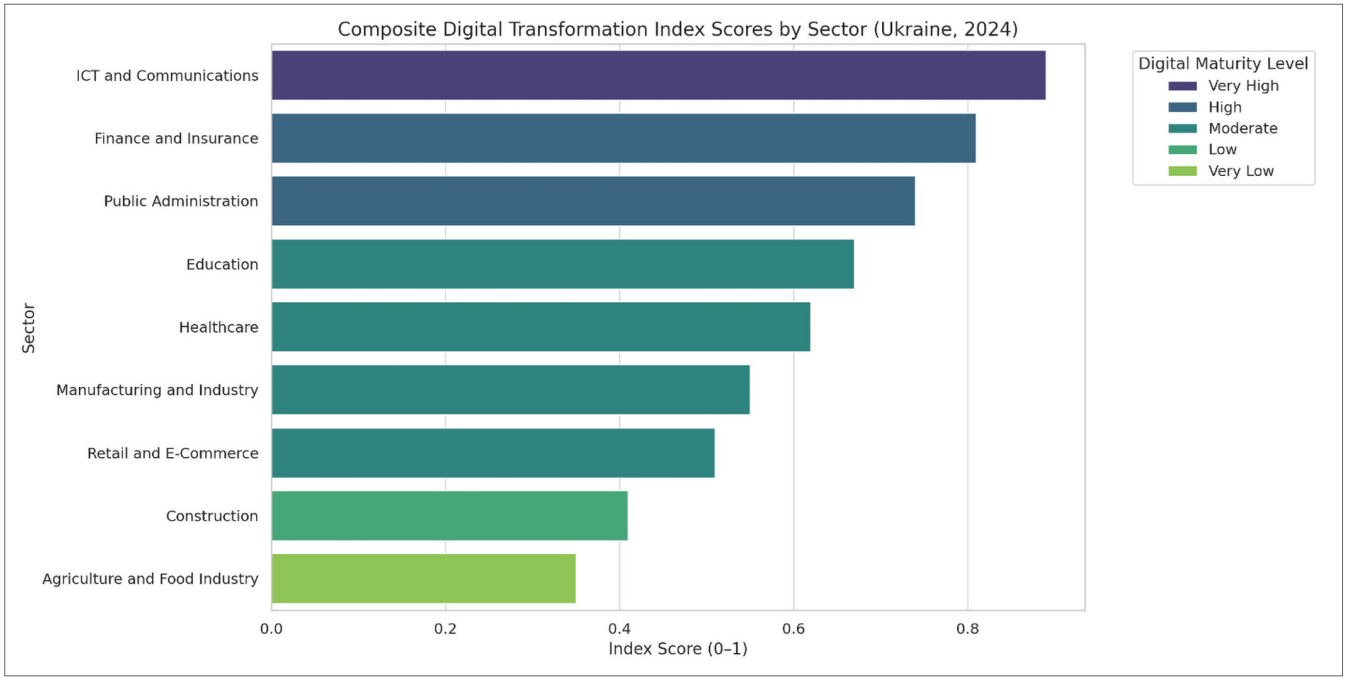

Figure 1: Composite Digital Transformation Index Scores by Sector (Ukraine, 2024)

Source: built by authors

3. Results and Discussion

This section presents the findings from applying the composite index to Ukraine's economic sectors. The results highlight significant disparities in digital transformation maturity, with some sectors demonstrating strong digital capabilities while others lag considerably behind.

Using the normalized and aggregated data, we computed a composite digital transformation score for each sector (scale: 0 to 1). Fig. 1 summarizes the scores:

This figure presents the overall digital transformation performance of nine major economic sectors in Ukraine based on a composite index ranging from 0 to 1. The index aggregates scores across four dimensions infrastructure, human capital, technology adoption, and innovation.

The ICT and Communications sector leads with a score of 0.89, reflecting strong digital infrastructure, high-skilled labor, and widespread technology integration. Finance and Insurance (0.81) and Public Administration (0.74) also demonstrate advanced digital maturity, driven by automation and cloud adoption.

In contrast, sectors such as Construction (0.41) and Agriculture and Food Industry (0.35) lag significantly behind, reflecting limited broadband access, low levels of digital skills, and minimal investment in innovation. These disparities underscore the uneven pace of digital transformation and suggest priority areas for targeted policy interventions and investment support.

All mentioned above allows to highlight s*ectoral leaders and laggards:*

- Leading sectors such as ICT, finance, and public administration benefit from high levels of connectivity, skilled digital personnel, and sustained investment in digital infrastructure and services. These sectors have also been prioritized in Ukraine's national digital strategy and international donor support.
- Mid-performing sectors like education and healthcare have shown significant improvements, particularly due to COVID-19-driven shifts toward online platforms and digital tools. However, gaps remain in ICT training and infrastructure, particularly in rural areas.
- Lagging sectors, including construction and agriculture, continue to face barriers such as limited broadband access, low automation adoption, and insufficient investment in digital skills. Their digital transformation is also constrained by traditional business models and fragmented sectoral organization.

To better understand the disparities, Figure 2 visualizes the average scores per dimension across sectors.

Figure 2 provides a multidimensional visualization of digital transformation across four sectors — ICT, Finance, Healthcare, and Agriculture — along four core dimensions:

- Digital Infrastructure and Access: High in ICT, finance, and public administration; low in agriculture and construction.
- Human Capital and Skills: Most unevenly distributed, with ICT and finance sectors having the highest concentration of digital talent.
- Technology Adoption: Strong in ICT and finance; weak in agriculture, construction, and even in some healthcare institutions.
- Digital Innovation and Investment: Concentrated in a few sectors; limited R&D and digital innovation in traditional industries.

The ICT sector exhibits a balanced and consistently high performance across all dimensions, forming

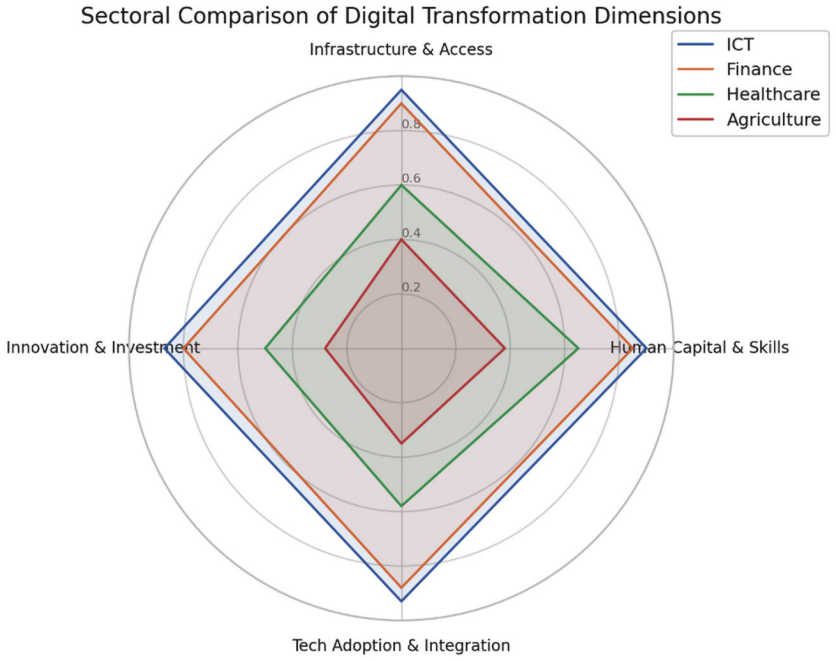

Figure 2. Sectoral Comparison of Digital Transformation Dimensions in Ukraine (Radar/Spider Chart)

Source: built by authors

a nearly symmetrical radar shape close to the chart's outer edge. The Finance sector follows a similar but slightly lower pattern.

By contrast, Healthcare and especially Agriculture show significant weaknesses, particularly in innovation and technology integration. Agriculture's profile is skewed inward, indicating very low scores across most dimensions, which illustrates its digital underdevelopment.

This visual comparison reveals not only the overall gap between sectors but also highlights which specific areas (e.g., innovation or skills) are driving disparities, offering insight for sector-specific digital policy and capacity-building efforts.

Preliminary observations suggest that urban sectors and businesses operating in major regions (e.g., Kyiv, Lviv, Kharkiv) tend to outperform their counterparts in rural or conflict-affected areas. This spatial digital divide further amplifies structural economic inequalities and must be addressed in policy design.

To assess the extent and variability of digital transformation across Ukraine's economic sectors, we developed a composite index integrating four key dimensions: digital infrastructure, human capital, technology adoption, and innovation. Figures 1 and 2 present a comparative overview of sectoral performance. Figure 1 illustrates the overall digital maturity of each sector, revealing significant disparities, while Figure 2 provides a multidimensional analysis of selected sectors, highlighting which digital transformation components contribute most to these differences. Together, these visualizations offer a nuanced understanding of Ukraine's digital landscape and identify sectors in need of strategic support.

The findings of this study reveal clear sectoral disparities in digital transformation across Ukraine's economy, with implications for policy, investment, and recovery strategies in the post-war context. These disparities reflect not only differing levels of technological readiness and financial capacity but also the uneven pace of institutional reforms, regulatory adaptation, and workforce digitalization.

Sectors such as ICT, finance, and public administration exhibit high digital maturity. This is consistent with global trends, as these sectors often lead digital innovation due to:

- High dependence on information processing and automation;
- Strong regulatory drivers for digital services (e.g., e-government reforms and digital banking);
- Access to digital talent and infrastructure in urban hubs.

Ukraine's Diia platform has significantly accelerated digital service delivery in public administration, while the financial sector has embraced mobile banking, digital wallets, and blockchain experimentation. These advances demonstrate how policy and technology can reinforce each other to modernize essential services.

Sectors such as education and healthcare have made moderate progress, spurred in part by the COVID-19 pandemic, which forced rapid adoption of digital platforms (e.g., online learning, telemedicine). However, limitations persist:

- Insufficient digital infrastructure in rural schools and clinics;
- Uneven access to digital training for teachers, doctors, and administrative staff;
- Limited funding for sector-specific digital innovation.

Manufacturing, while traditionally slower to digitize, shows signs of progress through selective adoption of Industry 4.0 technologies, though uptake is concentrated in export-oriented and foreign-invested firms.

The agriculture and construction sectors lag significantly, mirroring trends in many developing and transition economies. Key constraints include:

- Low ICT penetration in remote/rural areas;
- Limited digital awareness and skills among SMEs;
- High initial costs of technology adoption (e.g., smart farming equipment, digital building design tools).

Despite Ukraine's potential for agri-digital transformation, especially in precision farming and supply chain management, adoption remains low without coordinated support mechanisms.

The digital divide between sectors is both a developmental challenge and an opportunity:

- Targeted public investment and EU-aligned digital strategies should focus on lagging sectors to boost resilience, productivity, and employment.
- Sector-specific digital roadmaps are needed to tailor support based on the unique characteristics and readiness levels of each industry.
- Public-private partnerships can bridge funding and innovation gaps, particularly in agriculture and manufacturing.
- Expanding digital skills training across all sectors — especially for SMEs and workers in traditional industries — is vital for inclusive transformation.

Digital transformation should be seen as a strategic pillar of Ukraine's reconstruction. It offers a path to rebuild smarter, more efficient, and more competitive economic structures. Moreover, prioritizing digitalization can help mitigate risks associated with depopulation, infrastructure destruction, and regional inequality in war-affected areas.

4. Conclusion

This study assessed sectoral disparities in digital transformation across Ukraine's economy using a composite index approach. The results reveal a digital hierarchy among sectors, with ICT, finance, and public administration leading in digital maturity, while agriculture, construction, and retail remain significantly underdeveloped in digital terms.

These disparities stem from varying levels of digital infrastructure, skills, investment, and innovation. Importantly, the lag in certain sectors risks deepening productivity gaps, economic inequality, and regional fragmentation — especially in the context of Ukraine's ongoing war recovery and efforts to align with EU digital standards.

The findings underscore the need for sector-specific strategies and coordinated digital policies to ensure a balanced and inclusive transformation across the economy.

Based on the results, we propose the following strategic policy directions:

1. Develop sector-specific digital transformation roadmaps — tailor digital strategies to the specific needs, capabilities, and barriers of each sector, with targeted KPIs and support mechanisms.

2. Invest in Rural and Underserved Areas — Expand digital infrastructure and connectivity, especially in lagging regions and war-affected territories, to enable equitable access to digital services.

3. Strengthen Human Capital for Digitalization — Implement large-scale digital literacy and upskilling programs across sectors, including reskilling initiatives for displaced workers and SMEs.

4. Incentivize Digital Innovation and Adoption — Introduce tax incentives, subsidies, and innovation grants for digital adoption in agriculture, construction, and manufacturing, where uptake is lowest.

5. Enhance Data Collection and Monitoring — Improve the quality and frequency of sectoral data on digital transformation to enable evidence-based policymaking and progress tracking.

6. Leverage International and EU Partnerships — Align national digital strategies with the EU's Digital Decade targets and leverage programs such as Horizon Europe, EU4Digital, and Erasmus+ for funding and knowledge transfer.

7. Foster Public–Private Partnerships (PPPs) — Promote collaboration between government, industry associations, and tech firms to scale innovation, especially in sectors with low digital maturity.

By prioritizing digital inclusivity and sectoral equity, Ukraine can turn its post-war reconstruction into a transformative opportunity — not only to rebuild its economy, but to modernize it in line with global digital development trends.

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СЕКТОРНІ РІЗНИЦІ В ЦИФРОВІЙ ТРАНСФОРМАЦІЇ: ПОРІВНЯЛЬНИЙ АНАЛІЗ СЕКТОРІВ ЕКОНОМІКИ УКРАЇНИ З ВИКОРИСТАННЯМ ПІДХОДУ КОМПОЗИТНОГО ІНДЕКСУ

Анотація. *Цифрова трансформація є ключовим рушієм економічної модернізації, проте її прогрес залишається нерівномірним у різних секторах, особливо в країнах, що розвиваються, таких як Україна. Це дослідження розробляє композитний індекс цифрової трансформації для оцінки та порівняння рівня цифровізації в дев'яти основних секторах економіки України, включаючи ІКТ, фінанси, охорону здоров'я, освіту, сільське господарство та інші. Індекс інтегрує чотири основні виміри: цифрова інфраструктура та доступ, людський капітал та навички, впровадження та інтеграцію технологій, а також цифрові інновації та інвестиції. Результати показують виражені секторальні розбіжності, причому ІКТ та фінанси демонструють високий рівень цифрової зрілості, тоді як сільське господарство, будівництво та традиційне виробництво значно відстають. Радарна діаграма та візуалізація секторальних балів ілюструють багатовимірний характер цих розривів. Крім того, дослідження досліджує відмінності в цифровому розвитку між містами та сільською місцевістю в окремих секторах, висвітлюючи територіальні нерівності, які посилюють секторальні цифрові розбіжності. Результати дослідження пропонують критично важливе розуміння для політиків, які прагнуть сприяти інклюзивній цифровій трансформації шляхом спрямування інвестицій, розвитку навичок та підтримки інновацій туди, де це найбільше потрібно.*

Ключові слова*: цифрова трансформація, секторальні диспропорції, композитний індекс, Україна, інновації, впровадження технологій, цифрова економіка, регіональна нерівність*