A Structural Analysis of Digital Transformation Development in Ukrainian Regions

Natalia Ivanova
Doctor of Economic Sciences, Full Professor,
Professor at Department of Management,
Marketing, and Information Technologies,
Kherson State Agrarian and Economic University, Ukraine
E-mail: ivanova_n@ksaeu.kherson.ua
ORCID: https://orcid.org/0000-0002-5010-2668

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Abstract. *The accelerated progression of digital transformation processes has emerged as a strategic imperative for regional development, particularly in countries grappling with institutional, infrastructural, and security challenges. The objective of this study is to conduct a structural analysis of digital transformation development across Ukrainian regions, with a view to identifying typical regional groups and their digital characteristics. The study will use data from the national Digital Transformation Index. The impetus for this research stems from the necessity to enhance the governance capacities at the regional level and to formulate diversified digital policies that reflect the unique characteristics and developmental stages of subnational entities. The methodological framework combines cluster analysis based on a composite Digital Transformation Index with entropy-based validation and structural interpretation of clustering outcomes. The clustering procedure was executed by means of standardised subindex values reflecting institutional capacity, digital infrastructure, service digitalisation, human capital, and innovative initiatives. The results of the study indicate a marked disparity in digital maturity across different regions, thereby identifying three structurally distinct groups. The initial cluster encompasses regions characterised by inadequate digital readiness, infrastructural deficiencies, and institutional impediments, necessitating targeted foundational assistance. The second cluster comprises digital frontrunners, characterised by comprehensive integration of digital services, strong administrative capacity, and innovative local initiatives. The third cluster encompasses moderately advanced regions with potential for development yet facing challenges in digital innovation and strategic coherence. Each cluster exhibits a distinct internal digital profile, thereby calling into question the efficacy of uniform digital policies. The practical value of the study lies in providing a typology-based model for regional digital transformation policymaking. The approach advocated here is predicated on the premise that it facilitates data-driven decision-making, enables the prioritisation of interventions, and contributes to the reduction of digital inequality.*

Keywords: *digital transformation, regional development, cluster analysis, digital inequality, digital governance, Regional Digital Transformation Index, Ukraine.*

JEL Classification: *O33, R11, C38*

1 Introduction

Digital transformation has been identified as a primary catalyst for sustainable regional development, particularly in contexts characterised by war-related risks and market turbulence. It has been demonstrated that this results in new opportunities for enhancing competitiveness, institutional adaptability, innovation activity, and integration into the global digital space (Bughin et al., 2016; World Economic Forum, 2020). In countries undergoing reform and systemic challenges, such as Ukraine, digital transformation acquires not only economic but also strategic significance for regional equalisation and the implementation of long-term development policies (OECD, 2020).

In this context, the assessment of regional digital development that accounts for spatial disparities, the level of digital infrastructure, digital skills, innovativeness, and the quality of digital governance becomes increasingly relevant. In the context of international practice, such assessments are predominantly informed by multidimensional indices (e.g., DESI, NRI), which integrate both quantitative and qualitative parameters (OECD, 2020; United Nations, 2022). In Ukraine, an official

Regional Digital Transformation Index has been developed and is published on an annual basis by the Ministry of Digital Transformation. The index is composed of multiple subindices, each of which reflects a distinct aspect of digital development (Ministry of Digital Transformation of Ukraine, 2024).

The objective of this study is to conduct a structural analysis of regional digital transformation development in Ukraine, with the goal of identifying typical groups of regions and their specific characteristics, based on data from the Regional Digital Transformation Index.

The research methodology is based on a comprehensive approach that combines quantitative analysis of official digital indicators, cluster analysis using Statistica v.10 software (StatSoft Inc.), and a critical review of existing assessment methodologies. The cluster analysis conducted in this study was not based on raw statistical indicators, but rather on subindices calculated using the official Regional Digital Transformation Index of Ukraine. This approach facilitates a focus on comparing the integral characteristics of regional digital development, which are more stable and representative from the perspective of public policy analysis. The methodology employed in this study aligns with the principles of multidimensional analysis, a widely adopted approach in international research practice (OECD, 2020; European Commission, 2022).

2 Theoretical and Methodological Foundations of the Study of Regional Digital Transformation

Digital transformation is a multidimensional process involving the integration of digital technologies into social and economic systems. It encompasses institutional and structural changes, impacting management models, organisational culture, and stakeholder interaction (Vial, 2019; Gobble, 2018). Beyond the adoption of ICT, it has been demonstrated to redefine business models and strategies that are aligned with digital opportunities (Westerman et al., 2014).

In the academic literature, digital transformation is considered across four levels: national (policy and infrastructure), regional (local capacity), sectoral (transformation in specific domains), and organisational (integration into internal processes) (OECD, 2024; Fitzgerald et al., 2014; Andal-Ancion et al., 2003; Kyrylenko et al., 2023; Yang et al., 2024).

Key dimensions of digital transformation, such as infrastructure, e-services, inclusion and institutional capacity, are measured using international indices such as the DESI (European Commission, n. d.).

Scholarly interest in examining the relationship between the development of the digital economy and spatial (regional) development is growing. This highlights the importance of taking a comprehensive approach to assessing digital transformation.

As shown in Table 1, composite indices are effective tools for evaluating digital transformation and supporting strategic decision-making and regional comparisons.

The Digital Economy and Society Index (DESI), developed by the European Commission, and the E-Government Development Index (EGDI), developed by UNDESA, are widely used international tools for assessing digital development. The DESI focuses on five dimensions of digitalisation in EU countries, offering comparability and transparency. However, it lacks subnational detail and excludes non-EU states. The EGDI provides a global view based on online services, infrastructure and human capital; however, it overlooks intra-country disparities.

In Ukraine, the Regional Digital Transformation Index (RDTI), as published by the Ministry of Digital Transformation, offers a subnational perspective on the development of the digital sphere. The index is composed of nine sub-indices, which are derived from 27 indicators and over 82 metrics. These sub-indices are designed to capture various aspects of regional digital capacity and progress (see Table 2 for details).

In 2024, the methodology of the Regional Digital Transformation Index (RDTI) underwent an update. A new subindex, "CDTO Projects", was added to reflect over 125 local initiatives coordinated by regional Chief Digital Transformation Officers. Other changes included updated normalisation bases and revised subindex weights, with the emphasis being shifted towards digital services and innovation.

While these updates enhance the index's responsiveness to dynamic digital contexts, concerns have been raised about comparability over time and methodological transparency. The annual changes in subindex composition and weighting complicate longitudinal analysis. Furthermore, the absence of public access to formulae and weights has been demonstrated to impede reproducibility.

The index also relies heavily on administrative data, which may be inconsistent or out of date. For instance, the "Digital Education" sub-index is primarily based on usage data from the Diia. Education platform, overlooking significant alternatives such as Prometheus, EdEra, Coursera

Table 1 Comparative characteristics of digital development indices

Parameter	DESI (EU)	EGDI (UN)	Regional Digital Transformation Index (Ukraine)
Developer	European Commission	United Nations Department of Economic and Social Affairs (UNDESA)	Ministry of Digital Transformation of Ukraine
Coverage level	National (EU Member States)	Global (all UN Member States)	Subnational (regions of Ukraine)
Assessment focus	Digital economy and society	E-government development	Regional-level digital transformation
Key components / subindices	Connectivity, human capital, internet use, integration of digital technology in business, digital public services	Online services, telecom infrastructure, human capital	Institutional capacity, internet, Administrative Service Centres (ASCs), paperless services, e-education, basic e-services, CDTO projects, etc.
Methodology	Quantitative and qualitative indicators aggregated into five dimensions	Composite indicator comprising three components based on normalised data	Multi-component index with 9 subindices, primarily based on administrative data
Advantages	Comparability across EU countries; high methodological transparency	Global scope; longstanding reputation	Regional orientation; high level of detail; reflection of local specificities
Limitations	Does not cover non-EU countries; lacks regional disaggregation	Limited to national level; lacks regional disaggregation	Limited access to some data; need for continuous methodological updates

Source: compiled by the author according to (UNDESA, 2022; European Commission, n.d.; Ministry of Digital Transformation of Ukraine, 2025)

and Udemy. This restricts the scope of the digital literacy assessment.

In order to improve analytical validity, it is advisable to diversify data sources and include behavioural and social indicators. While the RDTI's structure supports regional analysis, it requires regular methodological refinement to remain relevant in an ever-evolving digital environment.

3 Analysis and Clustering of Ukrainian Regions by Digital Transformation Indicators

In 2023, Ukraine's overall Regional Digital Transformation Index (RDTI) value was 0.632, indicating a moderate level of digital development nationwide. Analysis of RDTI data from that year revealed a significant degree of regional disparity. The regions with the highest overall index scores were Dnipropetrovsk (0.908), Lviv (0.891), Poltava (0.833), Volyn (0.831) and Ternopil (0.827). In contrast, the lowest scores were recorded in the Zaporizhzhia (0.289) and Sumy (0.178) regions.

By 2024, the national average of the Regional Digital Transformation Index had fallen to 0.497. This decline may be attributed to the impact of external crisis factors, particularly the ongoing martial law and related disruptions (see Table 3).

Nevertheless, some of the top-performing regions retained their leading positions: Lviv (0.850) and Dnipropetrovsk (0.844) were once again among the frontrunners, this time joined by Odesa (0.804). Conversely, regions such as Mykolaiv (0.180) and Donetsk (0.129) were at the opposite end of the ranking.

These figures confirm the persistence of a significant digital divide between regions and the susceptibility of digital transformation processes to socio-economic and political factors.

A detailed analysis of the sub-indices of the Regional Digital Transformation Index (RDTI) for 2024 (see Table 3) confirms that digital development is uneven across Ukraine's regions. For example, the highest scores in the "Institutional Capacity" sub-index were observed in the Dnipropetrovsk (1.000) and Odesa (1.000) regions, as well as in the Poltava region (0.937), while significantly lower values were recorded in the Donetsk (0.341) and Kirovohrad (0.320) regions. A similar pattern emerges in the "Internet Development" sub-index, with Chernivtsi (0.982) and Poltava (0.964) performing best, and Donetsk (0.174) and Zaporizhzhia (0.462) performing worst.

Table 2 Structure of the Regional Digital Transformation Index

No	Subindex	Number of indicators	Examples of indicators
1	Institutional capacity	5	Digital transformation strategy, informatisation programme, CDTO unit, number of CDTOs in Regional Administrations, structure of digital projects
2	Internet development	4	Internet speed in social institutions, Wi-Fi in libraries/schools, mobile internet coverage
3	Administrative service centre (ASC) development	4	Number of ASCs, share of digital services, process automation, staff training
4	Paperless mode implementation	3	Availability of e-data centres, digital registers, e-signature, Diia. QR in documents
5	Digital education	3	Use of e-journals, participation of teachers in Diia.Education, number of available courses
6	Regional digital identity	3	Regional administration websites, GIS services, representation in Diia.Business
7	Penetration of basic e-services	3	Use of eMalyatko, online registration, digitalisation in social services
8	Sectoral digital transformation	3	E-permits, cybersecurity, application of IT in healthcare and public safety
9	CDTO projects (2024)	3	Environmental projects, cybersecurity initiatives, defence-related IT initiatives (125+)

Source: compiled by the author according to (Ministry of Digital Transformation of Ukraine, 2025; Ministry of Digital Transformation of Ukraine, 2024)

Table 3 Regional Digital Transformation Index of Ukrainian regions by subindices, 2024

Region	Overall index	Institutional capacity	Internet development	ASCs development	Paperless services	Digital education	Regional web profile	Basic e-services penetration	Sectoral digital transformation	CDTO projects
1	2	3	4	5	6	7	8	9	10	11
Ukraine (average)	0.497	0.687	0.686	0.523	0.421	0.575	0.579	0.759	0.483	0.436
Vinnytsia	0.755	0.802	0.708	0.594	0.427	0.668	0.654	0.680	0.652	0.826
Volyn	0.711	0.603	0.722	0.613	0.674	0.642	0.790	1.000	0.664	0.710
Dnipropetrovsk	0.844	0.897	0.790	0.811	0.752	0.760	0.757	0.885	0.650	0.882
Donetsk	0.129	0.341	0.174	0.250	0.172	0.534	0.288	0.526	0.297	0.000
Zhytomyr	0.343	0.183	0.732	0.473	0.248	0.438	0.291	0.680	0.327	0.290
Zakarpattia	0.647	0.901	0.806	0.525	0.451	0.626	0.759	0.888	0.379	0.633
Zaporizhzhia	0.209	0.625	0.462	0.249	0.078	0.552	0.202	0.513	0.243	0.105
Ivano-Frankivsk	0.436	0.790	0.674	0.532	0.301	0.352	0.763	0.680	0.357	0.356
Kyiv	0.474	0.733	0.782	0.531	0.426	0.562	0.686	0.720	0.431	0.384
Kirovohrad	0.407	0.503	0.438	0.408	0.134	0.468	0.486	0.728	0.359	0.384
Lviv	0.850	0.854	0.766	0.818	0.777	0.906	0.671	0.968	0.964	0.882
Luhansk	–	–	–	–	–	–	–	–	–	–
Mykolaiv	0.180	0.327	0.680	0.275	0.237	0.322	0.763	0.706	0.292	0.000
Odesa	0.804	0.853	0.876	0.710	0.537	0.582	0.712	0.707	0.523	0.882
Poltava	0.640	0.937	0.964	0.593	0.763	0.742	0.726	0.786	0.694	0.549
Rivne	0.632	0.854	0.798	0.523	0.390	0.514	0.783	0.797	0.465	0.626
Sumy	0.435	0.714	0.812	0.456	0.229	0.520	0.421	0.697	0.407	0.371

End of Table 3

1	2	3	4	5	6	7	8	9	10	11
Ternopil	0.341	0.851	0.708	0.639	0.683	0.544	0.631	0.712	0.792	0.105
Kharkiv	0.617	0.491	0.514	0.571	0.543	0.900	0.940	0.982	0.553	0.571
Kherson	0.582	0.775	0.352	0.374	0.203	0.574	0.507	0.665	0.407	0.648
Khmelnytskyi	0.230	0.781	0.726	0.428	0.439	0.410	0.276	0.810	0.393	0.028
Cherkasy	0.538	0.483	0.634	0.587	0.252	0.516	0.366	0.680	0.311	0.577
Chernivtsi	0.254	0.769	0.982	0.521	0.328	0.532	0.398	0.818	0.402	0.028
Chernihiv	0.362	0.726	0.684	0.549	0.641	0.568	0.437	0.840	0.536	0.189
Autonomous Republic of Crimea	–	–	–	–	–	–	–	–	–	–

Notes: in regions affected by active hostilities, figures are calculated based on data from municipalities under the control of the Government of Ukraine. The Autonomous Republic of Crimea is Ukraine.

Source: compiled by the author according to (Ministry of Digital Transformation of Ukraine, 2025)

The significant variation in the index and its sub-index values across regions underscores the necessity for the implementation of multivariate statistical methodologies. A linear ranking of regions based solely on the aggregate digital transformation index is not sufficient to reflect the structural differences between regions in terms of the substantive characteristics of digital development. In this regard, a method of hierarchical cluster analysis was applied to identify latent patterns, similarities in digital transformation profiles, and to group regions according to their shared characteristics.

Cluster analysis is an effective tool for identifying homogeneous groups in multidimensional data spaces and is widely used in regional socio-economic and technological studies (Rencher & Christensen, 2012; Kaufman & Rousseeuw, 2005). In this study, cluster analysis is employed to typologise Ukrainian regions based on integral and sub-integral indicators of the RDTI. This methodological approach facilitates the identification of spatial patterns of digital development, the identification of clusters of regions exhibiting similar characteristics, and the establishment of an analytical foundation for the development of differentiated digital transformation policies at the subnational level. The clustering procedure encompassed 23 regions of Ukraine. The Autonomous Republic of Crimea and Luhansk region were excluded from the study due to the absence of complete sub-index data for 2024.

Methodologically, the cluster analysis was performed using the hierarchical agglomerative clustering method, which involves the stepwise aggregation of objects (regions) into larger clusters based on the calculation of inter-cluster distances. In order to identify groups of Ukrainian regions with similar levels of digital transformation, Ward's method was combined with the use of the Euclidean distance. Ward's method is particularly suited for the clustering of objects distributed over space, due to its ability to minimise within-cluster variance (Kaufman & Rousseeuw, 2005; Everitt et al., 2011).

To determine the optimal number of clusters, two complementary approaches were applied: the plot of linkage distances across steps (also known as the amalgamation schedule plot), entropy analysis.

1. The plot of linkage distances across steps, also referred to as the amalgamation schedule plot, is a visual representation of the point at which there is a significant increase in the distance between clusters. This finding suggests the convergence of groups that are substantively distinct (Figure 1).

A pronounced jump can be clearly observed at the 20th step of agglomeration in the linkage distance plot (see Figure 1), indicating a substantial decline in homogeneity following the transition from four to three clusters. Nevertheless, visual interpretation alone may be inherently subjective. Consequently, to bolster the validity of the cluster number selection, an ancillary entropy-based analysis was conducted.

2. Entropy analysis provides a quantitative assessment of the balance in the structure of the clustering solution based on the ratio of the observed entropy to its theoretical maximum (see Table 4).

As illustrated in Table 4, the results of entropy calculations are presented for varying numbers of clusters. The most minimal discrepancy between the observed entropy and its theoretical maximum ($\Delta H = 0.5\%$) was documented when the regions were categorised into three clusters. This finding serves to confirm the structural balance and internal homogeneity of this clustering configuration. In light of the findings from both the agglomeration schedule plot and the entropy analysis, the regional

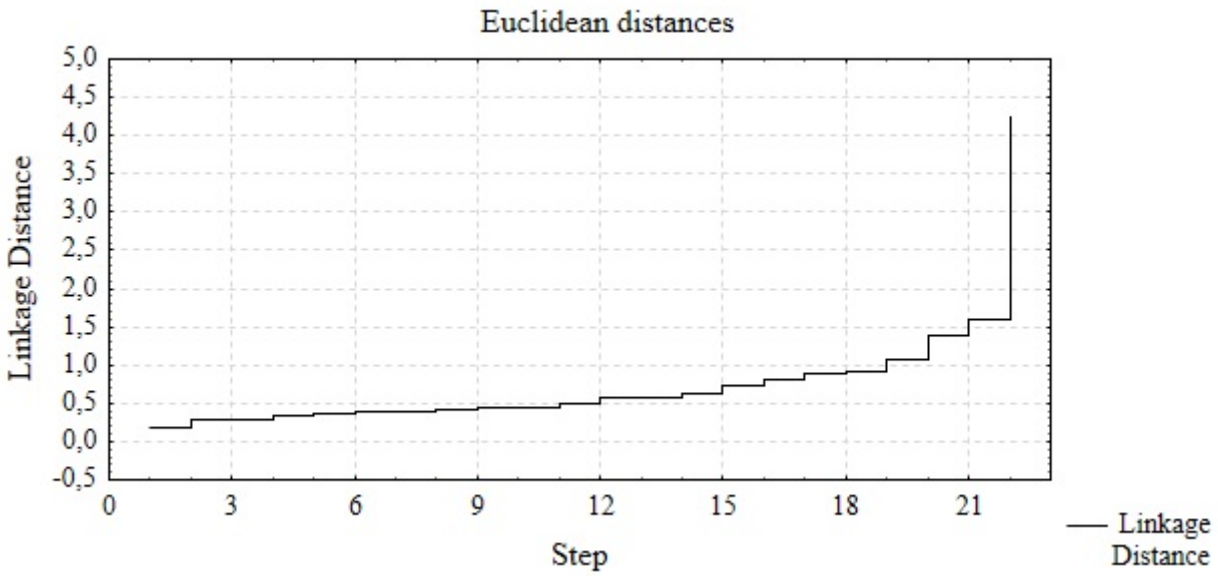

Figure 1 Amalgamation schedule plot (hierarchical clustering), 23 regions

Source: author's elaboration using Statistica 10.0 based on data from the Ministry of Digital Transformation of Ukraine (2025)

Table 4 Entropy-based evaluation of optimal cluster number for Ukrainian regions, 2024

Number of clusters	Number of regions in each cluster							Maximum possible entropy (bits)	Observed entropy (bits)	Deviation from maximum entropy (%)
	1	2	3	4	5	6	7			
2	10	13						0,999	0,988	1,10
3	7	9	7					1,582	1,574	0,50
4	5	7	7	4				1,996	1,962	1,69
5	4	2	6	6	5			2,314	2,235	3,38
6	4	2	4	4	2	7		2,578	2,452	4,89
7	6	7	1	3	2	3	1	2,794	2,494	10,73

Source: author's elaboration based on the Regional Digital Transformation Index (Ministry of Digital Transformation of Ukraine, 2025)

clustering by digital transformation indicators in 2024 was performed based on the three-cluster scheme.

The application of the k-means clustering method enabled the identification of the composition of each cluster. The list of regions (observations) belonging to each of the resulting clusters was obtained using the "Members for each cluster & distances" function within the "Statistics / Multivariate Exploratory / Cluster Analysis (k-means method)" module of the Statistica 10.0 software (StatSoft, Inc., 2011), as presented in Table 5.

The quality of the classification was verified using discriminant analysis, implemented through the "Multivariate Exploratory / Discriminant" module. In this procedure, the cluster number was employed as the grouping variable. The findings of the analysis substantiated that the three constructed

Table 5 Cluster composition of Ukrainian regions based on subindices of the Regional Digital Transformation Index, 2024

Cluster 1 (7 regions)	Cluster 2 (9 regions)	Cluster 3 (7 regions)
Donetsk, Zhytomyr, Zaporizhzhia, Kirovohrad, Mykolaiv, Kherson, Cherkasy	Vinnytsia, Volyn, Dnipropetrovsk, Zakarpattia, Lviv, Odesa, Poltava, Rivne, Kharkiv	Ivano-Frankivsk, Kyiv, Sumy, Ternopil, Khmelnytskyi, Chernivtsi, Chernihiv

Source: compiled by the author

clusters are statistically significant and well-separated based on the subindices of the Regional Digital Transformation Index. This is evidenced by a low value of Wilks' Lambda (0.03819) and a high level of statistical significance for the F-statistic ($p < 0.0001$).

In order to assess the validity of the classification, a classification matrix was generated (see Figure 2).

The results of the classification matrix further confirmed the validity of the regional grouping achieved using the k-means method.

Furthermore, the robustness of the clustering is supported by the scatterplot of canonical values (Figure 3). In this plot, each point represents a region, and its position is determined by the values of the two principal discriminant functions

Group	Classification Matrix (RDTI (2024)) Rows: Observed classifications Columns: Predicted classifications			
	Percent Correct	2 p=,39130	1 p=,30435	3 p=,30435
2	100,0	9	0	0
1	100,0	0	7	0
3	100,0	0	0	7
Total	100,0	9	7	7

Figure 2 Classification matrix (discriminant analysis)

Source: author's calculations using Statistica 10.0 based on the Regional Digital Transformation Index, 2024 (Ministry of Digital Transformation of Ukraine, 2025)

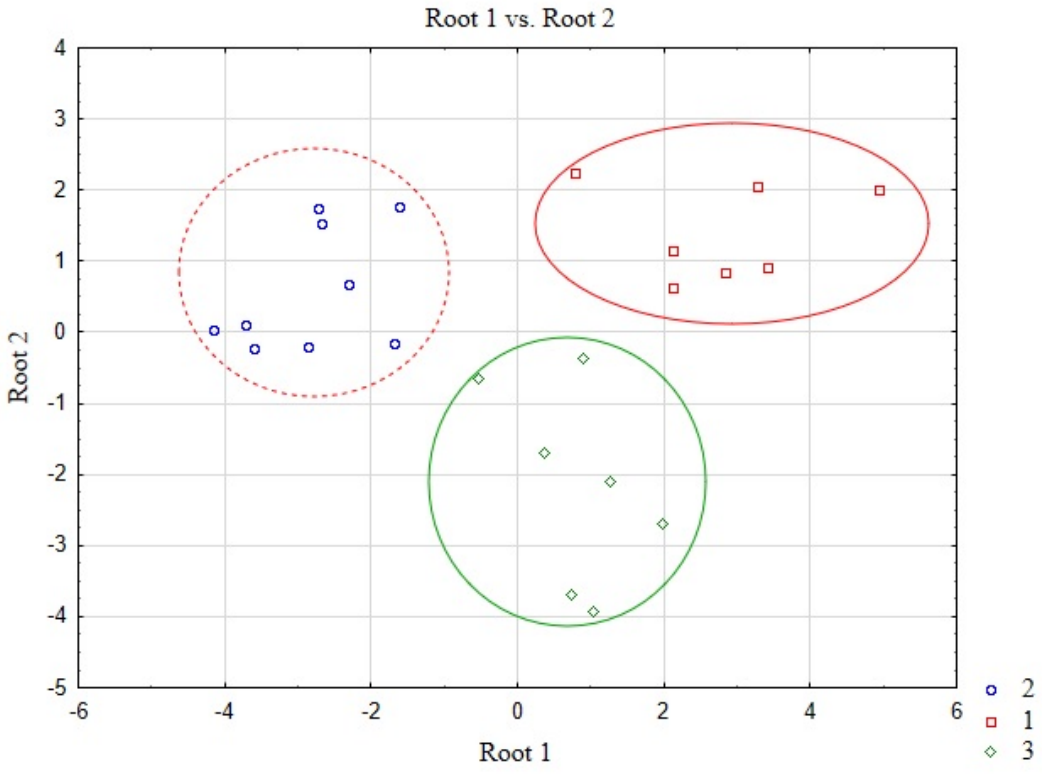

Figure 3 Scatterplot of canonical scores (discriminant analysis)

Source: author's calculations using Statistica 10.0 based on the Regional Digital Transformation Index, 2024 (Ministry of Digital Transformation of Ukraine, 2025)

(Root 1 and Root 2), which provide the greatest separation between the clusters.

As demonstrated in Figure 3, the three identified clusters (labelled with different colours and symbols: blue circles, red squares, green diamonds) are visually well separated from one another.

Each cluster is characterised by the formation of a distinct, relatively compact group of points, with considerable distances between the group centroids. The minimal overlap between clusters provides visual confirmation of the strong discriminant capacity and homogeneity of the regions within each cluster. The ellipses on the plot represent 95% confidence regions for each cluster, thereby further illustrating the spatial distinction among them.

Overall, the results of the discriminant analysis and the visualisation of canonical values provide compelling evidence for the statistical validity and robustness of the obtained three-cluster solution for regional classification.

4 Specific Features and Managerial Implications of the Identified Structural Types of Regions

Following the identification of the optimal number of clusters and the verification of the clustering results (including linkage distance jumps and entropy coefficient analysis), the regions of Ukraine were grouped according to the values of the sub-indices of the Regional Digital Transformation Index (RDTI). Consequently, three structural types of regions were identified, each characterised by a distinct digital profile. The Autonomous Republic of Crimea and Luhansk region were excluded from the analysis due to an absence of complete and reliable data for the respective indicators as of 2024.

The analysis of average values of the Index and its sub-indices for each of the three clusters (Figure 4) enabled the identification of their specific features and the formulation of corresponding managerial implications.

Cluster of Digital Transformation Leaders (Cluster 2). This cluster is characterised by the highest average values of the overall Digital Transformation Index (DTI) (0.722) and most of its sub-indices. Regions in this cluster have made significant achievements in institutional capacity (0.799), internet development (0.767) and penetration of basic e-services (0.754), as well as achieving high scores in sectoral digital transformation (0.616) and individual CDTO projects (0.729). These results suggest a systematic approach to digitalisation,

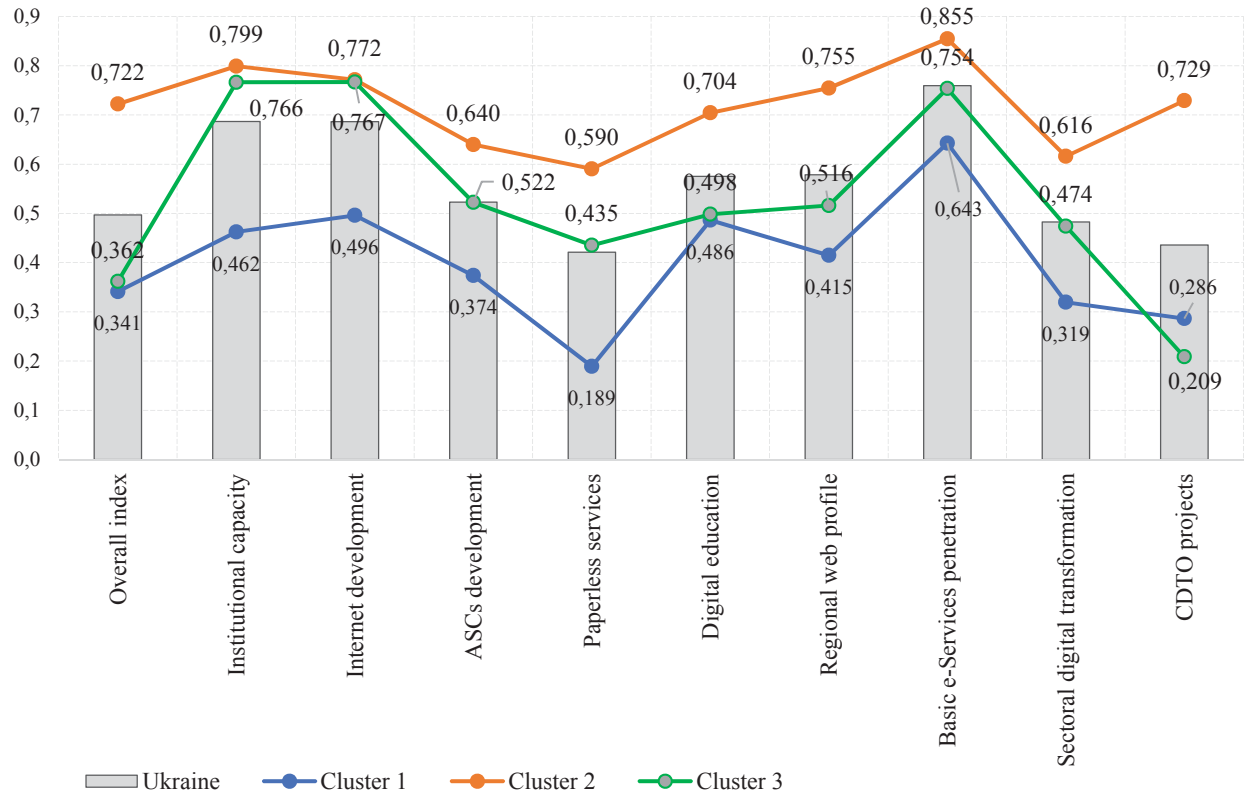

Figure 4 Mean values of subindex scores by cluster (Regional Digital Transformation Index)

Source: author's calculations based on the Regional Digital Transformation Index, 2024 (Ministry of Digital Transformation of Ukraine, 2025)

with the necessary qualified personnel and well-developed infrastructure in place, as well as the active implementation of e-services across various sectors.

Cluster with a Medium Level of Digital Transformation (Cluster 3). The regions in this cluster perform averagely in terms of the overall Index (0.498) and most sub-indices. Moderate progress is exhibited in institutional capacity (0.462), internet penetration (0.496) and basic e-services (0.643). However, the paperless mode implementation (0.189) and individual CDTO projects (0.209) indicators are considerably lower compared to those of the leading regions. This suggests a lack of systematic implementation of electronic document flow and initiative in launching proprietary digital projects.

Cluster of Regions with a Low Level of Digital Transformation (Cluster 1). This cluster comprises regions with the lowest average scores in the Digital Transformation Index (0.341) and in almost all sub-indices. Particularly low scores are observed in the following areas: institutional capacity (0.341); internet development (0.377); paperless mode implementation (0.435); and individual CDTO projects (0.286). The findings indicate significant challenges in establishing the fundamental prerequisites for digital transformation, including weak infrastructure, limited implementation of e-services, and low engagement in digital initiatives.

A thorough analysis of the mean values of the integral index and the nine sub-indices for each cluster enabled the identification of the strengths and weaknesses of digital development within each typological group, as well as the formulation of differentiated managerial implications (see Table 6).

Digital Transformation Leaders (Vinnytsia, Volyn, Dnipropetrovsk, Zakarpattia, Lviv, Odesa, Poltava, Rivne, Kharkiv). This cluster comprises regions that exhibit the highest mean values of both the overall Digital Transformation Index and the majority of its constituent indices. It is evident that high performance is observed in a number of areas. These include institutional capacity, internet infrastructure, digital services and the implementation of individual CDTO projects. The findings of this study suggest a considerable degree of integration of digital technology into public governance, as well as a notable degree of cross-sectoral collaboration.

Recommended managerial actions:

– Development of digital ecosystems through collaboration with businesses, universities, and startups.

– Scaling local innovations to the interregional level (e.g., creating a network of digital leaders).

– Integration of advanced digital services (AI-based solutions, one-stop shops, registry automation).

– Financing of experimental and R&D projects.

– Exporting digital models to Clusters 1 and 3 through joint initiatives.

Regions with a Medium Level of Digital Transformation (Ivano-Frankivsk, Kyiv, Sumy, Ternopil, Khmelnytskyi, Chernivtsi, Chernihiv). Regions within this cluster exhibit moderate Digital Transformation Index values. While a certain equilibrium exists between existing digital infrastructure and institutional foundations, these regions demonstrate deficiencies in the implementation of digital transformation projects, CDTO initiatives, and selected innovative services.

Recommended managerial actions:

– Addressing digital imbalances across sectors (e.g., improving the effectiveness of CDTO projects).

– Stimulating regional initiatives, particularly at the community level (e.g., pilot projects, digital accelerators).

Table 6 Managerial implications by types of digital transformation clusters, 2025

Type of digital development	Cluster	Key challenges	Strategic managerial priorities
High level – Digital leaders	2	Institutional fatigue, insufficient innovation in certain domains	Scaling up innovations, developing digital ecosystems, exporting best practices, integrating higher-level digital services
Medium level – Structurally stable regions	3	Uneven development, gap between potential and outcomes	Balancing development, disseminating pilot projects, stimulating local initiatives, supporting institutional strengthening
Low level of digital transformation	1	Weak infrastructure, shortage of skilled personnel, lack of local initiatives	Building basic digital infrastructure, developing digital literacy and education, launching essential e-services, providing methodological and financial support

Source: compiled by the author

– Strengthening inter-municipal co-operation and adopting governance models from leading regions.

– Introducing digital "mentorship" from Cluster 2 (digital leaders).

– Allocating financial resources to the least developed sub-indices within the region.

Regions with a Low Level of Digital Transformation (Donetsk, Zhytomyr, Zaporizhzhia, Kirovohrad, Mykolaiv, Kherson, Cherkasy). This cluster encompasses regions that exhibit the lowest mean values of the Digital Transformation Index and the majority of its sub-indices. A particularly salient finding of the study is the fact that the lowest scores were recorded in the areas of institutional capacity, internet penetration, individual CDTO project implementation, and the adoption of paperless procedures. This finding suggests the existence of systemic barriers to digital development.

Recommended managerial actions:

– Deployment of basic digital infrastructure in internet access, administrative service centres (ASCs), and document management systems.

– Targeted methodological and financial support from central authorities.

– Training programmes for local government personnel.

– Launch of scalable pilot digital services (e.g., eMalyatko, Diia.QR, e-registration).

– Enhancing digital literacy of the population through partnerships with educational platforms and NGOs.

5 Conclusions

This study uses a multi-level methodological framework and data from the official Regional Digital Transformation Index (RDTI) to provide a comprehensive assessment of regional digital transformation in Ukraine. The findings confirm significant disparities in digital development across Ukrainian regions, highlighting the need for tailored policy approaches.

Hierarchical clustering revealed three distinct groups of regions, differentiated by their digital transformation profiles: leaders, intermediate performers and lagging regions. These groups differ in terms of institutional capacity, digital service provision, infrastructure and participation in innovation initiatives. Discriminant analysis confirmed the statistical significance of the cluster structure, demonstrating the internal homogeneity of each group and the robustness of the classification.

Regions in the leading cluster (e.g., Dnipropetrovsk, Lviv, Odesa, Poltava, Kharkiv) exhibit high digital maturity across all subindices. However, they may face emerging risks such as organisational fatigue, staff stagnation, and declining innovation drive in less advanced areas (e.g., paperless services). In order to circumvent the phenomenon of digital stagnation, it is imperative that these regions undertake systematic updates to their digital strategies, allocate resources towards capacity building, foster regional digital ecosystems, and augment R&D initiatives and AI-based solutions.

Regions exhibiting moderate digital development (e.g., Kyiv, Sumy, Ivano-Frankivsk, Chernihiv) demonstrate a stable foundation; however, there is an imperative to translate their potential into tangible outcomes. The primary objectives of these initiatives encompass the reduction of internal imbalances, the promotion of local digital projects, and the consolidation of partnerships. The efficacy of mentorship programmes involving leading regions as an instrument of horizontal digital policy is a subject that merits further investigation.

Regions experiencing lag (e.g., Donetsk, Mykolaiv, Zaporizhzhia, Kherson) encounter systemic challenges in digitalisation, from inadequate infrastructure to limited digital literacy and insufficient citizen engagement. In order to address these challenges, there is a necessity for targeted public investment in fundamental infrastructure, in addition to the provision of support for service centres and the enhancement of connectivity. Furthermore, the implementation of grassroots-level digital literacy programmes is imperative.

The study emphasises the importance of structural analysis in understanding regional digital transformation and formulating responsive and inclusive digital strategies. The applied approach has the potential to facilitate evidence-based policymaking and contribute to more balanced and resilient regional development in the digital age.

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