
CHAPTER 7

Smart economy in the conditions of post-war recovery of Ukraine: digital tools of remediation and their impact on regional development

Bohdan Cherniavskyi
Tetiana Cherniavska
Alla Rusnak
Iryna Nadtochii
Viktor Nadtochii
Anatolii Nadtochy

Abstract

This study is devoted to an in-depth exploration of the concept of "smart economy" in the context of post-war remediation and revitalization of Ukraine, with a focus on the application of digital tools in these processes through the lens of regional development. The relevance and significance of digital transformation for the prompt and effective recovery of the country after the military aggression are indisputable, as the future format of a revived Ukraine directly depends on it. The authors have developed and proposed a theoretical and methodological justification as well as empirical testing of an architecturally hybrid and context-sensitive model of smart economy for digital recovery, based on the integration of digital solutions with regional conditions, behavioral perception of the population, and institutional support. The methodology of the research is based on an interdisciplinary synthesis of systemic, adaptive, behavioral, and bio-inspired approaches. In the framework of the simulation, modern tools were used (Python, Jupyter Notebook, QGIS, SPSS), along with real data on internet coverage, usage of the Diia and eRecovery platforms, as well as indicators of recovery (RI) and population engagement. The proposed model allows not only to diagnose the current level of digital receptiveness of a region, but also to forecast the "activation point" of digital growth, identifying priorities for digital remediation and reconstruction. The practical significance of the work lies in its applicability for the development of regional digitalization strategies in the context of post-war recovery, as well as an analytical tool for public authorities and international partners.

Keywords

Post-war recovery, remediation, smart economy, regional development, phenotypic adaptation, inclusivity of digitalization, regional stratification.

7.1 Introduction

As a result of the full-scale military aggression that began in February 2022, Ukraine has suffered colossal destruction of infrastructure, industry, and housing. According to estimates by the World Bank and the government, the direct damage to infrastructure amounts to tens of billions of dollars, while full economic recovery will require hundreds of billions. However, the post-war reconstruction presents a unique opportunity not merely to restore what was lost, but to "reboot" the economy based on new principles. President Volodymyr Zelenskyi, even before the war, declared a course toward digitalization, aiming to build a "state in a smartphone", and by the beginning of 2022 Ukraine had achieved substantial progress: more than 10 million citizens (approximately one-third of the adult population) had installed the Diia application for access to electronic public services [1]. It can be confidently stated that this project laid the foundation for the future development of the smart economy. Paradoxically, the full-scale war further stimulated the accelerated scaling of digital transformation. The necessity for the state and businesses to function under conditions of hostilities and mass population displacement served as an impetus for the accelerated implementation of digital solutions. Mass use of electronic documents and services during the war became routine: Ukrainians increasingly use digital passports when necessary, receive payments and humanitarian aid via online platforms, etc. [2]. According to studies, over the years of the war, the level of Internet penetration increased from 62% in 2019 to 78% in 2023, and the number of users of online government services reached record values [3]. All the facts listed above indicate that digitalization has become an integral part of the state's resilience and adaptation in emergency conditions such as war.

It is logical that, after the cessation of hostilities, Ukraine will face a simultaneous triple task, namely: restoring the destroyed potential by eliminating the consequences of military activities (through a set of remediation measures), ensuring rapid recovery of the socio-economic system, and conducting informational and technological modernization according to the best global standards [4].

Ukraine's post-war recovery requires a transition from traditional centralized management to a smart, flexible, and inclusive model of regional development, in which digitalization plays not an auxiliary but a system-forming role. Under conditions of destroyed infrastructure, demographic instability, institutional failures, and

limited access to basic services, the key issue becomes not merely the availability of digital solutions, but their real acceptance and ability to become a platform for inclusive growth [5]. Modern research shows that successful digital transformation is impossible without digital convergence – that is, without integrating digital platforms, data, and solutions at all levels: from local united territorial communities (UTCs) to a unified territorial system. Only such integration will allow the formation of a unified digital space capable of serving as a catalyst for the smart economy and reducing territorial and social gaps [6].

However, according to the authors' vision, digital convergence is not only an infrastructure issue. Socio-psychological aspects and the behavioral readiness of the population to accept digital solutions become key barriers or, conversely, conditions for success. Precisely the aspects mentioned above determine the necessity of conducting empirical analysis.

Thus, the focus of this research is an inclusive smart economy, in which digitalization is considered not as an end in itself, but as a mechanism for sustainable, equitable, and adaptive post-war recovery of regional growth [6]. Within the framework of digital remediation, the authors of the monograph will deeply study the integration of digital convergence, behavioral receptivity, and territorial adaptation, which can become a strategic key to solving the complex of problems related to Ukraine's post-war revival.

The aim of the study is the theoretical substantiation, development, and empirical testing of an architecturally hybrid and context-sensitive model of Ukraine's digital recovery based on the principles of the smart economy, taking into account regional characteristics and differences in digital perception, institutional activity, and the degree of destruction. In accordance with this aim, the following objectives were identified: to systematize scientific approaches to understanding the smart economy in the context of crisis and post-crisis recovery; to develop the causal architecture of the digital recovery model; to conduct regional stratification of the territories of Ukraine based on simulation analysis and to justify strategic scenarios of digital intervention; to test the model using the example of three regions (Kherson, Chernihiv, and Ternopil area's), differing in the level of destruction, digital involvement, and institutional activity; to validate the model and formulate conclusions on its applicability for the development of strategies for regional recovery and digital transformation.

7.2 Theoretical and methodological basis of the research

Digital remediation in the context of regional development means the integration of digital technologies and intelligent solutions into remediation processes and

the subsequent socio-economic recovery of territories affected by military operations, emergencies, or technological accidents. In this aspect, digitalization acts as a catalyst for remediation, significantly increasing the efficiency of damage assessment, planning of restoration works, as well as forecasting possible risks and subsequent adaptive management. Geographic Information Systems (GIS), unmanned aerial vehicles (drones), Internet of Things (IoT), Digital Twins (DT) and Artificial Intelligence (AI) technologies become key instruments of digital remediation, allowing rapid and accurate inventory of damage, identification of the most vulnerable territories, and prioritization of restoration activities [7, 8]. According to the authors' conviction, digitalization of remediation serves not merely as a mechanism for eliminating consequences, but rather as a strategic driver of a new quality of regional development based on data, intelligent platforms, and active citizen participation. The close correlation between the digitalization of remediation and the socio-economic recovery of regions is due to the fact that smart digital management of remediation can serve as a systemic mechanism for the revitalization of affected territories, ensuring sustainable growth based on the principles of adaptive management, digital inclusion, and civic participation.

To comprehensively study the above-defined problem area, the authors employed a synthesis of interdisciplinary approaches, modern scientific concepts, and original methodological solutions, including phenotypic adaptation, emergent strategy, a behavioral approach to remediation perception, and principles of inclusive digitalization [9].

Digital convergence as a connecting factor between elements of the model. It is proposed to begin the decomposition of the theoretical and methodological foundation with digital convergence. It is convinced that it is located at the core of the architecture of the smart economy and the effective remediation of war-affected territories in Ukraine. It is precisely digital convergence that ensures the coherence, compatibility, and scalability of digital solutions implemented in regions with varying degrees of destruction, recovery, and social receptiveness.

Digital convergence refers to the interpenetration and merging of various technologies, platforms, and industries in the digital age. It combines diverse digital technologies, such as GIS, artificial intelligence, and smart devices, with business models and processes to stimulate innovation as well as digital transformation. In the present study, digital convergence is understood as the process of technological, organizational, and institutional integration of digital platforms, data, services, and standards between:

- different levels of the structural hierarchical territorial system;
- sectors of the economy (industrial sector, transport and logistics, housing and communal services, healthcare, agriculture);

- elements of digital infrastructure (GIS, AI platforms, ML, blockchain, IoT, etc.);
- national digital initiatives (including such as Diia, Prozorro, DREAM, EcoCity, etc.) (Fig. 7.1) [10].

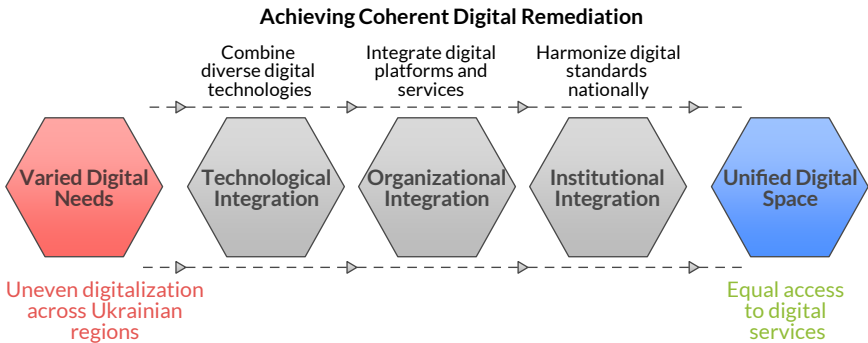


Fig. 7.1 Key results of coherent digital remediation

Digital convergence is based on the approaches of digital cohesion (EU), the concept of "smart connectivity" as well as the logic of constructing architecturally resilient digital systems, where modular components interact through standardized interfaces and form a unified digital space of remediation.

According to the authors, it is digital convergence that serves as the unifying layer that will ultimately enable:

- the scaling of successful digital practices from isolated pilot projects to the national level;
- the synchronization of remediation, reconstruction, and recovery processes between individual territorial units and regional centers;
- the provision of equal access to digital services, regardless of geographical location and the level of destruction of territories affected by military actions.

This is especially relevant for Ukraine, where the disparity between the level of digitalization and institutional capacity, the extent of destruction in regions as a result of military actions, and the digital need of territories is significantly varied.

The author's interpretation of the concept of "digital convergence" is that it is a multi-component and multi-level process of systemic and purposeful integration of digital technologies, platforms, data, standards, and services into a unified, architecturally sustainable digital ecosystem that ensures compatibility, interconnection, and scalability of digital solutions at all levels of governance and in all sectors of the economy. This reflects not only technological compatibility, but also methodological,

institutional, and territorial coherence, without which sustainable and inclusive digital recovery of Ukraine is impossible. This element performs an architectural linking function, ensuring the coherence and compatibility of digital solutions. Digital convergence serves as the infrastructural framework for the entire methodological model.

Digitalization as an inclusive mechanism of remediation and recovery of Ukraine's territory. This mechanism serves as the goal-forming foundation of the entire model. It defines the normative framework: the use of specific digital technologies for the purpose of post-war recovery of the country should not merely be applied as technical solutions, but should function as a tool of spatial and social justice, allowing equal opportunities for their use in all regions, regardless of the degree of destruction and institutional capacity.

This is especially important in the context of imbalance between severely affected territories and relatively preserved ones.

According to the authors, it is precisely this element of the methodological model that is capable of ensuring equal access to the opportunities of digitalization, their transparency, and scalability.

Thus, digitalization plays the role of an inclusive, and therefore fair, mechanism for engaging the population and municipal authorities first in the processes of remediation, and then in the revitalization of war-affected territories (Fig. 7.2).

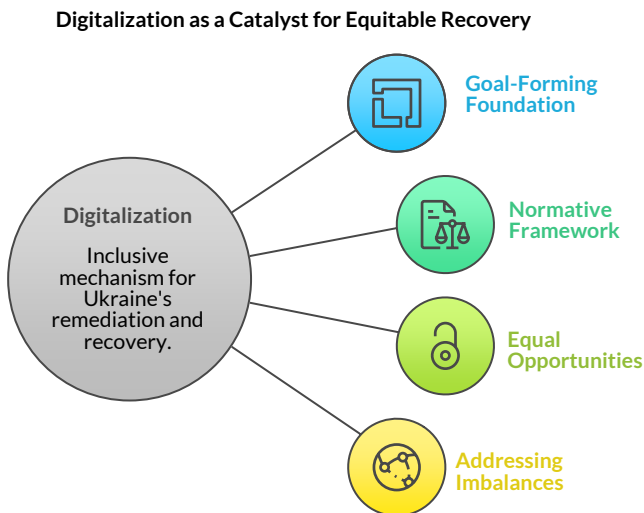


Fig. 7.2 Essence of the inclusive approach for the purposes of digital regional development

Behavioral perception of digitalization as a behavioral modifier of effectiveness.

The authors of the monograph, in the course of an in-depth study of the issues of successful digitalization, came to the conclusion that the population must be ready to perceive digital tools – otherwise, they simply will not work. It was established that in the context of instability caused by varying degrees of destruction, digital initiatives are perceived by the population ambiguously and depend primarily on the satisfaction of basic needs and public trust.

Ignoring behavioral aspects can lead to an overestimation of the expected effects of digital initiatives, without taking into account that the population of regions with a high degree of destruction and a low level of recovery may not perceive digital technologies as a priority or important. Behavioral perception of digitalization in the methodological model plays the role of a behavioral filter. Without taking this approach into account, digitalization will be ineffective even in the presence of infrastructure; it allows formalizing the differences between regions with the same level of digital saturation but with different effectiveness.

Thus, digital transformation of regions in post-war Ukraine cannot be implemented without integrating the behavioral aspect of the population's perception of digital technologies. It is precisely the use of this approach that can ensure the sustainability and adaptability of digital strategies for regional development under conditions of uncertainty, as well as form the basis for further practical recommendations on the implementation of regional digital transformation in Ukraine (Fig. 7.3).

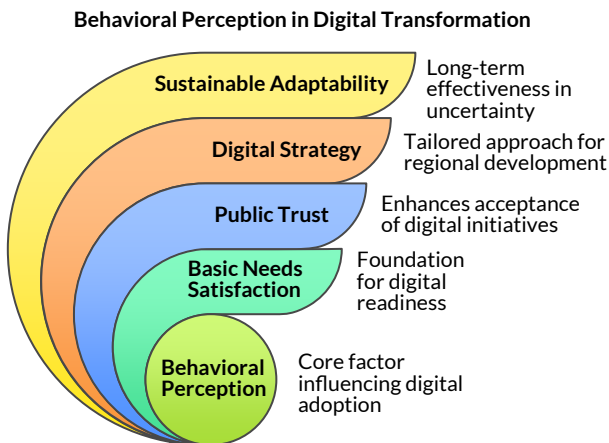


Fig. 7.3 Characteristic of behavioral perception of digital transformation of regional development

Phenotypic adaptation as a flexible adaptive architecture of regional development. This is a methodological principle borrowed from biology, in which digital solutions are not defined centrally, but evolve and adapt to the conditions of a specific region: destruction, resources, perception, infrastructure. In the commonly accepted sense, phenotypic adaptation represents the ability of an organism to change its phenotype (referring to external characteristics and behavior) in response to environmental changes, despite having the same genotype. The expediency of borrowing bio-inspired approaches has already been deeply studied, including in the scientific works of the authors of this monograph [7, 11, 12].

Further developing this scientific approach, the authors of the monograph concluded that under post-war remediation and recovery conditions, it is necessary to differentiate regions, since they have different levels of destruction, resource potential, digital maturity, and social capital.

In this regard, the strategy of identical digital solutions for all regions will not work.

Why not a centralized Smart Nation, but rather a dispersed Smart Regions strategy should be prioritized?

Phenotypic adaptation (PA) will allow to:

- ensure institutional and behavioral flexibility of digitalization;
- dynamically adapt services, architecture, and digital development strategies to local conditions;
- minimize the risk of digital rejection and inefficiency, especially in zones of destruction and social instability;
- create a foundation for building digital development trajectories oriented toward the real level of regional recovery after a complex of remediation measures.

Thus, in the authors' view, PA is capable of optimizing the implementation strategy of Smart Regions to the maximum extent possible, because it allows for the formation of localized phenotypes of digital solutions based on the contextual criteria of each region. Instead of a "one-size-fits-all" Smart Nation strategy template, it will be much more effective to implement a network of regional digital ecosystems capable of maximum adaptation, but not unification (Fig. 7.4).

Digitalization as a factor of sustainable regional development. In this study, the authors consider digital transformation as a long-term driver of socio-economic and spatial development at the level of territorial communities and within the regions of the country as a whole. It refers primarily to the idea that digitalization is not only and not so much a key factor in effective remediation and post-war recovery, but also a strategic driver of a new quality of regional development, based on the principles of sustainable development and environmental safety [13].

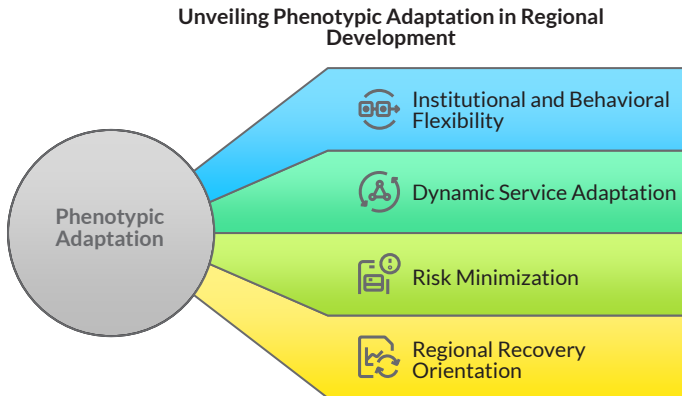


Fig. 7.4 Essence of phenotypic adaptation in the context of digital regional development

Digitalization is capable of integrating actual and potential resources into economic, social, and spatial development strategies, transforming the step-by-step post-war recovery into sustainable growth. This structural element of the methodological model reflects the success of digital transformation not in isolation, but as a result of a complex influence – the level of digital need, the quality of technological integration, and the population's readiness for progressive digital practices. Thus, digitalization is considered not as a goal, but as a tool of regional development, productivity enhancement, and institutional resilience of regions (Fig. 7.5).

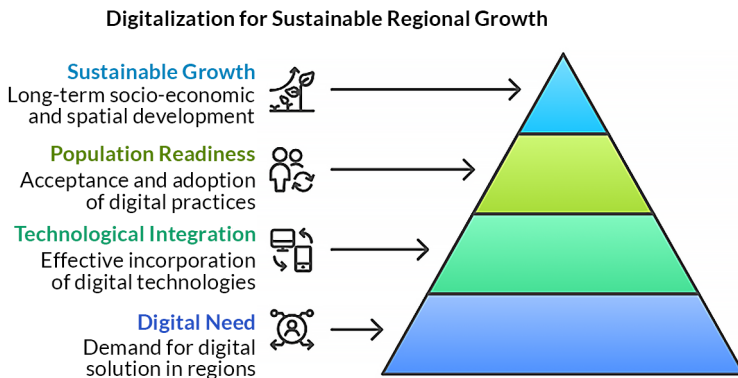


Fig. 7.5 Essence of digitalization for the purposes of sustainable regional development

All the above-mentioned structural components are interdependent and methodologically complementary, and therefore must be fully included in the theoretical and methodological model. They ensure the architectural, behavioral, institutional, and regional integrity of the smart economy model in the context of Ukraine's post-war recovery.

The research is based on the following scientific concepts (Table 7.1).

For building the model, a synthesis of classical and modern scientific approaches was used (Table 7.2).

Table 7.1 Theoretical foundations of the study

Theoretical basis	Significance for the study
Smart Economy Concept	Foundation of digital transformation based on data, innovation, GIS, AI, IoT, ML, and platform solutions
Theory of Sustainable Regional Development	Justification of the need for balanced development of all territories
Theory of Digital Inclusion	Guarantee of equal participation of all regions and social groups in digital platforms and services
Concept of Phenotypic Adaptation	A digitalization model that adapts to local conditions: destruction, resources, level of trust
Emergent Strategy (Mintzberg)	Strategies and digital solutions are formed from local practices, not imposed top-down [14]
Smart Connectivity	Ensures structural connectivity of regions, services, and solutions
Unified Digital Space	Operationalization of digital convergence in the architecture of the remediation model

Table 7.2 Methodological approaches used in the study

Methodological approach	Function
System Approach	Study of digitalization as a system of interacting elements: subsystems, technologies, people, processes
Comprehensive Approach	Consideration of multifactoriality: social, infrastructural, behavioral, and digital factors
Cybernetic Approach	Ensuring feedback, self-regulation, and controllability of the digital remediation system in a dynamically changing environment
Regional Governance Approach	Adaptation of digital strategies to regional specificities, coordination of actors, and decentralization of decision-making
Adaptive Approach	The model's ability to adapt to changing conditions of remediation and post-war recovery
Situational Approach	Decision-making based on the specific conditions of a region
Synergetic Approach	Mutual reinforcement of digital and institutional mechanisms in remediation
Bio-Inspired Approach	Phenotypic adaptation and emergence as a catalyst for digital regional development

The developed and presented theoretical and methodological foundation of the research integrates systemic, behavioral, technological, and institutional aspects of Ukraine's recovery. Digital remediation is considered as a tool not only for development but also for inclusion, resilience, and social justice. According to the authors of the monograph, it is precisely this approach that contributes to the formation of the basis for a smart, sensitive, and differentiated strategy of remediation and post-war recovery of Ukraine, which is necessary for long-term success.

7.3 Architecture of the methodological framework and the smart economy model of Ukraine's digital recovery

It is possible to assess how digital technologies actually influence remediation and subsequently the further development of Ukraine's regions, depending on the behavioral perception of the population, the adaptiveness of solutions, digital connectivity, and institutional support, through an architecturally hybrid and context-sensitive model of Ukraine's digital recovery.

The entire model is built on causal logic:

$DRem \rightarrow \text{modified through } \psi(t) \rightarrow \text{forms EffectiveDRem} \rightarrow \text{influences } RDI(t)$.

The structural context of the model is presented in **Fig. 7.6**.

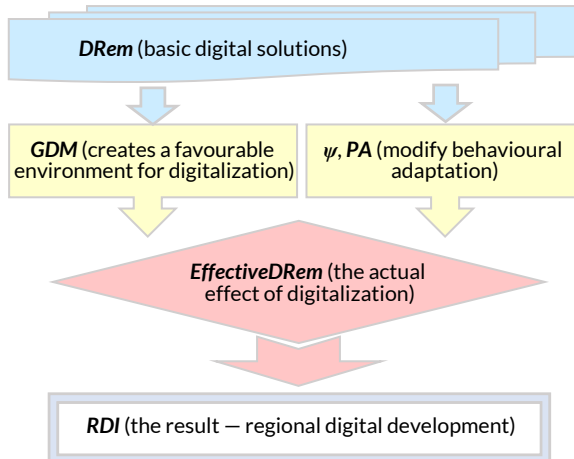


Fig. 7.6 Structural context of the architecturally-hybrid and context-sensitive model of Ukraine's digital recovery

Decomposition of the model architecture can be presented as follows:

Block 0. Regional analysis and diagnostics.

One of the key preliminary elements of the proposed model is the indicator *DNI* (Digital Needs Index) – the index of a region's digital need.

According to the authors' vision, the *DNI* should be included in Block Zero, as it forms:

- the starting point of regional analysis;
- the basis for predictive modeling;
- a filter for the feasibility of implementing digital solutions.

It depends on two parameters:

- ψ (behavioral perception of digitalization) – the readiness of the population and local communities to participate in digital initiatives;
- *RI* (Recovery Index) – the level of restoration of infrastructure, basic safety, housing, and utility systems.

Thus, the formalization of this indicator is as follows

$$DNI_r(t) = (1 - \psi_r(t)) \cdot (1 - RI_r(t)), \quad (7.1)$$

where $\psi_r(t) \in [0.3; 1.0]$ – the coefficient of digital perception of the population in region *r* at time *t* (scientific justification of value limits is provided in Block 2); $RI_r(t) \in [0; 1.0]$ – the recovery index of the region; $DNI_r(t) \in [0; 0.7]$ – the higher the value, the greater the digital need.

A high *DNI* value indicates a digital deficit – that is, a situation in which:

- the population is not ready, but the region objectively requires digitalization due to a low level of recovery;
- or digital initiatives have not yet been deployed, and behavioral inertia remains high.

If *DNI* is low → the need for digitalization is low, and even effective implementation will bring low societal significance. In the authors' opinion, this will help avoid planning errors where digital solutions are implemented and then scaled in conditions where they are either not urgently needed or will not be accepted by the population.

Thus, *DNI* is not a result of digitalization but a function for assessing necessity, applicable at the planning stage.

Block 1. Basic digital technologies (DRem).

These are the basic digital solutions implemented in the region, including the functioning of the Diia platform, the digital cadaster, IoT sensors, etc.

Notation

$DRem_r(t)$,

where r – region; t – point in time.

Block 2. Modification through perception and condition coefficients.

The ψ (*psi*) indicator (coefficient of digitalization perception) is a behavioral-contextual variable introduced by us that reflects the population's readiness to use digital solutions. It is not measured directly but can be diagnosed through a set of indicators.

According to the authors, two approaches can be used to diagnose this indicator:

– survey-based or expert assessments (for example, a questionnaire on trust in digital services through the Diia digital platform, or expert assessment of digital literacy based on statistical sampling of user activity data from the Ministry of Digital Transformation of Ukraine);

a) use of proxy indicators, namely:

b) of Diia users – reflects actual use of digital platforms;

c) number of registered users in eRecovery – reflects readiness to participate in digital processes;

d) number of requests for online services – reflects activity and digital need;

e) level of internet coverage and speed – reflects accessibility and inclusiveness of digitalization.

For the purpose of formalizing secondary indicators, the authors introduced the Recovery Index (*RI*) as a reflection of correlation with the population's basic needs, which directly influences the ψ indicator.

$RI_r(t)$ (Recovery Index) – a normalized indicator of the degree of recovery of region r at time t , calculated within the range from 0 (complete destruction) to 1 (full recovery).

The mathematical formula for its calculation is as follows

$$RI_r(t) = \frac{\omega_1 \cdot I_{infra} + \omega_2 \cdot I_{utilities} + \omega_3 \cdot I_{housing} + \omega_4 \cdot I_{safety}}{\omega_1 + \omega_2 + \omega_3 + \omega_4} \quad (7.2)$$

Structural components of the index:

– I_{infra} – restoration of critical infrastructure objects (railway stations, bridges, roads, etc.);

– $I_{utilities}$ – availability of access to electricity, water, gas;

– $I_{housing}$ – share of restored residential housing for the population;

– I_{safety} – level of population life safety (including absence of shelling, environmental safety after remediation and demining, etc.).

During the simulation, expert assessments and rating scores on a 0–1 scale were used, as well as open data from the relevant ministries and agencies.

The overall mathematical formalization is represented by the following formula

$$\psi r(t) = \max(0.3, \min(RI_r(t), DIIr(t))) (1 + \lambda \cdot SC(t)). \quad (7.3)$$

The interpretation of the indicator is as follows:

- $RI_r(t)$ – defines the physical and social readiness for digitalization;
- $DIIr(t)$ – Digital Inclusion Index defines technological and behavioral inclusiveness;
- C (*Social Capital*) a modifier of ψ reflects the level of trust and participation,

where λ is the weight of trust;

- ψ – represents the final behavioral coefficient of digital perception with a lower limit of 0.3 (apathy, rejection), above which digitalization begins to be "perceived".

It is possible to model $\psi \in [0.3; 1.0]$, where:

- 1.0 – full readiness (maximum perception);
- 0.3 – threshold of apathy or social rejection, below which digitalization loses its meaning.

The authors of the monograph rely on the interpretation of the five-point Likert scale, which is widely used in empirical social and behavioral studies (Table 7.3) [15].

Table 7.3 Application of the Likert scale in behavioral research

Evaluation	Behavioral interpretation
1.0	Fully agree/active acceptance
0.75	Rather agree/positive receptiveness
0.5	Neutral/cognitive inertia
0.3	Rather disagree/apathy, rejection
<0.3	Complete refusal to participate/destructive perception

Thus, the practical significance of the obtained results will be interpreted as follows:

- if $|\psi < 0.3| \rightarrow$ then digitalization is not perceived, and behavioral interventions must be implemented;

- if $|\psi = 0.3| \rightarrow$ then social inertia is observed, and there is a minimal digital basis;

- if $|\psi > 0.5| \rightarrow$ then digitalization begins to produce an effect in the Effective DRem model;

- if $|\psi \rightarrow 1.0| \rightarrow$ then full digital maturity is observed, which indicates ideal conditions [16–18].

Block 3. GDM (Governmental Digital Mobilization) – index of governmental digital mobilization.

GDM is an aggregated indicator of the level of institutional activity, political will, and systemic support for digital transformation by government authorities at the national, regional, and local levels. It reflects the intensity and quality of the state's participation in creating conditions for the digitalization of regional development, especially in the context of post-war remediation, housing and infrastructure recovery, social and medical services, as well as transport provision and communication with the population [4, 7].

It should be noted that, according to the scientific views of Douglass North and other representatives of the new institutional school, the quality of institutions and the effectiveness of their actions directly determine the success of any transformational processes, including technological and digital ones. The aggregated GDM indicator can reflect: the density of digital institutions (including Diia, Prozorro, etc.); the volume of funding for digital development; the level of decentralization and digital autonomy of regions [18].

According to the authors' conviction, even with a high level of digital solutions (*DRem*) and population perception (ψ), the absence of institutional support leads to: lack of coordination in digital processes; data fragmentation; slowdown of the *RDI* (Regional Development Index). *GDM* can be included in the formula for calculating the optimal level of digitalization

$$\text{EffectiveDRem}_r(t) = \text{DRem}_r(t) \cdot \psi_r(t) \cdot \text{PA}_r(t) \cdot (1 + \mu \cdot \text{GDM}_r(t)), \quad (7.4)$$

where μ – the weighting coefficient of amplification from institutional mobilization.

Block 4. PA – Phenotypic adaptation, which means the extent to which digital solutions are adapted to local conditions (actual destruction, staffing, internet availability, living conditions of the population, etc.).

As described earlier, phenotypic adaptation represents a bio-inspired methodological principle borrowed from biology, in which the behavior, functions, and properties of a system (in this case – a digital platform or architecture) are modified depending on environmental conditions, while preserving its general "genotype", that is, the basic architecture of digitalization.

Within the studied model, the key elements of *PA* are:

- the "genotype" is the core of the digital platform (including, for example, Diia, eRecovery, etc.);
- the "phenotype" is the specific way it is implemented, including the interface, digital accessibility, methods and channels of scaling, as well as the adaptation of the platform taking into account regional differences and needs.

As described in the previous block, PA is included in the calculation of effective digital remediation as a modifying adaptive coefficient.

$PA_i(t) \in [0.5; 1.0]$ is capable of reflecting the degree of adaptability of a digital solution to the conditions of a specific region. Values below 0.5, according to the authors of the study, will be destructive – when a centralized solution "breaks" against local reality (technically, legally, behaviorally).

Why is this critically important in the context of Ukraine? The fact is that since the beginning of active military actions in February 2022, Ukraine has become a country with extreme regional asymmetry, namely:

- some regions are radically destroyed and continue to suffer the consequences of military activities (Mariupol, Kharkiv, Kherson, etc.);
- others are partially affected and have partial consequences from military actions (Kyiv, Chernihiv, Zhytomyr, Vinnytsia, etc.);
- a third group of regions is comparatively stable (Lviv, Ternopil, Ivano-Frankivsk, etc.).

According to the authors' conviction, implementing the same approach to smart economy development across all regions (following the logic of "Smart Nation") may lead to misunderstanding, cognitive rejection, and overall technical infeasibility of use.

In contrast to this, PA proposes the model of "Smart Regions" – dispersed adaptation of digital solutions taking into account phenotypic differences.

7.4 Current assessment and prospects for the implementation of smart economy principles at the regional level: model testing and validation

The model developed within the framework of this monographic study represents an architecturally hybrid digital system, built on causal relationships between the implementation of digital solutions ($DRem$), behavioral perception of the population (ψ), solution adaptability (PA), digital need (DNI), institutional support (GDM), and the final result in the form of the Regional Digital Development Index (RDI).

In order to confirm the realism, applicability, and predictive accuracy of the proposed model under Ukrainian conditions, it is necessary to carry out two stages:

Stage I. Model testing (approbation).

Stage II. Model validation.

Thus, approbation is the process of experimental application of the model on a limited set of empirical data or regional cases, in order to:

- test the adequacy of the proposed hypotheses and the logic of interrelations between the indicators described above;

- identify behavioral, institutional, and technical features of regional development;
- detect bottlenecks and risks related to the transition of the model from theoretical to applied use;
- assess the sensitivity of the developed model to changes in key parameters.

As part of the approbation process, it was decided to test the model on three typologically different regions of Ukraine, reflecting the full spectrum of regional asymmetry characteristics. In turn, validation is the scientific verification of the model's correctness, which focuses on:

- comparing the obtained modeling results with actual or close-to-reality scenarios;
- assessing the consistency of the model's internal relationships with the logic of real post-war regional recovery and development processes;
- measuring the accuracy, sensitivity, and resilience of the model to various input data;
- identifying discrepancies and refining the model's parameters (including indicators such as ψ , *GDM*, *PA*, *SC*, *DNI*).

Validation will be based on statistical, expert, and scenario analysis methods (including correlation analysis, scenario modeling with fluctuations, as well as comparative analysis of logistic growth charts).

As part of the testing and validation of the digital recovery model of Ukraine based on smart economy principles, an integration of several types of tools, software, and computational resources, scientifically grounded, was used.

Table 7.4 presents a detailed description and structured explanation.

Table 7.4 Tools and software used for model testing and validation

Tool/Environment	Purpose	Characteristic
Python (v3.11)	Algorithmic implementation of the model	Open scientific environment, supports large-scale simulations
NumPy, Pandas	Data formalization and storage, statistics	Processing of time series and matrix structures
Matplotlib, Seaborn	Visualization of growth dynamics and region comparison	Graphs of $RDI(t)$, $\psi(t)$, $EffectiveDRem(t)$
Jupyter Notebook	Documentation of simulation and scenarios	Enhances transparency and reproducibility
QGIS	Spatial validation and mapping of regional differences	Visualization of ψ , <i>RI</i> , <i>DNI</i> levels across regions
SPSS/Excel	Post-processing and statistical verification	Calculation of averages, deviations, correlations

The next step of the study is the cluster selection of regions – based on the criterion of the degree of destruction and the impact of the war (Table 7.5). According to the authors of the study, this creates ideal conditions for comparative verification simulation. All of this will allow for testing the validity of the selection of key indicators in the mathematical model, validating the model as a whole, and most importantly, confirming the applicability of the theoretical and methodological approaches of the regional digital development strategy.

Table 7.5 Proposed regions for cluster modeling: characteristics and justification

Cluster	Region	Characteristic	Reasons for Selection
1. Catastrophic level of destruction	Kherson	Massive destruction, daily military actions, destruction of Kakhovka HPP, environmental catastrophe, mass migration	Maximum load on the digital remediation system
2. Medium level of destruction	Chernihiv	Significant destruction in 2022, but partially restored, presence of civil administration	Medium level of adaptation, cases of local digitalization
3. Almost no destruction	Ternopil	No hostilities, calm situation, internal migration, high digital engagement	Reference region – condition of a "normal" smart economy

As previously noted, Ukraine is currently facing high asymmetry, namely:

- in the nature and scale of destruction (different *RIs*);
- in the level of digital maturity;
- in the population structure (internally displaced persons, socially vulnerable groups, working-age population);
- in access to basic services.

At the same time, the same digital platform may be in demand in Ternopil region (high digital need), yet ignored in Kherson region (where the population has not yet restored its basic life functions). This means that the implementation of digital policy must rely not only on ψ and *DRem*, but also on the digital need parameter.

According to the authors, this forms the fundamental core of the digital transformation model in the context of post-war recovery – the interconnection between digital need, digital remediation, and the smart economy of the regions.

The next step was to carry out simulation modeling of ψ and *DNI* across the selected sample of regions (Table 7.6).

To obtain the results of the simulation modeling, a parametric model was used, implemented in the MS Excel environment with the use of built-in logical-arithmetic formulas and customizable simulation tables, as well as software tools Statistica and

Python (NumPy and Pandas libraries) for the verification of calculations and scenario construction. The modeling was carried out using the method of deterministic simulation, based on predefined input coefficients (ψ , RI , GDM , PA) and multiplicative relationships between them.

Table 7.6 Digital perception and needs diagnostics table

Region	Digital Usage	Internet Coverage	Infrastructure Access	Recovery Index (RI)	Digital Perception (ψ)	Digital Need Index (DNI)	GDM	PA
Kherson Region	0.21	0.31	0.28	0.23	0.32	0.52	0.42	0.50
Chernihiv Region	0.49	0.76	0.62	0.72	0.62	0.106	0.61	0.65
Ternopil Region	0.86	0.92	0.89	0.93	0.91	0.006	0.87	0.93

The obtained results confirm the identification of clearly expressed regional differentiation and the logical choice of the Kherson, Chernihiv, and Ternopil regions as representative polar case studies in the context of post-war digital recovery. Thus, the Ternopil region demonstrates a mature digital environment with a high degree of perception and adaptation ($\psi = 0.91$; $PA = 0.93$) and minimal digital need ($DNI = 0.006$), which indicates a high institutional and social readiness for the implementation of comprehensive digital solutions.

At the same time, the Kherson region stands out as the region with the highest digital need ($DNI = 0.52$) among all regions in the sample, against the background of the lowest level of digital perception ($\psi = 0.32$), which indicates weak adaptation and a low level of institutional support. This makes the region a clear example of inertial digital development, requiring prioritization of efforts in the direction of technological and managerial impact in the context of remediation and post-war socio-economic recovery. The Chernihiv region occupies an intermediate position, characterized by a moderate level of perception ($\psi = 0.62$) and a relatively low digital need ($DNI = 0.106$), reflecting the transition phase toward a smart regional model, where the factors of adaptability, trust in digital services, and the ability of government structures to ensure the inclusiveness of digital solutions play a special role. *This allows to conclude that Ternopil Region is a region where digitalization works, and the population is actively engaged in the smart economy.*

The next step was the construction of scenario development graphs showing the S-shaped growth of RDI depending on ψ . (**Fig. 7.7**).

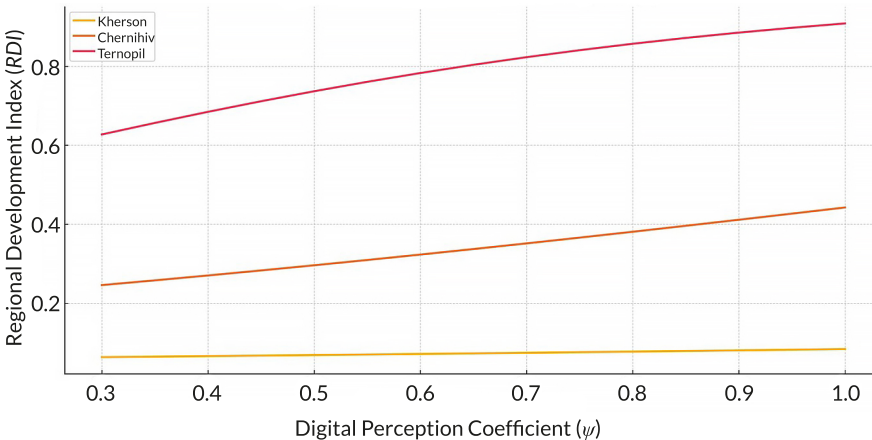


Fig. 7.7 Logistic growth: RDI and digital perception (ψ) in the context of Kherson, Chernihiv, and Ternopil regions

The presented graph reflects the following:

- In Kherson region, the growth of *RDI* begins only after surpassing the threshold of $\psi \approx 0.4-0.5$. Before this, almost zero sensitivity is observed;
- Chernihiv region enters the "active phase" of digital growth more quickly, but also requires time to accelerate;
- Ternopil region, unlike the other two regions in the sample, is initially at a high level, so growth begins earlier and reaches saturation already at $\psi \approx 0.7-0.8$.

Next, a simulation of digital dynamics over the time period 2025–2032 was conducted for the three regions. The authors of the study set the following objectives:

- to forecast when each region will enter the "active phase" of digital growth;
- to identify the transition point (ψ_0) after which digitalization begins to significantly influence regional development;
- to assess the pace, barriers, and potential of the growth scenarios for ψ , *DNI*, *PA*, and their contribution to the formation of *RDI* (regional growth) over time (**Fig. 7.8**).

The simulation results allow the interpretation as follows:

- in Kherson region, slow growth of *RDI* is observed until 2028–2029, followed by a noticeable acceleration. This corresponds to the "entry into the active phase of digital growth" after surpassing the critical $\psi \approx 0.54$;
- in Chernihiv region, the beginning of the active phase of digitalization is forecasted around 2026. At the same time, a moderate growth trajectory is

observed, without saturation – by 2032, the potential for digitalization development still remains;

- in Ternopil region, digital active development is currently taking place, but saturation is forecasted closer to 2029. This is one of the examples of regional development where early digitalization quickly transitions into a stage of maturity.

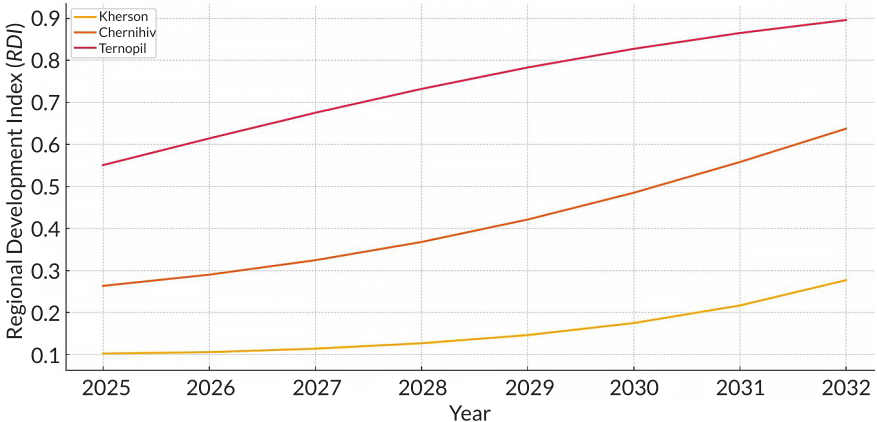


Fig. 7.8 Forecasted effective digital remediation of key parameters across Kherson, Chernihiv, and Ternopil regions for the years 2025–2032

The next logical step will be the study of complex dynamics across five key parameters for each region for the period 2025–2032 (**Fig. 7.9**).

At the conclusion of the analytical part of the study, a correlation analysis was conducted and the sensitivity of the model was evaluated (**Table 7.7**).

Based on the calculated data, the following conclusions and generalizations can be made. The conducted study confirmed the necessity of a differentiated approach to implementing digital strategies depending on the specific conditions of each region:

- in regions with a high degree of destruction (such as Kherson region, etc.), digital initiatives have a limited effect unless accompanied by the restoration of basic infrastructure and growth in public trust;
- in regions with medium destruction (such as Chernihiv region, etc.), digital initiatives are positively perceived and ensure stable growth;
- in regions without significant destruction (such as Ternopil region, etc.), a saturation effect of digitalization is observed, requiring a focus on innovative approaches rather than on the quantitative expansion of digital initiatives.

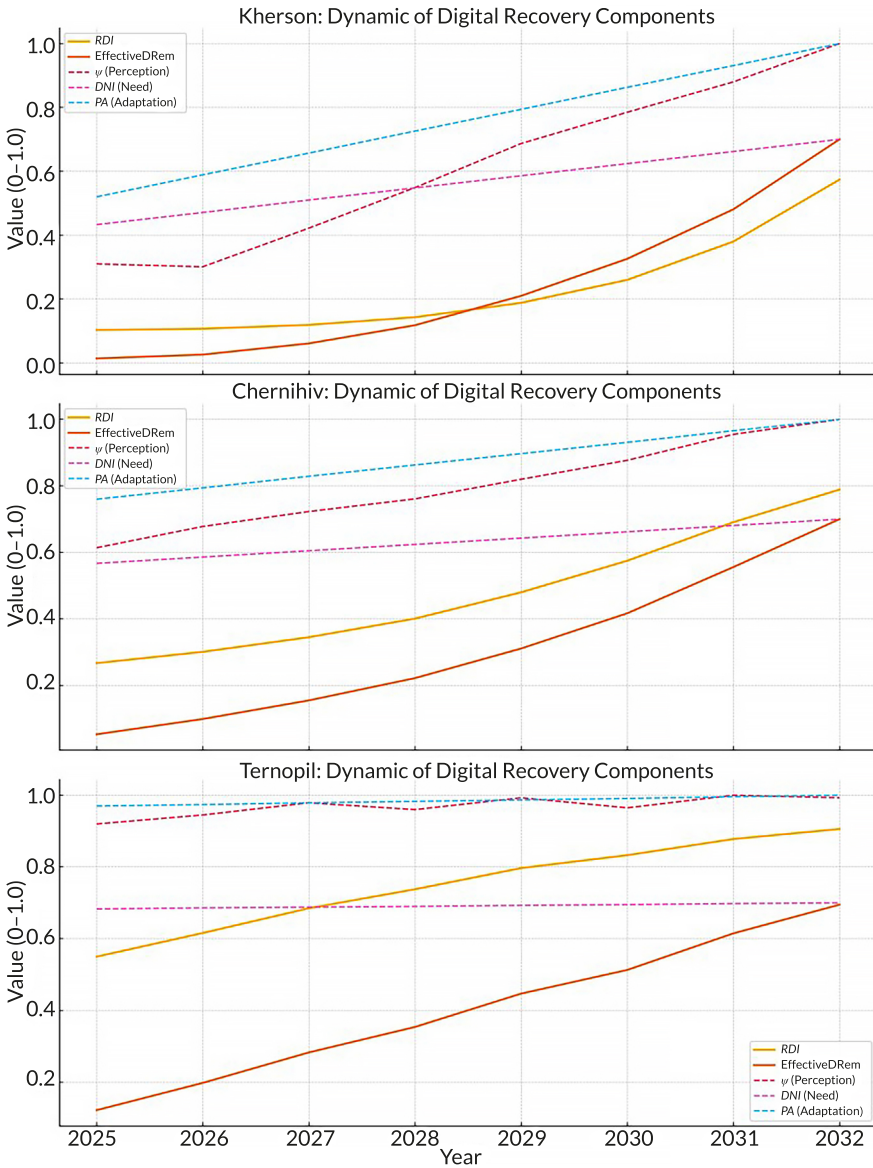


Fig. 7.9 Comprehensive dynamics of key parameters across Kherson, Chernihiv, and Ternopil regions for the years 2025–2032

Table 7.7 Results of correlation and sensitivity analysis of the model

Region	Correlation (r)	$\Delta RDI/\Delta DRem$	R^2	Description of results
Kherson Region	0.851	0.723	2.401	Strong correlation; digitalization "works" only with the growth of ψ
Chernihiv Region	0.947	0.896	1.036	Almost linear dependence, even considering behavior; well perceived
Ternopil Region	0.651	0.424	0.482	Saturation effect appears – digitalization is perceived steadily, but RDI growth slows down

The correlation analysis demonstrates the fact that the hypothesis about the non-universality of the digitalization effect under different recovery conditions is confirmed. Moreover, under the same digitalization principles, the regions produced different digital development trajectories. All of this confirms the idea of an adaptive model sensitive to local conditions. In the context of state governance of regional development, this means that a unified template for digital remediation and recovery cannot be applied to all regions. According to the authors' view, the most reasonable course of action would be:

- to assess the region's sensitivity to digitalization;
- to forecast the saturation effect;
- to launch pilot projects based on the principle of emergent ecosystems, rather than directive reforms.

Within the constructed model, dynamic simulation of key components of digital recovery was carried out for three regions with different levels of destruction and institutional capacity: Kherson, Chernihiv, and Ternopil regions.

Kherson region - "Delayed Start" scenario. The model demonstrates extremely slow development of the Regional Development Index (RDI) in the first years of simulation forecasting. Despite the growth of the formal level of digital remediation ($DRem$), the key parameters – the digital perception coefficient (ψ), the Digital Needs Index (DNI), and the phenotypic adaptation coefficient (PA) – remain at a low level up to 2028. This confirms a high level of behavioral inertia, distrust, and the prioritization of basic needs over digital initiatives under conditions of prolonged military threats and destruction. The activation point of digital growth (in terms of RDI) is forecasted for 2028. The management conclusion drawn by the authors is that the most appropriate actions would be the implementation of soft forms of public engagement, building trust in digital platforms, their scaling, and simultaneous deployment of locally adaptive services.

Chernihiv region – "Balanced Growth" scenario. The model shows steady growth of ψ and *EffectiveDRem* from the current period, i.e., from 2025, which is reflected in the progressive growth of *RDI* starting in 2026. According to the forecast, the region enters the active phase of digital recovery under conditions of a moderate level of destruction (as recorded during the simulation), already formed experience of digital interaction, and institutional flexibility. The activation point of digital growth is forecasted for 2026. The management conclusion of the monograph's authors is that the region is ready for the scaling of digital practices, including through the integration of local and national platforms, and the optimization of interaction between authorities and the population via digital services.

Ternopil region – "Early Saturation" scenario. The simulation results show that the region possesses high initial digital receptiveness. Already in 2026, an entry into the active growth phase of *RDI* is observed, however by 2029, a slowdown in growth rates is expected due to reaching the upper limits of *EffectiveDRem* and institutional base saturation. This is a typical case of the digital plateau effect, when formal digitalization growth ceases to significantly influence socio-economic indicators. The activation point of digital growth is forecasted for 2026. The management conclusion to be drawn is that in regions like Ternopil, it is advisable to transition from implementing digital solutions to qualitative modernization, ensuring cyber-resilience, and digitally scaling into adjacent territories.

7.5 Regional stratification as a tool for context-sensitive management of digital transformation in the conditions of Ukraine's post-war recovery

By regional stratification, let's mean the process of systematic classification of regions based on their degree of digital receptiveness and actual readiness for digital transformation, using the key indicators of the model proposed in the study, namely: ψ (coefficient of digital perception of the population); *RDI* (integral index of regional digital development). Stratification in this context is based on the results of simulation modeling, where each region was assessed by the growth trajectories of *EffectiveDRem* and the logistic function $RDI(t)$.

According to the authors' conviction, regional stratification is a critically important tool for transformational governance under post-war recovery conditions. It allows the architectural flexibility of the model to be combined with institutional realism and socio-behavioral sensitivity, thereby providing a foundation for a fair and effective digitalization of Ukraine [19].

In our view, regional stratification can ensure built-in adaptability of the entire architecture of the proposed digital recovery model. It reinforces the principles and reveals the theoretical-methodological foundation on which it is built, namely:

- phenotypic adaptation – each region receives its own digital phenotype;
- inclusiveness of digitalization – stratification reduces the risk of digital inequality;
- digital cohesion, which means that regions with different levels of maturity are connected to a shared digital infrastructure, but with different depth and speed;
- emergent strategy – decisions are formed based on the analysis of regional cases and are not imposed from above [20].

Regional stratification allows for the implementation of four interrelated functions:

- differentiated governance – the ability to form strategies not on the principle of "one format for all regions" but on demand;
- resource optimization – a rational approach to providing resources for digital transformation, meaning resources are directed where the effect will be maximal;
- justification of the prioritization of digital remediation in the context of identifying territories with the greatest need and impact potential;
- creation of a digitalization roadmap – stratification can form the foundation for the phased digital activation of regions by identifying growth points [21].

The simulation showed that: in Ternopil region, the $RDI(t)$ growth curve has a steep logistic character, confirming readiness for digitalization scaling; Chernihiv region demonstrated moderate dynamics and correlation with targeted digital interventions; Kherson region showed $\psi = 0.32$, which, according to the model, indicates a lack of behavioral readiness for digital remediation. This result highlights the need to implement basic infrastructural and trust-building measures, as well as significant state support in this regard.

Thus, the developed model and regional stratification have practical significance and can be used by government authorities to form region-oriented strategies for digital transformation. It enables forecasting and evaluating the effectiveness of digital solutions in the context of post-war remediation, as well as determining the priority of regional investments and digital interventions.

7.6 Conclusion

In the presented study, theoretical notions of digital remediation as an instrument of regional recovery policy are expanded. An interdisciplinary foundation is created for assessing the digital receptiveness of regions based on models that combine behavioral economics, the theory of sustainable development, and information technologies [22].

Overall, the conclusions and generalizations made by the authors indicate that digital technologies and solutions can and must become the core of Ukraine's post-war development strategy. The principles of the smart economy – innovation, data orientation, openness, and flexibility – have already proven effective in local situations during the war. The current task is to scale them up across the entire country during the post-war recovery period. Of course, this implementation will require coordinated efforts from all stakeholders: the government, business, the scientific community, international partners, and the citizens themselves. But the potential benefits are immense – from accelerating GDP growth to transforming Ukraine into a competitive player in the global digital economy [22, 23].

The architecturally hybrid and context-sensitive model of digital remediation of Ukraine, developed and presented in the monograph, offers a scientifically grounded basis for the implementation of differentiated regional development strategies, based on adaptability, inclusiveness, and scalability of digital transformation. Regional stratification, as a key mechanism of this model, will enable decision-making that aligns digital policy with local needs, capabilities, and the population's behavioral readiness. The implementation of the model proposed by the authors will contribute to strengthening strategic coherence between national objectives and regional development trajectories, transforming digitalization from a fragmented process into a catalyst for progressive and sustainable post-war revival of Ukraine [24, 25].

References

1. Motkin, A. (2023). Post-war Ukraine needs a smart digital transformation strategy. Atlantic Council. Available at: <https://www.atlanticcouncil.org/blogs/ukrainealert/post-war-ukraine-needs-a-smart-digital-transformation-strategy/>
2. 63% of Ukrainians use state e-services, user numbers grow for third year in row – survey (2023). United Nations Development Programme. Available at: <https://www.undp.org/ukraine/press-releases/63-ukrainians-use-state-e-services-user-numbers-grow-third-year-row-survey>
3. Kolodiziev, O., Shcherbak, V., Kostyshyna, T., Krupka, M., Riabovolyk, T., Androshchuk, I. et al. (2024). Digital transformation as a tool for creating an inclusive economy in Ukraine during wartime. *Problems and Perspectives in Management*, 22 (3), 440–457. [https://doi.org/10.21511/ppm.22\(3\).2024.34](https://doi.org/10.21511/ppm.22(3).2024.34)
4. Cherniavska, T., Tanklevska, N., Cherniavskyi, B. (2024). A decision-making system for managing the remediation of water resources in the Kherson region: agent-oriented modeling in the context of post-war economic recovery. *Transformations*

- of National Economies under Conditions of Instability. Tallinn: Scientific Route OÜ, 223–256. <https://doi.org/10.21303/978-9916-9850-6-9.ch8>
5. Ukraine 2024 Report. 2024 Communication on EU enlargement policy (2024). European Commission. Available at: https://enlargement.ec.europa.eu/document/download/1924a044-b30f-48a2-99c1-50edeac14da1_en?file-name=Ukraine%20Report%202024.pdf
 6. Androshchuk, A., Androshchuk, H., Bodnarchuk, T., Venher, L., Verbova, O., Hakhovych, N. et al.; Nebrat, V., Bieliak, A., Groblewska-Bogush, B., Drach, I., Kurbet, O. et al. (Eds.) (2023). Reconstruction for development: foreign experience and Ukrainian perspectives. Kyiv, 570.
 7. Cherniavskiy, B.; Slavinska, O., Danchuk, V., Kuniyska, O., Hulchak, O. (Eds.) (2025). Integration of Drones and Dio-Inspired Algorithms into Intelligent Transportation Logistics Systems for Post-war Remediation of Ukraine. Intelligent Transport Systems: Ecology, Safety, Quality, Comfort. Cham: Springer, 426–437. https://doi.org/10.1007/978-3-031-87379-9_39
 8. Bratchuk, D. (2023). Tsyfrovii dviinyky ta internet rechei: yaki tekhnolohii pryskoriai vidbudovu Ukrainy. Minfin.ua. Available at: <https://minfin.com.ua/ua/2023/03/28/103067003/>
 9. Ivchenko, Y. (2025). Vosstanovlenie Ukrainy pri podderzhke OON s uporom na ustoichivost i inkluzivnost. Novatorstroi. Available at: <https://novatorstroy.com/press-relizy/vosstanovlenie-ukrainy-pri-podderzhke-oon-s-uporom-na-ustojchivost-i-inklyuzivnost/?srsId=AfmBOorG55ZUweO-ur4P28DcJn94o-Ak9DpU-pH6N1Q64qAZxzLawaTY>
 10. Prozorist povoiennoi vidbudovy bude zabezpechuvaty elektronna systema DREAM: u chomu rishennia (2023). Rubryka. Available at: <https://rubryka.com/2023/07/20/prozorist-povoyennoyi-vidbudovy-bude-zabezpechuvaty-elektronna-systema-dream-u-chomu-rishennya/>
 11. Cherniavska, T., Cherniavskiy, B., Sanikidze, T., Sharashenidze, A., Tortladze, M., Buleishvili, M. (2024). Optimization of medical logistics with bee colony algorithms in emergency, military conflict and post-war remediation settings. IDDM'24. Birmingham.
 12. Cherniavska, T., Cherniavskiy, B., Sanikidze, T., Sharashenidze, A., Tortladze, M., Buleishvili, M. (2024). Optimization of medical logistics with bee colony algorithms in emergency, military conflict and post-war remediation settings. IDDM 2024. Birmingham, 3892, 220–235. Available at: <http://www.scopus.com/inward/record.url?eid=2-s2.0-85215809690&partnerID=MN8TOARS>
 13. Shpak, L. (2025). Tsyfrova ekonomika mozhe staty lokomotyvom rozvytku povoiennoi Ukrainy. Dengi.ua. Available at: <https://dengi.ua/ua/blog/9753072->

lyubov-shpak-tsifrova-ekonomika-mozhe-stati-lokomotivom-rozvitku-povojennoyi-ukrayini

14. From Access to Empowerment: Digital Inclusion in a Dynamic World (2024). United Nations Development Programme. Available at: https://www.undp.org/sites/g/files/zskgke326/files/2024-05/undp_digital_inclusion_in_a_dynamic_world.pdf
15. Taherdoost, H. (2019). What is the best response scale for survey and questionnaire design; review of different lengths of rating scale/attitude scale/Likert scale. *International Journal of Academic Research in Management (IJARM)*, 8 (1), 1–10.
16. Azzopardi, D., Lenain, P., Molnar, M., Mosiashvili, N., Parelussen, J. (2020). Seizing the productive potential of digital change in Estonia. OECD Economics Department Working Papers, 1639. Paris: OECD Publishing. <https://doi.org/10.1787/999c7d5a-en>
17. Schäfer, F., Projer, S., Wortmann, F. (2021). Navigating Companies through the Jungle of Emerging Digital Technology Strategies. The ISPIM Innovation Conference – Innovating Our Common Future. Berlin, 1–22.
18. World distribution 2021. Digital Readiness Index (2021). Cisco Systems, Inc. Available at: [https://www.cisco.com/c/m/en_us/about/corporate-social-responsibility/research-resources/digital-readiness-index.html#/#](https://www.cisco.com/c/m/en_us/about/corporate-social-responsibility/research-resources/digital-readiness-index.html#/)
19. Natalukha, D. (2023). Ukraina zaluchyla na URC \$60 mlrd. Chym shche hotovyi dopomohty Zakhid ta yakykh pomylok pryuskaietsia Ukraina shchodo vidbudovy. Rozpovidaie holova ekonomichnoho komitetu VRU Dmytro Natalukha. *Forbes Ukraine*. Available at: <https://forbes.ua/money/kontsepsiya-shvidkogo-vidnovlennya-spodobalasya-partneram-tvereziy-poglyad-golovi-ekonomichnogo-komitetu-vru-dmitra-natalukhi-na-ukraine-recovery-conference-26062023-14410>
20. Mintzberg, H. (1979). An Emerging Strategy of “Direct” Research. *Administrative Science Quarterly*, 24 (4), 582–589. <https://doi.org/10.2307/2392364>
21. Bezvershenko, Y., Ganguli, I., Talavera, O., Gorodnichenko, Y. (2025). Policy Insight 138: Innovation for economic resilience: Strengthening Ukraine's human capital and science sector. Paris & London: CEPR Press. Available at: <https://cepr.org/voxeu/columns/innovation-economic-resilience-strengthening-ukraines-human-capital-and-science>
22. Rogaczewski, R., Cieślak, R., Suszyński, M. (2020). The impact of digitalization and Industry 4.0 on the optimization of production processes and workplace ergonomics. *The Malopolska School of Economics in Tarnow Research Papers Collection*, 48 (4), 133–145. <https://doi.org/10.25944/znmwse.2020.04.133145>

23. A Smart Specialization Strategy for Ukraine (2024). German Marshall Fund. Available at: <https://www.gmfus.org/event/smart-specialization-strategy-ukraine>
24. Enhancing Resilience by Boosting Digital Business Transformation in Ukraine (2024). Paris: OECD Publishing. Available at: https://www.oecd.org/en/publications/2024/05/enhancing-resilience-by-boosting-digital-business-transformation-in-ukraine_c2e06e50.html
25. North, D. C. (1990). *Institutions, Institutional Change and Economic Performance*. Cambridge University Press. <https://doi.org/10.1017/cbo9780511808678>
26. Cherniavska, T.; Cherniavska, T. (Ed.) (2024). Introduction. Focus on the transformation of economic systems in conditions of instability. *Transformations of National Economies under Conditions of Instability*. Tallinn: Scientific Route OÜ. <https://doi.org/10.21303/978-9916-9850-6-9.introduction>