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CONCEPTUAL MODEL OF ENTERPRISE DIGITAL TRANSFORMATION MANAGEMENT FOR ENSURING SUSTAINABLE REGIONAL DEVELOPMENT[1]

КОНЦЕПТУАЛЬНА МОДЕЛЬ УПРАВЛІННЯ ЦИФРОВОЮ ТРАНСФОРМАЦІЄЮ ПІДПРИЄМСТВА ДЛЯ ЗАБЕЗПЕЧЕННЯ СТАЛОГО РЕГІОНАЛЬНОГО РОЗВИТКУ

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This article explores the potential of enterprise digital transformation as a tool for inclusive and sustainable regional development in Ukraine amidst multiple overlapping crises caused by war, socio-economic inequality, environmental challenges, and technological divides. The study begins with a critical analysis of existing digitalization approaches, which, while primarily focused on large corporations, tend to overlook environmental, social, and regional dimensions, as well as the specific needs of small and medium-sized enterprises as key agents in local economies. The main objective of this research is to conceptualize digital transformation within the context of regional SMEs and develop an integrated management model that, unlike existing frameworks, addresses the challenges of post-war recovery while aligning digitalization strategies with sustainable development principles. The study substantiates the necessity of transitioning from fragmented digital initiatives toward a comprehensive approach that combines strategic vision, organizational adaptability, resource availability, process agility, and a culture of innovation. This approach integrates ecological and social priorities into the digital transformation framework, while also reflecting the specificities of a post-

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crisis economy. Special emphasis is placed on identifying and analyzing the barriers that hinder sustainable digital transformation among regional SMEs. Based on empirical and secondary data, the study identifies critical challenges including limited access to finance, a shortage of digital and «green» skills, resistance to change, lack of institutional support, and underdeveloped digital infrastructure in certain regions. The article highlights the growing digital divide as a key factor exacerbating regional disparities and undermining the inclusivity of the recovery process. These barriers are recognized as interconnected and require coordinated, cross-sectoral responses from government, businesses, academia, and international partners. The practical value of the proposed model lies in its potential to serve as a roadmap for SMEs aiming to implement sustainable digital transformation, as well as a foundation for designing public support policies and guiding international donor programs. The successful realization of digital transformation's potential calls for coordinated efforts across all stakeholders, including the state, business sector, academic institutions, and civil society. Priority areas for implementation include expanding digital infrastructure, enhancing digital competencies, addressing institutional gaps, and creating an enabling regulatory environment. This research offers a holistic perspective on sustainable digital transformation as a multidisciplinary and multilevel process that merges innovation with the principles of equity, resilience, and equal access. The proposed approaches and findings hold practical relevance for achieving sustainable, inclusive, and regionally balanced development.

Keywords: digital transformation, sustainable development, regional development, inclusivity, small and medium-sized enterprises, change management, conceptual model, post-war recovery.

У статті досліджено потенціал цифрової трансформації підприємств як основи для інклюзивного та сталого регіонального розвитку України в умовах множинних криз, спричинених війною, соціально-економічною нерівністю, екологічними викликами та технологічними розривами. Вихідною позицією дослідження є критичний аналіз існуючих підходів до цифровізації, які, орієнтуючись переважно на великі корпорації, залишають поза увагою екологічні, соціальні та регіональні аспекти, а також не враховують потреб малих та середніх підприємств як ключових агентів місцевих економік. Метою роботи є концептуалізація цифрової трансформації в контексті потреб регіональних МСП та розробка інтегрованої моделі управління нею, що на відміну від існуючих відповідає викликам повоєнного відновлення та поєднує принципи сталого розвитку з управлінською логікою діджиталізації. Обґрунтовано необхідність переходу від фрагментарних цифрових рішень до застосування комплексного підходу, який поєднує стратегічне бачення, організаційну гнучкість, ресурсну забезпеченість, адаптивні процеси та інноваційну культуру, інтегруючи екологічні та соціальні пріоритети у цифрову рамку трансформації, та враховує особливості посткризової економіки. Особливу увагу при формуванні моделі приділено аналізу бар'єрів, що стримують сталу цифрову трансформацію у регіональних МСП. На основі емпіричних та вторинних даних ідентифіковано ключові проблеми, такі як обмежений доступ до фінансування, дефіцит цифрових та «зелених» навичок, опір змінам, нестача інституційної підтримки та слабка цифрова інфраструктура в окремих регіонах. Підкреслюється значущість цифрового розриву, який поглиблює регіональні диспропорції та ставить під загрозу реалізацію принципів інклюзивності у відновленні. У статті наголошується, що ці бар'єри є взаємопов'язаними та вимагають міжсекторального реагування з боку держави, бізнесу, наукової спільноти та міжнародних партнерів. Практична цінність розробленої моделі полягає в її здатності виконувати функцію дорожньої карти для МСП, що прагнуть реалізувати сталу цифрову трансформацію, а також слугувати основою для розробки політик державної підтримки та орієнтиром для міжнародних донорських програм. Успішна реалізація потенціалу цифрової трансформації вимагає скоординованих дій від усіх стейкхолдерів: держави, бізнесу, академічної спільноти та громадянського суспільства. Розвиток цифрової інфраструктури, підвищення рівня цифрових компетентностей, подолання інституційних прогалин і створення стимулюючого регуляторного середовища визначені основними напрямами, без яких повноцінна реалізація моделі є неможливою. Дане дослідження забезпечує цілісне бачення сталої цифрової трансформації як мультидисциплінарного й багаторівневого процесу, що поєднує інноваційність із принципами справедливості, стійкості та рівного доступу. Запропоновані підходи та висновки мають практичну цінність як засіб досягнення стійкого, інклюзивного та регіонально збалансованого розвитку.

Ключові слова: цифрова трансформація, сталий розвиток, регіональний розвиток, інклюзивність, малі та середні підприємства, управління змінами, концептуальна модель, післявоєнне відновлення.

Formulation of the problem. Under the influence of global, national, and regional challenges, such as escalating geopolitical instability, accelerated climate change, and deepening socio-economic inequality, a fundamental shift is taking place in the paradigm of socio-economic development. These transformations necessitate a rethinking of traditional governance models and the search for integrated solutions to ensure sustainability. In this context, the sustainable and inclusive development of regions, functioning as complex socio-economic systems, becomes particularly relevant. It is at the regional level that global issues manifest most directly, responses to them are shaped, and core economic activity takes place, including job creation and the provision of decent quality of life for the population.

Enterprises play a vital role in maintaining the viability and development of Ukraine's regions, with small and medium-sized enterprises (SMEs) occupying a special position. According

to the Organization for Economic Co-operation and Development, in 2022 SMEs accounted for 99.9% of all registered enterprises in the country. They provided more than 81.7% of total employment in the business sector and generated 67.5% of turnover that exceeds the European Union average [1].

Following the full-scale invasion in 2022, Ukraine's enterprises encountered numerous crisis-related consequences, including the destruction of production capacities, disrupted logistics chains, loss of sales markets, and significant financial losses, averaging USD 227,000 per SME [2]. Even though 84% of these businesses resumed operations within six months, systemic challenges such as electricity shortages, ongoing attacks on critical infrastructure, forced relocation, and declining demand continue to undermine the stability of enterprises [1]. This combination of problems, spanning both the direct consequences of war and operational difficulties, as well as long-term threats such as climate change and deepening socio-economic inequality underscores the urgent need for enterprises to fundamentally reframe their operating paradigms.

Under these conditions, digital transformation can be considered as a strategic process of deep restructuring of organizational structures, business processes, and corporate culture. It emerges as a powerful tool capable of catalyzing the necessary changes and offering opportunities for improving operational efficiency and competitiveness while ensuring environmental responsibility and social sensitivity in business practices [3]. However, digital transformation remains a high-risk undertaking, as evidenced by the global failure rate of such initiatives, which exceeds 70% [4], resulting in considerable investment losses and missed strategic opportunities.

Analysis of the reasons behind digital transformation failures points to predominantly organizational, strategic, and human-related factors rather than technological deficiencies. These include the absence of a coherent strategy, ineffective leadership, employee resistance to change, and a lack of necessary competencies. Such factors highlight the urgent need to develop comprehensive approaches to digital transformation management. Nevertheless, existing models and frameworks exhibit significant limitations in the Ukrainian context, as they are largely tailored to the needs of large transnational corporations, overly focused on technological aspects, and often fail to consider the characteristics of SMEs. Furthermore, these tools tend to ignore regional specifics, conditions of extreme uncertainty, and the need for explicit integration of sustainable development goals into digital transformation governance.

Therefore, there is a clear need for the development of a scientifically grounded and practically oriented conceptual model for digital transformation management. This model should be adapted to the needs of Ukrainian regional SMEs, ensure the integration of sustainability and incluusivity goals, and reflect the unique conditions of martial law and post-war recovery.

Analysis of the recent research and publications. An analysis of recent research in the field of digital transformation confirms that its successful implementation depends on a systemic approach to managing organizational changes. Scholars emphasize that digital transformation encompasses all levels of enterprise functioning from strategy and structure to corporate culture and human resource management [5]. Researchers [3, 6] highlight that the key drivers of digital maturity include digital leadership, data governance, and the development of digital competencies among personnel. Digital transformation is considered not merely as a process of technological renewal but as a profound organizational shift requiring the adaptation and restructuring of internal mechanisms.

In this context, a key theoretical foundation for analyzing digital transformation processes is the concept of dynamic capabilities [7]. Within this framework, an enterprise's competitiveness in a dynamic environment is determined not so much by the resources it possesses, but by its ability to timely adapt, integrate, and reconfigure internal and external competences. Under the conditions of digital transformation, this capability involves sensing technological opportunities, seizing them through rapid assimilation, and transforming the organization to respond effectively to changes in the market and technological landscape. The authors [8] argue that successful digital transformation is impossible without the development of such dynamic capabilities, which enable companies not only to technologically upgrade, but also to ensure long-term resilience and adaptability. The formation of these capabilities includes the development of digital skills, restructuring of organizational frameworks, adaptation of managerial practices, and the integration of new decision-making approaches, particularly those based on artificial intelligence (AI) tools.

The academic literature presents a wide range of conceptual models and theoretical frameworks aimed at explaining the mechanisms of digital transformation in enterprises. These approaches differ in their analytical focus, degree of detail, and practical applicability reflecting the complexity and multidimensional nature of digital change in today's business environment.

Models oriented toward the business environment and market advantages, such as the Six Keys to Success framework [9], focus on how digital technologies facilitate the creation of new competitive advantages through personalization, platform-based business models, flexible operations, and asset sharing. The strength of this approach lies in its direct linkage between technological innovation and market growth potential. However, such models often overlook complex intra-organizational factors, including the transformation of corporate culture, changes in managerial practices, and the development of digital leadership which are crucial for the successful implementation of digital initiatives.

Models focused on organizational transformation, such as the Digital Orchestra Model [10], emphasize a holistic vision of digital transformation encompassing all functional areas of the enterprise from business models and customer experience to Information Technology (IT) architecture, data analytics, and innovation culture. While this approach allows for a systemic transformation of the organization, it suffers from limited empirical validation and insufficient consideration of external influences, such as market pressures or regulatory constraints.

Process-oriented models of digital transformation typically follow a staged structure from vision and goal setting to implementation and evaluation. Such approaches are commonly used in consulting practice, as seen in transformation roadmaps [11]. Although they offer a convenient tool for strategic planning, these models often oversimplify the nonlinear, iterative, and context-dependent nature of real-world transformation processes.

Process-based approaches conceptualize digital transformation as a sequence of stages, including goal definition, roadmap development, solution implementation, and performance monitoring [12]. These models are useful for changing planning and project management, yet they may fail to account for the adaptive and non-linear dynamics of transformation under conditions of uncertainty.

Technology acceptance models such as the Technology Acceptance Model (TAM) or the Unified Theory of Acceptance and Use of Technology (UTAUT) [13], explain the factors influencing individual adoption of digital tools. While these frameworks are highly empirically supported, they provide limited insight into the complex processes of organizational transformation, which involve collective actions, power structure shifts, procedural changes, and cultural adaptation.

Macro-level approaches to digital transformation, such as the macro-Schumpeterian model [14], interpret digital transformation as a fundamental process of systemic change driven by the interaction of technological innovation, organizational paradigms, and public policy. This perspective expands the analysis beyond the enterprise level, explaining how the digital era shapes broader institutional evolution including scenarios such as "digital authoritarianism" or "democratic digital humanism".

Thus, the analysis of contemporary literature demonstrates that the management of digital transformation in enterprises is based on a range of conceptual approaches, each with its own focus, methodological foundation, and practical implications as presented in Table 1. Synthesizing the key characteristics of these approaches reveals several unresolved issues and limitations, which underline the need to develop a fundamentally new conceptual model.

Highlighting previously unresolved parts of the general problem and formulating the goals of the article. Previous research demonstrates significant progress and offers various conceptual models for managing the digital transformation of enterprises. These models identify key dimensions, mechanisms, and instruments of digital change, encompassing a wide range of aspects from strategic planning and technology implementation to business model transformation and the management of organizational culture. However, most of these approaches are predominantly focused on operational efficiency and financial profitability, often overlooking the principles of sustainable development and inclusivity, as well as the scale-specific needs of small and medium-sized enterprises. Moreover, the existing frameworks exhibit limited contextual sensitivity, as they do not adequately capture the realities of doing business under conditions of high volatility, instability, and regional disparities, particularly in the context of martial law in Ukraine. The

Table 1

Comparative matrix of approaches to digital transformation management at enterprises

Model	Level of analysis	Analytical focus	Advantages	Limitations
Dynamic Capabilities	Organizational	Adaptability, transformation of competencies	Explains long-term sustainability; deep exploration of organizational dynamics	Theoretical complexity; requires empirical adaptation
Six Keys to Success	Business model / market	Innovations, new models of value creation	Focus on market advantages; applied orientation	Insufficient focus on internal changes in the organization
Digital Orchestra Model	Organizational	System transformation of all functions	Complexity; consistency of functions	Weak empirical validation; does not consider external pressure
Process-oriented	Operational / project	Implementation stages, strategic planning	Convenience for practical use	Can simplify complex, iterative processes
Technology adoption models (TAM, UTAUT)	Individual	Behavioral factors, perception of technology	High empirical validity; clear acceptance mechanism	Limited ability to explain organizational changes
Macro-Schumpeterian	Macro level / systemic	The interaction of technology, policy, and paradigms	High conceptual depth; vision of alternative futures	Not focused on management within a single organization

Source: systematized by the authors based on [9–14]

direct application of such international practices without proper adaptation to the Ukrainian context may result in the inefficient allocation of scarce resources.

Given the above, the aim of this article is to develop and validate a conceptual model for managing digital transformation as an effective instrument for achieving sustainable and inclusive regional development. The proposed model is tailored to the needs and operational environment of Ukrainian enterprises, particularly SMEs, and ensures the systematic integration of sustainable and inclusive development goals while accounting for the specific challenges of uncertainty and post-war recovery.

Presentation of the primary research material. In the context of technological evolution, digital transformation emerges as a profound and systemic process that reshapes the core elements of enterprise functioning from business models to managerial culture. Contemporary academic approaches and empirical research consider it as a key determinant of a firm's competitiveness and appreciate its ability to adapt amid high turbulence and technological dynamism. At the same time, there is growing societal awareness that digital transformation should serve not only as a tool for efficiency gains, but also as a means of fulfilling environmental, social, and economic responsibilities. This is particularly relevant for small and medium-sized enterprises, which, on the one hand, face resource constraints that limit the implementation of comprehensive digital strategies, and on the other hand, possess significant potential for flexibility, innovation, and close engagement with local communities.

In the Ukrainian context, the digital transformation of SMEs is taking place under conditions of pronounced instability. This process is hindered by numerous challenges, including the consequences of full-scale war, institutional weaknesses, limited access to finance, and insufficient digital skills at all managerial levels. At the same time, these difficulties are accompanied by new opportunities like rapid development of digital public services, an active and well-established IT community, expanding access to digital education, and the emergence of international support programs for digitization and sustainable development of Ukrainian SMEs.

Building upon an analysis of these opportunities, existing scholarly contributions and the practices of leading companies, as well

as considering the specificities of the national context, we have developed a conceptual model for managing the digital transformation of SMEs. The model is theoretically grounded on the concept of dynamic capabilities, which enables firms to adapt to rapid environmental change, foster innovation, and sustain competitive advantage over time.

The model is based on five interrelated components: strategy, structure, processes, resources, and organizational culture. This approach allows digital transformation to be integrated across all management levels of an enterprise, ensuring the coherence and consistency of transformation efforts. A key feature of the model is the embeddedness of sustainable development goals within each component, which transforms it from a technical improvement tool into a mechanism for sustainable and responsible growth.

Within the structure of the conceptual model, the strategic component defines the overall direction and objectives of transformation. Unlike traditional approaches that prioritize economic efficiency, the current paradigm of SME digital transformation demands an expanded strategic focus that incorporates environmental and social dimensions. In this context, strategy should be developed with sustainability principles in mind and aim not only at achieving financial performance but also at improving resource efficiency, enhancing social responsibility, and increasing enterprise resilience to external shocks [15]. Specific strategic objectives may include reducing the carbon footprint through AI-driven optimization of logistics processes; designing digital products aligned with environmental safety goals (i.e., green IT solutions); promoting digital inclusion for diverse user and employee groups; and shifting towards circular business models through the adoption of digital platforms that facilitate resource reuse and waste minimization [16]. Thus, the strategic component of sustainable digital transformation management should be designed as a multidimensional framework, where economic, environmental, and social goals are mutually reinforcing while ensuring not only efficiency, but also the long-term viability of the business.

The structural component of the conceptual model requires the adaptation of the organizational architecture to the realities of the digital and sustainable economy. This transformation goes beyond the mere introduction of digital-specific roles and entails deeper institutional shifts, including the formation of cross-functional units capable of coordinating the enterprise's environmental, social, and technological initiatives. Integrating sustainability principles into organizational structures requires the implementation of accountability systems based on relevant indicators. This includes, for instance, embedding sustainability-related key performance indicators (KPIs) into management processes, thereby making the achievement of environmental responsibility goals a part of the standard managerial cycle. Such an approach not only enhances decision-making transparency but also promotes a systemic orientation towards the long-term resilience of the business [4].

The process component encompasses the transformation of both production and managerial procedures within the enterprise through the integration of digital technologies. In the context of sustainable digital transformation, the focus shifts from automation to the implementation of sustainability principles in operational activities. This entails the use of digital solutions to improve energy efficiency, reduce resource consumption, and minimize emissions and waste. Of particular importance is the adoption of circular economy models supported by digital platforms. For instance, tools for product lifecycle tracking, resource-sharing services, and predictive maintenance systems enable more rational and responsible production practices [17]. Thus, processes serve not only as an object of optimization, but also as a key mechanism of deep organizational transformation aligned with sustainability goals.

The resource component of the model addresses the management of technological, financial, informational, and human assets of the enterprise. Within the framework of sustainable digital transformation, the effective use of these resources gains new strategic significance – namely, minimizing environmental impact and enhancing corporate social responsibility. From a technological perspective, this includes the adoption of green IT solutions such as energy-efficient equipment and low-carbon cloud computing. The financial dimension involves the mobilization of green financing specialized instruments designed to support digital solutions with sustainable outcomes. Informational resources, particularly data, play a dual role: they are both the foundation for business decision-making and a means of monitoring environmental and social performance. In turn, human capital must be equipped to meet new challenges through the development of green digital competencies the ability to leverage digital

technologies to address sustainability-related tasks and implement innovations oriented toward the common good [18].

Organizational culture is an integral factor in successful digital transformation, shaping the level of internal support for change, openness to innovation, and readiness for experimentation. In the context of sustainability, cultural transformation should foster responsibility, transparency, inclusiveness, and innovation. This includes the development of leadership focused not only on achieving economic results, but also on generating long-term social impact. It entails supporting employee initiatives aimed at sustainable development, promoting openness to new ideas and technologies, and cultivating shared values that recognize the importance of environmental and social responsibility in everyday operations [4].

Digital transformation requires a systemic approach to change management. Strategy, structure, processes, resources, and culture form an interconnected and holistic system, the effectiveness of which depends on the coordinated interaction of all its components. Accordingly, the transformation of an enterprise's strategy must be accompanied by corresponding changes in its organizational structure, operational processes, resource allocation, and internal culture.

To visualize the internal logic of this interdependence and the dynamics of digital transformation management processes, Figure 1 presents a graphical model that illustrates the nature and directions of influence among the specified components using graphical differentiation of connections (solid and dashed lines). This approach enables not only the structuring of the transformation's key elements but also the analysis of their interactions within the context of complex organizational dynamics.

The implementation of the proposed digital transformation model requires the effective deployment of key digital technologies that act as catalysts for achieving the goals of sustainable development goals. These technologies

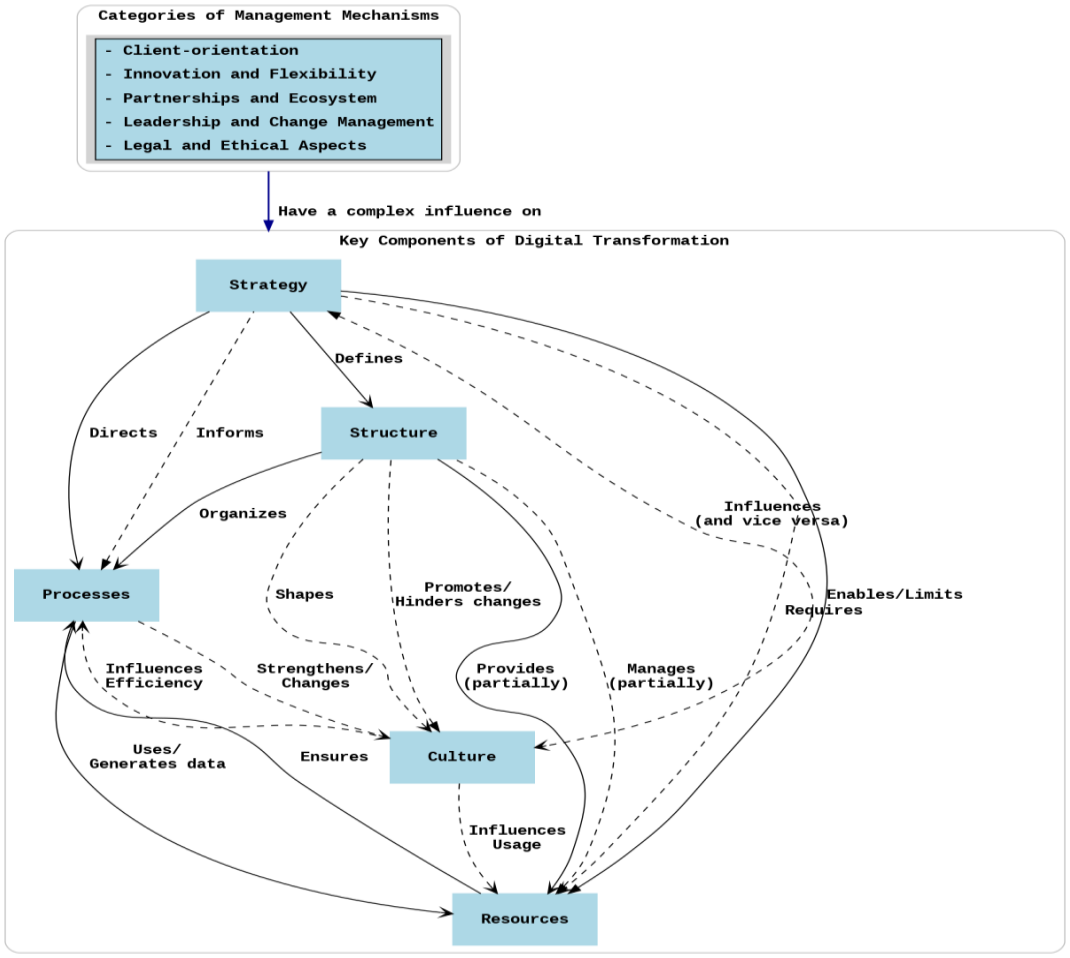

Figure 1. Conceptual model for managing enterprise digital transformation

Source: compiled by the authors

constitute an integrated and synergistic toolkit that supports managerial decision-making across all levels of transformation from strategic planning to operational execution. Their application facilitates resource optimization, reduction of environmental impact, increased process transparency, improved customer service quality, and the development of new business models based on the principles of responsibility and inclusivity.

Among the core digital technologies that enable the implementation of sustainable development within the context of digital transformation are the Internet of Things (IoT) and Big Data analytics. IoT serves as a kind of “nervous system” for the enterprise, providing real-time data collection on equipment performance, resource consumption, and environmental conditions. In turn, Big Data allows for the efficient processing and analysis of these large data volumes to identify patterns, make predictions, and detect inefficiencies. The synergy of these technologies enables the implementation of intelligent resource management mechanisms from energy and water usage optimization (e.g., through smart irrigation systems) to emission reduction via efficient logistics and waste management laying the groundwork for a transition toward a circular economy [16].

Artificial Intelligence and Machine Learning (ML) represent the intellectual core of the digital transformation system. These technologies provide the capability for in-depth data analysis and real-time optimization-driven decision-making. One key application area is predictive maintenance, which enables the anticipation of equipment failures and allows for repairs only when necessary. This extends asset lifespans, reduces waste volumes, and promotes more efficient resource use. AI is also employed for energy optimization, accurate demand forecasting to avoid overproduction, and improving product quality through computer vision technologies [19].

Blockchain technology functions as a decentralized “ledger of trust”, ensuring data transparency, traceability, and immutability across all stages of the value chain. In the context of sustainability, blockchain enables the creation of a digital product footprint from its origin to the end consumer including production conditions and environmental characteristics. This opens new opportunities for verifying compliance with fair trade standards, combating counterfeit products, managing carbon credits, and enhancing brand trust among consumers and partners [20].

Digital Twins represent another essential instrument of digital transformation, allowing for the creation of virtual models of physical assets or processes. These digital replicas enable enterprises to simulate, test, and optimize production systems, infrastructure or product design within a secure virtual environment before physical implementation. This approach improves decision accuracy, reduces resource consumption and manufacturing defects, and ensures maximum energy efficiency for complex systems such as buildings, industrial facilities or energy networks [17].

Thus, the integrated use of digital technologies provides a strong foundation for achieving sustainable development goals, enhancing enterprise competitiveness, and fostering responsible business practices in the digital economy, as illustrated in Figure 2. Each of these technologies provides targeted support to specific sustainability dimensions: IoT enables real-time resource monitoring and supports circular practices; Big Data ensures transparency and economic efficiency; AI/ML contributes to process optimization and risk prevention; blockchain strengthens trust, traceability, and compliance with ethical standards; and Digital Twins allow for testing and refining resource use strategies prior to physical implementation.

The next stage of the study involves analyzing the feasibility of practical implementation of the proposed model in the Ukrainian context. This requires consideration of a range of structural, political and economic factors that significantly influence the dynamics of digital transformation within SMEs.

Digital transformation in Ukraine is unfolding within a complex reality shaped by the consequences of the ongoing full-scale war, the intensification of integration processes within the framework of the European course, and pronounced regional disparities in access to digital infrastructure, education and institutional support. At the same time, state policy has consistently demonstrated support for digital modernization, as evidenced by the SME Recovery Strategy until 2027 [21], the Ukraine Recovery Plan [22] and strategic initiatives of the Ministry of Digital Transformation [23], in which digital transformation is defined as a priority for sustainable development and economic recovery.

However, despite the availability of numerous governmental initiatives and support programs, there remain risks of policy fragmentation,

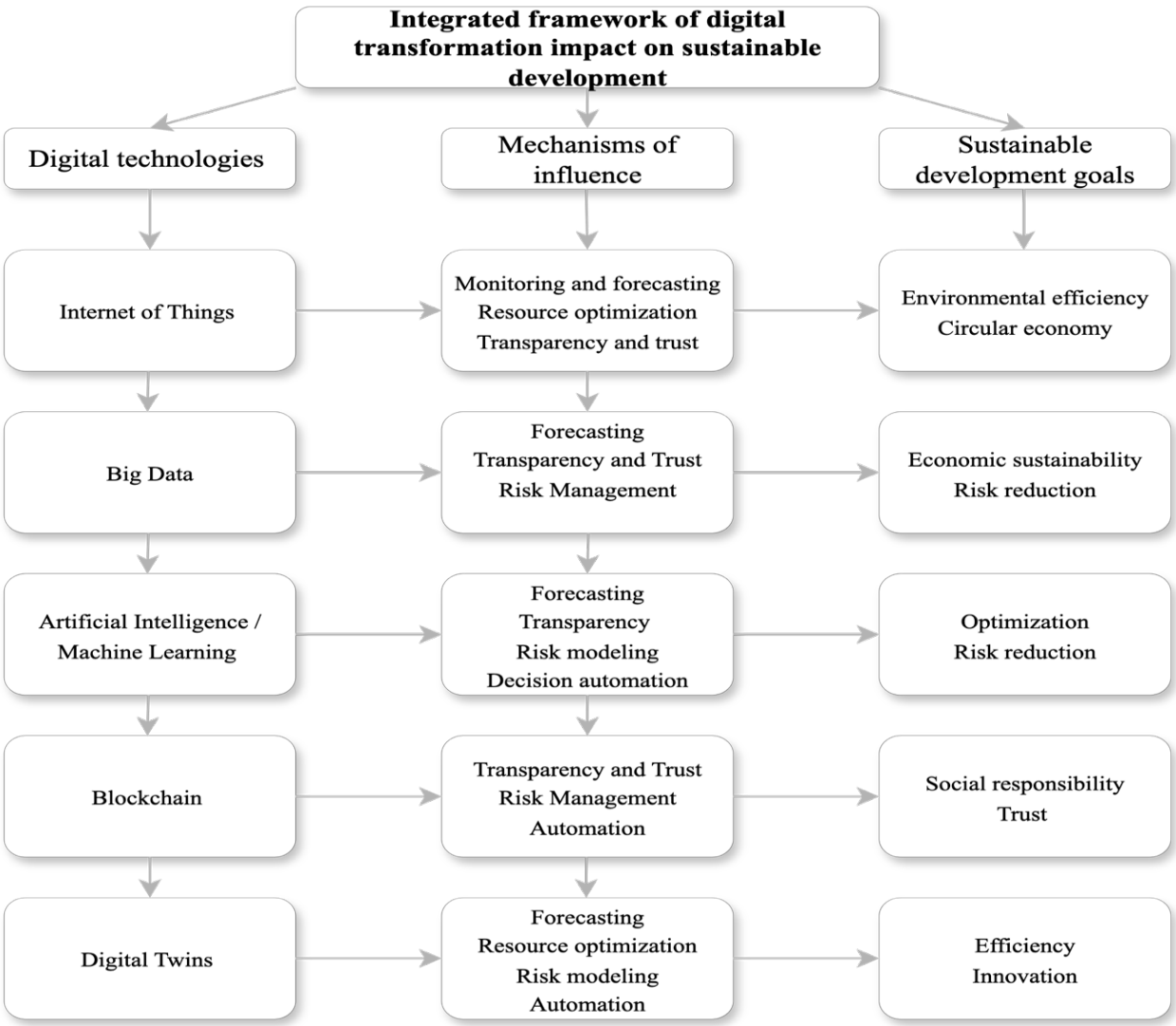

Figure 2. Conceptual framework of the digital transformation impact on the sustainable development of SMEs

Source: compiled by the authors

insufficient inter-institutional coordination, and low awareness among enterprises regarding available opportunities. These issues present significant barriers to the effective implementation of digital strategies and further exacerbate unevenness in the transformation process.

In the context of post-war recovery and digital transition, particular attention should be paid to the barriers faced by small and medium-sized enterprises. These barriers are multidimensional, encompassing infrastructural, human resource, financial, organizational, and security-related aspects. One of the most pressing challenges in this regard is the growing digital divide, which substantially affects the ability of SMEs to engage in the «twin transition», both digital and green. The digital divide manifests in unequal access to digital technologies, infrastructure, and competencies between regions and between urban and rural communities.

Empirical data confirms the scale of this problem. According to the results of a recent study [23], the average regional digital development index in the first quarter of 2025 was only 30 out of 100. Dnipropetrovsk and Lviv regions were the top performers with 43 points each, while the average score for rural communities remained critically low just 16 out of 100.

Regional asymmetry in digital development is leading to a two-speed transformation, which is already affecting the socioeconomic dynamics of the country. In regions with high levels of digitalization, such as Lviv and Dnipropetrovsk, the unemployment rate is 12% lower than in less developed regions, such as Zaporizhzhia and Luhansk. At the same time, approximately

65% of rural areas still lack access to high-speed internet, and only 52% of the population possesses basic digital skills. This situation not only hampers economic activity but also limits the ability of a significant portion of the population to participate in digital interactions with government services, education, healthcare and labor markets.

Thus, the digital divide is not merely a standalone issue but a cross-cutting factor that exacerbates other systemic barriers, particularly financial, human resource and organizational. To provide a comprehensive understanding of these constraints, Table 2 summarizes the key barriers hindering the sustainable digital transformation of SMEs across Ukraine's regions.

The identified barriers to sustainable digital transformation of SMEs are interrelated and constitute a complex, multi-level system of constraints. These barriers span financial, human, technological, managerial, infrastructural, and cultural dimensions, reflecting the structural depth of challenges faced by SMEs undergoing digital transformation in Ukraine's regions. Their synergistic nature implies that the presence of one barrier often amplifies the effects of others. For example, a lack of financial resources limits access to new technologies, which in turn hampers the development of digital skills among personnel and reduces the readiness for strategic planning of transformation processes.

These barriers are particularly acute in the regional context, where digital and institutional inequalities often intersect with spatial and security-related factors. In rural and frontline communities, SMEs face limited access to high-speed internet, a shortage of qualified personnel, and ongoing security threats all of which significantly reduce their capacity to engage in digital and sustainable transformations on equal footing with enterprises in more economically developed regions.

Table 2

Key barriers to sustainable digital transformation of SMEs in Ukraine's regions

Category	Barrier	Relevance	SME practice
1	2	3	4
Financial	Insufficient funds for investment in technology, training, and consulting	Very high: the war has caused financial losses, restricted lending and increased investment uncertainty	Lack of Customer Relationship Management (CRM), Enterprise Resource Planning (ERP) systems; rejection of cloud-based services
	High implementation costs of digital solutions	High: particularly critical for micro and small enterprises	Preference for the cheapest or free tools with limited functionality; postponement of modernization
Human Resources / Skills	Shortage of qualified professionals with digital competencies	Very high: mobilization and migration deepen labor shortages	One specialist, who is responsible for all digital processes
	Low level of digital literacy among management and staff	High: nearly half of the population lacks basic digital skills	No internal IT initiatives; reliance on external contractors
Strategic / Managerial	Lack of a long-term digital strategy	High: SMEs are focused on short-term survival	Fragmented digitalization without outcome assessment
	Difficulty in assessing return on investment (ROI) and impact on sustainable development	High: absence of evaluation methodologies for ROI and sustainability	No monitoring of transformation effects; weak analytics
Organizational / Cultural	Resistance to change among employees	High: stress and uncertainty foster inertia	Ignoration of innovations; passivity in learning; resistance to change
	Traditional organizational culture (low innovativeness, weak support for learning)	High: conservative management practices remain	Priority given to operational tasks over innovation; a lack of experimentation culture

Continue Table 2

1	2	3	4
Infrastructure / Technological	Uneven digital infrastructure and weak broadband coverage	Very high: significant urban–rural divide; infrastructure losses due to the war	Inability to serve clients online; technical disruptions
	Use of outdated IT systems	High: low rate of software updates; frequent use of obsolete systems	Low compatibility with new services; vulnerability to cyberattacks
Security (War-related)	Threats to business security in frontline regions	Very high: shelling, mining, property destruction	Investment delays; relocation; halted automation
	High uncertainty regarding war duration	Very high: prevents strategic planning	No planning beyond 6–12 months; avoidance of transformation projects
Sustainability	Short-term focus on survival instead of sustainable solutions	Very high: sustainability perceived as secondary in crisis	Neglect of environmental and social dimensions of digital transformation; no Environmental Social Governance (ESG) reporting

Source: completed by the authors based on [1–3]

Therefore, bridging the digital divide should not be viewed solely as an economic necessity, but as a strategic priority of national policy, one that encompasses security, justice and inclusive development. The implementation of sustainable digital change requires a comprehensive policy framework to support SMEs, focusing not only on infrastructure modernization but also on the development of digital culture, the stimulation of innovative entrepreneurship, the creation of an enabling regulatory environment and the provision of equitable access to knowledge and resources. An effective response to this challenge calls for coordinated and long-term efforts from the state, business sector, academic institutions, and civil society. Only a systemic and integrated approach will ensure sustainable digital inclusion for SMEs across all regions of Ukraine thereby laying the foundation for overcoming the consequences of war and building a competitive economy of the future.

Conclusions. The results of the conducted research confirm that the digital transformation of enterprises in Ukraine's regions is not merely a relevant managerial practice but a necessary condition for enhancing economic resilience, adaptability, and competitiveness in the face of multiple crises caused by war, climate change and socio-economic inequality. In this context, sustainable digital transformation acquires strategic importance as a tool for inclusive recovery that requires a holistic approach oriented toward long-term outcomes. However, the implementation of such transformation in regional SMEs remains limited due to several interrelated barriers, including financial constraints, a lack of digital and «green» skills, resistance to change, underdeveloped infrastructure and a deepening digital divide across territories. These challenges highlight the urgent need to move from fragmented solutions to a comprehensive policy framework that addresses both the technical and institutional-cultural dimensions of transformation.

The proposed conceptual model for managing sustainable digital transformation in SMEs, grounded in the interconnectedness of strategic, structural, processual, resource-based and cultural components, is both theoretically sound and practically relevant. Its potential lies in fostering a new managerial logic wherein digital change is integrated with ecological and social objectives and adapted to the conditions of a recovering economy. In this context, the consistent integration of sustainability principles into enterprise strategies, the development of internal competencies, the nurturing of an innovation-oriented organizational culture and the phased implementation of digital initiatives with an emphasis on quick returns in sustainability areas such as energy efficiency or resource decoupling are of particular importance. Furthermore, the active utilization of existing support ecosystems, including state and donor

programs, regional development agencies, and digitalization vouchers, can significantly reduce cost and organizational barriers for businesses.

On the part of the state, the creation of a favorable institutional environment is critical. This includes strengthening inter-agency coordination, developing coherent support policies for sustainable digital transformation, providing access to financial and advisory instruments through simplified mechanisms, and expanding digital infrastructure in rural and war-affected regions. Encouraging the integration of digital technologies with sustainability goals requires the introduction of tax incentives, grant programs, and concessional financing for SMEs implementing digital solutions with high ecological and social value. The successful implementation of this agenda is impossible without the active involvement of the academic community, which should focus on empirically validating the proposed model, developing applied methodologies for its sectoral implementation, and disseminating successful digital transformation cases. At the same time, international partners should direct their technical and financial support in line with national strategic priorities, prioritizing projects that combine digitalization with environmental and inclusive objectives and investing in the institutional capacity of regional business support structures.

To sum up, unlocking the potential of sustainable digital transformation as a driver of regional development in Ukraine requires strategic vision, cross-sectoral collaboration, and the deployment of context-sensitive and flexible implementation tools. The proposed conceptual framework provides a foundation for such efforts, and its further empirical elaboration and scaling will be a decisive step toward building a resilient, innovative, and inclusive economy in the context of post-crisis recovery.

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