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Theoretical foundations of the super-app for a public sector digitalisation: The case of Ukraine

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Abstract. The purpose of the research was to substantiate the theoretical foundations of the “super-app” concept and to evaluate its applicability for public sector digitalisation, with a particular focus on Ukraine. Although super-app ecosystems have become a prominent phenomenon in the private sector, the academic literature still lacks a unified definition of a super-app and provides limited analysis of its potential role in public service delivery. To address this gap, the study employs a mixed-methods approach that combines comparative analysis, structural-functional analysis and qualitative assessment of international and national case studies. The research compared mature super-app ecosystems (WeChat, Grab, Gojek and Kakao) with emerging super-app platforms (Uber, Revolut, Glovo and Diia) in order to identify the core criteria that distinguish fully developed super-apps from platforms at earlier stages of ecosystem formation. The results demonstrated that mature super-apps are characterised by deep service integration, embedded digital identity and payment infrastructures, ecosystem openness and sustained user engagement across multiple domains of daily activity. Emerging platforms only partially meet these criteria, revealing structural gaps related to governance models, regulatory environments and ecosystem coordination. Applying this analytical framework to Ukraine, the study examined Diia as a potential public-sector super-app. The findings indicated that Diia exhibits several defining features of a super-app, including centralised digital identification, wide service coverage and large-scale user adoption. The study proposed strategic directions for enhancing Diia’s evolution toward a public-sector super-app model, and also an

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authorial definition of a “super-app for the public sector”, which is expanding theoretical understanding of platform-based digital governance

Keywords: digital governance; platform ecosystems; public service integration; digital public infrastructure; e-government innovations

● INTRODUCTION

In the context of accelerated digital transformation and rising public expectations, governments worldwide face increasing pressure to provide public services that are as seamless, integrated and user-centric as those offered by the private sector. Digital platforms are gradually replacing fragmented administrative systems, enabling citizens to access services through unified digital interfaces. At the same time, the growing complexity of socio-economic challenges requires governments to adopt more efficient digital governance models capable of integrating multiple services and actors within a single digital environment. Under such conditions, the search for platform-based approaches that simplify interactions between citizens, businesses and public institutions has become increasingly relevant. One of the emerging concepts in this area is the super-app model, which consolidates multiple services into a single digital ecosystem accessible through one interface.

Academic research increasingly examines the super-app phenomenon from different perspectives. A. Balogh & J. Varga (2024) analysed the role of super-apps in enhancing customer experience and innovation management, concluding that these platforms represent a new type of digital ecosystem where multiple services are integrated within a unified technological environment. The authors emphasised that despite the rapid diffusion of super-apps in practice, the concept still lacks a precise academic definition and therefore requires further theoretical clarification. L. Ochoa (2025) explored the development of super-app ecosystems from an economic perspective and highlighted the importance of integrating diverse services such as payments, transportation, communication and digital commerce within a single platform. According to the author, the success of super-apps lies in their ability to reduce user friction by eliminating the need to switch between different applications for everyday tasks. Studies in information systems emphasised the broader role of digital platforms in strengthening institutional and economic resilience.

R. Floetgen *et al.* (2021) introduced the concept of platform ecosystem resilience and demonstrated that digital platforms can support adaptive responses to large-scale disruptions by coordinating services and actors within integrated ecosystems. W. Boh *et al.* (2023) examined how digital infrastructures contribute to building resilience during major shocks, highlighting the importance of flexible digital architectures and cross-sector collaboration. Y. Tim *et al.* (2023) further showed that crisis-driven information systems enable organisations to maintain service continuity during disruptive events through integrated digital solutions. The role of digital services has also been examined in the context of public administration. V. Levesque *et al.* (2024) analysed the contribution of municipal digital services to community resilience and concluded that digital service platforms can improve the ability of local governments to respond to socio-economic

challenges and deliver accessible public services. H. Li & G. Kostka (2022) investigated digital participation within government-operated digital platforms and demonstrated that the effectiveness of such systems largely depends on institutional design and citizen engagement mechanisms embedded in platform architecture. S. An *et al.* (2024) investigated the role of digital solutions in enhancing user engagement in public and semi-public service systems and demonstrated that platform-based approaches, including gamification mechanisms, can significantly improve user acceptance and interaction with digital services. The authors concluded that the effectiveness of digital service platforms depends not only on technological integration but also on user-centered design features that facilitate accessibility and sustained engagement.

Ukrainian researchers have also begun to analyse these processes within the context of national digital transformation. N. Gavkalova & O. Kunitsyn (2025) examined the development of digital platforms in the public sector and emphasised that Ukraine’s rapid digital transformation has created new opportunities for integrating public services within unified digital systems. The authors noted that the concept of a super-app remains insufficiently explored in relation to public administration, particularly regarding how platform-based ecosystems can be adapted to government service delivery. Another contribution to understanding Ukraine’s digital transformation was made by V. Vyhovska *et al.* (2025), who analysed the evolution of digital government reforms in Ukraine and demonstrated that the Diia platform significantly accelerated the digitalisation of administrative services.

Despite the growing number of studies devoted to digital platforms and super-apps, several important aspects remain insufficiently explored. Existing research primarily focuses on private-sector super-app ecosystems, particularly those developed in Asian markets, while the potential application of the super-app model in public governance remains largely understudied. Furthermore, the literature lacks a unified conceptual framework that distinguishes mature super-app ecosystems from emerging multi-service platforms. These limitations highlight the need for further research aimed at clarifying the theoretical foundations of the super-app concept and assessing its applicability to public sector digitalisation. The aim of this study was to substantiate the theoretical foundations of the super-app concept and evaluate its applicability to public sector digitalisation, with particular attention to the case of Ukraine. To achieve this aim, the study develops a conceptual definition of a super-app that incorporates public sector characteristics, distinguishes between mature super-app ecosystems and emerging multi-service platforms by identifying key criteria of maturity, and evaluates the extent to which the Ukrainian digital platform Diia corresponds to these criteria as a potential “super-app for the public sector”.

● MATERIALS AND METHODS

The research adopted a qualitative, theory-driven research design aimed at conceptualising the notion of super-apps and assessing their applicability to the digitalisation of public services, with a particular focus on Ukraine's digital platform Diia. Given the interdisciplinary nature of the super-app phenomenon, which situated at the intersection of digital platform theory, ecosystem economics, financial technologies and public administration, this research employs a comparative analytical methodology combined with systematic literature synthesis and case-based evaluation. This approach enabled the identification of structural characteristics that distinguished super-apps from conventional digital platforms and supports the development of an analytically grounded typology applicable to both private and public sectors.

The methodological framework of the research based on a comparative multiple-case study design, which is widely applied in platform and innovation studies to explore emerging digital phenomena characterised by heterogeneity and rapid evolution (Yazan & Vasconcelos, 2015). This approach allows for structured comparison across diverse platform configurations and supports theory building in contexts where unified definitions and measurement standards are still under development. This approach integrated two complementary methods. The first method is a qualitative comparative analysis which was applied to selected digital platforms using analytically derived criteria that reflect core dimensions of super-app functionality. The second method is an analytical synthesis which was used to translate comparative findings into structured recommendations for public-sector application, specifically in the Ukrainian context.

A key methodological contribution of this study was the introduction of a two-tier typology of super-apps, distinguishing between "Mature Super-App Ecosystems" and "Emerging Super-App Platforms". This classification responds to the lack of a unified academic definition of super-apps and reflects observed differences in platform maturity, ecosystem structure and also a functional integration identified in literature. "Mature Super-App Ecosystems" are defined as digital platforms that demonstrate a high degree of multi-service integration across sectors, including communication, payments, mobility, commerce and additional everyday services, supported by a unified identity and payment infrastructure. These platforms typically operate as ecosystem orchestrators, enabling third-party services through mini-app architectures or open APIs and exhibit strong user lock-in driven by network effects and service bundling. Studies of M. Hasselwander (2024) and L. Ochoa (2025) emphasised that such ecosystems function as quasi-operating systems for daily digital life, rather than as mere aggregators of services. By contrast, "Emerging Super-App Platforms" are characterised by partial fulfilment of super-app criteria. While these platforms integrate multiple services and may include embedded financial or identity components, they lack the full ecosystem openness, platform architecture or cross-sector depth observed in mature super-apps. This category reflects the evolutionary nature of super-app development, aligning with research of M. Hasselwander & D. Weiss (2025) that conceptualises platform maturity as

a dynamic process rather than a binary state. The distinction between mature and emerging platforms provides an analytical lens for identifying structural gaps and development trajectories.

The selection of platforms for comparative analysis was guided by three criteria: theoretical relevance to the super-app concept, empirical evidence of multi-service integration and availability of reliable academic and policy documentation. Based on these criteria, four platforms were classified as "Mature Super-App Ecosystems": WeChat, Grab, Gojek and Kakao. These platforms are consistently cited in academic and industry literature as paradigmatic examples of super-apps and represent diverse regional contexts, primarily in East and Southeast Asia, where market conditions and digital adoption patterns have historically favoured ecosystem consolidation (Hasselwander, 2024). WeChat is widely recognised as the archetypal super-app, integrating messaging, payments, commerce and a vast ecosystem of mini-programs within a single interface. Grab and Gojek exemplify the transformation of mobility platforms into multi-service ecosystems encompassing financial services, logistics and on-demand offerings. Kakao represents a similar trajectory within the South Korean digital ecosystem, combining communication, payments and content services. These cases collectively illustrate the structural features associated with super-app maturity, including ecosystem governance, financial integration and platform extensibility.

The group of "Emerging Super-App Platforms" includes Uber, Revolut, Glovo and Diia. These platforms were selected to capture different sectoral pathways toward super-app development. Uber represents a mobility-centred expansion strategy, Revolut reflects a finance-led integration model and Glovo illustrates service aggregation within logistics and delivery markets. Diia, as Ukraine's national digital public services platform, represents a unique public-sector case, enabling the examination of whether super-app logic can be effectively applied beyond commercial ecosystems. The inclusion of Diia is theoretically justified by scientific literature on digital public infrastructure and platform governance, which suggests that public digital platforms increasingly adopt features traditionally associated with private digital ecosystems, such as centralised identity, service bundling and API-based integration (Vyhovska *et al.*, 2025). At the same time, Diia's public mandate and regulatory context differentiate it from private super-apps, making it a critical case for exploring the boundaries of the super-app concept.

The comparative analysis was conducted using a set of criteria derived from the literature on super-apps and digital platform ecosystems. The criteria were selected through a structured review of academic and industry publications on super-app architectures and multi-service digital platforms. At the first stage, the key characteristics of super-app ecosystems most frequently discussed in the literature were identified, including service integration, embedded financial infrastructure, platform modularity, ecosystem partnerships and value creation mechanisms. At the second stage, these characteristics were systematised and grouped into analytical dimensions that allow for cross-platform comparison. As a result of this synthesis, six criteria were selected for the comparative framework:

the presence of integrated payment systems, platform or mini-app architecture, ecosystem openness, service bundling logic, economic value generation mechanisms and the degree of private-sector integration. These criteria were chosen because they reflect the core structural features that distinguish super-app ecosystems from conventional digital platforms and are consistently emphasised in platform research. Other potential characteristics discussed in the literature, such as user interface design or marketing strategies, were not included in the analytical framework because they are more context-dependent and less relevant for assessing the structural maturity of platform ecosystems. Each platform was assessed qualitatively against the selected criteria based on documented functionalities, institutional arrangements and strategic orientation. This analytical procedure follows methodological precedents in platform research that emphasise qualita-

tive, criteria-based comparison as a means of identifying structural patterns and development gaps.

● RESULTS

Mature super-app ecosystems: A comparative analysis

The comparative analysis of mature super-app ecosystems constitutes the empirical foundation for identifying the structural characteristics that distinguish super-apps from conventional multi-service digital platforms. Table 1 is representing an analysis of four internationally recognised mature super-app ecosystems, using a set of analytically derived criteria reflecting platform architecture, service integration, ecosystem governance and economic functionality. The purpose of this comparison is not to rank platforms, but to extract common structural features that collectively define super-app maturity and serve as a benchmark for evaluating emerging platforms in subsequent analysis.

Table 1. Criteria of mature super-app ecosystems

Criterion	WeChat (China)	Grab (Southeast Asia)	Gojek (Indonesia)	Kakao (South Korea)
Centralised digital identity	WeChat operates a unified account that ties social features (e.g., chat) to services like payments, mini-programs, commerce and public services via one login infrastructure. This identity persists across transactions and embedded mini-services.	Grab uses a single login that lets users access ride-hailing, food delivery, payment wallet (GrabPay) and other services from one account across multiple Southeast Asian markets.	Gojek provides one account for ride-hailing, logistics, payments (GoPay) and additional services, creating continuity across its ecosystem.	KakaoTalk's single user account spans messaging, payments (KakaoPay), mobility services (Kakao T) and entertainment, enabling integrated user access across services.
Integrated payment system	WeChat Pay is built into the app and supports peer-to-peer money transfer, QR payments in physical stores, in-app purchases and broad digital commerce.	GrabPay started as an in-app payment wallet and expanded to merchant payments, financial tools, micro-insurance and lending functions within the app ecosystem.	Gojek's GoPay wallet is integrated within the app, enabling payments for rides, deliveries, logistics and partner merchant services, creating a self-contained transactional layer.	Kakao integrates KakaoPay within its platform, enabling users to make digital payments, transfer funds and settle transactions across multiple Kakao services.
Multi-sector service integration	WeChat supports messaging, social networking, payments, commerce, travel booking, utility bill payments, government mini-services and mini-program integrations without leaving the app.	Grab combines transportation, food and grocery delivery, payments, hotel bookings and financial services, reflecting broad horizontal expansion across everyday user needs.	Gojek offers ride-hailing, food delivery (GoFood), logistics and payments, expanding into fintech and lifestyle services through partnerships and integrations.	Kakao provides messaging, mobile payments, ride-hailing via Kakao T, entertainment content and commerce services within its interconnected platform.
Platform architecture (mini-apps, APIs)	WeChat's mini-programs are internal ecosystems of lightweight apps that offer a wide range of services: from e-commerce to service booking, allowing third parties to build within the platform.	Grab's modular ecosystem (transport, delivery, payment, financial) enables expansion of partner services and internal modules under one interface.	Gojek's ecosystem provides modular access to varied services (GoRide, GoSend, GoShop) that operate within a unified app.	Kakao's ecosystem uses integrated service modules (e.g., KakaoPay, Kakao T) that operate within the Kakao platform across services.
Ecosystem openness	WeChat's mini-program ecosystem allows developers and merchants to deploy services inside the app interface, increasing third-party participation.	Grab collaborates with external brands and services, incorporating partner offerings like Agoda, third-party merchants and financial partners into its ecosystem.	Gojek works with local partners (e.g., payment partners, logistics providers) to broaden service offerings, supporting SME inclusion.	Kakao's API and developer interfaces enable some external integrations (e.g., KakaoPay integration with partner services) that expand the ecosystem.

Table 1, Continued

Criterion	WeChat (China)	Grab (Southeast Asia)	Gojek (Indonesia)	Kakao (South Korea)
Institutional embeddedness	WeChat’s broad adoption in China includes integrations with government services (e.g., civic functionalities in mini-programs) and deep market penetration, making it embedded in social and economic routines.	Grab’s super-app strategy involves partnerships across regulated domains (banking partners, insurers) and compliance with regional regulatory environments (e.g., finance, transport, data).	Gojek aligns with local regulatory standards and works with financial and logistic partners, embedding itself in Indonesia’s digital economy.	Kakao’s dominance in the Republic of Korea and collaborations with financial service providers (KakaoPay) position it within regulated digital infrastructures.
Economic value exchange	WeChat drives commerce and payments at massive scale, enabling merchants and consumers to trade, book services and transact inside one ecosystem.	Grab’s ecosystem generates value through transport, delivery fees, wallet transactions, merchant services insurance products and financial offerings.	Gojek’s integration of services and payments creates economic flows across mobility, logistics and merchant platforms.	Kakao’s economy spans payments, entertainment, mobility and digital services, creating transaction ecosystems across sectors.

Source: based on U. Florene (2020), J. Osio (2020), The rise of the super app (2022), Find more about WeChat... (2024), A. Mustapha (2024), P. Sanchez (2025), S. Jesse (2026), Creating the superapp (n.d.)

A defining characteristic observed across all mature super-app ecosystems is the presence of a deeply integrated payment infrastructure embedded within the core platform architecture. In all examined cases, digital payments are not treated as an auxiliary service but function as a foundational layer enabling transactions across multiple service domains. WeChat Pay, GrabPay, GoPay and KakaoPay operate as interoperable financial instruments tightly coupled with identity systems, service access and third-party integrations. The comparative findings confirm that without an integrated payment layer, platforms struggle to achieve the functional density required for super-app status. Closely related to financial integration is the existence of a platform-based architecture, typically manifested through mini-app or modular service frameworks. All mature super-apps analysed operate as extensible platforms rather than closed applications. WeChat’s mini-program ecosystem represents the most advanced example, allowing third-party developers to deploy services that operate natively within the super-app environment. Grab and Gojek similarly provide modular integration frameworks that enable partners to offer services ranging from food delivery to financial products. Kakao’s platform architecture integrates communication, content and transactional services within a unified ecosystem. Academic literature consistently identifies platform extensibility as a critical differentiator between super-apps and multi-service aggregators, as it enables continuous ecosystem expansion without proportional increases in platform complexity (Lucas & Lopes, 2024). The comparative analysis confirms that mature super-apps function as service orchestration platforms, not merely as collections of internally developed features.

Another core dimension of maturity evident in Table 1 is the openness of the service ecosystem, albeit within controlled governance frameworks. While none of the examined platforms operate as fully open systems, all demonstrate selective openness through APIs, certification mechanisms and partnership models that allow external actors to contribute services while maintaining platform control. The ability to incorporate third-party services

while enforcing technical, security and regulatory standards enables mature super-apps to scale rapidly without compromising platform integrity. The comparative evidence suggests that ecosystem openness is not binary but operates along a spectrum, with mature super-apps occupying a strategically managed middle ground. Service bundling logic emerges as another defining criterion differentiating mature super-apps from less developed platforms. In all analysed cases, services are organised around user life-contexts and everyday needs, rather than institutional or sectoral boundaries. For example, Grab and Gojek integrate mobility, food delivery, payments and financial services in ways that reflect daily consumption patterns, while WeChat embeds communication, commerce and public services into a continuous user journey.

Economic value generation mechanisms further distinguish mature super-app ecosystems from emerging platforms. All platforms examined generate value not only through direct monetisation, such as transaction fees or financial services, but also through indirect mechanisms including data-driven service optimisation, ecosystem participation fees and cross-subsidisation strategies. Studies on super-app economics emphasise that such platforms operate as multi-sided markets, where value creation extends beyond individual transactions to encompass ecosystem-wide efficiencies and innovation incentives (Garcia *et al.*, 2025). The comparative analysis confirms that economic sustainability in mature super-apps is closely tied to their ability to internalise multiple value streams across sectors, reinforcing their central role in digital economies. Another salient criterion evident across all mature super-apps is the integration of identity and trust mechanisms within the platform infrastructure. Digital identity systems, whether explicit or implicit, underpin user authentication, financial transactions and access to services. WeChat’s identity framework, Grab’s verified user profiles and Kakao’s authentication systems collectively illustrate how trust is operationalised at scale within super-app ecosystems. This finding aligns with researches highlighting trust infrastructure as a prerequisite for platform expansion, particularly when financial and quasi-public services

are involved (Hasselwander & Weiss, 2025). The comparative evidence indicates that identity integration is not merely a technical feature but a governance mechanism that enables ecosystem stability and user confidence.

The role of cross-sector integration further differentiates mature super-apps from platforms that remain sector-bound. All examined platforms extend across traditional sectoral boundaries, combining elements of mobility, finance, commerce, communication and in some cases public services. This cross-sector integration reflects a strategic shift from vertical specialisation to horizontal ecosystem control, a trend widely documented in digital platform research (Hasselwander, 2024). The comparative analysis demonstrates that super-app maturity is associated with the ability to operate at the intersection of multiple sectors, thereby embedding the platform into diverse aspects of users' daily lives. Importantly, while these platforms share common structural characteristics, the comparative analysis also reveals contextual variation in how super-app ecosystems evolve. Regional regulatory environments, market conditions and cultural factors shape platform strategies and service configurations. For instance, the prominence of financial inclusion goals in Southeast Asian super-apps reflects regional banking gaps, while communication-centred integration in East Asian platforms reflects different user behaviours and institutional contexts. These variations underscore that super-app maturity does not imply uniformity, but rather convergence around a set of functional and structural principles adapted to local conditions (Ochoa, 2025).

Synthesising the comparative findings from Table 1, the analysis identifies a constellation of interdependent criteria that collectively define mature super-app ecosystems: integrated payment infrastructure, platform-based architecture, controlled ecosystem openness, user-centric

service bundling, multi-channel economic value generation, embedded trust mechanisms and cross-sector integration. Crucially, none of these criteria alone is sufficient to confer super-app status. Instead, maturity emerges from the systemic interaction of these elements within a coherent platform governance framework (Jain & Jain, 2025). The comparative analysis thus provides an empirically grounded basis for distinguishing mature super-app ecosystems from emerging platforms and establishes a reference framework for assessing the developmental gaps of platforms aspiring to super-app status. In the context of this research, the results of this comparative analysis serve two key functions. First, they operationalise the concept of super-app maturity in analytically measurable terms, addressing the conceptual ambiguity identified in the literature. Second, they provide a benchmark against which emerging platforms, including public-sector platforms such as Diia, can be systematically evaluated. By identifying the structural features that enable mature super-apps to function as integrated digital ecosystems, this analysis lays the groundwork for subsequent examination of emerging platforms and the formulation of evidence-based recommendations for public-sector super-app development.

Emerging super-app platforms: A comparative analysis

The comparative analysis of emerging super-app platforms examines the structural and functional characteristics of selected digital platforms that exhibit partial fulfilment of the criteria identified for mature super-app ecosystems (Table 2). By applying these same criteria to emerging selected platforms, which are Uber, Revolut, Glovo and the Ukrainian Diia, this subsection identifies developmental gaps and contextual configurations that differentiate emerging platforms from mature super-app ecosystems and highlights potential pathways for platform evolution.

Table 2. Applying criteria of mature super-apps ecosystems to emerging super-app platforms

Criterion	Uber (USA)	Revolut (UK)	Glovo (Spain)	Diia (Ukraine)
Centralised digital identity	Uber provides a single user account that enables access to ride-hailing, food delivery (Uber Eats) and logistics services, but the identity remains service-centric rather than ecosystem-wide.	Revolut operates a centralised digital identity tightly linked to regulatory compliance, enabling access to banking, payments, investments and crypto services within one account.	Glovo uses a single user profile for food delivery, courier services and grocery purchases, though identity is limited to transactional usage.	Diia provides a state-verified digital identity linked to national registries, enabling secure access to multiple public services through a single government-issued account.
Integrated payment system	Uber integrates payments primarily for in-app transactions related to rides and deliveries, without offering an open financial ecosystem or wallet-based expansion.	Revolut offers a fully integrated digital banking infrastructure including payments, cards, transfers and financial instruments, positioning it as a financial super-app.	Glovo supports in-app payments for services but relies on external payment providers and lacks native financial services.	Diia currently does not provide native payment infrastructure; financial transactions remain external (banks, third-party payment systems).
Multi-sector service integration	Uber has expanded from mobility into food delivery and logistics, but remains concentrated within urban services and lacks broader lifestyle or public integration.	Revolut integrates multiple financial sectors (banking, investments, insurance, crypto) but remains largely confined to the financial domain.	Glovo integrates food delivery, groceries and courier services, focusing on urban consumption rather than cross-sector ecosystems.	Diia integrates administrative services, digital documents, social services and selected business services, covering multiple public-sector domains.

Table 2, Continued

Criterion	Uber (USA)	Revolut (UK)	Glovo (Spain)	Diia (Ukraine)
Platform architecture (mini-apps, APIs)	Uber provides APIs mainly for developers and partners but does not host third-party mini-apps within its interface.	Revolut offers APIs for fintech integrations but maintains a closed ecosystem centred on internal financial services.	Glovo's architecture is service-modular, but does not support third-party mini-applications within the app environment.	Diia is developing interoperability layers (e.g., Trembita) but does not yet support third-party service deployment within the app interface.
Ecosystem openness	Uber partners with restaurants, drivers and logistics providers, yet ecosystem participation is tightly controlled and platform-centric.	Revolut partners with external financial service providers, but access is limited by regulatory and compliance requirements.	Glovo collaborates with merchants and retailers, but integration is transactional rather than ecosystem-driven.	Diia operates as a closed state platform with limited openness to private-sector service integration beyond pilot initiatives.
Institutional embeddedness	Uber operates within regulated transport and labor frameworks but often faces regulatory challenges across jurisdictions.	Revolut is deeply embedded in EU financial regulation, operating under banking licenses and compliance regimes.	Glovo complies with labor, consumer protection and competition regulations but has limited institutional integration beyond commerce.	Diia is fully embedded in Ukraine's public administration system and legally recognised as a national digital governance platform.
Economic value exchange	Uber enables economic exchange primarily through mobility and delivery markets, monetising commissions and service fees.	Revolut facilitates extensive financial value exchange, including payments, investments and asset management.	Glovo generates value through service commissions and merchant partnerships in urban delivery markets.	Diia does not yet generate direct economic value but enables indirect economic effects by reducing transaction costs and administrative barriers.

Source: based on Resolution of Cabinet of Ministers of Ukraine No. 606 “Regulation on Electronic Interaction of Electronic Information Resources” (2016), European Commission (2022), Uber Technologies Inc (n.d.), Revolut Ltd (n.d.), How Glovo works... (n.d.), Ministry of Digital Transformation of Ukraine (n.d.)

A central observation from Table 2 is that while emerging platforms share certain features with mature super-apps, none fully embodies the systemic configuration of a mature super-app ecosystem. Most prominently, integrated payment infrastructure, which is considered as a foundational element of super-app maturity, is present only in its rudimentary forms or in a sector-specific context. In the case of Uber, for example, payment integration is limited to in-app transactions for ride-hailing, delivery and associated services, without the broader wallet-based ecosystem observed in mature super-apps. Although, Uber has introduced in-app wallets and supports multiple payment methods, it does not yet possess a comprehensive digital financial infrastructure that permeates cross-service interactions and third-party transactions. Similarly, the emerging fintech platform Revolut demonstrates a robust integrated payment and financial management framework, offering services such as digital banking, peer-to-peer transfers, savings, investments and cryptocurrency functionality. Revolut's financial breadth is notable and surpasses that of many mature super-apps in the financial domain alone. However, Revolut's integration remains largely confined to financial services and does not extend deeply into non-financial everyday services such as mobility, commerce, or communication. This sectoral limitation reflects a common pattern in the evolution of digital platforms, wherein platforms achieving depth in one functional domain, in this case it's finance, may lack horizontal integration across diverse daily life needs.

In the case of Glovo, which originated as a delivery and logistics platform, the integrated payment functionality is primarily transactional and confined to the pur-

chase and delivery workflow. Glovo enables users to pay for delivered goods within its app, but its payment system does not serve as a broader economy-wide tool that underpins a multi-service digital ecosystem. Unlike the embedded financial instruments of mature super-apps, which act as engines for economic exchange across sectors, Glovo's payment system is a domain-specific facilitator of delivery transactions (Hasselwander, 2024). This example illustrates how emerging private-sector platforms often retain a narrow functional focus despite expanding their service portfolios. In contrast to such market-driven platforms, the Ukrainian public digital platform Diia represents a different trajectory of platform development. Diia offers a unique configuration within the emerging super-app category, as its structural development is rooted in public administration and e-governance rather than in market-driven competition. Diia integrates digital identity, administrative services and access to public records within a single citizen portal, providing an institutionalised platform for state-citizen interaction. Its identity layer, supported by platforms such as BankID, offers secure authentication and critical service access, aligning with the trust mechanisms observed in mature super-app ecosystems. However, Diia currently lacks integrated financial infrastructure and a comprehensive mini-app ecosystem, positioning it as an emerging platform with distinct characteristics reflective of its public mandate.

The application of platform architecture criteria to emerging super-apps reinforces these observations. None of the platforms analysed hosts a broad suite of third-party mini-apps or supports an internal ecosystem where external developers can deploy services as independent

components of a unified interface. Uber's APIs facilitate limited partner integrations, mostly focused on transportation and delivery partners, but do not support a unified mini-app ecosystem within the core platform interface. Revolut's APIs primarily serve financial integrations and Glovo's modular service structure lacks an internal marketplace for third-party developers to contribute new service categories. Diia's architecture, although forward-looking in terms of interoperability frameworks (e.g., Trembita), currently functions as a centralised administrative portal rather than as an open platform accommodating third-party services. This pattern aligns with scientific literature demonstrating that platform architecture capable of supporting mini-apps or third-party modules is a critical determinant of ecosystem extensibility and, ultimately, super-app maturity (Hasselwander, 2024).

The criterion of ecosystem openness further reveals developmental distinctions. Mature super-apps selectively balance openness and control by establishing governance frameworks, certification processes and technical standards for ecosystem participation. In contrast, Uber's and Glovo's openness frameworks are predominantly transactional and partner-centric, reflecting a narrower integration logic. Revolut's openness is bounded within financial networks and fintech integrations, constrained by regulatory requirements and risk management imperatives. Diia's openness is shaped by public governance considerations, where access for private sector services must comply with legal standards, data protection norms and state oversight. These contextual configurations illustrate that ecosystem openness is not a singular structural property but rather a governance construct that varies significantly across platform types and institutional environments.

A salient finding across emerging super-apps concerns service integration and bundling logic. Mature super-apps integrate diverse services in a manner that reflects holistic daily life journeys, reducing friction and enhancing user retention. In contrast, emerging platforms exhibit partial or additive integration, where the range of services – albeit expanding – remains anchored to the platform's core domain. For instance, Uber's service portfolio extends from ride-hailing to food and parcel delivery, but the service transitions remain within the broader mobility and logistics domain, without extending into areas such as finance, communication, or civic services. Revolut's integration spans financial services but lacks adjacent service domains outside finance. Glovo's integration is rooted in delivery, while Diia's integration includes administrative and social services but has not yet expanded into economic transaction and lifestyle domains. This pattern suggests that horizontal integration, spanning distinct sectors aligned with daily life needs, is a hallmark of mature super-apps and its absence in emerging platforms underscores the partial nature of their super-app development.

On the dimension of economic value exchange, emerging platforms present varied trajectories. Uber generates value primarily through service fees, ride commissions and delivery charges, reflecting a transactional economy confined to the platform's primary service offerings. Revolut's economic model includes financial services revenue, interchange fees and subscription services, drawing closer to the multi-sided market logic of

super-apps, yet still constrained by the absence of broad non-financial services. Glovo primarily generates revenue through delivery commissions and marketplace fees and Diia, as a public digital platform, does not directly monetise transactions but facilitates economic and administrative efficiencies. These configurations illustrate that economic value generation in emerging platforms often remains domain-specific, rather than ecosystem-wide, a distinction recognised in digital ecosystem studies that highlight multi-service economic capture as a defining feature of mature super-apps (Hasselwander, 2024; Garcia *et al.*, 2025).

The comparative analysis also reflects institutional embeddedness and regulatory configurations as significant differentiators between emerging and mature super-app ecosystems. While Uber, Revolut and Glovo operate in competitive, market-driven environments subject to heterogeneous regulatory regimes, they lack the deep institutional integration observed in mature super-apps, which often operate across public and private domains with implicit or explicit state sanction. Diia's institutional embeddedness is distinct in that it represents a state-mandated digital platform linked to national governance structures. Although this embeddedness affords high legitimacy and broad citizen reach, it does not automatically confer super-app maturity due to the absence of core structural features associated with ecosystem extensibility, payment integration and economic value exchange. These findings align with public administration publications emphasising the role of institutional context in shaping platform development trajectories (OECD, 2022).

Despite the heterogeneity of emerging platforms, common patterns are evident. First, partial functional integration characterises emerging super-app platforms, wherein service expansion occurs within adjacent domains rather than across diverse sectors. Second, payment infrastructure varies in depth and integration logic, from domain-specific transactional systems to fully integrated financial instruments, but rarely extends to platform-wide economic ecosystems. Third, platform openness and modular architecture remain nascent or constrained by external regulatory and governance conditions. Finally, institutional roles and mandates significantly influence platform configuration, particularly in the public sector context represented by Diia. The comparative analysis of emerging super-app platforms reveals that while these platforms exhibit promising features indicative of evolutionary trajectories toward super-app maturity, they lack the systemic integration observed in mature ecosystems. The partial fulfilment of core criteria underscores the developmental gaps that emerging platforms must address if they are to evolve into fully integrated super-apps. These insights provide the empirical basis for the strategic recommendations developed in the subsequent section of the paper, which outlines targeted pathways for platform evolution, with particular emphasis on the public-sector potential of Diia.

Diia as a potential super-app for a public sector

The emergence of Diia represents a distinctive case in the global evolution of digital platforms, particularly when assessed through the lens of super-app development in the public sector. Unlike market-driven super-apps that evolve

through competitive expansion and ecosystem capture, Diia has been designed as a state-led digital public infrastructure with explicit governance, legal and public value objectives. This difference necessitates a separate analytical framing for evaluating Diia’s potential trajectory as

a public-sector super-app rather than assessing it solely against private-sector benchmarks. Based on the results of previous comparative analysis there were formulated strategic recommendation for advancing Diia to be a public sector super-app (Table 3).

Table 3. Strategic recommendations for advancing Diia toward a super-app for a public sector

Identified gap	Strategic recommendation	Implementation logic	Expected impact
Absence of integrated payment infrastructure	To introduce interoperable payment functionality through partnerships with Ukrainian commercial banks and fintech providers (e.g., PrivatBank, monobank, Oschadbank).	To integrate payment modules using BankID authentication and open banking APIs regulated by the National Bank of Ukraine; enable in-app payments for the wider range of administrative fees, fines and municipal services.	Closing the identified gap should enable fully transactional public services, while maintaining financial-sector neutrality and regulatory compliance.
Lack of platform (mini-app) architecture	To develop a modular platform architecture allowing third-party service modules from certified public and private providers.	To establish a Diia developer platform (SDK), enabling government agencies, municipalities and approved private developers to deploy mini-applications such as local public services, digital permits, or regional administrative tools.	The results should be a transformation of Diia from a service aggregator into a scalable digital platform ecosystem.
Limited ecosystem openness	Introduce controlled API access for selected private service providers including telecommunication operators (Kyivstar, Vodafone Ukraine, Lifecell), insurance companies (f.e. UNIQA), and logistics providers (f.e. Nova Poshta).	To create certification procedures for API access allowing telecom operators, insurance providers, mobility services and municipal utilities to integrate selected services.	The results should expand service availability, while ensuring compliance with national data protection and cybersecurity standards.
No marketplace or service bundling logic	To introduce integrated service packages that combine multiple public and private services around specific citizen needs (f.e. starting a business, purchasing property, or childbirth registration).	To develop digital service scenarios where Diia automatically links related services. For example, a “Start a Business” package could combine company registration (government service), business bank account opening (PrivatBank or Monobank), tax registration and accounting software access.	The impact should be a reduction of administrative fragmentation and improves citizen-centred service delivery.
Weak economic value generation mechanisms	To position Diia as national digital infrastructure supporting entrepreneurship and business services, with cooperation with organizations such as Diia.Business, the IT Ukraine Association, and SME-focused banks like f.e. Ukrsibbank.	To add business-oriented tools within Diia including SME support services, allowing entrepreneurs to manage key administrative procedures within one platform (f.e. digital signature already exist).	The expected impact is enhancing economic activity reduces administrative costs and supports SME participation.
Limited private-sector integration	To establish formal public-private partnership frameworks to integrate private digital services from sectors such as banking, telecommunications, and mobility platforms (f.e., Uber, Uklon, Kyivstar, Bolt).	To introduce public-private digital service agreements, where approved companies integrate selected services through secure APIs under government supervision.	Sustainable ecosystem growth and strengthens cooperation between government and the digital economy should be the results of this implementation.

Source: created by the authors

In this context, Diia exhibits several structural features commonly associated with emerging super-app platforms, including service aggregation, single sign-on functionality, mobile-first design and high-frequency user engagement. However, its development path also reflects constraints and opportunities unique to the public sector, including legal accountability, data sovereignty and non-market incentives. One of the defining characteristics of mature super-app ecosystems is the extensive horizontal integration of services across unrelated domains.

From a digital government perspective, the level of Diia’s functionality of integration aligns with the concept of “whole-of-government platforms”, where user-centric design replaces institutional fragmentation (OECD, n.d). However, unlike private super-apps that continuously expand into lifestyle, commerce and financial services, Diia’s service breadth remains bounded by public mandates, and it also creates a stable and trusted service environment. Research on public digital platforms suggests that trust and legal legitimacy can compensate for slower feature

expansion, particularly in contexts where service reliability and data protection are prioritised over commercial experimentation.

A key gap identified in Table 3 concerns ecosystem openness and third-party integration. Super-app literature increasingly highlights the importance of modular architecture and developer ecosystems in sustaining platform growth (Reuver *et al.*, 2018). Diia has taken initial steps toward this model through the development of application programming interfaces (APIs) and the Diia.Business and Diia.City initiatives, which signal a shift from a closed government application to a broader platform infrastructure. Nonetheless, the integration of private-sector services into Diia remains selective and heavily regulated. This reflects a broader tension in public platform governance between openness and control. Studies on government-as-a-platform models caution that excessive openness can undermine accountability and service equity, while excessive control can limit innovation. Diia's current architecture positions it as a controlled platform intermediary rather than a fully open super-app ecosystem, which is consistent with early-stage public platform development.

Financial services integration is widely recognised as a cornerstone of super-app maturity. In private ecosystems, embedded payments enable seamless transactions and data-driven service personalisation. In Diia's case, financial integration occurs indirectly through interoperability with banking infrastructure rather than through native wallet functionality. This approach reflects a public-value orientation that prioritises neutrality and competition over platform lock-in. Public administration literature suggests that governments integrating financial services into digital platforms must balance efficiency gains with risks related to market distortion and institutional overreach (European Commission, 2023). Diia's reliance on external banking systems can therefore be interpreted not as a deficiency, but as a deliberate governance choice that preserves financial sector plurality while enabling digital service delivery. This hybrid model differentiates Diia from private super-apps and supports its classification as a potential rather than mature super-app.

Another criterion distinguishing mature super-apps is high-frequency daily usage driven by consumer services such as messaging, payments and mobility. Diia's engagement patterns are more episodic, reflecting the nature of public services. However, wartime conditions and emergency-related functionalities have significantly increased usage frequency, demonstrating that contextual factors can temporarily substitute for commercial engagement drivers. Research on civic technology adoption indicates that repeated exposure to reliable digital public services can generate behavioural lock-in comparable to commercial platforms, particularly when digital identity becomes embedded in everyday interactions (OECD, n.d.). Diia's role as the primary digital identity interface in Ukraine positions it uniquely to achieve long-term user retention, even without entertainment or lifestyle services. Perhaps the most distinctive aspect of Diia's potential super-app trajectory lies in its governance model. Unlike private platforms governed by corporate strategy and shareholder value, Diia is embedded within Ukraine's administrative and legal framework. This institutional embeddedness

provides stability and nationwide scalability but limits rapid experimentation. Diia's governance structure aligns with this model, suggesting that its evolution toward a public-sector super-app must be evaluated using criteria adapted to public value creation rather than purely commercial success metrics.

Taken together, the analysis indicates that Diia does not fully meet the criteria of a mature super-app as it is defined for a private sector. However, it demonstrates a coherent configuration of features that justify its classification as a potential public-sector super-app. Its strengths lie in legal legitimacy, identity integration and nationwide adoption, while its limitations reflect deliberate governance choices rather than technological shortcomings. Importantly, Diia represents a prototype of a new category of super-app: one driven by public value, institutional trust and digital sovereignty. This model challenges existing super-app definitions rooted in commercial ecosystems and suggests the need for an expanded theoretical framework that accounts for state-led platform development. The findings of this study contribute to ongoing academic debates on digital platforms, e-governance and super-app ecosystems by demonstrating that existing definitions of super-apps, which is largely derived from private, market-driven platforms, are insufficient for capturing public-sector digital realities. Based on the comparative analysis of mature and emerging super-app ecosystems and the in-depth examination of Diia, the research proposes an authorial definition of a public-sector super-app that reflects institutional, legal and public value dimensions absent from dominant commercial frameworks.

A super-app for a public sector is defined as a state-led, platform-based digital ecosystem that integrates legally binding digital identity, interoperable public services and regulated access to private and financial services within a single user interface, aiming to maximise public value, administrative efficiency and citizen trust rather than commercial profit. This definition emphasises several distinguishing characteristics. First, unlike private super-apps, public-sector super-apps are anchored in legal identity and institutional legitimacy. Digital identity is not merely a convenience feature but a foundational governance mechanism that enables service interoperability, accountability and rights protection. Second, service integration in the public-sector context prioritises functional coherence and social necessity over lifestyle aggregation, reflecting the non-market mandate of the state. Third, ecosystem openness is deliberately constrained and regulated, balancing innovation with data protection, competition neutrality and public oversight. Importantly, positioning Diia as a potential rather than fully mature public-sector super-app avoids conceptual overreach while acknowledging its pioneering role. The proposed definition thus extends super-app theory into the domain of public administration and provides a transferable analytical lens for evaluating similar initiatives in other countries. Overall, the study argues that super-apps for a public sector constitute a distinct category of digital platforms, requiring adapted theoretical criteria and evaluation metrics. Recognising this distinction is essential for advancing both scholarly understanding and evidence-based digital governance policy.

● DISCUSSION

The results of this study reinforce the view that the super-app is not merely a technical artifact, but a new stage in the evolution of digital platforms with significant governance implications. The analysis demonstrates that mature super-app ecosystems are distinguished by comprehensive service integration, unified user identity, embedded payment infrastructure and high-frequency user engagement. In the public sector context, achieving this level of integration faces certain structural challenges. The results of the analysis echoes with findings by N. Jain, & V. Jain (2025), that super-app maturity therefore emerges not from individual technological features but from the systemic interaction of these elements within a coherent platform governance ecosystem. Legal regulations and data protection requirements can limit the openness and extensibility of government digital platforms, making it harder to replicate the fluid ecosystems seen in the private sector.

Comparing obtained results with existing literature reveals both concordance and novel contributions. Notably, there was established a two-tier typology distinguishing “Mature Super-App Ecosystems” from “Emerging Super-App Platforms”. This distinction echoes scholarly observations that super-app development is a dynamic continuum rather than a binary state. M. Hasselwander & D. Weiss (2025), for instance, argued that platforms evolve through degrees of maturity and do not simply flip from non-super-app to super-app overnight. Another important dimension of super-app maturity is the controlled openness of the service ecosystem. The identification of Diia and similar platforms (Uber, Revolut, Glovo) as “emerging” super-apps aligns with this view by illustrating intermediate cases that fulfill some, but not all, super-app criteria. The previous research by M. Hasselwander (2024) highlighted the importance of cross-service integration and financial functionalities in enabling platform expansion and the findings of the research empirically confirm that such features are present only partially in emerging platforms. By systematically comparing Diia to Asian super-app archetypes, the research contributes empirical evidence to support theoretical frameworks like that proposed by D. Lucas & E. Lopes (2024), who called for an ecosystemic perspective in defining super-apps across different contexts. Indeed, the work directly addresses the scholarly call to bridge the study of private and public digital platforms. Few prior studies have explicitly compared commercial super-app ecosystems with government platforms or examined how super-app logic might transfer to the public sector. The results of this research help to fill that gap by analysing Diia through the same analytical lens applied to private super-apps, thereby extending the super-app concept into the realm of public administration.

The findings about Diia validated that it has rapidly incorporated features traditionally found in private super-apps, such as digital payments, a wide service catalog and a growing user base, supporting optimistic views that it is on a super-app. Policy analyses prepared by Digital state UA... (2025) highlighted that the integration of digital identity, public services and financial-sector interactions within platforms such as Diia creates favorable conditions for the development of integrated digital governance

ecosystems. Similarly, the former Minister of Digital Transformation of Ukraine M. Fedorov (2025) argued that consolidating numerous administrative services within a single digital platform simplifies citizen-state interactions and enhances the overall efficiency of public administration. At the same time, the research by W. Lol *et al.* (2025) emphasised that the long-term effectiveness of such platforms depends on collaborative governance and value co-creation processes, where public institutions, private actors and users jointly contribute to service development and delivery. This perspective highlights that further evolution of Diia requires not only technological expansion but also the institutionalization of ecosystem-based collaboration mechanisms. On the other hand, there were also identified structural limitations in Diia’s current model, including its limited openness to third-party services and the nascent stage of cross-sector integration. These gaps mean that while Diia is arguably one of the most advanced public-sector platforms globally, it cannot yet be deemed a fully mature super-app in the way WeChat or Grab are.

The study thereby provides a realistic assessment that complements the enthusiasm of practitioners with critical insight into what is still required for Diia to reach super-app maturity. Based on findings of O. Dorofeev & O. Dubynka (2024) the results are consistent with the view that digital participation tools must be coupled with transparency and accountability measures to translate technical achievements into public trust. In practice, it suggests that any further development of Diia, or similar initiatives elsewhere, should proceed hand-in-hand with strengthening legal safeguards, user education and feedback mechanisms to address citizens’ concerns. As S. Vezzoso (2024) noted, Europe’s regulatory frameworks (e.g., the Digital Markets Act) emphasise contestability and interoperability, which can constrain the emergence of single dominant platforms. Such constraints suggest that a public-sector super-app must navigate a delicate balance between innovation and regulation. Additionally, practical barriers from uneven digital infrastructure to varying levels of digital literacy among citizens, may hinder the full realisation of a super-app in government, so issues that Ukraine has grappled with in rolling out Diia. Overcoming these hurdles requires not only technology but also investments in capacity-building and inclusive design to ensure broad access and trust in the platform.

Despite these challenges, the findings indicate that adopting a super-app approach in the public sector can yield transformative benefits. Diia’s example illustrates how a well-orchestrated digital ecosystem can democratise governance, enhance transparency and improve the resilience of service delivery. In Ukraine’s case, integrating numerous public services into one platform has streamlined citizen-state interactions and maintained service continuity even amid crises. This outcome aligns with the notion that electronic governance tools are not just technical systems, but mechanisms for modernising and strengthening public administration. In particular, Diia’s centralised digital identity and service bundle have fostered greater citizen participation and convenience, supporting the idea that digital platforms can reconfigure the relationship between government and society. Such a perspective resonates with contemporary digital

governance theories. For example, the “government as a platform” paradigm emphasises that the state can act as an ecosystem orchestrator – coordinating various services and stakeholders through a common digital infrastructure to create public value, as mentioned in the work by A. Cordella & A. Paletti (2019). This view was also supported by I. Mergel *et al.* (2019), who argued that digital transformation in the public sector involves a shift toward platform-based governance models that enable cross-sector collaboration and integrated service delivery. The study’s conceptualisation of Diia fits this paradigm, reinforcing arguments that platform-based public services can drive innovation in how government functions. The research defines that a public-sector super-app should be viewed not only as a service delivery tool but as a holistic governance platform that embodies new forms of collaboration, data sharing and citizen empowerment, which is consistent with findings by K. Kolesnikova (2024).

Furthermore, the discussion of security, privacy and governance trade-offs remains pertinent when translating super-apps into the public domain. The research done by Y. Yang *et al.* (2023) cautions that super-app ecosystem regarding heightened privacy and cybersecurity, which might be damaged by with numerous mini-apps. While the study focused on organizational and functional dimensions, these concerns underscore an important limitation and area for future research. Public-sector super-apps will need robust safeguards and regulatory oversight to ensure that integrated services do not compromise data security or equity. For instance, as Diia accumulates sensitive personal data across many services, ensuring compliance with data protection standards and maintaining citizen trust is paramount. The findings implicitly support this caution: the institutional trust and accountability aspect in a government super-app is as critical as technology or design.

In summary, this study has theoretical and practical implications for digital government innovation. Theoretically, the research broadens the super-app concept by framing it within public administration and demonstrating that the ecosystem principles of super-apps can cross into the public sector, albeit with adaptations. This aligns with evolving perspectives in digital governance that encourage viewing government platforms as dynamic ecosystems rather than as isolated e-service portals. The novel definition of a “public-sector super-app” lays groundwork for future research to further refine and test this concept across different countries and contexts. Practically, by examining Diia through the super-app lens, the research provided insights into how governments might pursue greater service integration. The Ukrainian case shows that even under conditions of crisis and resource constraints, a well-designed digital platform can significantly enhance service delivery and citizen engagement. It also highlights that sustaining such an ecosystem requires continuous policy support, innovation and attention to the unique demands of public value (as opposed to profit) generation. Ultimately, the super-app for public sector should be seen as a strategic model for digital governance – one that holds promise for creating more responsive, inclusive and efficient public services, if it is

implemented with careful consideration of context and with robust institutional support.

● CONCLUSIONS

The comparative analysis of mature super-app ecosystems reveals a stable set of criteria that distinguish super-apps from conventional digital platforms. These criteria include comprehensive service bundling, seamless integration of financial services, centralised digital identity mechanisms, strong ecosystem partnerships and high-frequency user engagement. Mature super-apps demonstrate that platform sustainability is achieved not through the expansion of individual services, but through the orchestration of interoperable services within a single user environment. This finding reinforces the view that super-app maturity is determined by ecosystem governance and institutional embeddedness rather than by technological sophistication alone. The examination of emerging super-app platforms indicates that many contemporary digital platforms exhibit partial alignment with super-app criteria but remain constrained by structural, regulatory, or organisational limitations. These platforms typically lack either full-service integration, public-sector interoperability, or advanced governance mechanisms necessary for ecosystem coordination. The analysis highlights that the transition from an emerging platform to a mature super-app requires deliberate strategic alignment across technological, institutional and regulatory dimensions.

Within this analytical framework, the case of Ukraine and the Diia platform occupies a unique position. The findings suggest that Diia cannot yet be fully classified as a mature super-app in the conventional sense; however, it represents one of the most advanced global examples of a public-sector super-app in formation. Unlike private-sector platforms, Diia operates within a public governance logic, prioritising legal validity, inclusivity and state accountability over commercial optimisation. The study demonstrates that Diia already fulfills several core super-app criteria, including unified digital identity, multi-sector service integration and embedded interactions with financial institutions. At the same time, identified gaps, such as limited third-party ecosystem openness and constrained cross-sector interoperability, define its current status as a potential public-sector super-app. Future research should focus on empirical validation of the proposed framework across different national contexts, comparative assessment of public and private super-app governance models and longitudinal analysis of ecosystem evolution in public-sector platforms. Additional attention should be given to regulatory design, data governance and citizen trust as critical determinants of sustainable super-app development in the public sector.

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Теоретичні основи концепції суперзастосунку для цифровізації публічного сектору: досвід України

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Анотація. Метою дослідження було обґрунтування теоретичних засад концепції «суперзастосунку» та оцінювання можливостей її застосування у процесі цифровізації публічного сектору з особливим акцентом на український контекст. Було встановлено, що, попри поширення екосистем суперзастосунків у приватному секторі, в академічній літературі залишалося відсутнім уніфіковане визначення цього поняття, а також бракувало системного аналізу його потенційної ролі в наданні публічних послуг. Для подолання цієї прогалини у дослідженні було застосовано змішаний методологічний підхід, який поєднав порівняльний аналіз, структурно-функціональний аналіз та якісну оцінку міжнародних і національних кейсів. У межах дослідження було здійснено порівняння зрілих екосистем суперзастосунків (WeChat, Grab, Gojek, Какао) з платформами, що перебувають на етапі становлення (Uber, Revolut, Glovo, Diia), з метою визначення ключових критеріїв, які відрізняли повноцінні суперзастосунки від платформ на ранніх стадіях формування екосистеми. Результати аналізу засвідчили, що зрілі суперзастосунки характеризуються глибокою інтеграцією сервісів, наявністю вбудованих інфраструктур цифрової ідентифікації та платежів, відкритістю екосистеми й стабільною залученістю користувачів у різних сферах повсякденної діяльності. Платформи, що перебувають на етапі становлення, лише частково відповідають цим критеріям, виявляючи структурні обмеження, пов'язані з моделями управління, регуляторним середовищем і координацією екосистеми. Застосування запропонованої аналітичної моделі до українського контексту дало змогу розглянути застосунок «Дія» як потенційний суперзастосунок для публічного сектору. Було виявлено, що «Дія» вже демонструє низку визначальних ознак суперзастосунку, зокрема централізовану цифрову ідентифікацію, широке охоплення послуг і масштабне залучення користувачів. За результатами дослідження було окреслені стратегічні напрями подальшої еволюції «Дії» у напрямі становлення суперзастосунком для публічного сектору, що має практичне значення, та було сформульоване авторське визначення поняття «суперзастосунок для публічного сектору», що дозволило розширити теоретичне розуміння платформних моделей цифрового публічного управління.

Ключові слова: цифрове врядування; платформні екосистеми; інтеграція публічних послуг; цифрова публічна інфраструктура; інновації електронного урядування

Artificial intelligence in project management

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Abstract. Artificial intelligence (AI) provides assistance at all stages of project implementation – from planning to achieving specific results and profits. Modelling the practical application of AI tools for various routine and managerial tasks is therefore becoming increasingly relevant. The aim of this study was to examine the role of artificial intelligence and the potential of its tools in project management. The principal research methods were qualitative analysis of academic publications, documents, observations, and web-based content, as well as comparative, generalisation, synthesis, and systemic-logical analyses. Academic publications from 2021-2025 on the research topic were analysed, and studies on the use of artificial intelligence in management were systematised. The websites of companies developing the tools AI, as well as those of reputable international organisations providing project management training, were examined. AI tools developed by leading providers were analysed, and their key characteristics and functionalities were compared. A range of artificial intelligence tools that may be effectively applied in business depending on the project type was also considered. The functionality of each tool and its capabilities for performing specific tasks across various project types were determined. A classification of tools based on project types and objectives was studied. Finally, artificial intelligence tools and possible combinations of several such tools, which can be recommended for practical application, are presented. The practical value of the research results lies in their potential use by managers and specialists to optimise project work

Keywords: sstages of project implementation; artificial intelligence tools; artificial intelligence technologies; performance evaluation; project type; project management tasks

● INTRODUCTION

The integration of artificial intelligence (AI) into various spheres of human activity has become particularly relevant due to the rapid advancement of AI technologies since 2022. Project management has also experienced this transformation, with AI being applied in areas such as risk management, planning, reporting, statistical analysis, and decision support, particularly in routine tasks requiring limited human involvement. The application of AI in project management has encompassed both technical and

organisational dimensions, reflecting its interdisciplinary nature. Consequently, research in this field has been structured across domains such as business, management, technical implementation, and the underlying principles of AI development.

S. Bento *et al.* (2022) conducted a systematic literature review and found that, despite growing academic interest, the practical implementation of AI remained limited, although it improved forecasting, resource allocation, and

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decision-making; however, broader implications for human resource management were insufficiently explored. K. Friedrich (2023) examined project management approaches and demonstrated a shift from traditional metrics to a broader perspective incorporating environmental, social, and long-term impacts, concluding that a more holistic and interdisciplinary approach was required. M. Lee *et al.* (2023) examined AI integration within organisations and found that its successful implementation required not only technological adoption but also organisational transformation, including alignment with strategy, data management, and structural adaptation. T. Fridgerisson *et al.* (2023) investigated the use of AI in project planning, cost estimation, and risk analysis, demonstrating that it effectively supported analytical and forecasting tasks, while project managers retained strategic and communicative responsibilities.

F. Shoushtari *et al.* (2024) analysed AI development methodologies and showed that their application improved decision-making accuracy, resource efficiency, and overall project performance, although further research was required for practical implementation. Q. Liang *et al.* (2024) examined human-AI collaboration and concluded that AI increasingly functioned as a team member, emphasising the need to balance automation and augmentation depending on task complexity and trust. M. Nenni *et al.* (2024) analysed the role of AI in project management and found that its benefits in planning, task optimisation, and decision support were already well established. The authors concluded that AI had transformed project management practices and required the development of digital competencies and a rethinking of professional roles. J. Zhang & A. Dhakir (2025) investigated the adoption of AI across sectors and reported that its implementation had enhanced organisational performance and innovation. The study demonstrated that integrating AI into decision-making and delegating responsibilities had improved employee autonomy, engagement, and productivity. T. Batista *et al.* (2025) explored the role of AI in big data analytics within agile environments and found that its integration with agile practices had improved project performance. The authors concluded that combining AI with business analytics had optimised time, cost, and quality management while supporting organisational sustainability. O. Khilukha (2025) investigated AI tools for automation, data analytics, and predictive modelling, and found that they enhanced planning accuracy and managerial efficiency; however, more advanced AI applications were not addressed. I. Kriskun & A. Bondarchuk (2026) analysed project management effectiveness within modern management frameworks and concluded that AI supported data analysis, forecasting, and decision-making, but it was considered primarily at a conceptual level.

Overall, the reviewed studies demonstrated the benefits of AI while revealing a lack of focus on advanced tools and specific software implementations. The reviewed literature demonstrated that AI was capable of addressing complex and dynamic project management challenges, serving as an effective assistant to managers and specialists. At the same time, the analysis identified certain limitations, as most studies focused primarily on fundamental AI technologies such as chatbots, virtual assistants, machine learning, big data analytics, and predictive modelling. More advanced solutions – including AI-based resource allocation,

risk mitigation platforms, decision support systems, and generative AI – were less frequently examined. Furthermore, the literature tended to address AI at a conceptual level, with limited reference to specific software implementations. Insufficient attention was also given to interdisciplinary integration and practical application, which suggests the need for further research into comprehensive AI solutions for enhancing project management efficiency. The main objective of this study was to present the role of AI and the potential of its tools in project management. To achieve the stated objective, the following tasks were undertaken: the AI tools developed by reputable providers available on the information market were analysed; the functionality of AI tools in project management was examined; and the technologies and AI tools, as well as combinations of several such tools that may be practically applied by managers and company specialists, were identified and presented.

● MATERIALS AND METHODS

The work was conducted in two directions: a literature review to summarise knowledge on the issue under study, and an analysis of existing AI tools for the effective practical use in project management. The keywords “artificial intelligence”, “project management” and “AI tools and technologies” were defined, along with the inclusion and exclusion criteria for the publications selected for the literature review. The search for sources was conducted using the scientific databases Scopus, Web of Science, and Google Scholar, covering the past five years (2021-2025). Scopus and Web of Science were selected due to their high relevance, strict indexing criteria, and widespread use in bibliometric studies. In total, 21 scientific publications were analysed. Their synthesis and interpretation helped to systematise knowledge on this topic. The analysis of publications allowed to proceed to the second direction of the study and establish the role of AI tools in project management.

The other line of work was carried out using qualitative empirical methods, including searching, document analysis, observation, and the classification of AI tools via the Internet. The key characteristics of each AI tool were identified, and their functions were structured based on the project type or optimal role in completing project tasks. For this purpose, qualitative primary data were analysed – specifically, the key characteristics of AI tools presented on the websites of developer companies. Forty-nine functional AI tools were studied. A selection of reliable and effective solutions was identified as illustrative examples to demonstrate the role of AI and the potential of its tools in project management. The selection of AI tools was guided by a structured evaluation framework that prioritised both technical robustness and practical applicability in project environments. Particular attention was paid to three key criteria: functionality for solving key project management tasks, financial accessibility, and data security. These were complemented by additional considerations, including integration capabilities and API availability, usability and ease of implementation. Was also given to the availability of advanced AI functionalities, such as automation, predictive analytics, and decision support.

Each tool was assessed qualitatively against these criteria, with preference given to solutions demonstrating a

strong balance between high functional, accessible pricing, and reliable data protection standards. Tools offering functionality without imposing excessive financial or implementation burdens were prioritised, particularly where they also ensured secure handling of project data and seamless integration within existing digital ecosystems. Overall, the selected tools represent a balanced combination of functionality, economic accessibility, and data security, alongside ease of use and compatibility with cloud-based and collaborative project management practices. The analytical examination of AI tools demonstrated that it is important not only to know which tool can be used to assist in work, but also to understand how to use it and to have sufficient guidance on future innovations and developments from reputable companies. Such knowledge can reduce the costs of important human resources, such as time and energy, and also impact decision-making timelines.

The identification of SWOT components (Strengths, Weaknesses, Opportunities, Threats) was performed through thematic coding of the selected sources, followed by aggregation of recurring concepts into corresponding categories. Strengths were defined as internal advantages of AI implementation (e.g., process automation, improved forecasting accuracy), while weaknesses referred to internal limitations (e.g., integration complexity, dependence on data quality). Opportunities and threats were conceptualised as external factors that respectively facilitate or hinder effective adoption. To enhance the robustness of the findings, cross-source synthesis and comparative analysis of different scholarly perspectives were applied. Several principles for synthesising AI tool combinations were also applied. These include: the principle of functional complementarity (combinations of tools are formed so that each utilises different but complementary functions); the principle of integrating management and analytical functions (for example, combining project management systems with data analysis and forecasting tools allows for the unification of operational management with analytical support); the principle of visualisation and support for collective decisions (ensures better data understanding and facilitates collective decision-making); the principle of automation of operational processes (optimises task distribution, calendar management, and team workload monitoring); and the principle of adaptation to project type (combinations of tools are selected based on the specifics of the industry or project type). These principles provide the rationale for the functional synergy underlying this study. Thus, a synthesis of tools was conducted based on the unification of three key functional blocks: operational project management; analytics and forecasting; and visualisation, communication, and decision support. Their integration enables analytical results to be translated into management decisions, while visualisation and communication ensure the coordination of teamwork.

● RESULTS AND DISCUSSION

The study demonstrated that AI is increasingly being implemented in various areas of project management – from project preparation (stage planning, resource utilisation/allocation, risk forecasting) and real-time implementation (big data analysis, situation assessment, resource control, decision-making) to the delivery of specific

project results (interim and final reports). Research on the functioning and use of AI in the modern world is interdisciplinary in nature. Alongside these tasks, resource control and decision support are also considered key areas of modern project management. However, experts emphasised that the use of AI in such tasks still faces technical and practical challenges (e.g., algorithmic bias, lack of transparency).

According to D. Adamantiadou & L. Tsironis (2025), AI has significantly expanded the capabilities of project management, with machine learning, deep learning, and hybrid models enhancing key project management processes such as cost estimation, schedule forecasting, and risk analysis. A review of 97 publications by the authors found that AI methods improved forecast accuracy, automated decision-making, and optimised project task management during the planning, implementation, and closure stages. However, the authors pointed to several unresolved limitations: the insufficient adaptability of AI models to changing project conditions, their limited validation against initial data, and insufficient research into the application of AI in project lifecycle phases such as the post-project review. By processing large amounts of data at the project planning stage, AI can solve the problem of low accuracy in traditional time and cost forecasting. AI plays different roles across industries. In IT and software development, most studies focus on bug tracking, defect prediction, and effort estimation. Many works have demonstrated that AI tools can successfully classify bug-fixing requests and predict software defects. Effort estimation has attracted the most attention from researchers and the using of various platforms for collaborative project management.

AI contributes to more accurate forecasting and improved project management efficiency, a vivid example of which is ChatGPT. V. Aramali *et al.* (2025) focused primarily on generative AI tools based on large-scale language models. Key tools include ChatGPT, Google Bard/Gemini and Microsoft Bing Assistant. These systems are used to automate project documentation, data analysis, report generation and support project planning and monitoring. While these tools can accelerate management tasks and improve project management efficiency, the authors also note the need for human oversight, as well as consideration of ethical issues, data privacy and organisational adaptation of employees to the use of AI technologies. Researchers are examining the impact of AI tools on decision-making. According to researchers S.M. Ismail & G. Salama (2025), project management information systems (PMIS) are a comprehensive digital environment that integrates tools for collecting, processing, storing and analysing project information to support management decision-making. The authors emphasised that the dynamism of a PMIS is manifested in its ability to integrate various data sources, support team collaboration and provide project managers with up-to-date analytical information for operational monitoring and project progress adjustments. A properly designed PMIS architecture is an important tool for improving project management efficiency and the validity of management decisions. At the same time, process automation through AI presents challenges associated with technical limitations and ethical aspects of AI adoption. Scholars S. Salimimoghadam *et al.* (2025) noted that AI-assisted

process automation was fraught with challenges, interruptions, and technical limitations, as well as other aspects of AI development. Thus, the spread of AI technologies in project management was accompanied by factors including organisations' lack of readiness for digital transformation, limited quality data, a shortage of specialists who ensure competence, and organisational and ethical barriers. Successful integration of AI into project management required the development of digital adaptation, personnel training, and the creation of an appropriate regulatory and organisational environment.

Therefore, the integration of AI with emerging technologies becomes a key factor in achieving sustainable project management. Scholar M. Aslam (2025) noted that the introduction of AI technologies into project management has created new approaches to planning, analysing

and monitoring project activities. The author noted that the integration of machine learning algorithms, analytical platforms and intelligent decision support systems improves the efficiency of strategy management and project implementation. At the same time, the researcher emphasised the need for scientific research aimed at integrating AI into project management methodologies, as well as the need for new competencies from specialists in this field. AI technologies have begun to be widely used in project management. Of course, AI tools continue to grow rapidly, with new ones being developed and improvements constantly being made. It is difficult to keep up with innovations in such a rapidly evolving field, and it is practically impossible to present the entire spectrum of available tools in a single paper. Therefore, Table 1 presents only some of the AI tools for optimising key project management tasks.

Table 1. The AI tools by area of use

The main function in project management	AI tools and technologies	Features and additional functions
Project management in marketing	ClickUp	Allows structuring projects, assigning roles, tracking time, sharing files, and communicating in real time, ensuring process transparency. More suitable for marketing
Agile project management in software development	Jira AI	Task management and role assignment in the IT field. Integration with other tools (Confluence, Slack, GitHub)
A universal tool for project management in large teams	Wrike	Unlike Jira and ClickUp, it allows managing projects in any field. However, it comes at a higher cost compared to other options
Creating visual reports based on existing data	Mokkup.ai	Rapid creation of data visualisations based on existing information
Analysis of large amounts of data for forecasting and pattern identification	WEKA	Forecasting project success and stages, identifying risks and problem areas, and supporting decision-making
Visualisation and tracking of tasks for real-time team collaboration	Miro AI	Creates charts, task maps, and visualises the entire project. Integrates with Jira, Asana, Slack, and other external tools
Management of testers' work and bug tracking	Backlog	A workspace for tracking bugs
Automates routine tasks and is well-suited for creating Gantt charts	Monday	Smart automation summarises text, highlights key points, and performs translations. Makes creating Gantt charts easy
Accelerates decision-making, provides project data analytics, automates processes, and tracks individual employees' KPIs	Smartsheet	Summarises project work, generates forecasts, and can track the performance of individual employees
For group decision-making: facilitates discussion and voting	Loomio	The platform enables collaborative decision-making through structured discussions and surveys. It integrates with other tools and systems
Assessment of project participants' workload	Motion AI	Evaluates participants' workload, assigns tasks based on available hours, and optimises resources
KPI visualisation and project monitoring, creation of interactive dashboards	Tableau	Creates interactive dashboards with statistics for the entire project

Source: created by the authors based on Atlassian (n.d.), Backlog (n.d.), ClickUp (n.d.), G2 (n.d.), Loomio (n.d.), Miro (n.d.), MOGE (n.d.), Mokkup.ai (n.d.), Monday.com (n.d.), Motion (n.d.), Smartsheet (n.d.), Tableau (n.d.), WEKA (n.d.), Wrike (n.d.), M. Rebelo (2026), G. Low (2026)

The classification of AI tools was examined by distinguishing between AI-native solutions and AI-enhanced systems, as they perform different roles in project management. The following are examples of such tools. AI-native solutions (WEKA, n.d.; Motion, n.d.; Mokkup.ai, n.d.) are based on AI algorithms and are characterised by a high level of automated analysis and decision-making. They are used for analysing large data sets, machine learning, forecasting, and automatically generating recommendations. AI-enhanced systems (ClickUp, n.d.; Wrike, n.d.; Monday.com, n.d.; Smartsheet, n.d.; Tableau, n.d.; Miro, n.d.; Loomio, n.d.; Backlog, n.d.) are traditional digital systems that have been subsequently integrated with

AI functions. They support user work, while key decisions are made by the manager. Their functions include task management, teamwork facilitation, and document and process management.

This distinction allows for a more accurate description of the role of AI in project management. AI-native solutions generate analytical knowledge, with AI serving as the core of such systems' functioning. AI-enhanced systems provide practical applications in project planning, implementation, and monitoring, with AI performing additional or supporting functions. Thus, AI in project management operates at two levels: the intellectual and analytical level (provided by AI-native solutions – analysis, forecasting,

recommendations) and the organisational and managerial level (implemented by AI-enhanced project management systems and platforms – process organisation, team coordination). The study examined the classification of AI tools based on their functional roles in project management, revealing how different solutions support specific stages and processes across the project lifecycle. The proposed technological and software solutions (Table 1) were shown to exert a targeted influence on key project management parameters – namely time, cost, and quality – through the implementation of specialised functional mechanisms at each stage. Overall, the findings demonstrate that AI tools form an integrated system that enhances both the analytical and operational dimensions of project management, augmenting rather than replacing the role of the project manager.

At the initiation stage, the project manager defined project objectives, identified stakeholders, and facilitated early discussions. Project management platforms supported the structuring of initial project frameworks, role allocation, and coordination of early workflows. In parallel, collaboration enabled structured communication, collaborative idea generation, and visual representation of project concepts. These functionalities reduced ambiguity in project scope, improved decision-making quality, and indirectly contributed to cost control by preventing scope creep at later stages. During the planning stage, the project manager focused on developing detailed schedules, allocating resources, and assessing risks. AI-enabled tools supported task structuring, workload optimisation, and predictive analytics. Additionally, platforms such as Smartsheet (n.d.) enabled forecasting and performance modelling. The use of backlog prioritisation, sprint planning, and data-driven risk assessment improved the accuracy of time estimates, enhanced cost efficiency through optimised resource allocation, and strengthened quality through risk-informed planning.

At the execution stage, the project manager coordinated team activities, ensured task completion, and maintained communication among stakeholders. Tools such as Jira (Atlassian, n.d.) and Backlog (n.d.) played a central role in workflow management, task tracking, and agile coordination. Real-time updates and integration capabilities facilitated rapid responses to emerging issues, reducing delays and associated costs. In addition, collaborative platforms such as Miro (n.d.) enhanced team interaction, while systematic bug tracking and task verification processes contributed to improved quality and accountability. During the monitoring and control stage, the project manager

tracked performance, analysed progress, and implemented corrective actions where necessary. Data visualisation and analytics tools, including Tableau (n.d.), Mokkup.ai (n.d.), and Smartsheet (n.d.), enabled the monitoring of key performance indicators, forecasting, and the identification of deviations from planned schedules and budgets. These capabilities supported timely interventions, thereby mitigating time and cost overruns, while enhancing quality through continuous performance evaluation and data-driven decision-making.

At the closure stage, the project manager evaluated project outcomes, documented results, and ensured knowledge transfer. Analytical and reporting tools such as Tableau (n.d.) and Smartsheet (n.d.) facilitated the preparation of final reports, visualisation of outcomes, and synthesis of insights. This contributed to organisational learning, improved the quality of future projects, and enabled a more accurate assessment of cost performance and schedule adherence. In addition, cross-cutting tools such as Loomio (n.d.), Miro (n.d.), and Motion (n.d.) played a significant role across all stages of the project lifecycle. These solutions enhanced communication, supported collective decision-making, and optimised workload distribution, thereby simultaneously improving time efficiency, cost control, and overall project quality.

Overall, the classification demonstrated that different categories of AI tools formed an integrated system for supporting project management processes across the entire project lifecycle, with clearly identifiable roles at each stage and a direct causal relationship between their functionality and improvements in time, cost efficiency, and project quality. Together, these tools and technologies create an AI-supported project management system that covers project planning, execution, analysis, and control. When selecting AI tools for this purpose, it is important to consider a number of key factors, starting with defining clear business objectives, such as network automation, communication, task allocation or forecasting. At the same time, it is necessary to consider the team's current workflow and structure, taking into account legacy methodologies and internal organisation. It is also important to test the capabilities of new solutions to ensure their full compatibility with existing tools and lifecycles. Based on these considerations, Table 2 presents examples of AI tool combinations tailored for different types of projects, demonstrating how specific tools can be effectively linked to achieve project objectives.

Table 2. Examples of AI tool combinations for different project types

Project Type/Task	Recommended AI Tools	Description
Marketing Project Management	ClickUp + Miro + Loomio + Mokkup.ai/WEKA	ClickUp will serve as the primary workspace, while Miro and Loomio will support visualisation and decision-making, drawing on data presented through Mokkup.ai or WEKA, depending on the volume of data
Project management in creative industries	Wrike + Miro + Loomio + Mokkup.ai	Wrike will serve as the main workspace for project management in creative industries, while Miro and Loomio will be used for visualisation and decision-making support, based on data visualised with Mokkup.ai
Project management in software development	Jira + Monday + Motion.ai + Smartsheet	Jira will serve as the main workspace for software development project management, Monday and Motion.ai will automate routine tasks and optimise scheduling, while Smartsheet will provide data analytics, forecasting, and KPI tracking for each member of a team

Table 2, Continued

Project Type/Task	Recommended AI Tools	Description
Data Analysis and Forecasting	WEKA + Smartsheet	WEKA is used for data analysis and forecasting, identifying patterns and predicting outcomes, while Smartsheet translates this information into project plans
Data Visualisation & Reporting	Mokkup.ai + Tableau	Mokkup.ai is used to rapidly create visual representations of data, while Tableau transforms these visuals into interactive dashboards for project monitoring, KPI tracking, and reporting
Bug Tracking & QA Management	Backlog + Motion.ai	Backlog is used to manage testers' work and track bugs, while Motion.ai helps optimise task allocation and team workload, ensuring efficient QA management

Source: created by the authors based on Atlassian (n.d.), Backlog (n.d.), ClickUp (n.d.), G2 (n.d.), Loomio (n.d.), Miro (n.d.), MOGE (n.d.), Mokkup.ai (n.d.), Monday.com (n.d.), Motion (n.d.), Smartsheet (n.d.), Tableau (n.d.), WEKA (n.d.), Wrike (n.d.), M. Rebelo (2026), G. Low (2026)

Taking into account the specifics and type of projects, it is possible to combine different tools (Table 2). Developers continue to create new AI tools and improve existing ones, increasing the efficiency of specific areas of project management. Methods are being developed to integrate AI tools for use by managers to automate many routine business processes, eliminate management uncertainty (time, cost, quality, and resources), ensure accurate decision-making, and improve overall project success. They combine information and engineering developments, as well as the integration of knowledge in the field of organisation and management. This requires a strategic approach to managing business processes using AI tools, attention to data protection, ethical aspects of application, and personnel training (training managers and company specialists). Moreover, particular attention should be paid to the potential risks.

F. Abuamria *et al.* (2024) also drew attention to the risks associated with data security and job security. The authors emphasised that technologies such as AI, cloud services, big data, data transfer, and digital collaboration platforms enable organisations to manage projects effectively across countries and time zones. Their findings indicated that these technologies significantly improve the efficiency of project planning, implementation, and communication. However, they also create new challenges, particularly in the areas of intercultural communication and the development of soft skills. This has created a need for project managers to acquire new technological competencies and for organisations to invest in continuous training to ensure the development of information technology. Researchers discuss barriers and strategies to overcome these obstacles in AI implementation. According to A. Kiani (2024), AI plays a key role in managing entrepreneurial projects, improving planning, forecasting, and decision-making processes in conditions of high uncertainty and resource constraints. The author examined the role of AI in strategic and tactical projects, proposed a conceptual model for using AI to optimise project management, and produced a paper that provides a foundation for further study of its application. The researcher also noted barriers and strategies for mitigating limitations in the implementation of AI. Researchers M. Méndez-Suárez *et al.* (2025) noted that the spread of AI technologies in the workplace has created a phenomenon called “FOMO” – a level of tension or fear among workers about missing out on opportunities associated with the use of AI. This

phenomenon in workers’ professional behaviour, which has stimulated their exploration of AI technologies, has simultaneously led to increased stress, psychological strain and professional insecurity. Thus, the implementation of AI in organisations requires not only technological but also management solutions aimed at supporting employees and maintaining a balanced work environment.

D. Herath *et al.* (2025) analyse the use of different types of AI tools in business management education. The study focuses on generative language models, AI-powered content retrieval systems and text paraphrasing tools. The study examines the ecosystem of AI tools, including content generation, transformation and retrieval, to compare the effectiveness of AI and humans in performing business management tasks. The authors used an exploratory qualitative design with comparative text analysis, including the generation, evaluation and detection of AI-generated essays alongside human works, as well as the use of tools for assessing the quality and identifying AI content in the educational environment. This approach allowed for a comprehensive comparison of the performance of modern large language model systems with that of humans in standardised educational assessments. The researchers noted that, although AI tools can effectively solve a number of business management and process learning tasks, they are unable to fully utilise the human factor. AI has demonstrated high performance in information processing, data analysis and automation of routine processes, but important aspects such as critical thinking, creativity, emotional intelligence and ethical decision-making remain the domain of humans.

Data privacy, information security, and maintaining human oversight remain essential considerations. D. Vergara *et al.* (2025) conducted a large-scale bibliometric analysis of publications over the past 10 years, focusing on the main thematic areas of AI use in project management, including embedded machine learning, decision support, information management, and resource optimisation. The authors concluded that the integration of AI into project management has fundamentally transformed the processes of project planning, execution, and control, and has become a promising area for improving project management effectiveness. According to the authors, AI has not only expanded the toolkit of project managers but also shaped new promising areas of research and practical training in project management. The conclusions drawn by the scholars in the reviewed studies align with the observations

made in this research. To provide a more comprehensive and structured evaluation of the implementation of AI in project management, a SWOT analysis was conducted and

complemented by an expanded discussion of implementation barriers and the transformation of the project manager's role within the "Augmented PM" concept (Table 3).

Table 3. SWOT analysis of AI implementation in project management

Strengths	Weaknesses
<p>Improved accuracy of forecasting (costs, timelines, risks) through advanced data processing and machine learning.</p> <p>Automation of routine tasks, increasing efficiency and reducing managerial workload.</p> <p>Enhanced decision-making through analytical and decision support systems.</p> <p>Real-time monitoring, resource optimisation, and improved coordination of project teams.</p> <p>Support for digital transformation and interdisciplinary project environments.</p>	<p>Limited adaptability of AI models to dynamic and uncertain project environments.</p> <p>Dependence on the quality, availability, and consistency of data.</p> <p>Limited transparency and explainability of AI systems ("black box" issue).</p> <p>Fragmented integration of AI tools across project lifecycle stages.</p> <p>Underutilisation of advanced AI tools in practical applications.</p>
Opportunities	Threats
<p>Integration with emerging technologies (IoT, blockchain, cloud computing) to enhance project performance.</p> <p>Development of AI-native and AI-enhanced systems tailored to industry-specific needs.</p> <p>Expansion of AI applications in predictive analytics, automation, and decision-making.</p> <p>Increased efficiency through the combined use of multiple AI tools.</p> <p>Growing demand for new competencies, including AI literacy among project managers.</p>	<p>Data privacy and cybersecurity risks associated with AI adoption.</p> <p>Ethical concerns, including algorithmic bias and accountability challenges.</p> <p>Organisational resistance to change and low levels of digital readiness.</p> <p>"FOMO" (fear of missing out), contributing to employee stress and professional insecurity.</p> <p>Over-reliance on AI, potentially weakening critical thinking and human judgement.</p>

Source: created by the authors

The SWOT analysis (Table 3) demonstrated that AI offered substantial advantages in improving project efficiency, decision-making, and automation, while also presenting notable limitations related to technical constraints, data dependency, and integration challenges. At the same time, significant opportunities were identified in the expansion of AI applications and integration with other digital technologies; however, these were accompanied by critical threats, including data security risks, ethical concerns, and the psychological impact on employees. This structured evaluation provided a holistic understanding of AI implementation in project management and supported more informed managerial decision-making. Thus, the study demonstrated the growing role of AI in modern project management. AI, along with blockchain and the Internet of Things (IoT), is being applied in various sectors under conditions of globalisation – for instance, in construction, energy, healthcare, and information technology. The results show that these technologies significantly enhance planning, execution, and communication efficiency in projects. However, they also introduce new challenges, particularly in intercultural communication and the development of interpersonal skills. This creates the need for project managers to acquire new competencies and for organisations to invest in continuous learning to ensure effective technology adoption. Further research in the development and implementation of AI tools is becoming increasingly important for fully use its potential to improve the efficiency and success of real-world management projects.

● CONCLUSIONS

The study confirms that AI is becoming an important component of modern project management and is being actively integrated into different stages of the project lifecycle. The analysis demonstrated that AI technologies can significantly enhance project planning, implementation, monitoring and reporting processes. Through the processing of large datasets and the use of machine learning algorithms, AI improves the accuracy of forecasting, supports decision-making, optimises resource allocation and enables more effective monitoring of project performance. As a result, organisations gain opportunities to increase productivity, transparency and the overall efficiency of project activities, while also achieving improvements in time management, cost optimisation and quality of outcomes. A key contribution of the study lies in demonstrating the capabilities of AI and the practical potential of its tools to enhance project management processes across diverse application contexts. The study demonstrates that the effectiveness of AI adoption increases when tools are selected according to their functional roles and combined to create integrated management environments. In this context, the distinction between AI-native solutions and AI-enhanced systems allows for a clearer understanding of how AI operates within project management structures.

AI-native solutions primarily perform analytical and forecasting functions, while AI-enhanced platforms support organisational coordination, task management and collaboration within project teams. The proposed

classification of AI tools and examples of their functional combinations illustrate how different technologies can complement each other and create a synergistic system that supports the main stages of the project lifecycle. At the same time, the study highlights several challenges related to the implementation of AI in project management. These include technical limitations of algorithms, the need for high-quality data, organisational readiness for digital transformation, as well as ethical and security considerations. Effective integration of AI technologies therefore requires continuous staff training, the development of digital competencies among project managers and the establishment of appropriate organisational and technological infrastructures. Future research may focus on the empirical

evaluation of AI tool effectiveness in different industries, the development of integrated AI-based project management frameworks and the exploration of human-AI collaboration models that ensure both technological efficiency and sustainable organisational development.

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Штучний інтелект в управлінні проектами

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Анотація. Штучний інтелект (ШІ) надає допомогу на всіх етапах реалізації проекту – від планування до досягнення конкретних результатів та прибутку. Тому моделювання практичного застосування інструментів ШІ для виконання різних рутинних та управлінських завдань стає дедалі актуальнішим. Метою даного дослідження було вивчення ролі штучного інтелекту та потенціалу його інструментів у сфері управління проектами. Основними методами дослідження були якісний аналіз наукових публікацій, документів, спостережень та веб-контенту, а також порівняльний аналіз, узагальнення, синтез і системно-логічний аналізи. Проаналізовано наукові публікації за 2021-2025 роки з теми дослідження та систематизовано дослідження щодо використання штучного інтелекту в менеджменті. Було вивчено веб-сайти компаній, що розробляють інструменти ШІ, а також авторитетних міжнародних організацій, які проводять навчання з управління проектами. Було проаналізовано інструменти ШІ, розроблені провідними постачальниками, та порівняно їхні ключові характеристики та функціональні можливості. Також було розглянуто низку інструментів штучного інтелекту, які можуть бути ефективно застосовані в бізнесі залежно від типу проекту. Було визначено функціональність кожного інструменту та його можливості щодо виконання конкретних завдань у різних типах проектів. Вивчено класифікацію інструментів на основі типів та цілей проектів. У завершених представлено інструменти штучного інтелекту та можливі комбінації декількох таких інструментів, які можна рекомендувати для практичного застосування. Практична цінність результатів дослідження полягає в можливості їх використання менеджерами та фахівцями для оптимізації проектної роботи

Ключові слова: етапи реалізації проекту; інструменти штучного інтелекту; технології штучного інтелекту; оцінка ефективності; тип проекту; завдання управління проектами

Functional aspects of the National Bank of Ukraine's activities in the field of insurance market regulation

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Abstract. The relevance of the study was due to the growing systemic role of the insurance market in the financial system of Ukraine and the need to increase the efficiency of financial supervision in the context of the concentration of regulatory powers in the National Bank of Ukraine. The purpose of the article was to substantiate the role of insurance market regulation as a component of a unified financial risk management system and to determine the management logic of the implementation of the regulatory, supervisory, control and protective functions of the central bank. The research methodology was based on a comprehensive analytical approach that combined systemic and structural-functional analysis with a comparative study of insurance regulation models in Ukraine, Poland, Germany, and Romania. As a result of the study, it was established that the insurance market of Ukraine performed a dual function of a financial shock absorber and an institutional investor, forming several channels of systemic risk through investment, group and behavioural connections with other segments of the financial sector. It was found that the objectives of state regulation of the insurance market – financial stability, solvency of insurers and consumer protection – formed a hierarchically interconnected risk management system, within which solvency acted as a functional condition of stability, and consumer protection – the basis of trust in the market. It was shown that the regulatory and supervisory instruments of the central bank were focused on preventive risk identification and differentiation of supervisory influence, but the practical effectiveness was limited by the heterogeneous financial capacity of insurers and the formalisation of risk management systems. The comparative analysis showed that in Poland and Germany, risk-oriented and proportional supervision was characterised by higher institutional maturity, while the experience of Romania demonstrated the risks of formal harmonisation of regulatory standards without proper institutional adaptation. The practical significance of the study was the possibility of using the obtained results to improve proportional and risk-based supervision, develop analytical tools of the regulator and increase the stability of the insurance market of Ukraine in the context of European integration

Keywords: financial supervision; risk-based approach; financial stability; risk management; behavioural supervision

● INTRODUCTION

The insurance market is an element of the state's financial system, as it ensures the redistribution of risks, promotes financial stability and performs a social function of protecting the property interests of the population. In Ukraine, its role is strengthened in conditions of economic instability, military risks and an increasing need for financial mechanisms for compensation for losses. Under such conditions, state regulation of insurance activities plays a key role in the functioning of the insurance market. The transfer of

powers to regulate the non-banking financial sector to the National Bank of Ukraine (NBU) in 2020 changed the institutional model of insurance supervision, which necessitates the scientific understanding of the functional aspects of the NBU's activities in the field of insurance market regulation (Law of Ukraine No. 1953-IX, 2021).

Researcher L.V. Fedoruk (2025) found that the dispersion of supervisory powers and insufficient coordination between regulators led to the accumulation of financial

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risks in the activities of insurance companies. The author concluded that in the absence of a single regulatory centre, control over the solvency of insurers was inconsistent, and regulatory decisions were often formal in nature, which negatively affected the stability of the insurance market and the level of trust of insurance consumers in Ukraine. O. Polova (2022) established that the dominance of the formal regulatory approach did not ensure the timely detection of financial imbalances in the insurance sector. The author justified the feasibility of switching to risk-based regulation, which was intended to focus on assessing the real risks of insurers' activities. A. Prylutskiy (2020), analysing the development of the insurance market of Ukraine, concluded that the implementation of such an approach contributed to the gradual cleansing of the market from financially weak companies and stimulated an increase in the quality of insurance services. After the start of the financial supervision reform, the attention of scientists focused on the role of the central bank in ensuring the stability of the financial sector. V. Shkurko (2024) argued that the concentration of regulatory functions in the National Bank of Ukraine made it possible to form a more comprehensive system of financial risk assessment. The author noted that the integration of the insurance segment into the general system of financial supervision contributed to increased consistency of regulatory decisions.

In their work, O. Prokopchuk *et al.* (2022) analysed the trends in the functioning of the insurance market in Ukraine in the context of the transformation of the financial supervision system. The authors showed that the expansion of the regulatory and macroprudential powers of the National Bank of Ukraine affected the structure of the non-banking financial sector, while noting that the practical implementation of these approaches in insurance required further regulatory clarification and adaptation to the specifics of insurance business models. The adaptation of Ukrainian insurance legislation to international standards was the subject of analysis by O. Zharikova & K. Cherkesenko (2021), who studied the integration processes in the activities of banks and insurance companies in Ukraine. The authors concluded that the harmonisation of regulatory requirements with European Union norms was accompanied by increased requirements for capitalisation, corporate governance, and financial discipline of market participants. S. Yehorycheva *et al.* (2020) focused on the impact of innovations and international standards on the development of the Ukrainian insurance market. Researchers found that the implementation of international approaches to insurance supervision was associated with increased transparency in the activities of insurance companies, pointing out the dependence of the effectiveness of such changes on the practice of implementing regulatory functions at the national level. I. Allahverdiyeva (2022) studied the introduction of the insurance ombudsman institution as an element of the consumer protection system in the insurance market of Ukraine. The author found that the functioning of an independent complaint review mechanism contributes to increasing trust in insurance institutions and reducing conflicts between insurers and clients. At the same time, the effectiveness of such a tool depends on the institutional conditions for the functioning of financial supervision and the consistency

of interaction between the regulator and the mechanisms for out-of-court dispute resolution.

Thus, the analysis of scientific sources showed that the functional aspects of the activities of the National Bank of Ukraine in the field of insurance market regulation remained insufficiently comprehensively covered. Most studies have focused either on the general principles of insurance regulation or on the role of the NBU in the financial system as a whole, without an in-depth analysis of the relationship between its functions and the development of the insurance market. This study aimed to reveal the functional aspects of the activities of the National Bank of Ukraine in the field of insurance market regulation and assess the significance for ensuring the stability of the insurance sector. To achieve this goal, the following research tasks were defined: to analyse the regulatory framework for the regulation of the insurance market by the National Bank of Ukraine; to characterise the key functions and instruments of the NBU's regulatory influence on the activities of insurers; to determine problematic aspects and possible directions for improving the regulation of the insurance market of Ukraine.

● MATERIALS AND METHODS

The study was conducted as a theoretical and analytical one with elements of institutional and comparative analysis and was aimed at studying the regulation of the insurance market as a component of the financial supervision system. The chronological boundaries of the study covered the period 2020-2025, that is, the stage of the functioning of the National Bank of Ukraine as a mega-regulator after the transfer of powers to it in the field of supervision of non-bank financial institutions. Territorially, the study was focused on Ukraine using comparative material from individual countries of the European Union. An analysis of the objectives of insurance market regulation and the legal basis for the activities of the National Bank of Ukraine as a mega-regulator in the context of the financial supervision system of Ukraine was carried out. The materials used were regulatory and analytical sources that determine the management logic of insurance market regulation and the practice of financial supervision. These included the provisions of the current legislation of Ukraine, in particular Law of Ukraine No. 1953-IX (2021), which established the institutional model of financial supervision and the powers of the regulator, as well as analytical materials of the NBU (Sirenko, 2021; National Bank of Ukraine, 2024), which allowed assessing the development trends of the insurance sector and the risks associated with it. To analyse the objectives and principles of insurance supervision, international standards and recommendations in the field of insurance regulation prepared by the International Association of Insurance Supervisors (2023; 2024) and the European Insurance and Occupational Pensions Authority (n.d.) were additionally used.

The problems of the functioning of the insurance regulation system were also studied based on modern scientific publications devoted to the implementation of Solvency II requirements, distribution risk management in the context of digitalisation and validation of internal solvency assessment models (Marano, 2021; Borgonovo *et al.*, 2024; Bulantsov, 2025). In addition, a comparative analysis of

approaches to insurance regulation in Poland, Germany, and Romania was conducted based on official documents of national insurance supervisory authorities. For Poland, the report of the Polish Financial Supervision Authority (2023) on the activities of financial supervisory authorities in 2023 was used, for Germany, the annual report of the Federal Financial Supervisory Authority (2025), for Romania, the current Law of Romania No. 236/2018 (2018). As part of the comparison, Ukraine was also analysed based on the provisions of the Law of Ukraine No. 1953-IX (2021), relevant regulatory acts of the National Bank of Ukraine, and analytical reports of the regulator on the state of the insurance market (Sirenko, 2021; National Bank of Ukraine, 2024).

The study used qualitative content analysis and a comparative approach to assessing modern challenges in insurance regulation. The empirical basis was scientific publications and analytical materials (2020-2025) covering the implementation of Solvency II requirements and risk-based supervision, the development, and validation of internal models (in particular, the role of sensitivity analysis and stress testing), as well as regulatory gaps in the field of digital distribution and behavioural supervision. The comparative analysis of insurance regulation models in Poland, Germany, Romania, and Ukraine was carried out according to unified criteria: the model of insurance supervision organisation; application of prudential requirements within the framework of Solvency II; use of a risk-based approach; the presence and development of behavioural supervision elements. The identified criteria ensured methodological consistency of the study and the possibility of comparing national approaches to insurance regulation. According to the results of the analysis, the defined problems were systematised into the matrix “problem area – nature of manifestation – potential consequences – priority direction of improvement”, which was reflected in Table 6, and directions for overcoming these problems and recommendations for improving the regulatory model in Ukraine were also formulated.

● RESULTS

The role of insurance regulation in financial supervision

A detailed analysis has shown that the Ukrainian insurance market plays a dual role in the financial supervision system: (1) as a financial “shock absorber” mechanism for

households and businesses (compensation of losses, reduction of the need for budget expenditures), and (2) as an institutional investor that accumulates long-term resources and places these resources in financial instruments. It is this duality that makes the insurance sector not just a “services market”, but a channel for risk transmission between the real sector and the financial system. The integration of insurance regulation into the architecture of financial supervision means that the stability of insurers affects the stability of the broader financial environment. This is primarily manifested in the interdependence of assets and liabilities: insurers form reserves for future payments, and the quality of the assets in which these reserves are invested determines the ability to meet obligations (International Association of Insurance Supervisors, 2023). If the system contains instruments with increased risk (credit risk, interest rate risk, liquidity risk), then the insurance sector is able to amplify negative shocks (due to forced asset sales, payment delays, reputational losses and “chain” distrust of financial institutions) (International Association of Insurance Supervisors, 2024).

The relationship with the banking sector in the supervisory system is manifested through several channels: the investment channel: a significant part of insurers’ assets may be related to banking instruments (deposits, bank bonds, accounts, settlement infrastructure); the financial group channel: the presence of business relationships within groups, agency networks, financial intermediation; the trust channel: the insurer’s problems are quickly transmitted to expectations regarding other financial institutions, especially if products are sold through common channels (National Bank of Ukraine, 2024). The insurance market is connected to non-bank segments (financial companies, credit unions, pension institutions) due to common risk profiles, competition for resources and clients, and the fact that violations of transparency and corporate governance standards in one segment often signal similar problems in others. Therefore, supervision of insurers in Ukraine is logically considered as part of a single risk management of the financial sector, and not just “industry control” (International Association of Insurance Supervisors, 2023). To systematically explain why insurance regulation is an element of financial supervision, it is advisable to decompose the relationships into risk channels and corresponding management (supervisory) emphases (Table 1).

Table 1. The relationship between insurance regulation and elements of financial supervision through systemic risk channels

Interaction segment	Communication channel	Potential systemic risk	What should supervision consider?
Banking sector	Investing insurers’ assets in banking instruments; settlement infrastructure	Concentration of risk in individual instruments; liquidity risk under stress	Concentration limits; asset quality; liquidity/market risk stress testing
Real sector	Insurance payments and loss coverage; liability, property, agricultural risk insurance	“Failure” of insurance coverage → increasing business/population losses, budget pressure	Sufficiency of reserves; tariff adequacy; quality of loss settlement
Other non-bank financial institutions	Competition and customer flows; shared sales channels	Regulatory arbitrage; “spill-over” of problematic practices	Uniform transparency standards; compliance; control of business models
Financial groups	Intra-group transactions, related parties	Hidden risks, capital withdrawal	Related party control; transfer transactions; consolidated supervision
Financial services consumers	Trust and expectations; information asymmetry	Mass complaints, reputational crises, customer churn	Disclosure standards; protection of rights; oversight of conduct

Source: compiled by the author based on International Association of Insurance Supervisors (2023; 2024)

The insurance sector creates not one, but several channels of systemic risk (liquidity, concentration, trust, group risks). This confirms that insurance regulation is not a “narrowly sectoral” function, but a systemic component of financial supervision. The managerial logic of supervision consists in proactive control of risks and incentives (and not only checking formal norms).

The analysis has established that state regulation of the insurance market within the framework of financial supervision has three interrelated goals: (a) financial stability, (b) solvency of insurers, (c) protection of consumer rights. At the same time, these goals are interrelated: the solvency of insurers forms the prerequisites for financial stability, and the protection of consumer rights affects the level of trust and the sustainability of the functioning of the insurance market. Financial stability in the insurance sector means minimising the likelihood of insurers’ problems spilling over into the wider financial sector (through assets, liquidity, trust, related structures) (International Association of Insurance Supervisors, 2024). In the financial supervision system, this objective requires not only a response to violations, but also risk management policies: early indicators, asset quality requirements, concentration control, scenario analysis (stress scenarios), and coordination of approaches between financial market segments (European Insurance and Occupational

Pensions Authority, n.d.). The solvency of insurers as an objective is a practical “reality check”: whether companies are able to meet the obligations to policyholders under normal conditions and in stress scenarios. This is why regulatory tools tend to gravitate towards a prudential logic: capital, reserves, asset and liability management, corporate governance, and internal control. At the same time, the risk-based approach assumes that supervision differentiates the intensity of control depending on the risk profile of the company, and does not apply the same requirements “for everyone”. The protection of consumer rights in insurance is due to the presence of information asymmetry: the client often does not have the opportunity to fully assess the quality of the insurance product before the insured event occurs. Therefore, the regulatory logic includes not only financial regulations, but also behavioural supervision: transparency of contract terms, correctness of sales, handling of complaints, standards for settling losses, prevention of unfair practices. This is where the role of the mega-regulator manifests itself in coordinating consumer protection standards for the entire financial sector. To show how the goals of regulation are built into the system of financial supervision, it is advisable to compare “goal→risks→tools→performance indicators”, that is, the management chain of regulatory policy (Table 2).

Table 2. Regulatory objectives and management logic for the implementation

The purpose of regulation	What risks does it mitigate?	Management logic (what the regulator should do)	Examples of tools/mechanisms (functional)	Performance evaluation benchmarks (key performance indicators, KPIs)
Financial stability	Systemic risks, correlation of shocks, liquidity, concentrations	Defining risks early; prevent “knock-on” effects	Stress assessment, asset concentration control, risk management requirements	Reduction in the frequency of crises/market exits; stability of key sector indicators
Solvency of insurers	Insufficient reserves/capital, investment risk, ALM gaps	Ensuring that liabilities match assets and capital	Prudential requirements, asset quality assessment, reserve requirements, corporate governance oversight	Share of companies with sufficient capital/reserves; reduction in defaults
Consumer protection	Information asymmetry, unfair sales, payment delays	Minimising “unfair incentives” and ensuring fair practices	Transparency standards, behavioural oversight, complaint procedures, oversight of loss settlement	Reduction of complaints/violations; reduction of settlement times; increase of customer trust

Source: compiled by the author based on European Insurance and Occupational Pensions Authority (n.d.), International Association of Insurance Supervisors (2024)

The objectives of regulation form a hierarchy of risk management: from the systemic level (stability) to the micro level (solvency) and the level of customer interaction (protection). This demonstrates that the role of the NBU as a mega-regulator is one of policy-management coordination: aligning prudential and behavioural supervision, and not just “applying the rules”. It is the combination of these three goals that makes supervision effective: without consumer protection, trust falls, without solvency, fulfilment of obligations collapses, without stability, systemic risk increases. The conclusions obtained confirmed that the role of the National Bank of Ukraine as a mega-regulator is not only to exercise supervisory powers, but also to form a holistic regulatory policy and manage systemic risks in the insurance sector. It is this model that creates the prerequisites for increasing the stability of the insurance market and its contribution to the financial stability of Ukraine.

Functional aspects of the NBU’s activities as a mega-regulator

The functional aspects of the National Bank of Ukraine’s activities in the field of insurance market regulation are manifested through a complex of interrelated regulatory, supervisory, control and protective functions implemented within the framework of a unified system of financial supervision. The results obtained confirmed that the role of the National Bank of Ukraine as a mega-regulator goes beyond formal control over compliance with regulatory requirements and consists in forming a management logic for the development of the insurance market, taking into account systemic risks and financial stability goals. The regulatory function in the insurance sector is strategic in nature and is aimed at creating conditions for the financially sustainable functioning of insurance companies. Through the licensing mechanism, the National Bank of Ukraine carries out the initial selection of market

participants, assessing the business models, ownership structure, sources of capital and management capacity (Law of Ukraine No. 1953-IX, 2021). This approach allows minimising the risks of companies entering the market with opaque or excessively risky business models, which has preventive significance not only for the insurance sector, but also for the financial system as a whole.

Setting capital ratios, insurance reserves and asset structure requirements is a key tool for implementing prudential policy. The results of the analysis showed that these requirements are aimed at ensuring compliance between the risks taken by insurers and the financial capabilities. Thus, the regulatory activities of the NBU perform not only a restrictive but also a disciplinary

function, stimulating insurers to implement effective risk management systems, internal control and corporate governance. The supervisory function of the National Bank of Ukraine (2024) is implemented based on a combination of prudential and risk-oriented approaches. Risk-oriented supervision allows for differentiating the intensity of regulatory influence depending on the risk profile of a particular insurer. Companies with higher risk levels are subject to increased supervision, while financially sound market participants are subject to less regulatory pressure. This indicates a shift from universal control to risk management, which increases the efficiency of supervisory resources and contributes to the early detection of potential threats (Table 3).

Table 3. Regulatory and supervisory tools in the insurance sector

Tool	Management appointment	Main risks being minimised	Systemic effect
Licensing	Formation of a high-quality market composition	Entry of financially weak and untransparent companies	Increasing market confidence
Capital and reserve requirements	Ensuring solvency	Insurance and credit risks	Stability of fulfilment of obligations
Asset restrictions	Investment risk control	Concentration and market risks	Volatility reduction
Risk-based supervision	Focus on troubled insurers	Systemic and accumulated risks	Early response to threats
Corporate governance	Improving the quality of management	Agency and operational risks	Sustainability of business models

Source: compiled by the author based on Law of Ukraine No. 1953-IX (2021)

Regulatory and supervisory tools form a holistic risk management system, in which the emphasis is on preventing problems, rather than responding to already implemented violations. A risk-oriented approach allows for increased targeting of supervision and reducing the regulatory burden on financially stable insurance companies. The control function of the National Bank of Ukraine complements regulatory and supervisory activities, ensuring actual compliance with established requirements. The results of the study showed that the combination of remote monitoring with inspections allows the regulator to obtain comprehensive information about the financial condition of insurers and the quality of the operational activities. Control measures are mainly preventive in nature and are aimed at timely correction of the behaviour of market participants before violations become systemic. The application of enforcement measures is an element of

the control function and is implemented according to the principle of proportionality. The National Bank of Ukraine uses a phased scale of impact – from requirements to eliminate violations to restricting certain types of activities or revoking the licence. Such management logic allows minimising negative shocks to the insurance market and at the same time ensuring discipline of market participants. The protective function of insurance market regulation is aimed at protecting the rights of consumers of insurance services and overcoming information asymmetry between insurers and clients. The analysis showed that this function is implemented through requirements for the transparency of insurance products, information disclosure standards, control of sales practices and monitoring of insurance claims settlement. It is the protective function that builds trust in the insurance market and creates the prerequisites for its sustainable development (Table 4).

Table 4. Control and protective mechanisms for regulating the insurance market

Mechanism	Functional purpose	Object of influence	Expected result
Remote monitoring	Early detection of violations	Financial indicators of insurers	Crisis prevention
Inspection checks	Assessment of actual activity	Business processes	Improving discipline
Enforcement measures	Behaviour correction	Insurance companies	Reducing violations
Transparency standards	Eliminating information asymmetry	Insurance contracts	Informed customer choice
Complaints handling	Consumer protection	Insurer-client interaction	Growing trust

Source: compiled by the author based on I. Sirenko (2021), National Bank of Ukraine (2024)

Control and protective mechanisms complete the regulatory cycle, combining risk management with direct protection of consumer interests. The effectiveness depends on the balance between the rigidity of regulatory influence and the preventive, corrective logic of supervision, which is critically important for the stability of the insurance market in modern conditions. The results of the

study showed that the functional aspects of the National Bank of Ukraine's activities in the field of insurance market regulation form a holistic risk management system that combines regulatory, supervisory, control and protective functions. The regulatory and supervisory tools of the NBU are focused on ensuring the solvency of insurers and early detection of risks, while the control and protective

mechanisms are aimed at compliance with established requirements and protecting the rights of consumers of insurance services. Such a functional approach confirms the role of the NBU as a mega-regulator, which not only controls the activities of insurers, but also forms the management logic of the development of the insurance market and contributes to increasing its stability in the conditions of modern financial challenges.

Problems and directions of improvement of insurance regulation

The results of the study show that the insurance regulation system in Ukraine is in a phase of structural transformation, which is associated with the gradual harmonisation of legislation with the requirements of the European Union and the implementation of Solvency II standards. At the same time, the adaptation process remains incomplete, in particular due to the lack of full implementation of the Solvency Capital Requirement (SCR) and Own Risk and Solvency Assessment (ORSA), which limits the level of real integration of the national insurance market into the pan-European space (Bulantsov, 2025). The institutional incompleteness of the reforms is combined with the challenges of practical implementation of risk-based

supervision, especially in terms of the use of internal solvency assessment models. The increasing complexity of such models creates the risk of formal compliance with regulatory requirements without proper transparency, interpretability, and sensitivity testing of key assumptions. In the absence of a systematic approach to uncertainty analysis and standardised procedures for validating internal models, risk-based supervision may lose its preventive nature and turn into a formal compliance procedure (Borgonovo *et al.*, 2024). Thus, improving insurance regulation in Ukraine should combine institutional harmonisation with European standards and improving the quality of the methodological tools of prudential supervision (Bulantsov, 2025).

In this context, the issue of harmonising insurance regulation in Ukraine with European standards, which has a managerial and practical nature, becomes relevant. To assess the areas of improvement of supervisory tools, a comparative analysis of approaches to insurance regulation in Ukraine, Poland, Germany, and Romania was conducted according to the following criteria: the model of insurance supervision organisation, the application of prudential requirements within the framework of Solvency II, the use of a risk-based approach and elements of behavioural supervision (Table 5).

Table 5. Comparative characteristics of insurance supervision models

Criterion	Ukraine	Poland	Germany	Romania
Model for the organisation of insurance supervision	Mega-regulator (NBU)	The single financial regulator	BaFin's integrated supervision	The single regulator Romania's Financial Supervisory Authority (ASF)
Risk-oriented approach	Partially implemented	Basic principle of supervision	Complete and integrated	Formally implemented
Behavioural supervision	Being formed	Developed	Integrated into the prudential	Limited
The application of prudential requirements under Solvency II	Partial harmonisation	Full implementation	Full implementation	Formal implementation

Source: compiled by the author based on European Insurance and Occupational Pensions Authority (n.d.), Law of Romania No. 236/2018 (2018), Law of Ukraine No. 1953-IX (2021), Polish Financial Supervision Authority (2023), National Bank of Ukraine (2024), Federal Financial Supervisory Authority (2025)

The comparison shows that in Ukraine, risk-based supervision is in its infancy and largely relies on formal reporting, which limits its preventive nature. In Poland, a risk-based approach within the framework of the full implementation of Solvency II allows for differentiating requirements for insurers depending on the risk profile. In Germany, prudential and behavioural supervision are integrated into a single financial risk management system within Solvency II and are supplemented by stress testing. The experience of Romania demonstrates that the formal implementation of Solvency II requirements without proper institutional adaptation can cause crisis phenomena in the insurance market.

Based on the comparative analysis, it was established that increasing the effectiveness of the supervisory tools of the National Bank of Ukraine requires a comprehensive improvement of regulatory practice. Firstly, it is advisable to expand the application of the proportionality principle, under which the requirements for insurers are differentiated depending on the scale of activity and the

level of risk profile, which will avoid excessive regulatory burden on financially stable companies and at the same time strengthen control over risky market participants. A significant direction is the integration of behavioural and prudential supervision into a single system for assessing the activities of insurers, which will ensure simultaneous control of the financial stability and the quality of interaction with consumers of insurance services. In addition, it is advisable to introduce systemic stress testing to assess the impact of macroeconomic and financial shocks on the insurance sector and timely identification of potential threats to financial stability.

The presented analysis of prudential, behavioural and model aspects of insurance regulation has shown the presence of complex challenges that are formed at the intersection of European integration processes and the digital transformation of the insurance market. On the one hand, adapting Solvency II requirements requires not only regulatory harmonisation, but also the development of institutional capacity and the real implementation of

risk-based supervision. On the other hand, the digitalisation of distribution channels and the use of complex internal models create new regulatory risks related to the management of distribution risks and ensuring transparency

in the assessment of solvency. In view of this, it is advisable to systematise the identified problems by regulatory levels and determine priority areas for overcoming these challenges (Table 6).

Table 6. Systemic challenges of insurance regulation in the context of European integration and digital transformation

Regulatory level	Problem area	Nature of manifestation	Potentials and risks	Direction of improvement
Digital surveillance	Scaling of digital channels without enhanced control	Limited interpretability of risks in the digital environment	Regulatory gaps and accumulation of hidden risks	Integration of SupTech/RegTech and strengthening of analytical regulator functions
Institutional	Fragmented harmonisation of legislation	Lack of a systematic roadmap for adaptation	Regulatory gaps and asymmetry of standards	Strategic model of integration into the pan-European insurance space
Behavioural (IDD)	Limited regulation of online distribution	Application of the proportionality principle to ancillary intermediaries	Growth of mis-selling and violation of consumer protection	Review of the application of IDD to digital sales channels
Model (Internal models)	Increasing complexity of internal models	Black-box effect, use of artificial intelligence/machine learning	Opacity of solvency assessment and capital management	Introduction of sensitivity analysis and explainability approaches into the validation process
Solvency II	Incomplete implementation of SCR and ORSA	Formal implementation of risk-based supervision elements	Insufficient assessment of the real risk profile of insurers	Phased full integration of Solvency II requirements and development of institutional capacity

Source: compiled by the author based on P. Marano (2021), E. Borgonovo *et al.* (2024), I. Bulantsov (2025)

Systematisation of problems and directions for overcoming these challenges shows that modern challenges of insurance regulation in Ukraine are multi-level in nature and cover prudential, behavioural and model dimensions. The effectiveness of the regulatory system is determined not only by the formal implementation of Solvency II requirements, but also by the ability to ensure the real functioning of risk-oriented supervision, proper management of distribution risks in the conditions of digitalisation and transparency of internal models for assessing solvency. The combination of harmonisation with European standards, improvement of approaches to validation of internal models through the use of sensitivity analysis and explainability practices, as well as the development of digital supervision tools form the prerequisites for creating a sustainable, transparent and competitive model of insurance regulation in Ukraine.

It is advisable to consider the improvement of insurance regulation in Ukraine in the context of the transition from a reactive to a proactive risk management model. This approach involves not only responding to already implemented violations or crisis phenomena, but also systematic early detection of potential threats, forecasting the accumulation of systemic risks and preventing the transformation into financial instability. At the heart of this model is the regulator's ability to generate analytical signals based on complex data, assess the relationships between financial market segments, and timely adjust supervisory tools. The combination of risk-based and proportional approaches to supervision allows avoiding excessive regulatory pressure on financially stable companies and at the same time strengthening the requirements for participants with an increased risk profile. In this context, the experience of the European Union countries, in particular Romania, indicates the need to adapt European standards to national

institutional conditions, rather than mechanically copying these standards. Disproportionate implementation of Solvency II requirements without proper preparation of the regulatory infrastructure can lead to reduced competition and weakening trust in the insurance market.

Increasing the effectiveness of insurance regulation is associated with the development of the institutional capacity of the supervisory authority. This is not only about staffing, but also about investments in analytical tools, digital platforms for data collection and processing, as well as improving internal procedures for regulatory decision-making. Under such conditions, insurance regulation is transformed from a formal control of compliance with regulations into a tool for strategic provision of financial stability. Thus, the formation of an effective model of insurance regulation in Ukraine is based on a combination of adaptive harmonisation with European standards, the development of risk-oriented supervision and strengthening the institutional capabilities of the regulator. The implementation of these approaches creates the prerequisites for increasing the stability of the insurance sector, preserving the competitive environment and ensuring its ability to function in conditions of growing financial and regulatory complexity.

● DISCUSSION

The obtained research results allow for a comprehensive interpretation of the functional aspects of the National Bank of Ukraine's activities in the field of insurance market regulation and to assess the significance in the system of modern financial supervision. The analysis showed that the concentration of regulatory, supervisory, control and protective functions within one institutional centre creates the prerequisites for improving the manageability of the insurance sector. At the same time, the effectiveness of this

model depends on the level of development of risk-based supervision, the institutional capacity of the regulator and the ability of the regulatory environment to adapt to structural changes in the insurance market. In this context, the research results are important not only for assessing the current state of regulation, but also for understanding the managerial logic of state influence on the insurance sector.

The research results correlate with the approaches presented in scientific works devoted to the transformation of financial supervision after the introduction of the mega-regulator model. T. Basse (2020), applying time series analysis methods to 30-year government bond yields of Germany, France, Italy and Spain, showed that after the financial crisis, markets began to take into account a significant probability of sovereign default and redenomination risk when pricing government debt instruments. The author emphasised that long-term bonds are an important asset for European life insurers, while the Solvency II regulatory model does not fully take into account sovereign credit risk when calculating capital requirements. In this context, the study underlined the need to further improve the regulatory regime, taking into account the potential risks of sovereign debt for the financial stability of insurers. In the study, N. Ettlin *et al.* (2020) considered risk transfer in a network of insurance companies as a tool for managing capital and profitability. The authors showed that optimising the allocation of risks between insurers in a network environment reduces the total cost of capital and increases the efficiency of the system as a whole. At the same time, at the individual level there is no single optimal solution for risk transfer, while from the network perspective it is possible to determine a unique “fair” solution based on the principles of cooperative game theory. The results obtained point out the importance of the structure of relationships between insurers for ensuring systemic stability and reducing potential risks of interdependence. These studies underscored that the optimal distribution of risks between insurance companies within the network structure allows reducing the total cost of capital and increasing the stability of the system without the need for strict centralisation of management. The results obtained in this study are consistent with the above theoretical provisions, but show that institutional centralisation alone does not guarantee an increase in the effectiveness of insurance regulation without the development of analytical and risk-oriented supervision tools.

E. Siopi *et al.* (2023) found that strengthening capital requirements and insurance reserves has a positive effect on the solvency of insurance companies and is associated with increased consumer confidence in insurance services. A. Neill (2024), analysing macroprudential regulation in the financial sector as a whole, showed that stricter prudential standards contribute to the reduction of systemic risks, provided that the quality of supervisory control and transparency of reporting are adequate. The results obtained within the framework of this study are consistent with the above provisions and indicate that prudential requirements perform a stabilising function, but the effectiveness decreases in the case of formal implementation of risk management systems and insufficient integration of risk management into the corporate governance of insurance companies.

Researchers A. Garayeta *et al.* (2022) and G. Bonaccorto *et al.* (2025), in the studies of risk-based supervision in insurance, show that focusing regulatory attention on the most vulnerable market segments increases the efficiency of the use of supervisory resources and allows for timely detection of risk accumulation. The authors also emphasised the importance of using quantitative risk assessment models in the activities of insurance companies. D.K. Nguyen & D.-T. Vo (2020) in the broader context of risk management of financial institutions, proved that the implementation of systemic risk management increases the ability to detect financial imbalances early, and the effectiveness of such an approach depends on the quality of available regulatory data. The results of this study were consistent with the above provisions and indicate that in Ukrainian conditions the potential of risk-based supervisory information and the uneven development of internal risk management systems in insurers.

In studies by European scholars, the principle of proportionality is considered as a tool for combining financial stability and market competitiveness. S.S. Labini *et al.* (2025) investigate the relationship between sustainable development-oriented management practices (ESG) and the financial performance of insurance companies in an international sample of 167 insurers for 2018-2022. The authors found that ESG-oriented strategies have a positive impact on the return on equity, with a statistically significant relationship confirmed for American insurance companies. The results also indicated the importance of high-quality corporate governance and the integration of environmental, social and governance factors into decision-making processes, which can contribute to increasing the financial sustainability of insurers. The results of this study were consistent with such provisions and indicate that the unified application of requirements to insurers with different levels of risk can contribute to the crowding out of small and medium-sized companies and increased market concentration.

F.-W. Huang *et al.* (2022), in the study, analyse the investment behaviour of insurers in the context of the decarbonisation of the economy and develop a model of two insurers, one of which makes carbon-linked investments, while the other adheres to a traditional investment strategy. The authors showed that in an environment with positive externalities from reducing emissions, a “free riding” effect arises, in which the benefits from improving environmental quality are partially distributed among market participants. The model establishes that policyholders act as “free consumers” of environmental benefits, while the costs of ensuring stability are borne by insurers through a decrease in the interest margin. The relationship between the volatility of carbon-linked investments, default barrier risks and insurance stability indicators are also demonstrated. M. van Bekkum *et al.* (2025) investigated the interaction of prudential and behavioural regulatory instruments and show that the combination helps to strengthen trust in financial institutions and increases the effectiveness of the protective function of the regulator. The results obtained within the framework of this study are consistent with such approaches and indicate that in Ukraine the protective function of the regulator is strengthening,

but is not yet fully integrated into the risk management system of the insurance market.

In studies of the harmonisation of financial regulation with European standards, significant attention is paid to risk-based assessment of solvency and development of supervisory tools. W. Ullah *et al.* (2024) pointed out the importance of comprehensive consideration of risks when assessing the stability of financial institutions, and C.P. Pedro *et al.* (2023) highlighted the need to develop national supervisory practices and analytical capacity of the regulator. The results of this study were consistent with such approaches and showed that the formal transfer of European requirements without the development of analytical and management tools limits the effectiveness of insurance supervision. Comparative studies of the implementation of Solvency II standards in the European Union countries also indicated the importance of gradual adaptation of regulatory changes. E. Borgonovo *et al.* (2024) noted that the phased implementation of regulatory requirements contributes to increasing the financial stability of insurers and reduces the risks of abrupt structural changes in the market. K. Puławska *et al.* (2026) investigated the sensitivity of insurance company quotes to extreme macro risks – climate, geopolitical and cyber risks – on a sample of insurers in the European Union, the United Kingdom, and the United States for 2015-2024. The authors found that climate risk causes the strongest reaction of stock prices and is systematically taken into account in risk premiums, while geopolitical and cyber risks have a weaker direct impact, but are also integrated into the risk premia formation mechanism. At the same time, markets quickly adjust prices after extreme events without long-term distortions, which indicates the adaptability of the insurance sector to systemic shocks. The results obtained confirm the relevance of these findings for Ukraine and justify the feasibility of an adaptive approach to the harmonisation of insurance regulation.

A.E. Camacho & R.L. Glicksman (2021) noted that the concentration of supervisory functions within a single regulatory centre contributes to greater consistency of regulatory policy, but at the same time increases the requirements for the regulator's institutional capacity, in particular regarding analytical expertise and managerial flexibility. H. Meral *et al.* (2026) prove that the integration of ESG factors into the activities of insurance companies is statistically associated with increased asset profitability, more effective cost management and increased investment returns. Taken together, these approaches indicated that both the institutional quality of the regulatory environment and the strategic orientation of insurers towards sustainability are important prerequisites for increasing the sustainability of the insurance sector. In summary, the discussion of the results showed that the study is consistent with the key provisions of the modern scientific discourse on insurance regulation and at the same time expands it, focusing on the managerial logic of implementing the functions of a mega-regulator. The revealed patterns confirmed the need to combine European regulatory standards taking into account the national characteristics of the development of the Ukrainian insurance market, which logically leads to the transition to the formulation of generalised conclusions of the study.

● CONCLUSIONS

The analysis outlined the systemic role of insurance regulation in the architecture of financial supervision in Ukraine and substantiated its importance as a mechanism for managing financial sector risks. It was shown that the insurance market performs a dual function: on the one hand, it acts as a financial shock absorber for households and businesses, on the other hand, as an institutional investor that accumulates long-term resources and transfers risks between the real and financial sectors. This gave grounds to argue that insurance regulation is not sectoral in nature, but is a component of a single financial supervision, within which the stability of insurers directly affects the liquidity, trust, and stability of the financial system as a whole.

The results of the analysis of the objectives of state regulation of the insurance market made it possible to clearly structure the managerial logic of regulatory policy. The analysis showed that financial stability, solvency of insurers and protection of consumer rights form an inter-related hierarchy of objectives, in which each element is a necessary condition for the effective functioning of the market. It is established that achieving financial stability requires early detection of systemic risks and coordination of supervisory approaches between segments of the financial market, while solvency is implemented through prudential requirements for capital, reserves, and asset management. Consumer protection, in turn, is considered a key factor in trust and sustainable development of the insurance sector in conditions of information asymmetry.

Within the framework of the analysis of the functional aspects of the National Bank of Ukraine, its role as a mega-regulator is justified, which forms not only the control environment, but also a holistic management model for the development of the insurance market. It is established that the regulatory and supervisory tools of the NBU are focused on preventive risk management through licensing, capital ratios, risk-based supervision and corporate governance requirements. Control and protective mechanisms complement this cycle, ensuring compliance with standards, correction of insurers' behaviour and increasing the level of consumer protection. Analytical generalisation shows that the effectiveness of this system does not depend on the rigidity of regulation, but on its proportionality and analytical capacity. At the same time, the generalisation of the analysis results allowed outlining a number of limitations and problems, in particular, the heterogeneity of the financial capacity of insurers, the formalisation of risk management systems, limited regulatory flexibility and institutional challenges in implementing risk-based supervision. A comparative analysis of the practices of the European Union countries shows that the key factor in effectiveness is not formal harmonisation of standards, but gradual adaptation taking into account national characteristics and the development of the regulator's analytical tools.

Based on the analysis, practical recommendations were formulated, which consist in the feasibility of further developing proportional and risk-based supervision, strengthening the regulator's analytical capabilities, as well as integrating behavioural supervision into the insurance market risk management system. The limitations

of the study are related to its analytical and theoretical nature and the lack of an expanded empirical dimension. Promising areas of further research include empirical assessment of the effectiveness of regulatory instruments, analysis of the impact of digitalisation and InsurTech solutions, and research into the long-term impact of regulatory changes on the financial stability of the insurance sector of Ukraine.

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Функціональні аспекти діяльності Національного банку України у сфері регулювання страхового ринку

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Анотація. Актуальність дослідження була зумовлена зростанням системної ролі страхового ринку у фінансовій системі України та необхідністю підвищення ефективності фінансового нагляду в умовах концентрації регуляторних повноважень у Національному банку України. Метою статті було обґрунтування ролі регулювання страхового ринку як складової єдиної системи управління фінансовими ризиками та визначення управлінської логіки реалізації регуляторних, наглядових, контрольних і захисних функцій центрального банку. Методологія дослідження ґрунтувалася на комплексному аналітичному підході, що поєднував системний і структурно-функціональний аналіз із порівняльним вивченням моделей страхового регулювання України, Польщі, Німеччини та Румунії. У результаті дослідження було встановлено, що страховий ринок України виконував подвійну функцію фінансового амортизатора та інституційного інвестора, формуючи кілька каналів системного ризику через інвестиційні, групові та поведінкові зв'язки з іншими сегментами фінансового сектору. Було виявлено, що цілі державного регулювання страхового ринку – фінансова стабільність, платоспроможність страховиків і захист прав споживачів – утворювали ієрархічно взаємопов'язану систему управління ризиками, у межах якої платоспроможність виступала функціональною умовою стабільності, а захист споживачів – основою довіри до ринку. Показано, що регуляторні та наглядові інструменти центрального банку були орієнтовані на превентивне виявлення ризиків і диференціацію наглядового впливу, однак їх практична ефективність обмежувалася неоднорідною фінансовою спроможністю страховиків і формалізацією систем управління ризиками. Порівняльний аналіз засвідчив, що у Польщі та Німеччині ризик-орієнтований і пропорційний нагляд характеризувався вищою інституційною зрілістю, тоді як досвід Румунії продемонстрував ризики формальної гармонізації регуляторних стандартів без належної інституційної адаптації. Практичне значення дослідження полягало у можливості використання отриманих результатів для вдосконалення пропорційного та ризик-орієнтованого нагляду, розвитку аналітичних інструментів регулятора та підвищення стійкості страхового ринку України в умовах європейської інтеграції

Ключові слова: фінансовий нагляд; ризик-орієнтований підхід; фінансова стабільність; управління ризиками; поведінковий нагляд

State support and digitalisation in the innovative development of Ukraine's biotechnology sector

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Abstract. The relevance of the research lies in determining the role of state support and digitalisation in ensuring the innovative development of biotechnologies in Ukraine in conditions of war and economic instability. The purpose of the work was a comprehensive analysis of the relationship between state policy, digital transformations and innovative development of the biotechnology sector of Ukraine. The research methodology included a systematic analysis of strategic documents, state support programs, the startup ecosystem, and the practical implementation of digital technologies in biotechnology, including the analysis of cases of Ukrainian companies and startups. It has been established that the state policy of Ukraine in the field of biotechnology, in particular the Concept of Bioeconomy Development until 2030 and the Biosafety Strategy, creates systemic conditions for the development of innovative products in pharmaceuticals, agrobiotechnologies, and bioenergy. The impact of digitisation on the sector is analysed, in particular the introduction of artificial intelligence, bioinformatics, big data, blockchain and the Internet of Things, which ensures optimisation of production processes, improvement of management efficiency and reduction of costs. It was found that the interaction of the Ukrainian IT sector and biotechnology forms a competitive advantage, accelerates the transformation of scientific potential into commercial products and ensures the sustainability of the startup ecosystem even in war conditions. The practical value of the results lies in the possibility of their application by public administration specialists, economists and innovation managers for the formation of an effective policy of post-war economic recovery and stimulation of innovative development of the biotechnology sector of Ukraine

Keywords: innovation infrastructure; digital transformation of the industry; artificial intelligence in biotechnology; big data; blockchain technologies; IT-biotech synergy; managerial and economic efficiency

● INTRODUCTION

Biotechnology is recognised as one of the most dynamic and economically promising sectors globally, transforming key areas of the economy from medicine and pharmaceuticals to agro-industry and energy. The global biotechnology market demonstrates sustained growth driven by the active adoption of digital technologies, in particular artificial

intelligence (AI), the development of personalised medicine, and increased investment in knowledge-intensive research. Ukraine possesses significant potential in this field by virtue of its highly qualified human capital, developed IT sector and scientific base, as well as its unique natural resources. At the same time, digitalisation processes are

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becoming a key factor in increasing research effectiveness and accelerating innovation. Under conditions of economic turbulence, wartime challenges, and resource constraints, examining the interaction between state support and digitalisation as a foundation for biotechnology sector development becomes especially pertinent. The multifaceted nature of this issue generates growing scholarly interest, reflected in research spanning a broad range of questions from an analysis of global digitalisation trends to the study of sector-specific barriers and prospects in biotechnology.

In the study by R. Kostiuk & R. Romanov (2023), dedicated to analysing the economic problems and challenges facing Ukrainian biotechnology organisations under crisis conditions, the critical role of digitalisation and the automation of managerial and production processes is substantiated as a factor in stabilising the sector. Although the work made an important contribution to understanding intra-sector barriers and possible strategies for overcoming them, the question of integrating Ukrainian startups into global value chains through digital platforms remained beyond the scope of detailed consideration. This aspect is important for creating a favourable regulatory environment for biotechnology; however, the specific characteristics of “regulatory sandboxes” for biotechnological innovations were not examined in the paper. In their work, scientists A. Rachynskyi & O. Tytarenko (2024) analysed the “servitisation” of public administration to improve the provision of public services and reduce bureaucracy. This aspect is important for the creation of a favorable regulatory environment for biotechnologies, however, the specifics of “regulatory sandboxes” specifically for biotechnological innovations have not been investigated in the paper.

Research by H. Honchar & O.L. Shpatakova (2024) demonstrated how digital technologies increase efficiency and productivity, contributing to the development of new economic sectors and job creation that is, the potential of biotechnology sector digitalisation as a mechanism for productivity growth. However, quantitative modelling of AI’s impact on reducing R&D costs in the biotechnology sector would constitute a valuable contribution. Researchers O. Brechko & N. Kryvokulska (2023) connected digital transformation with environmental objectives through IT systems, however, the economic effect of introducing blockchain in agrobiotechnology was left unaddressed. Y. Liu *et al.* (2025) summarised contemporary scientific achievements regarding the application of AI in drug development processes and the creation of biotechnological products, with an emphasis on key performance indicators. The authors emphasised that the adoption of AI significantly transforms the therapeutic development landscape, bringing qualitative changes to research approaches and helping to overcome longstanding sector challenges in particular, excessively high development costs (exceeding one billion US dollars), prolonged timelines for bringing drugs to market (exceeding ten years), and a significant rate of failures at various stages of clinical trials.

A. Bhushan & P. Misra (2025) conducted a comprehensive study of AI applications in biotechnology and digital medicine, encompassing both the economic dimensions of its impact and ethical considerations, including the question of equitable technology implementation. The authors substantiated how AI integration has significantly

transformed the biotechnology sector accelerating drug discovery, advancing genomics, improving medical imaging, and introducing personalised medicine, thereby contributing to increased healthcare system efficiency and reduced costs. The paper analyses the economic effects of AI, its role in stimulating innovation, and its impact on decision-making at both the research and policy levels. Particular attention is devoted to the quantitative assessment of AI’s economic impact on the biotechnology sector. The review of the literature revealed a number of unresolved issues directly related to the research topic. In particular, the specifics of AI implementation in biotechnology under martial law and resource constraints remain insufficiently studied, as does the relationship between state support, the level of digitalisation, and indicators of innovative development in the sector. Academic works lack systemic models and applied mechanisms for the implementation of strategic decisions, as well as an analysis of the effectiveness of state support instruments (grants, tax incentives, regulatory simplifications) in terms of maximising returns on limited budgetary resources. At the same time, the synergy potential of the IT sector and biotechnology as a unique competitive advantage for developing countries has not been sufficiently articulated. This necessitates a comprehensive study aimed at addressing these gaps and developing practical recommendations.

The aim of this article was a comprehensive examination of the impact of state support instruments and digitalisation processes on the innovative development of Ukraine’s biotechnology sector under martial law and global digitalisation, the identification of managerial and economic effects of digital technology adoption and the substantiation of practical recommendations for enhancing the sector’s competitiveness in global markets, drawing on international experience and contemporary technological trends. To achieve this aim, the following objectives were identified: to identify key problems and challenges facing Ukraine’s biotechnology sector, to analyse the managerial advantages and economic effects of digital technology adoption in the biotechnology domain, including impacts on investment, costs, productivity, and market expansion and to formulate practical recommendations for strengthening public policy and stimulating innovative development in the biotechnology sector under conditions of limited resources and wartime challenges.

● MATERIALS AND METHODS

The methodological foundation of this research comprises a set of general scientific and specialised methods, ensuring a systematic analysis of the influence of state support instruments and digitalisation processes on the innovative development of Ukraine’s biotechnology sector under wartime conditions and in anticipation of post-war recovery. The research drew on: regulatory and legal acts of Ukraine (Decree of the President of Ukraine No. 668/2021, 2021; Law of Ukraine No. 3339-IX, 2023); strategic state policy documents in the field of biotechnology and digitalisation (Concept of the Bioeconomy Development..., 2019; BioTech Sectoral Strategy, 2024); international analytical reports (Precedence Research, 2025; Precedence Research, 2026); statistical data (UANPIO statistics and reports, n.d.; Seeds of Bravery, n.d.); and scientific publications indexed in

scientometric databases (Kostiuk & Romanov, 2023; Rachynskiy & Tytarenko, 2024).

The sample includes sources meeting the following criteria: relevance, thematic pertinence (innovative development, biotechnology, digitalisation, state policy), and scientific and practical significance. To achieve the stated aim, the following research methods were employed: systematic analysis for the comprehensive examination of the interrelationship between state support, digitalisation, and the development of the biotechnology sector as an integrated system; comparative analysis to compare Ukrainian approaches to supporting biotechnology with international practices, and to evaluate the effectiveness of various state regulatory instruments; analysis and synthesis for the processing of scientific sources, statistical data, and analytical materials, and for the formation of generalised conclusions regarding sector development trends; structural-functional analysis to determine the role of digital technologies in transforming managerial and production processes in biotechnology; economic analysis to assess the managerial and economic effects of digital technology adoption (changes in costs, productivity, and investment attractiveness); and the method of generalisation for formulating practical recommendations to improve the effectiveness of state policy in the field of innovative biotechnology development.

The empirical basis of the analysis comprised open statistical data on the development of the biotechnology sector, investment activity, and research and development (R&D) funding (UANPIO statistics and reports, n.d.; Seeds of Bravery, n.d.), as well as information on the implementation of state and international innovation support programmes, grant programmes, startup initiatives, digital platforms (Brovinska, 2022; Horizon Europe Office in Ukraine, n.d.; Diia.City, n.d.). The research was conducted in several stages. The first stage involved an analysis of the scientific literature and regulatory framework. The second stage entailed the systematisation of state support instruments and digital technologies applied in the biotechnology sector. At the third stage, an assessment of their impact on managerial and economic indicators of sector development was carried out. The final stage involved the generalisation of results and the formulation of practical recommendations. The methodology applied ensures the reproducibility of the research and allows other scholars to employ an analogous approach when analysing the innovative development of sectors undergoing digital transformation under conditions of limited resources.

● RESULTS

Ukraine's state policy regarding the innovative development of the biotechnology sector is characterised by a systemic approach reflected in a range of strategic documents and initiatives. The Concept of the Bioeconomy Development Strategy in Ukraine until 2030 defines biotechnology as the basis for creating new types of high-value-added products and provides for the development of biopharmaceuticals, agrobiotechnology, bioenergy, and related fields (Concept of the Bioeconomy Development..., 2019). The objective of this strategy is to lay systemic foundations for the development of the bioeconomy and to ensure the establishment of new sub-sectors of industry focused on innovative biotechnological products for the chemical,

petrochemical, pharmaceutical, and wood-processing industries. The implementation of this Concept is directed not only at modernising industry but also at stimulating demand for research outputs, supplementing existing support systems in agriculture, medicine, and pharmaceuticals.

An important step towards ensuring national security and developing biotechnology was the approval of the Presidential Decree No. 668/2021 (2021). This document defines the goals, objectives, and principal directions of state socioeconomic policy with respect to biosecurity and biological protection as a component of Ukraine's national security. This approach enables the transformation of biotechnology's role from a purely economic one into an interdisciplinary sphere combining economic, security, and social functions. Such a status makes it possible to provide the sector not only with financial support but also with expedited regulatory procedures, priority access to resources, and integration into defence and security programmes. This will afford biotechnology significant advantages over sectors viewed in purely economic terms, and is also capable of attracting investment oriented towards resilience and security rather than profitability alone.

A significant contemporary approach to implementing state policy in the field of biotechnology is the application of the Strategy for the Digital Development of Innovative Activity of Ukraine until 2030 WINWIN. This strategy envisages the formation of a mutually beneficial model combining state support, private investment, and scientific capacity, grounded in digital tools, the development of innovative ecosystems, and the commercialisation of research outputs, with the aim of creating competitive innovative products. For the state, implementing the "win-win" approach means increasing the economy's technological capacity, strengthening biosecurity, and increasing tax revenues; for business reducing innovation risks and simplifying access to financial resources and digital infrastructure; for scientific institutions expanding opportunities for the practical application of research results and integration into international research networks (WINWIN. Global innovation strategy of Ukraine, n.d.).

The BioTech Sectoral Strategy is an integral component of WINWIN's broader global innovation strategy for Ukraine, which also encompasses digital transformation, artificial intelligence, and environmental initiatives. This strategy provides for the integration of modern biotechnologies in biopharmaceuticals, bioenergy, and agrobiotechnology. During 2025, the provisions of the Strategy for the Digital Development of Innovative Activity until 2030 began to be implemented through the expansion of grant programmes, public-private partnership instruments, and support for deep-tech and biotechnology startups. In particular, support for innovative projects combining digital and biotechnological developments – through both state and international funding was strengthened (WINWIN. Global innovation strategy of Ukraine, n.d.). This contributes to the formation of a sustainable innovation ecosystem and the practical implementation of "win-win" principles.

As noted above, active state support for the innovative development of Ukraine's biotechnology sector and the "win-win" concept enshrined in the WINWIN Strategy are complementary factors in the sector's development. Through modern technologies and the automation of

production processes, the efficient use of limited resources is enhanced and conditions are created for transforming scientific potential into tangible economic results something of particular importance in the context of Ukraine's post-war economic recovery. Financial support for innovation in the biotechnology sector is delivered through a number of programmes. The "Seeds of Bravery" programme has become a significant source of funding for Ukrainian startups, providing 117 companies with € 3.5 million (Seeds of Bravery, n.d.). Grants ranging from € 25,000 to € 50,000 were directed at innovative services, innovative entrepreneurship, deep-tech incubators, Ukraine's reconstruction, and the scaling and acceleration of deep-tech startups. Among the supported projects in the Agricultural and Biotechnology domain were, for example: Yes Straws, Mosqitter, MELT WATER Inc., AgriMSME, HOWCOW, GreenSync.ai, Foodwise, PROFEED, Parostok, Agrobon:prelude, and Biogenic Silver. In the Healthcare domain, support was received by, inter alia: InTempo, eXtra Vision, CheckEye, Anima, Clearly, WildfiresUA, and Health Helper (Yarova, 2025).

The WINWIN strategy also provides financial support for start-ups and enterprises through grants and tax breaks. Companies engaged in R&D can become residents of "Action.City", which opens up new opportunities for technology development and additional tax advantages for business (Diia.City, n.d.). Furthermore, the integration of Ukrainian BioTech companies into EU cooperation and research and development support programmes in particular Horizon Europe, which provides access to significant financial resources and collaboration opportunities is being actively promoted (Horizon Europe Office in Ukraine, n.d.). Non-financial support includes the creation of a favourable regulatory environment for product registration and clinical trials, with the aim of simplifying procedures and reducing bureaucratic obstacles. The adoption of Law No. 3339-IX (2023) is an example of such efforts. Infrastructure development is also envisaged, including the establishment of shared equipment centres, the modernisation of laboratory equipment, and the launch of pilot production facilities for scaling biotechnological developments. The creation of biotechnology clusters is proposed to facilitate the exchange of ideas, resources, and expertise among business, science, and the state. To strengthen cooperation, the Ministry of Education and Science, the Ministry of Digital Transformation, and the Ministry of Economic Development, Trade and Agriculture of Ukraine are conducting surveys of business representatives to enable the effective allocation of budgetary funds for research and development. This contributes to establishing systematic communication among the state, business, higher education institutions, and scientific organisations to enhance the competitiveness of Ukrainian products and services.

Despite considerable potential and existing support programmes, Ukraine's biotechnology sector faces a number of significant problems and challenges, the most acute of which is limited funding and insufficient scientific and technical support. The overall level of expenditure on scientific and technical activities as a percentage of GDP has shown a downward trend: from 0.70% in 2013 to 0.29% in 2021, with a slight increase to 0.33% in 2022-2023. This indicator is substantially lower than in EU countries, where the average level in 2023 stood at 2.22% of GDP (WINWIN.

Global innovation strategy of Ukraine, n.d.). According to experts, at a research intensity of less than 0.3% of GDP, Ukrainian science has practically ceased to perform an economic function, being limited to a socio-cultural one (Pysarenko *et al.*, 2023). This leads to the degradation of the discipline and the emigration of specialists abroad in search of better conditions for developing their potential.

There is a paradox between Ukraine's enormous scientific potential and abundance of qualified personnel on the one hand, and low research and development expenditure and brain drain on the other. This gap points to a systemic inability to translate existing capacity into truly innovative products and economic growth. Low research and development expenditure (0.17% of GDP) and the outflow of specialists are interconnected manifestations of a systemic crisis in Ukrainian science. The root causes lie in institutional and economic conditions: governance quality, weak regulatory policy, limited access to funding, the ineffectiveness of innovation commercialisation mechanisms, weak science-business interaction, and the absence of adequate incentives for retaining and developing talent within the country. Consequently, the brain drain and insufficient funding which fails to sustain the minimum research intensity required for science to fulfil an economic function initially manifest as symptoms of an ineffective environment and subsequently become independent drivers of the system's further decline. This leads to the erosion of scientific potential and an intensified outflow of specialists, which diminishes the effective use of available resources and ultimately gives rise to a vicious cycle in which consequences reinforce causes.

Without addressing these systemic problems, even increased funding may not produce the expected results, as innovations will not be effectively translated into commercial products and services, and skilled workers will continue to seek employment abroad. Resolving this issue requires a comprehensive approach encompassing not only funding but also regulatory reform, infrastructure development, and a culture of commercialisation. In this regard, digitalisation can serve as a tool for bridging a certain gap. Serious obstacles are also posed by the instability of state policy and the inadequacy of legislation. Frequent legislative changes in the sector and insufficient protection of intellectual property rights hinder investment and innovation. Although the genetically modified organisms (GMO) law has been adopted, the entire legal framework particularly with respect to genome editing and clinical trials is outdated and does not conform to contemporary scientific trends or international standards.

Ukrainian enterprises face challenges that constrain the adoption of modern biotechnologies. There is insufficient expertise in the development and commercialisation of biological technologies, which slows the market entry of innovative products. The weak level of cooperation among scientific institutions, business, and the state also inhibits commercialisation. Additional obstacles include an outdated material and technical base and the absence of systematic audits of laboratory equipment, which reduce innovation capacity. Low purchasing power and a conservative business environment limit the potential for growth in demand for biotechnology products and solutions. Moreover, low trust in biological products amongst workers and

the general public constitutes a significant barrier to their wider adoption. Over the past two decades (2005-2025), the implementation of advanced information technologies in Ukraine has been marked by notable progress. During this period, modern communication systems were established, advanced information systems were introduced into industry, and mass access to the internet and mobile communications was achieved. The modern development of biotechnology is impossible without digital infrastructure.

By increasing labour productivity and reducing costs, AI plays a key role in transforming biotechnology. Ukraine is actively adopting these technologies: for example, RECEPTOR.AI develops AI platforms for the identification of biopharmaceutical compounds, whilst DEEPTRAIT creates AI tools for genome analysis (Brovinska, 2022). AI transforms managerial functions from reactive (post-occurrence problem monitoring) to predictive (real-time risk prevention). Because RECEPTOR.AI's machine learning algorithms automate the drug discovery phase, for instance, the development cycle is shortened. Consequently, the managerial function is transformed: managers receive automated recommendations based on current data, the management structure becomes decentralised, and responsiveness to market changes (shifts in drug demand, new regulatory requirements, competitive products, clinical trial results, etc.) increases. Big data analysis is of great importance for scientific research and development in biotechnology. Through big data, for example, genomic sequence monitoring for the management control function shifts from selective to continuous, giving rise to hybrid organisational units in which biologists, IT specialists, and managers operate within a single ecosystem in contrast to traditional departmental structures. Bioinformatics is also an important area of development, encompassing the collection, storage, and processing of genetic information, as well as the development of software for biological analysis. The adoption of such advanced technologies requires biocluster infrastructure with access to computing power and AI.

The Internet of Things (IoT) and blockchain, along with cloud computing and mobile services, are fundamentally transforming business structures and automating production processes. IoT shifts operational management from centralised to adaptive, adjusting processes through edge computing, reducing waste, and enabling company management with minimal or no middle management layers between leadership and operators. A concrete example of blockchain use in agrobiotechnology is Agrobion: prelude an agricultural marketplace built on a Ukrainian digital blockchain platform (AgroBon, n.d.). Blockchain transforms the supply chain coordination function: payments and the certification of genetically modified crops occur without intermediaries, and the vertically integrated corporate governance model is replaced by a decentralised network of stakeholders (farmers, suppliers, and biotechnology firms). Advanced technologies such as tissue engineering and bioprinting make it possible to create artificial tissues and organs using innovative technologies to «print» living cells and biological materials into predetermined forms. The Ukrainian company Biodrook, for example, produces implants based on biopolymer materials and 3D printing, capable of replacing bone tissue. Genome editing, which enables precise modifications to the genetic structure of

organisms, opens new possibilities for the treatment of genetic diseases and the development of accurate diagnostic methods. Synthetic biology as a branch of biotechnology involves the creation and modification of living systems to develop new biological structures or improve existing ones (Zayonts, 2026).

In Ukraine, a powerful IT sector serves as a prerequisite for the accelerated development of biotechnology through bioinformatics, artificial intelligence, and big data analysis not merely as a parallel industry. Such interaction provides Ukraine with a unique competitive advantage. Importantly, the IT sector offers not only technology but also highly skilled professionals, software development methodologies, data processing infrastructure, and a culture of rapid innovation – all of which are critical to the biotechnology sector. This enables Ukrainian biotech startups to develop and test solutions more rapidly using advanced computational capabilities. Such interaction may allow Ukraine to bypass certain stages of traditional biotechnology development and focus on deep technologies and data-driven innovation, where IT expertise is particularly valuable. It also renders the Ukrainian biotechnology sector attractive to international investors seeking the integration of biological and digital solutions (BioTech Sectoral Strategy, 2024).

The managerial effect of digital technology adoption in Ukraine's biotechnology sector is clearly evident through the optimisation of business processes, enhanced transparency, analytical capabilities, improved management efficiency and decision-making, and the reduction of bureaucracy. Among the important components of this effect are the digital transformation of companies and business models, as well as the automation of production processes. The introduction of digital applications and other solutions optimises operations, minimises bureaucracy, and increases the efficiency of, for example, accounting and reporting systems, internal corporate management, and state administration. AI enables the forecasting of demand for goods and services through data analysis, allowing companies to optimise production processes and improve marketing effectiveness.

Ukrainian companies are actively researching and implementing digital solutions in their management systems. For example, YURIA-PHARM LLC is actively investigating the organisational and economic dimensions of digitalising its management system, assessing its current level and developing proposals for improvement (YURIA-PHARM, n.d.). This indicates awareness of the importance of digital transformation at the level of individual biotechnology enterprises. The digital transformation of public administration in Ukraine reflects a trend towards "servitisation", whereby the state focuses on delivering high-quality, accessible services through digital channels (Rachynsky & Tytarenko, 2024). Although this applies to government as a whole, this paradigm can be extended to the government's interaction with the biotechnology sector, simplifying procedures, reducing administrative barriers, and enhancing the effectiveness of support. Rather than the traditional approach of regulation and control, the government becomes a "service provider" to business. Outcomes of such collaboration include streamlined licensing, rapid approval of research and development projects, prompt access to state support programmes, and a

reduction in bureaucracy one of the key priorities for the biotechnology sector. Such a paradigm shift at the government level can significantly accelerate the biotechnology innovation cycle, shorten time-to-market, and increase Ukraine's investment attractiveness, as businesses will encounter a more flexible and supportive government system.

Prior to the full-scale invasion, Ukraine had firmly established itself on the international startup map. According to the Global Innovation Index and the Ministry of Digital Transformation of Ukraine, the total value of Ukrainian startups reached € 27.1 billion, and the number of active projects exceeded 1,500. The country consistently ranked amongst the top 50 most innovative countries worldwide. Biotechnology companies created breakthrough solutions, from innovative prosthetics to health monitoring systems. Following 24 February 2022, Ukraine's startup ecosystem underwent a significant transformation. In 2022, a 45% decline in investment was observed due to general uncertainty. However, 2023 saw a partial market recovery, with US \$ 292 million in investments 34% more than in 2022. In the first quarter of 2024, US \$ 42 million was raised. State and grant support plays an important role in attracting investment. The "Seeds of Bravery" programme provided € 3.55 million to 117 Ukrainian startups, including those in the deep-tech, HealthTech, and AgriTech domains (Seeds Of Bravery, n.d.). Ukrainian startup Esper Bionics, which develops bionic prostheses, attracted significant investment and appeared on the cover of Time magazine; its product, Esper Hand, was recognised as one of the 200 best inventions of 2022 (Sabadyshina, 2024). Other successful examples include the startup Releaf Paper, which raised € 2.5 million for a factory producing paper from fallen leaves (Pykalo, 2024).

The global biotechnology market competes actively with IT for investment, ideas, and human capital. In Ukraine, despite a low overall level of research and development expenditure (0.33% of GDP in 2022), there are examples of attracting substantial funding to biotechnology research and development projects. In particular, investment in a biotechnology platform for the development and licensing of protein therapies amounted to US \$ 18 million (of which US \$ 6 million has already been received), alongside a US \$ 13 million grant from Google (Investment in a biotechnology platfor..., 2025). This attests to targeted successes and continued interest in high-technology biotech solutions.

In 2022, there was a significant decline in investment in Ukrainian startup projects. Nevertheless, despite the ongoing war, investment activity is recovering, and the inherent resilience and value of technological solutions continue to attract capital. This resilience is not fortuitous. It is attributable to several factors: the high quality of human capital; reorientation towards needs that have emerged in wartime and reconstruction contexts (e.g., bionic prostheses and agricultural technologies for food security); and active grant support, including from international sources. These factors enable continued investment attraction and development even under difficult conditions. Such resilience serves as an important signal to potential investors and international partners that the Ukrainian biotech sector, despite its challenges, is a promising destination for long-term investment, as

it is focused on solving real and urgent problems and has demonstrated an adaptive character.

The positive economic effect of digitalisation is evident through cost reduction, increased labour productivity, and enhanced investment attractiveness. These benefits include time savings, reduced transport costs (especially for rural residents), and the elimination of the need for physical visits to various facilities. One of the key economic effects is a reduction in production costs. AI technologies are used to automate production processes, thereby increasing productivity and reducing production costs. This is particularly relevant for biotechnology, where the automation of laboratory research, data analysis, and production lines enables significant process optimisation, cost reduction, quality improvements, and additional competitive advantages on markets. As marginal costs decrease, digital services become cheaper and more accessible. Digitalisation constitutes a driver of economic growth, founded on increasing efficiency and productivity through the use of digital technologies. Research shows that companies employing AI are able to improve customer interaction productivity through rapid data processing and first-contact problem resolution (Haan & Watts, 2023). Digital transformation can improve the efficiency of existing infrastructures and reduce costs across contemporary business models.

Digitalisation plays an important role in combating corruption by creating conditions for zero tolerance and reducing opportunities for corrupt practices. The actual economic and anti-corruption effect of introducing services in Diia over two years amounts to UAH 16.3 billion, whilst the potential effect is estimated at UAH 48 billion (Bankik, 2023). This demonstrates the direct economic impact of digitalisation on the efficiency of public administration and the business environment. Under wartime conditions and economic instability, digitalisation not only optimises processes but also becomes an essential instrument for the survival and competitiveness of biotechnology companies. Cost reduction through automation and greater transparency allows companies to use limited resources more effectively and remain profitable. The ability of digitalisation to optimise costs (operational, transactional, and corruption-related) under crisis conditions when every resource is precious is not merely an advantage but a necessity. For biotechnology companies, which frequently face high research and development costs, this frees up resources for innovation and operational continuity. Thus, digitalisation not only contributes to long-term economic growth but also ensures short-term stability and the adaptability of the biotechnology sector to adverse external conditions a key factor in its survival and development in Ukraine.

The COVID-19 pandemic and growing attention to ESG factors have accelerated the sustained growth of the global biotechnology market. According to forecasts, the market is expected to double in size by 2030 (Precedence Research, 2025; 2026). This global trend creates enormous opportunities for Ukrainian biotechnology enterprises. Through digitalisation, Ukraine has the opportunity to accelerate economic recovery, strengthen its position in the international arena, and integrate into the European digital space, whilst simultaneously enhancing the competitiveness of its economy. Ukraine's integration into the EU

and legislative harmonisation will facilitate the export of Ukrainian biotechnology products to international markets.

Digital transformation is associated with the emergence of new, high-quality business models and increased profitability. The development of new economic sectors, the creation of new jobs, and the establishment of a foundation for the development of all industries including the digital economy are prospects opened up by digital technologies. The WINWIN 2030 Digital Innovation Development Strategy envisages the opening of markets in priority industries, the development and support of innovative infrastructure, and the deregulation of innovative activity, with the aim of creating new jobs. Patent activity is an important indicator of innovation potential. In 2022, 2,760 applications for inventions were filed in Ukraine (18.6% fewer than in 2021) and 1,566 patents were issued (31.9% fewer than in 2021), of which 630 (40.2%) were in the name of domestic applicants. In 2023, the State Biotechnology University received 19 patents (all utility models), whilst the National University of Life and Environmental Sciences of Ukraine received 50 patents (11 inventions and 39 utility models) (UANIPIO statistics and reports, n.d.). This reflects the active patenting activity of universities, although utility models predominate.

Digitalisation enables Ukraine to strategically position its biotechnology sector in global markets not only focusing on exports but also gaining a reputation as a centre of digital innovation. This attracts foreign investment and partnership, particularly given Ukraine's lower research and development costs compared with EU countries and North America. A focus on deep technologies and AI-based solutions, combined with market access through digital platforms, can accelerate market penetration and allow Ukraine to capture a larger share of the growing global biotechnology market. In order to fully realise the potential of Ukraine's biotechnology sector under conditions of digitalisation, a comprehensive approach to its development is necessary. Above all, this concerns increasing the efficiency of investment in scientific research and establishing mechanisms for the commercialisation of developments. The formation of a flexible and predictable regulatory environment capable of responding promptly to technological change is of considerable importance. The creation of specialised digital infrastructure in particular, high-performance computing capacity and platforms for the analysis of biological information is becoming increasingly important. At the same time, it is necessary to establish innovation communities bringing together scientific institutions, business structures, and state bodies. Investment in developing human potential and ensuring conditions for retaining highly qualified employees also warrants particular attention. Simultaneously, encouraging domestic consumption and strengthening public trust in biotechnology products will contribute to expanding the domestic market and reinforcing the sector's competitive capacity.

● DISCUSSION

The results of the study confirm the growing importance of the synergistic interaction between state support mechanisms and digitalisation processes as key drivers of innovation development in the biotechnology sector, particularly under conditions of heightened uncertainty and wartime

challenges. The findings demonstrate that digital transformation not only enhances operational efficiency but also fundamentally reshapes the economic architecture of the sector, supporting the hypothesis that sustainable development of biotechnology requires systemic integration of technological, institutional, and managerial components. The study by S. Aliyah & A. Widiyatmoko (2023) demonstrates the effectiveness of entrepreneurship-based biotechnology e-modules in enhancing students' critical and creative thinking, emphasising the role of digital educational tools in strengthening innovation-oriented competencies. This conclusion aligns with the findings of research, which identify digitalisation as a key driver of transformation in the biotechnology sector, capable of improving efficiency, fostering innovation, and supporting the development of resilient ecosystems even under conditions of resource constraints and external shocks. However, this study extends argument by showing that the foundations of such transformation lie in human capital development: without the integration of entrepreneurial and digital competencies at the educational level, the practical implementation of digitalisation strategies and the realisation of the sector's potential particularly in contexts such as Ukraine, characterised by institutional instability, underfunding, and wartime challenges remain significantly constrained.

At the same time, the results resonate with the findings of O. Annahlka & A. Diniati (2025), who highlight the importance of digital communication strategies for increasing brand awareness in biotechnology startups. While their research focuses on marketing aspects, this study broadens the discussion by positioning digital communication not only as a promotional tool but as a critical element of market integration and trust-building in conditions of low consumer awareness. In the Ukrainian biotechnology sector, where scientific products often remain poorly commercialised, the role of digital platforms and content strategies becomes essential for bridging the gap between research and market demand.

The study also contributes to the ongoing debate on the development of biotechnology sectors in latecomer economies, as analysed by K. Szczygielski *et al.* (2022). Their findings on the role of innovation activity in overcoming structural disadvantages are partially confirmed. However, this research argues that innovation alone is insufficient without effective institutional support and digital infrastructure. In contrast to Poland's relatively stable development trajectory, Ukraine faces compounded challenges of institutional instability and wartime risks, which significantly limit the realisation of innovation potential despite high scientific capacity. Technological advancements in biotechnology, particularly in nanobiotechnology, as discussed by A. Bharadwaj *et al.* (2024), further reinforce the transformative potential of digitalisation. This study supports their conclusion regarding the role of advanced technologies in improving efficiency and personalisation. However, it also highlights a critical limitation: without adequate state support and investment mechanisms, the diffusion of such technologies remains constrained, particularly in developing or crisis-affected economies. Similarly, the findings of P. Nayak *et al.* (2026) on the role of green biotechnology in promoting sustainability are consistent with the results of this study. The integration of digital

technologies can significantly enhance resource efficiency and environmental performance. Nevertheless, this study emphasises that in the Ukrainian context, sustainability strategies must be complemented by economic feasibility and security considerations, particularly in light of disrupted supply chains and energy constraints.

A significant point of discussion concerns the role of artificial intelligence in biotechnology. The results are consistent with the findings of A. Bhushan & P. Misra (2025), who demonstrate the economic efficiency and transformative potential of AI in genomics and personalised medicine. However, this study adds a critical dimension by highlighting the importance of state regulation and ethical governance in ensuring equitable access to these technologies. Without such frameworks, digital transformation risks exacerbating existing inequalities within the sector. The issue of biosecurity, raised by N. Wheeler (2025), introduces an important policy dimension. This study supports the need for balancing innovation with risk management but extends the argument by emphasising that in wartime conditions, biosecurity becomes not only a technological concern but also a matter of national security. Consequently, digital monitoring systems and transparent data governance should be integral components of state support policies. The importance of digital infrastructure for enabling AI applications, as discussed by A. Holzinger *et al.* (2023), is fully confirmed by the findings of this study. The integration of Big Data and AI technologies significantly enhances research productivity and reduces development timelines. However, the study argues that the lack of a unified digital ecosystem in Ukraine limits the scalability of these innovations, pointing to the need for coordinated national digital strategies.

The application of AI in drug development, as analysed by M. Mulat *et al.* (2025), is also supported by the results. The study confirms that digitalisation reduces costs and accelerates innovation processes. Nevertheless, it critically highlights the insufficient integration of these technologies into digital business models and market platforms, which limits their commercialisation potential. This gap is particularly relevant for Ukraine, where the transition from research to market remains one of the key barriers to the development of the industry. The study also contributes to the ongoing debate on the role of artificial intelligence in the development of biotechnology and healthcare systems, as analysed by S. Quazi (2022). The findings on the potential of artificial intelligence and machine learning to enhance precision and genomic medicine are partially confirmed. However, this research argues that technological advancements alone are insufficient without adequate digital infrastructure, data accessibility, and institutional support. In contrast to the advanced healthcare systems considered in aforementioned study, the Ukrainian biotechnology sector operates under conditions of infrastructural constraints and wartime disruptions, which significantly limit the effective implementation of AI-driven solutions.

The study also contributes to the scientific debate on the role of deep learning technologies in the development of biotechnology and medical systems, as discussed by A. Anaya-Isaza *et al.* (2021). Their findings regarding the significant potential of deep learning in increasing the accuracy of medical diagnosis and image processing

are partially confirmed. At the same time, this study substantiates that the implementation of such technologies is insufficient without proper digital infrastructure, access to quality data and institutional support. Unlike the conditions considered by the authors, where the emphasis is on technological capabilities, the Ukrainian context is characterised by limited resources and the influence of crisis factors, which significantly complicates the scaling and effective use of solutions based on deep learning. The findings of S. Askin *et al.* (2023) regarding the possibilities of using AI to improve the efficiency of clinical trials in particular, the optimisation of participant selection and data management are partially supported. At the same time, this study substantiates that the adoption of AI technologies is insufficient without proper institutional support, access to quality data, and developed digital infrastructure. Unlike the conditions considered by the authors where the emphasis is on technological capabilities and improving the efficiency of clinical processes the Ukrainian context is characterised by institutional instability, limited resources, and the influence of military risks, which significantly complicates the scaling and practical implementation of AI solutions in the biotechnology sector.

An important aspect of the scientific discussion is the role of biotechnology in the development of sustainable wastewater treatment and circular economy models. The obtained results are consistent with the conclusions of A. Das *et al.* (2025), which prove the effectiveness of biotechnological solutions in restoring resources and ensuring environmental sustainability. At the same time, this study expands their approach, focusing on the need to integrate digital technologies, in particular artificial intelligence and data analytics, to improve the efficiency and monitoring of these processes. In addition, the key role of public policy and regulatory support in scaling such innovations is emphasised, especially in the context of economic recovery and limited resources. The results of this study are consistent with P. Pokataiev *et al.* (2022), who emphasise biotechnology as a strategic sector contributing to economic diversification, technological progress, and cross-industry multiplier effects. Building on their analysis, this study demonstrates that in the Ukrainian context, the development of biotechnology is increasingly shaped by mechanisms of adaptive resilience, in which digitalisation and institutional support act as important tools for growth and survival during wartime. In addition, digital platforms and communication strategies are critical for bridging the gaps between research, market engagement, and consumer trust, extending the focus to human capital and infrastructure.

Overall, this study contributes to the existing literature by integrating the analysis of digitalisation, state support, and innovative development within a unified framework adapted to crisis conditions. It introduces the concept of digitalisation as a resilience mechanism rather than solely an efficiency tool and emphasises the necessity of institutional coordination, financial support, and regulatory stability. The findings suggest that the key challenge for Ukraine is not a lack of technological potential but rather an inability to effectively translate this potential into sustainable economic outcomes. Therefore, the focus of policy should shift from fragmented support

measures towards the creation of an integrated digital and institutional ecosystem that enables innovation, ensures transparency, and strengthens the global competitiveness of the biotechnology sector.

● CONCLUSIONS

In the course of this research, the key systemic problems and challenges constraining the development of Ukraine's biotechnology sector were identified, and the complex interrelationship among state support, digitalisation, and the innovative development of Ukrainian biotechnology was elucidated. Despite strategic initiatives and scientific potential, the sector faces underfunding of research, legislative instability, staff emigration, and insufficient integration of science and business. This creates a paradox of unrealised potential in the presence of all the prerequisites for leadership. The work substantiates the necessity of translating strategies into practical action. At the same time, it has been demonstrated that digitalisation is the driving force behind the transformation of the sector. The analysis confirms that the adoption of digital technologies contributes to improved management efficiency, cost optimisation, productivity growth, expanded investment opportunities and access to new markets, and the creation of new business models. The interaction

between Ukraine's IT sector and biotechnology constitutes a competitive advantage for focusing on data-driven innovation and ensures the resilience of the startup ecosystem even under wartime conditions. On the basis of the results obtained, a set of practical measures is proposed, aimed at improving state policy and stimulating the innovative development of biotechnology whilst accounting for resource limitations and wartime risks. The results of this research have direct practical significance for the formation of post-war economic recovery policy. Further research directions include the evaluation of the effectiveness of individual state support programmes, comparative analysis with successful international practices in scaling innovation, and the examination of the ethical and social consequences of introducing advanced biotechnologies into the public sphere.

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Державна підтримка та цифровізація в інноваційному розвитку біотехнологічного сектору України

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Анотація. Актуальність дослідження полягає у визначенні ролі державної підтримки та цифровізації у забезпеченні інноваційного розвитку біотехнологій в Україні в умовах війни та економічної нестабільності. Метою роботи був комплексний аналіз взаємозв'язку між державною політикою, цифровими трансформаціями та інноваційним розвитком біотехнологічного сектору України. Методологія дослідження включала системний аналіз стратегічних документів, програм державної підтримки, стартап-екосистеми, а також практичного впровадження цифрових технологій у біотехнологіях, зокрема аналіз кейсів українських компаній і стартапів. Встановлено, що державна політика України у сфері біотехнологій, зокрема Концепція розвитку біоекономіки до 2030 року та Стратегія біобезпеки, створює системні умови для розвитку інноваційної продукції у фармацевтиці, агробіотехнологіях і біоенергетиці. Проаналізовано вплив цифровізації на сектор, зокрема впровадження штучного інтелекту, біоінформатики, великих даних, блокчейну та Інтернету речей, що забезпечує оптимізацію виробничих процесів, підвищення ефективності управління та зниження витрат. З'ясовано, що взаємодія українського IT-сектору та біотехнологій формує конкурентні переваги, прискорює трансформацію наукового потенціалу у комерційні продукти та забезпечує стійкість стартап-екосистеми навіть в умовах війни. Практична цінність результатів полягає у можливості їх застосування фахівцями публічного управління, економістами та менеджерами інновацій для формування ефективної політики післявоєнного відновлення економіки та стимулювання інноваційного розвитку біотехнологічного сектору України

Ключові слова: інноваційна інфраструктура; цифрова трансформація галузі; штучний інтелект у біотехнологіях; великі дані; блокчейн-технології; IT-біотех синергія; управлінська та економічна ефективність

Assessment of the state of e-governance in Ukraine in the context of civil society's access to e-participation tools

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Abstract. The relevance of the development of e-governance in Ukraine is conditioned by the need to ensure the continuity of public administration in war conditions, the public's demand for transparency of management processes, and increased civic participation. The purpose of the study was to systematically assess the level of e-governance development in Ukraine considering civil society's access to digital participation tools. The methodology of the study was based on the initial analysis and systematisation of data from the questionnaire of states parties used by the United Nations to prepare the global report on e-governance. As a result of the study, it was established that Ukraine has made some progress in the digital transformation of the public administration system. Among the key achievements are the launch of the national digital platform for public services, the adoption of strategic digital policy documents, and the development of the regulatory framework in the field of personal data protection, cybersecurity, and information openness. However, the study also revealed a number of barriers: the absence of a national coordinator of digital technologies, fragmented legal regulation of innovations, the lack of a unified state strategy for digital inclusion, weak integration of the results of public consultations into policy-making processes, limited collection of gender-specific statistics on the use of digital services. It is recommended to introduce the position of National Coordinator for Digital Transformation, develop a comprehensive strategy for digital inclusion, update the regulatory framework for innovative technologies, and ensure that citizens' views are considered more widely in public decision-making. The practical significance of the study lies in the development of recommendations for improving the digital policy of Ukraine, improving the effectiveness of electronic participation, and strengthening cooperation between the state and civil society⁵

Keywords: digital transformation; digital inclusion; strategy; electronic democracy; information and communication technologies

● INTRODUCTION

The relevance of the study was determined by the need to analyse the development of e-governance in Ukraine in the context of the current global challenges, in particular a full-scale war. Digitalisation of management processes and transformation of mechanisms of interaction between the state and citizens determine the need to expand the use of electronic services and participation tools. Ensuring the continuous provision of public services and the availability of digital tools requires a systematic approach to assessing the state of e-governance. Analysis of the state of e-governance in Ukraine remains important for identifying

existing achievements, identifying problem areas, and forming recommendations for further development of digital services and tools for electronic participation of citizens.

The assessment of the level of e-governance development in Ukraine was analysed by M. Halushchak *et al.* (2023). In their study, the researchers focused on the results of global monitoring of e-government conducted by the UN Department of Economic and Social Affairs. It was noted that there is an imbalance between the overall level of development of digital services and institutional mechanisms for attracting citizens. L. Ligonenko *et al.* (2022)

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focused on assessing the impact of the level of digital competence of citizens on the effectiveness of implementing digital services in the field of public administration. The researchers concluded that it is the sufficient level of digital skills of the population that is the key factor that determines citizens' satisfaction with digital transformation and contributes to the successful implementation of appropriate tools. O. Amosov *et al.* (2020) noted that now e-governance in Ukraine goes beyond the technical introduction of electronic services and becomes a tool for a deeper transformation of the public administration system. The paper drew attention to the limitations of international indicators, which mainly focus on quantitative technical parameters, such as access to services, the level of education of the population and infrastructure development.

N. Gavkalova & N. Yushchenko (2022) focused on assessing the level of development of e-democracy in Ukraine, paying attention to regional differences and factors influencing its implementation. The study used the cluster analysis method to assess and group regions by the intensity of using e-democracy tools. The researchers noted that the availability and quality of information and communication technologies are key criteria for evaluating the effectiveness of implementing digital participation mechanisms. A.M. Yeryna (2024) focused on assessing the development of e-government through the prism of the international E-Government Development Index (EGDI), which is a key tool for measuring the progress of digital transformation of governments on a global scale. The researcher analysed the methodological basis for calculating this index, and its adaptation to new functions of e-governance due to the evolution of digital technologies. Yu. Akulov (2024) focused on evaluating the effectiveness of e-governance in Ukraine through the prism of socio-economic factors of digitalisation. The researcher stressed that despite the active development of digital services, evaluating their effectiveness requires a transition from quantitative to qualitative approaches, considering accessibility, inclusivity, and regional balance.

Among foreign scholars who have investigated ways to evaluate e-government, it is worth noting S. Sheoran & S. Vij (2022), who analysed existing approaches to evaluating e-governance. The researchers systematised studies that focused on such key dimensions as e-readiness, acceptance of e-services, citizen engagement, and quality and efficiency assessment. As part of the study, a thematic analysis was carried out using NVivo and QDA Miner software, which allowed identifying the main conceptual areas, variables, and relationships between different evaluation models. The researchers stressed the need to develop an integrated approach to evaluating e-governance, which would consider all stages – from the level of digital readiness to the actual achievement of public results.

B.J. Tiika *et al.* (2024) focused on analysing the level of e-governance development among African Union member states. Within the framework of the study, a mixed approach was applied: quantitative assessment was carried out using the Technique for Order Preference by Similarity to an Ideal Solution based on secondary statistics on key indicators of e-governance, and the qualitative component was provided through interviews with representatives of the public sector. The researchers emphasised that positive

developments in countries such as Ghana are conditioned by the consistency of digital strategies with national policies, which contributes to improving the effectiveness of public administration. Among the fundamental research devoted to the analysis of approaches to the assessment of e-governance, it is necessary to highlight the study by M. Heidlund & L. Sundberg (2022), who conducted a systematic review of the scientific literature on the topic of e-governance assessment. The researchers applied bibliometric keyword analysis combined with a narrative review of the most cited papers, which helped to identify seven main research topics.

A.C. Chumaceiro Hernández *et al.* (2023) investigated EGDI in various regions of the world. The researchers analysed the level of progress made in the implementation of e-governance, finding that since 2020, digital transformation has contributed to increasing access of citizens and businesses to public services. However, in their opinion, the effectiveness of e-governance depends not only on the intensity of use, but above all on the stability, clarity, and consistency of information interaction between the state, society, and organisations. Despite considerable attention to certain aspects of digitalisation, in the contemporary scientific discourse, there is a lack of a systematic approach to assessing the level of development of e-governance in Ukraine, which would consider organisational, strategic, legal, and social factors together. The purpose of this study was a comprehensive assessment of the state of development of e-governance in Ukraine through the prism of citizens' access to e-participation tools using the criteria of the Member States Questionnaire (MSQ) for UN E-Government Survey 2024, and the development of recommendations for improving e-participation mechanisms.

• MATERIALS AND METHODS

The methodological basis of the study was general scientific and applied methods, in particular, the primary analysis of the state of e-governance and data systematisation. In the course of the study, a thorough analysis of the criteria of the MSQ questionnaire (United Nations, 2024a) was carried out, which was a unified tool for assessing the digital transformation of government structures by key indicators. The use of the primary analysis method allowed assessing the presence of the main elements of e-governance in Ukraine and set binary estimates (0/1) for each criterion. To improve the consistency of the assessment, the questionnaire criteria were unified according to the main thematic sections, within which evaluation questions were formulated.

Evaluation according to the MSQ criteria was carried out according to a unified procedure: each indicator was assigned a value of "1" if there was a corresponding e-government element, confirmed based on analysis of official sources, and a value of "0" – if it was not available or there was no confirmation. The analysis included selected MSQ survey questions representing key areas of e-governance development, namely organisational, strategic, legislative, digital inclusion and participation, usage and satisfaction, international cooperation, which were selected based on their relevance to the research goal, coverage of key functional aspects of e-governance and the possibility of their application to the analysis of the national context. The totality of the analysed sources covered official web resources

of state authorities of Ukraine, national digital platforms and portals of electronic services, laws and regulations, strategic documents, and analytical reports of international organisations, in particular United Nations (2024b), results of research initiatives of the Evidence in Governance and Politics (EGAP) project, and information and analytical materials on the development of e-democracy in Ukraine, which ensured the representativeness of the findings.

The data systematisation method was used to summarise the estimates obtained and identify the strengths and weaknesses of national e-governance practices. This approach helped to objectively determine the level of implementation of certain criteria for digital development, identify problem areas, and form recommendations for improving electronic services and tools for citizen participation. To process the collected information, the method of content analysis of regulatory acts and strategic documents was used, which helped to identify key elements and indicators of digital development. With the help of an analytical approach, a systematic study of laws and regulations was carried out, in particular, Law of Ukraine No. 2297-VI (2010), Law of Ukraine No. 2939-VI (2011), Law of Ukraine No. 922-VIII (2016), Law of Ukraine No. 2163-VIII (2017), bylaws and strategic documents regulating the digitalisation of public administration. The analysis of regulations and strategic documents was carried out in accordance with certain criteria for evaluating e-governance. This integrated approach provided an objective generalisation of the results of the initial analysis, identification

of problem areas, and development of practical recommendations for improving electronic services and mechanisms for citizen participation, and also allowed for a systematic assessment of the level of development of e-governance in Ukraine according to certain criteria.

● RESULTS AND DISCUSSION

Ukraine during 2015-2025 showed some progress in the development of e-governance, but this process was accompanied by a number of institutional, technological, and regulatory restrictions that remained relevant for further scientific analysis. The analysis of e-government assessment methods showed that there are various international approaches, in particular, the EGDI index for assessing the development of online services, telecommunications infrastructure, and human capital; the E-Participation Index for measuring the level of electronic participation of citizens; the Digital Economy and Society Index for assessing the digital competitiveness of states; and the multi-criteria method for evaluating web resources Website Assessment Evaluation System.

However, these approaches have limited applicability for integrated internal audit, since they either focus on macro-level indicators, or cover only certain aspects of electronic participation. This allowed using the criteria of the MSQ questionnaire, which allowed conducting a detailed analysis of the state of e-governance in Ukraine and assessing citizens' access to e-participation tools. Detailed evaluation results for individual criteria are shown in Table 1.

Table 1. Evaluation of the state of e-governance in Ukraine based on MSQ

Criterion code	Criteria	Evaluation question	Compliance assessment (0/1)
A1	Organisational	Is there an official national e-government portal?	1
A2	Organisational	Is there a ministry or agency that is responsible for e-governance at the national level?	1
A3	Organisational	Does the country have a national Chief Information Officer (CIO) or a similar role?	0
B1	Digital strategy and implementation	Is there a national strategy for e-government or digital transformation?	1
B2	Digital strategy and implementation	Is there a separate budget for the development of digital services?	1
C1	Legislative	Does the country have legislation or regulations on a wide range of digital issues, including the latest technologies?	1
D1	Digital inclusion and electronic participation	Is there a digital inclusion strategy for vulnerable groups?	0
D2	Digital inclusion and electronic participation	Are special services/programmes implemented for such groups?	1
D3	Digital inclusion and electronic participation	Does the government use social media to inform, consult, and make decisions?	1
D4	Digital inclusion and electronic participation	Is information published about considering public opinion in policy development?	0
E1	Usage and satisfaction	Are statistics on the use of e-services collected?	1
E2	Usage and satisfaction	Are gender statistics considered when evaluating users?	0
E3	Usage and satisfaction	Is the level of user satisfaction measured?	1
F1	International cooperation	Does the country participate in international or regional digital initiatives?	1

Source: developed by the author based on United Nations (2024a)

Within the framework of the “organisational” criterion of electronic governance, it is worth noting the functioning of the official state portal Diia (A1) in Ukraine. The introduction of this platform in 2020 was an institu-

tional response to the need to modernise public services due to global digital trends and the growing public demand for transparency and accessibility, while at the initial stage of its operation, 50 administrative services were

available (Danyliuk *et al.*, 2021). As of 2026, Diia combines more than 70 public services, including access to electronic documents, business registration, registration of assistance to displaced persons, submission of electronic petitions, and other services. The platform integrates the principles of mobility, minimisation of bureaucratic procedures and user convenience, which corresponds to the European citizen-centric governance model. Responsibility for the development of digital transformation is assigned to the Ministry of Digital Transformation of Ukraine, established in 2019 (A2). Its functioning ensured the development of a sustainable institutional architecture of digitalisation at the central level. Simultaneously, the lack of a separate position of Chief Information Officer (CIO) limits the ability to strategically coordinate digital processes between different sectors and levels of government (A3). In international practice, the appointment of a CIO allows for the management of an e-governance architecture, which, in particular, contributes to data unification, resource optimisation, and integration of innovative solutions into interagency interaction (Criado & de Zarate-Alcarazo, 2022).

When analysing the criteria of digital strategy and implementation, it was found that Ukraine has a set of strategic documents (B1) that determine the priorities of digital transformation. Concept for the Development of E-Democracy in Ukraine (Resolution of the Cabinet of Ministers of Ukraine No. 797-r, 2017) established the principles of attracting citizens through digital mechanisms, while the Concept for the Development of the Digital Economy and Society of Ukraine (Resolution of the Cabinet of Ministers of Ukraine No. 67-r, 2018) focuses on modernising government institutions and stimulating the development of digital business models. Currently, the process of developing a national digital strategy until 2030 is underway, which provides for the integration of digitalisation in all spheres of public life. It is worth noting that the previously adopted strategies provided for a medium-term planning horizon (up to 5 years), which in the context of dynamic transformations requires constant updating and adaptation to new challenges. Considering international experience, the effectiveness of such strategies depends on the balance between technological readiness, process management, and the development of digital skills in government employees (David *et al.*, 2023).

Financing of digital transformation in Ukraine is carried out according to a mixed model that combines the resources of the state budget (B2) and external donor support. Among the most significant initiatives is the Swiss-Ukrainian EGAP programme, which is implemented by the Eastern Europe Foundation with the support of the Swiss Development and Cooperation Agency. This programme introduces state-of-the-art digital services, e-democracy tools, community digital maturity monitoring systems, and digital literacy educational projects. European initiatives play an important role, in particular the Digital Europe programmes, EU4Digital, and national digital reconstruction strategies, such as the United 24 Plan (Kuzhda & Lutsykyv, 2022). A significant part of the projects are implemented in the format of public-private partnership, which helps to attract international investment and ensures the sustainability of digital changes. Assessment of the legislative criterion for the development of digital governance has

shown that there are significant developments in this area. Ukraine has ensured the adoption of key regulatory acts (C1), in particular the Law of Ukraine No. 2939-VI (2011), which guarantees openness and transparency of government activities. Law of Ukraine No. 2297-VI (2010) defines the legal basis for processing and protecting information about individuals. Law of Ukraine No. 2163-VIII (2017) forms institutional and legal mechanisms for countering cyber threats. Law of Ukraine No. 922-VIII (2016) introduces an electronic procurement system to ensure transparency and competition in this area.

Among contemporary digital governance tools, a separate place was occupied by ICT solutions, in particular the ProZorro electronic public procurement system and the information portal Spending.gov.ua. These platforms promote transparency and openness of public financial management, providing broad access to data on the use of budget funds, and minimising the risks of abuse in public procurement processes. An important component of their effectiveness is proper legal regulation, which sets clear rules for the functioning of digital tools and guarantees the responsibility of participants in the process. ProZorro has become an example of successful integration of digital technologies with regulatory mechanisms, which has helped to reduce corruption risks and increase the efficiency of public spending even under martial law (Kelman & Yukins, 2022).

In the field of data management between government agencies, certain changes have taken place due to the introduction of the Trembita system, which provides interagency information exchange based on common standards of interaction, but the legislative framework in this part is still in a state of gradual development (Resolution of the Cabinet of Ministers of Ukraine No. 606, 2016). Regarding the regulation of the latest tools, such as artificial intelligence, blockchain, 5G, and other digital innovations, the regulatory framework in Ukraine is fragmented. The Concept for the Development of Artificial Intelligence in Ukraine (Resolution of the Cabinet of Ministers of Ukraine No. 1556-r, 2020), which defines the strategic areas for the development of AI technologies, their areas of application and the basis for policy development in this area, the absence of a special Law of Ukraine on "Artificial intelligence" or appropriate ethical standards creates gaps in the regulatory environment (Yara *et al.*, 2021). A similar situation is observed in the field of blockchain technologies: there are only separate resolutions and documents of a recommendatory nature without a holistic legal mechanism for implementing these decisions in public administration.

The lack of a comprehensive regulatory approach to digital innovations can slow down the pace of their integration into the e-government system, limiting the potential for technological renewal of the public sector, and reducing the level of legal certainty for developers, authorities, and users of digital services. In the context of evaluating the criteria of digital inclusion and electronic participation, it was revealed that Ukraine does not have a unified state strategy for digital inclusion of vulnerable groups (D1). However, some educational initiatives have been implemented to improve the digital skills of older people, people with disabilities, and internally displaced persons (D2). Platform Diia.Digital Education offers courses for different

categories of citizens, but the issue of infrastructure accessibility, providing specialised devices and supporting the individual needs of vulnerable groups remains open. Digitalisation expands opportunities for access to information and social services, which is critical for the social integration of vulnerable categories. The lack of equal access to digital technologies exacerbates the problem of the digital divide, which can deepen social inequality (Khlivniuk & Kiriak, 2024). The government actively uses social networks as a channel of communication with citizens (D3), in particular, for conducting electronic consultations and discussing regulations. However, the systematic integration of the results of public discussion into the final versions of decisions remains limited (D4), which reduces the real influence of citizens on policy development.

Regarding the criterion of use and satisfaction with digital public services, there is a steady positive trend. Although analysis of statistics by gender, age, region, or social group remains limited (E2), the instant feedback tools integrated into the Diia platform allow quickly assessing user satisfaction (E1). According to the results of an annual nationwide survey conducted by the Kyiv International Institute of Sociology in 2024 on behalf of the UNDP in Ukraine, with support from Sweden (UNDP, 2025), 84% of respondents who had used government e-services rated their experience as somewhat or very positive (E3). This is 5.5% more than in 2023 (78.5%). Thus, the trend towards increasing trust and satisfaction with digital services in Ukraine continues. International cooperation is one of the key components of Ukrainian digital policy. Ukraine is actively involved in numerous international initiatives (F1), in particular Open Government Partnership, Eastern Partnership Initiative, EU4Digital programme, and other projects of the European Union and the United Nations. Such participation contributes to the integration of the best international practices of digital transformation, provides

access to technical expertise and financial resources, and increases the international legitimacy of Ukrainian reforms. As noted by H. Bondar (2023), Ukraine's participation in the Digital Europe programme opens up new opportunities for national authorities and businesses by expanding access to funding, institutional support and cutting-edge digital solutions, which significantly enhances the country's digital transformation potential.

Based on the assessment of the MSQ criteria, a number of problematic aspects were identified that hinder the further development of e-governance in Ukraine. These barriers are both organisational and regulatory in nature. Interpretation of the results obtained requires considering the conditions of martial law, which affect the functioning of e-government tools. Limiting access to individual data, reducing the level of openness of public information, and prioritising security aspects of state activities objectively affect the indicators of electronic participation of citizens, and the possibility of implementing feedback mechanisms. In such circumstances, individual indicators that characterise the level of participation and openness may be reduced due to temporary security restrictions, which makes it difficult to unambiguously interpret them as indicators of the effectiveness of the national policy. Certain problems, in particular the lack of a holistic digital inclusion strategy and the lack of integration of the results of public consultations into decision-making processes, are systemic in nature and cannot be explained solely by the impact of martial law. Overcoming barriers to the development of e-governance in Ukraine requires targeted actions, in particular through the formulation of appropriate recommendations for improving the institutional mechanism, legal regulation, and increasing the inclusiveness of digital services. The key problems of individual evaluation criteria and practical recommendations for overcoming them are summarised in Table 2.

Table 2. Problems and recommendations for the development of e-governance in Ukraine

Criterion code	Criteria	Problem	Recommendations
A3	Organisational	Lack of a national CIO position	Formalise the position of national CIO to strengthen coordination of digitalisation
C1	Legislative	Lack of a special law on AI and ethical standards; lack of a complete legal framework for blockchain	Develop a legal framework for AI and blockchain technologies, including ethical and legal standards
D1	Digital inclusion and electronic participation	Lack of a digital inclusion strategy	Develop a state strategy for the inclusion of vulnerable groups
D4	Digital inclusion and electronic participation	Limited consideration of public opinion in decision-making	Integrate mechanisms for influencing discussion outcomes into policy decisions
E2	Usage and satisfaction	Lack of collection of gender statistics	Implement gender-sensitive data collection and analysis

Source: compiled by the author

It is important to note that the effective development of e-governance is impossible without the active involvement of civil society, which acts not only as an object of providing public services, but also as an equal partner in the process of forming public policy. Civil society, using the capabilities of digital platforms, plays a significant role in ensuring transparency, accountability and openness of public bodies, and in mobilising social capital to overcome the challenges caused by crisis situations. In the post-war

periods, interaction between the state and civil society takes on a special role, since it is the activity of public initiatives in the digital environment that contributes to the effective restoration of the country and the strengthening of democratic processes (Karamyshev & Dziundziuk, 2023). The development of sustainable channels of electronic participation, the improvement of digital literacy of citizens, the creation of favourable conditions for online consultations and discussion of regulations are necessary conditions for

strengthening the influence of civil society on management processes. In this context, even the relatively short period of functioning of e-government systems indicates a transformation of the role of the state in an integrated and globalised world, where interaction with citizens takes on new forms and significance (Okun'ovs'ka, 2023). Further research on the processes of electronic participation and institutional support of public initiatives in the digital environment should become an important area of scientific analysis and practical implementation to ensure the sustainable development of Ukraine.

The results of the study show that Ukraine has a high level of use of electronic services and satisfaction with them, but this is not accompanied by proper integration of citizens into the processes of the national policy development. Similar aspects were considered by M.N. Kholid & D.N. Sari (2022), where it was found that technological parameters are the determining factors in the use of electronic services, while trust in the government does not have a statistically significant impact. The results are consistent with this approach, demonstrating that the efficiency and convenience of digital services can ensure their active use without the development of full-fledged electronic participation.

The results correlate with the findings of S. Syefulloh *et al.* (2026), who found that even with the high level of digital presence of authorities assessed based on EGDI indicators, the functional maturity of electronic services may remain limited. This opinion is consistent with the results of the study, which demonstrate that the quantitative growth of digital solutions does not ensure their qualitative effectiveness, in particular, in terms of ensuring the participation of citizens. The study by M.F. Razanakoto (2026) determined that the use of e-governance contributes to increasing the level of institutional trust in the state, provided that the quality of services, transparency, and effective interaction with citizens are ensured. The results obtained are partially consistent with these conclusions, as they indicate a high level of satisfaction with digital services, but simultaneously indicate limited interaction between citizens and the state in decision-making processes, which can affect the completeness of the realisation of the potential of trust.

The study showed that in Ukraine, the development of e-governance is accompanied by the introduction of digital services, but their effectiveness is limited by institutional and organisational factors. Similar conclusions were given in a study on the implementation of e-governance in the city of Pekanbaru, conducted by S. Pahmi *et al.* (2025), during which it was found that a significant number of digital initiatives do not ensure sustainability due to institutional weakness, lack of coordination, and limited resources. The results obtained correlate with these conclusions and confirm that the key limitation of the development of e-governance is the institutional ability to ensure the effective implementation of digital solutions. G. Umbach & I. Tkalec (2022) noted that the assessment of e-governance is context-sensitive and should consider the institutional and managerial features of its implementation. The study found that without considering the level of citizen participation and institutional capacity, the assessment of the development of e-governance may be incomplete and does not reflect its real effectiveness.

The results of the study showed that the effectiveness of e-governance in Ukraine in terms of ensuring citizen participation remains limited due to the lack of a holistic strategy for digital inclusion. Å. Waara (2025) emphasised that a significant part of digital maturity management assessment models do not sufficiently consider the inclusive component or formally integrate it. The results are consistent with these conclusions and demonstrate that ignoring issues of digital inclusion and citizen participation leads to an incomplete reflection of the level of development of e-governance. It was found that the lack of a holistic digital inclusion strategy limits the level of citizens' participation in the use of electronic tools. J. Li *et al.* (2025) noted that digital inequality increases social exclusion, as individual populations face difficulties accessing electronic services. The study by M. Tokovska *et al.* (2023) found that the level of use of e-governance is determined by the socio-demographic characteristics of the population, in particular, the level of education and income, even if the necessary digital infrastructure is available. These factors affect not only access to electronic services, but also the ability of citizens to use them effectively, which leads to uneven involvement of various social groups in digital interaction with the state. This indicates that the technical availability of digital services is not a sufficient condition for their full use. The analysis is consistent with these approaches, pointing out that even in the context of the development of digital services, the lack of an inclusive approach limits the level of citizen engagement.

Special attention was paid to the introduction of artificial intelligence technologies in the electronic management system. The conducted research showed that this process takes place in the absence of specialised legal regulation and ethical standards. I. Savveli *et al.* (2025) found that citizens' perception of AI solutions in e-governance largely depends on the level of trust, perceived utility, usability, and risks associated with data privacy. The results of the study extend these conclusions, demonstrating that the lack of a legal and ethical framework can affect the effectiveness of using appropriate technologies in the public administration system.

The study demonstrates consistency with existing scientific approaches to the analysis of e-governance and reflects the specifics of national development, which is manifested in the gap between technological progress and institutional support for citizen participation. This allows considering e-governance as a complex phenomenon that requires a combination of technological, institutional, and social components. This highlights the need for an integrated approach to development, which provides for the alignment of digital solutions with citizen participation mechanisms and institutional tools, and creates prerequisites for optimising the functioning of the public administration system and more fully realising the potential of digital transformation.

● CONCLUSIONS

The study showed that Ukraine has made some progress in the development of e-governance. A systematic analysis of the MSQ questionnaire criteria allowed identifying both achievements and existing problems in the context of ensuring civil society's access to electronic

participation tools. In particular, the development of the national digital infrastructure, the creation of the Diia platform, active international cooperation, and the availability of strategic documents in the field of digitalisation indicate a sustainable digital transformation of management processes. Simultaneously, the study revealed a number of problematic aspects that require further attention. Legislative regulation of innovative technologies such as artificial intelligence, blockchain, and the ethics of their use remains limited, which hinders the integration of advanced digital solutions into public administration. Insufficient integration of the results of public consultations into policy-making processes reduces the effectiveness of electronic citizen participation. The use of detailed statistics on user satisfaction with electronic services is limited, which makes it difficult to make managerial decisions based on the real needs of society. The issue of digital inclusion of vulnerable groups remains fragmentary and requires the development of a comprehensive state strategy.

To overcome the identified problems, it is advisable to take comprehensive measures, in particular: formalise the position of national CIO to strengthen institutional coordination of digitalisation; develop a legislative framework for regulating artificial intelligence, blockchain technologies, and ethical standards for their application; create a state strategy for digital inclusion of vulnerable groups of the population; ensure the integration of the results of public discussions into political decisions; introduce a systematic collection and analysis of user statistics considering gender and social characteristics. Special attention should be paid to the further development of civil society as a subject in the processes of e-democracy. The establishment of sustainable channels of interaction between the state and the public through electronic participation mechanisms is

a prerequisite for strengthening government accountability, increasing transparency of management decisions, and building citizens' trust in state institutions. The activation of civil society in the context of digital transformation requires not only expanding technical access to services, but also providing a real opportunity to influence public policy through inclusive and effective electronic platforms.

The results obtained fully correlate with the goal of the study set out in the introduction – to carry out a systematic assessment of the state of development of e-governance in Ukraine and to form reasonable recommendations on improving the mechanisms of electronic participation on this basis. The assessment provided an opportunity to objectively assess the achievements and identify areas for improving e-governance in accordance with international standards. Further research should be directed to the development and implementation of integrated strategies for digital inclusion, deepening the legal regulation of innovative technologies, improving mechanisms for involving the public in decision-making processes through electronic platforms, in-depth study of tools for supporting civil society in the context of digital transformation, and creating indicators for a systematic assessment of the impact of electronic participation on the effectiveness of public administration.

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● REFERENCE

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Оцінювання стану електронного врядування України в контексті доступу громадянського суспільства до інструментів електронної участі

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Анотація. Актуальність розвитку електронного врядування в Україні обумовлена потребою забезпечення безперервності публічного управління в умовах війни, запитом суспільства на прозорість управлінських процесів і посиленням громадянської участі. Метою дослідження було системне оцінювання рівня розвитку електронного врядування в Україні з урахуванням доступу громадянського суспільства до цифрових інструментів участі. Методологія дослідження базувалася на первинному аналізі та систематизації даних, отриманих за допомогою опитувальника держав-учасниць, що використовується Організацією Об'єднаних Націй для підготовки глобального звіту з електронного врядування. У результаті проведеного дослідження встановлено, що Україна досягла певного прогресу в цифровій трансформації системи державного управління. Серед ключових досягнень – запуск національної цифрової платформи державних послуг, ухвалення стратегічних документів цифрової політики, розбудова нормативно-правового поля у сфері захисту персональних даних, кібербезпеки та відкритості інформації. Однак дослідження також виявило низку бар'єрів: відсутність національного координатора цифрових технологій, фрагментарність правового регулювання інновацій, відсутність єдиної державної стратегії цифрової інклюзії, слабка інтеграція результатів громадських консультацій у процеси формування політики, обмеженість збору гендерно-специфічної статистики щодо використання цифрових сервісів. Рекомендовано запровадити посаду національного координатора цифрової трансформації, розробити цілісну стратегію цифрової інклюзії, оновити нормативно-правову базу інноваційних технологій та забезпечити ширше врахування думки громадян у прийнятті державних рішень. Практична цінність дослідження полягає у формуванні рекомендацій для вдосконалення цифрової політики України, підвищення ефективності електронної участі та зміцнення співпраці між державою і громадянським суспільством.

Ключові слова: цифрова трансформація; цифрова інклюзія; стратегія; електронна демократія; інформаційно-комунікаційні технології

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