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Digital Twin of an Enterprise as a Management Tool: Concept and Practical Significance

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Abstract. *The relevance of the study is determined by the growing need for modern data-driven management tools, which is associated with the deepening of digital transformation and the increasing complexity of the operational activities of enterprises.*

Aim. *The aim of the article is to elucidate the conceptual understanding of the digital twin of an enterprise as a management tool and to substantiate its practical significance for improving economic performance and enhancing decision-making processes.*

Methods. *The methodological basis of the study comprises general scientific methods of cognition, in particular the method of scientific literature analysis, applied to examine the current state of research on the issue, as well as the methods of scientific generalization and systematization, employed to structure and interpret the obtained results.*



Results. *The study substantiates the interpretation of the digital twin as an integrated dynamic virtual model that ensures continuous synchronization with real-world business processes and serves as a foundation for analytical and predictive management. It has been established that the implementation of digital twins contributes to enhancing operational efficiency through real-time monitoring, the optimization of resource allocation, and improved coordination among functional units. In view of this, the functional capabilities of digital twins in supporting managerial decision-making have been analyzed, in particular their ability to simulate alternative scenarios, reduce uncertainty, and strengthen the validity of strategic and operational decisions. Moreover, the economic effects of their application have been identified, namely cost optimization, productivity growth, and the enhanced capacity of enterprises to adapt to external changes. Within this context, the interrelation between digital twins and the digital ecosystem of the enterprise has been examined, which made it possible to clarify their role as a central analytical element that integrates heterogeneous data flows into a unified information space. At the same time, the organizational and technological obstacles to implementation have been analyzed, including an insufficient level of digital competencies, high initial investment costs, and issues related to data integration and cybersecurity. Taking the foregoing into account, it has been established that the development of advanced digital technologies creates favorable conditions for scaling digital twins across various sectors of the economy.*

Conclusions. *It has been substantiated that the digital twin of an enterprise constitutes not merely a technological innovation but also a transformational management tool that improves the quality of decision-making, strengthens business resilience, and supports sustainable development in the context of the digital economy.*



Keywords: *digital transformation, managerial innovations, virtual modeling, managerial decision-making, business processes, economic efficiency, information and analytical systems, predictive analytics.*

Цифровий двійник підприємства як інструмент управління: концепція та практичне значення

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Анотація. *Актуальність дослідження зумовлена зростанням потреби в сучасних інструментах управління на основі даних, що пов'язано з поглибленням цифрової трансформації та ускладненням операційної діяльності підприємств.*

Метою статті є концептуалізація цифрового двійника підприємства як інструменту управління, а також обґрунтування його практичної значущості для підвищення економічної ефективності та оптимізації процесів прийняття управлінських рішень.

Методологічну основу дослідження становлять загальнонаукові методи пізнання, зокрема метод аналізу наукової літератури, застосований для вивчення наявного стану розроблення зазначеної проблематики, а також методи наукового узагальнення й систематизації, використані для структурування та інтерпретації отриманих результатів.

Результати. У дослідженні обґрунтовано трактування цифрового двійника як інтегрованої динамічної віртуальної моделі, що забезпечує постійну синхронізацію з реальними бізнес-процесами та слугує основою для



аналітичного й прогностичного управління. Установлено, що впровадження цифрових двійників сприяє підвищенню операційної ефективності завдяки моніторингу в режимі реального часу, оптимізації розподілу ресурсів та поліпшенню координації між функціональними підрозділами. З огляду на це проаналізовано функціональні можливості цифрових двійників у підтримці прийняття управлінських рішень, зокрема їхню здатність моделювати альтернативні сценарії, зменшувати невизначеність і підвищувати обґрунтованість стратегічних та операційних рішень. Крім того, визначено економічні ефекти їхнього застосування, а саме оптимізацію витрат, зростання продуктивності та посилення здатності підприємств адаптуватися до зовнішніх змін. У цьому контексті розглянуто взаємозв'язок між цифровими двійниками та цифровою екосистемою підприємства, що дало змогу з'ясувати їхню роль як центрального аналітичного елемента, який інтегрує різноманітні потоки даних у єдиний інформаційний простір. Водночас проаналізовано організаційні та технологічні перешкоди на шляху впровадження, зокрема недостатній рівень цифрових компетенцій, високі початкові інвестиційні витрати, а також проблеми, пов'язані з інтеграцією даних і кібербезпекою. Зважаючи на наведене, установлено, що розвиток передових цифрових технологій створює сприятливі умови для масштабування цифрових двійників у різних секторах економіки.

Висновки. Обґрунтовано, що цифровий двійник підприємства є не лише технологічною інновацією, а й трансформаційним інструментом управління, який підвищує якість прийняття рішень, зміцнює стійкість бізнесу та підтримує сталий розвиток в умовах цифрової економіки.

Ключові слова: цифрова трансформація, управлінські інновації, віртуальне моделювання, прийняття управлінських рішень, бізнес-процеси, економічна ефективність, інформаційно-аналітичні системи, прогнозна аналітика.



Introduction. The problem of conceptualizing and practically implementing the enterprise digital twin as an effective management tool is becoming increasingly relevant in the context of accelerated digitalization, growing market uncertainty, and the rising complexity of business processes. Modern enterprises operate under conditions characterized by rapid technological change, intense competition, and the need for continuous adaptation, all of which substantially complicate the process of making timely and well-grounded managerial decisions. Traditional management approaches, which often rely on fragmented data and retrospective analysis, are no longer sufficient to ensure efficiency, resilience, and strategic flexibility. In this context, the digital twin emerges as a promising solution that integrates real-time data, advanced analytical tools, and modeling capabilities into a unified management system; however, despite its growing popularity, there is still no unified theoretical understanding of its essence, functional boundaries, or economic implications. In addition, the practical challenges associated with its implementation, including technological limitations, organizational resistance, and the need for significant investment, create additional barriers that hinder its wider adoption. Therefore, the relevance of the present study lies in the need to systematize existing scientific approaches, to refine the conceptual foundations of the enterprise digital twin, and to substantiate its practical significance as an innovative management tool capable of enhancing operational efficiency, supporting evidence-based decision-making, and ensuring sustainable business development in the conditions of the digital economy.

Literature Review. Considerable attention has been devoted to the issue of enterprise digital twins in contemporary scientific research within the context of the digital transformation of the economy and the enhancement of managerial processes. In particular, Yu. Semenenko [1] explores the potential of modeling digital twins of business processes as a means of improving company management through process optimization and analytical support for decision-making. The study by M. Malchyk,



I. Oplachko, and V. Vasylyv [2] emphasizes the role of the digital twin in fostering enterprise data transparency, as well as its influence on brand management and ESG-oriented performance indicators of industrial enterprises. O. Yurchenko [3] establishes that digital transformation, including the adoption of digital twins, constitutes a key factor in shaping the competitive advantages of enterprises under conditions of global economic instability. The research of L. Maznyk and K. Zhukovska [4] shows that digital twins can be effectively applied to offset labor shortages and to modernize production processes, particularly in Ukraine's food industry. Melnychenko S. [5] examines the impact of strategic management on organizational success, thereby indirectly underscoring the importance of digital technologies, including digital twins, in improving the quality of managerial decisions. The study by Yu. Maksymiuk, K. Dmytriiev, and M. Chernenko [6] confirms that the implementation of digital twins in the production processes of Ukrainian industry contributes to enhancing operational efficiency and advancing management automation. Pavlenko V. et. al. [7] substantiate the feasibility of integrating digital twins into transportation systems as a tool for improving the efficiency of flow and infrastructure management. The research of V. Shcheglov and O. Morozova [8] focuses on methods and technologies for creating digital twins for dependable Industrial Internet of Things systems, which is essential for ensuring the reliability of digital models. Finally, V. Shevchenko and O. Zamlynska [9] demonstrate that digital twins serve as an innovative tool for ensuring the sustainable development of agro-industrial enterprises through resource optimization and the environmental efficiency of production.

Identification of Previously Unresolved Aspects of the General Problem. Despite the considerable number of scientific works devoted to specific aspects of the use of digital twins in industry, logistics, the agricultural sector, and management systems, the issues of their comprehensive understanding as a universal enterprise management tool within a unified conceptual model remain insufficiently



investigated. The scientific literature addresses the economic effects and sectoral specifics of digital twin applications only fragmentarily, while their influence on the integration of managerial decision-making processes and on the formation of a holistic digital management architecture of the enterprise has not been adequately generalized. Further investigation is also required regarding the relationship between the digital twin and the enterprise digital ecosystem, as well as its role in ensuring the strategic adaptability of business.

Formulation of the Article's Objectives (Statement of the Task). The aim of the article is to reveal the conceptual understanding of the enterprise digital twin as a management tool and to substantiate its practical significance for improving economic performance and enhancing decision-making processes.

In accordance with this aim, the following objectives have been set: to reveal the essence and key characteristics of the enterprise digital twin as a managerial tool; to analyze its functional capabilities in managerial decision-making processes; to identify the economic effects and managerial advantages of implementing digital twins; and to examine the practical aspects of their application and the limitations encountered in enterprise activities.

Research Results. The concept of the digital twin as a management tool draws on the broader theory of digital transformation, within which data-driven technologies are reshaping the principles of decision-making and organizational control. The enterprise digital twin can be regarded as a dynamic virtual representation of a real economic system that integrates data from diverse sources in real time, thereby enabling the continuous monitoring, analysis, and modeling of business processes. Unlike static models, the digital twin evolves together with its physical counterpart, reflecting the latter's structural, functional, and behavioral characteristics. Its essence lies in the synchronization of the physical and digital environments, which allows managers to track the current state of the enterprise, forecast future scenarios, and assess the implications of various strategic and



operational decisions [9]. The principal characteristics of the digital twin include real-time data integration, a high level of detail, adaptability to changing conditions, interoperability with other digital systems, and the capacity for predictive and prescriptive analytics.

From a managerial perspective, the functional capabilities of digital twins substantially expand the analytical potential and decision-making capacity of enterprises. Owing to a comprehensive and continuously updated dataset, digital twins enable managers to shift from reactive to proactive and even predictive decision-making. They support scenario modeling, which makes it possible to evaluate alternative strategies under various assumptions without risking actual resources, a feature of particular importance under conditions of uncertainty. Digital twins also contribute to the optimization of business processes by identifying inefficiencies, bottlenecks, and potential risks, thereby reducing costs and improving performance. In addition, they enhance coordination across different organizational units by creating a unified information environment that increases transparency and reduces information asymmetry [10, p. 8–9]. As a result, decision-making becomes more evidence-based, timely, and aligned with the overarching strategic objectives of the enterprise.

The relationship between the digital twin and the enterprise digital ecosystem is complex and mutually reinforcing. The digital twin does not operate in isolation; rather, it is embedded within a broader digital infrastructure encompassing enterprise resource planning systems, customer relationship management platforms, Industrial Internet of Things devices, cloud computing services, and advanced analytical tools. Such integration ensures the continuous flow of data required to maintain the relevance and accuracy of the digital twin. At the same time, the digital twin functions as the central analytical hub of the ecosystem, synthesizing data from multiple sources and transforming them into actionable insights. This interconnectedness enhances the resilience and flexibility of the enterprise, enabling



it to respond more effectively to both external and internal changes. Furthermore, the digital ecosystem provides the technological foundation for scaling the digital twin across various organizational levels, from individual processes to the enterprise as a whole. In this context, the digital twin becomes not merely a technological innovation but a key element of the management architecture, reshaping the way enterprises perceive, analyze, and control their operations in the digital economy.

The implementation of digital twins at the enterprise level yields a wide range of economic effects and managerial benefits, primarily by transforming operational processes into data-intensive, analytics-driven systems. One of the most significant effects lies in enhanced operational efficiency, achieved through the continuous alignment between real-world activities and their digital representations. Such alignment enables enterprises to identify deviations from planned indicators in real time and to respond to them with greater precision. As a result, operational cycles become more predictable, downtime is reduced, and resource utilization improves substantially. The ability to model production, logistics, and service processes prior to their actual execution helps mitigate the inefficiencies that traditionally arise from uncertainty, incomplete information, or delayed feedback [11].

From an economic standpoint, digital twins serve as a powerful mechanism for cost optimization by allowing enterprises to test various operational configurations without incurring real financial expenditures. Through digital modeling, organizations can evaluate alternative production schedules, supply chain structures, and resource allocation strategies, selecting those that deliver the highest economic efficiency. This virtual experimentation reduces the need for costly trial-and-error methods and improves the accuracy of financial planning. At the same time, productivity gains are achieved through the identification and elimination of bottlenecks, as well as through the automation of routine analytical tasks. Digital twins foster a deeper understanding of process interdependencies, enabling managers to optimize workflows holistically rather than in isolation [12].



Consequently, enterprises are able to increase output without a proportional rise in costs, which directly contributes to improved economic performance.

Table 1 summarizes the principal economic implications of implementing digital twins and their managerial consequences.

Table 1

Economic Effects of Implementing Digital Twins and Their Impact on Enterprise Management Outcomes

Economic effect	Mechanism of influence	Management Outcome
Improved operational efficiency	Real-time monitoring and process synchronization	Faster and more accurate decision-making
Cost reduction	Virtual testing and resource allocation optimization	Reduced operational and transaction costs
Increased productivity	Identification of inefficiencies and optimization of workflows	Increased production volumes through optimized resource utilization
Risk minimization	Scenario modeling and predictive analytics	Improved planning and reduced uncertainty
Increasing adaptability	Continuous feedback and system responsiveness	Greater flexibility in dynamic environments

Source: compiled by the author based on [11–13]

Beyond efficiency and cost considerations, digital twins play a crucial role in mitigating risks and enhancing the sustainability of business operations. Through scenario analysis and predictive modeling, they allow companies to anticipate potential issues related to supply chains, market fluctuations, and disruptions in internal processes. These predictive capabilities transform risk management from a reactive function into a proactive and strategically integrated process. Managers are thus able to assess the consequences of adverse events before they occur and to implement preventive measures that limit their impact. Moreover, digital twins



foster business resilience by promoting more efficient resource utilization, reducing waste, and improving energy efficiency, all of which are particularly important in the context of growing demands for corporate environmental and social responsibility.

It should be noted that the integration of digital twins into management systems enhances organizational resilience by strengthening a company's capacity to adapt to external shocks and internal transformations [14, p. 273]. The continuous flow of data and the availability of analytical insights enable prompt adjustments to processes and strategies in response to changing conditions. This adaptability is not confined to short-term adjustments but extends to long-term strategic planning, in which digital twins provide a robust foundation for evaluating development trajectories and informing investment decisions. Accordingly, the economic benefits of implementing digital twins go beyond immediate efficiency gains and encompass a broader transformation of management practices, ultimately promoting the sustainable and competitive development of enterprises in the digital economy.

The practical application of digital twins in business operations is characterized by considerable variability, depending on industry-specific characteristics, the level of technological maturity, and organizational readiness for digital transformation. In the manufacturing sector, digital twins are primarily employed to replicate production systems, enabling real-time equipment monitoring, preventive maintenance, and process optimization. In logistics and supply chain management, their application is directed toward modeling material flows, warehouse operations, and distribution networks, thereby enhancing coordination and responsiveness to fluctuations in demand. In service-oriented industries, particularly in finance and telecommunications, digital twins are used to model customer behavior, optimize service delivery, and personalize interactions. These industry-specific differences indicate that the functionality and configuration of digital twins are not universal but are shaped by the operational logic, data



availability, and strategic priorities of each sector [15, pp. 695–697]. Consequently, the effectiveness of digital twin implementation depends largely on the alignment between technological capabilities and the specific conditions of the business environment.

At the same time, the implementation of digital twins in business operations is accompanied by a number of organizational and technological barriers that impede their widespread adoption. From an organizational perspective, one of the principal challenges is the insufficient level of digital competencies among staff, which limits the ability to effectively interpret and apply data-driven analytical insights. Resistance to change also plays a significant role, as the deployment of digital twins frequently necessitates the restructuring of established workflows and decision-making procedures. From a technological standpoint, the main obstacles include the high costs of implementation, the complexity of integrating heterogeneous data sources, and concerns related to data quality and cybersecurity. In many cases, companies continue to operate with legacy systems that were not designed to support real-time data exchange, which complicates the creation of a fully functional digital twin. Furthermore, the absence of standardized frameworks and interoperability protocols hinders seamless communication among different digital components, thereby reducing the overall efficiency of the system.

The relationship between industry-specific characteristics and implementation barriers can be systematized with reference to Table 2, which highlights the key features of digital twin deployment in particular economic sectors.

Table 2

**Sector-Specific Characteristics of Digital Twin Implementation in Business
Operations: Applications, Barriers, and Expected Economic Effects**

Industry	Main Application	Main barriers to implementation	Expected practical benefits
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Manufacturing	Modeling of production processes and equipment management	Integration with existing industrial systems	Improved operational reliability and quality
Logistics	, and distribution network modeling	Data fragmentation among different participants	Improved coordination and delivery efficiency
Energy	Infrastructure monitoring and load optimization	High infrastructure and implementation costs	Improved energy efficiency and system stability
Finance	Modeling customer behavior and assessing risks	Data privacy and regulatory constraints	More accurate forecasting and risk management
Healthcare	Modeling patient flow and treatment processes	Sensitivity and protection of personal data	Better resource allocation and service quality

Source: compiled by the author based on [14–16]

Despite these limitations, the prospects for the development and scaling of digital twins in the business environment remain strong. The rapid advancement of technologies such as artificial intelligence, cloud computing, and the Internet of Things is creating favorable conditions for expanding both the functionality and accessibility of digital twins. As these technologies become more affordable and standardized, barriers to market entry can be expected to decline, allowing a broader range of businesses, particularly small and medium-sized enterprises, to adopt digital twin based solutions. In addition, the emergence of platform-based ecosystems facilitates the integration of digital twins beyond organizational boundaries, enabling the formation of interconnected networks that extend well beyond individual enterprises.

The scaling of digital twins is directly linked to the evolution of data management practices and the regulatory framework [17]. As organizations establish more robust mechanisms for data governance, security, and



interoperability, the reliability and accuracy of digital twin systems will continue to improve, thereby further accelerating their adoption. In the long term, digital twins are likely to evolve from isolated analytical tools into comprehensive management infrastructures capable of supporting strategic decision-making at multiple organizational levels. Such a transformation will not only enhance the efficiency and adaptability of individual enterprises but also contribute to the formation of more resilient and integrated economic systems able to respond effectively to the challenges of the digital age.

Conclusions. The study generalizes the theoretical and applied approaches to understanding the enterprise digital twin as a contemporary management tool that ensures data integration, analytical support, and the real-time modeling of managerial decisions, thereby revealing its essence as a dynamic digital model capable of reflecting and forecasting enterprise performance. It is established that the use of digital twins contributes to enhancing operational efficiency, optimizing costs, increasing productivity, and improving the quality of managerial decisions through the capabilities of scenario analysis and the reduction of uncertainty. It is substantiated that the economic effects of implementing digital twins are manifested in greater flexibility of business processes, mitigation of risks, and strengthened resilience of enterprises to external and internal challenges, while their integration into the enterprise digital ecosystem forms a unified information and analytical management environment. At the same time, it is determined that the practical application of digital twins is constrained by a number of organizational and technological barriers, including an insufficient level of digital competencies, the complexity of data integration, high implementation costs, and cybersecurity concerns, all of which require a systematic approach to their resolution. Overall, it is demonstrated that the enterprise digital twin serves not only as an innovative technology but also as an effective management tool capable of improving economic performance and supporting evidence-based decision-making under the conditions



of the digital economy, whereas the prospects for further scientific research lie in developing methodological approaches to assessing the effectiveness of digital twin implementation and in formulating models for their adaptation to diverse industry contexts and business scales.

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