

Економіко-математичні методи та моделі фінансового розвитку

Economic and mathematical methods and models of financial development

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Development of methods for assessing the digital maturity of business

Abstract. The process of digital transformation is evident across all sectors of the Ukrainian economy. This underscores the importance of assessing the digital maturity of enterprises, particularly given regional differences, which has become a pressing issue during the full-scale invasion. The purpose of this study is to create an economic tool for assessing the digital maturity of organizations, taking into account the regional context. To achieve this goal, the following tasks were addressed: an analysis of theoretical approaches to the assessment of digital maturity was conducted, a system of indicators reflecting regional characteristics was identified, and an algorithm was developed to assess the digital maturity of organizations and interpret the results.

The article proposes an economic tool for assessing the digital maturity of organizations that considers both internal and external factors using quantitative indicators. Internal digital maturity is assessed according to two groups of factors: scientific and technical, and production, while external digital maturity considers four regional aspects: human resources, financial resources, consumer demand, and infrastructure. Methods of data normalization are used for comparison, and the analytic hierarchy process (AHP) is applied to account for the importance of each factor. The assessment of digital maturity enables the identification of the development level, as well as weaknesses that require attention to enhance digital transformation. The results can be utilized to develop strategies for managing the digital transformation of enterprises and shaping regional policies.

Keywords: digital transformation, digital maturity, regional differences, analytic hierarchy process, business development.

JEL Classification: M15, O33, L21, O32

Formulas: 0; Figures: 2, Tables: 1

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Introduction. In today's global economy, the transition to a digital paradigm has become a significant trend. Practically all advanced countries have already developed and adopted strategic documents regulating this transition, taking into account the new technological landscape based on the principles of Industry 4.0. The highest levels of digital business transformation are observed in Western European countries (for example, Finland - 50, Belgium - 49, the Netherlands - 48, etc.) and the Republic of Korea (42).

The development of the digital economy at the macro level is driven by appropriate policies at both the national and regional levels. Achieving a high level of digital transformation in a country that is at war and includes several occupied regions requires a balanced policy on the digital transformation of the regions, taking into account their specific characteristics and the level of digital maturity of organizations. Organizations are key participants in the regional economy and determine the possibilities for digital transformation within various sectors of the regional economy [3,9].

The level of digitization in Ukraine is at an average level of digital maturity. Among the reasons for this are a lack of funding, digital inequality, a lack of motivation among industrial enterprises, and their unpreparedness (including a lack of competence among employees).

In the field of management, many researchers and practitioners agree that effective management is only possible with what can be measured and evaluated. How can we effectively manage a business and implement digitalization projects if we do not understand its current level of development? Despite the availability of a wide range of economic management tools at both regional and organizational levels—which allow for the management of innovative development, evaluation of company competitiveness, socio-economic potential, and operational efficiency—there is still no economic tool for assessing the digital maturity of organizations.

The hypothesis of our research is that accounting for regional aspects when assessing the digital maturity of organizations will allow the identification of weak points in their digital transformation, enabling the development of appropriate measures to address these weaknesses through the implementation of regional policies and initiatives in education, IT infrastructure, and other areas.

Literature Review. The concept of the digital economy has evolved to include the active use of digital technologies across all sectors. According to various scholars [10, 13, 17], the digital economy integrates digital technologies into real economic processes, enhancing production, exchange, and consumption. Digital maturity, as a concept, refers to an organization's readiness to operate effectively in the digital economy. Several works [8, 12] define digital maturity as the extent to which an organization successfully implements digital processes and leverages IT solutions to achieve business objectives. Existing literature offers diverse approaches to assessing digital maturity but lacks an economic tool that accounts for regional differences.

Purpose, Objectives, and Research Methods. The purpose of this study is to create an economic toolkit for assessing the digital maturity of organizations with a focus on regional characteristics. Objectives:

- Analyze theoretical approaches to the assessment of digital maturity.
- Identify a system of indicators reflecting regional aspects.
- Develop an algorithm for assessing and interpreting digital maturity.

This study utilizes expert evaluations, data normalization methods, and the analytic hierarchy process (AHP) to assess internal and external digital maturity. The regional aspects considered include human resources, financial stability, consumer demand, and IT infrastructure.

Research Results. The developed economic tool evaluates an organization's readiness for digital transformation based on internal and external factors. Internal digital maturity is assessed through scientific and technological readiness, while external maturity focuses on regional characteristics such as workforce, financial resources, and digital infrastructure. The tool applies quantitative indicators, enabling comparisons across organizations and regions, and uses the AHP method to weigh the importance of each factor. The results indicate that regions with higher digital maturity are better positioned for successful digital transformation.

The digital economy is characterized by the active use of digital technologies for data processing, storage, transformation, and transmission in all spheres of human activity [13]. It expands opportunities for all, including small and medium-sized enterprises, and not only enriches knowledge but also facilitates growth. According to N. Lane, the term "digital economy" refers to the fusion of computing and communication technologies via the Internet, which facilitates electronic commerce and leads to significant organizational changes [13]. Other authors view the digital economy as the penetration of digital technologies into real economic processes across all spheres of interaction between subjects [10, 17]. The general concept of the digital economy, formulated on the basis of these studies, can be defined as a system of relations between economic entities that encompasses the spheres of production, exchange, distribution, and consumption, and is based on the application of digital technologies and the management of large volumes of data [7].

In the scientific literature, the term "digital maturity" is used to assess an organization's readiness to operate in the digital economy. Various approaches to defining digital maturity have been considered in numerous scientific works and analytical reports [8, 12]. One of the most precise definitions of digital maturity is as follows: "The state of digital maturity is determined by how effectively digital processes are implemented within an organization, and whether the team uses IT solutions cohesively to achieve business goals" [8].

The assessment of an economic entity's readiness to operate within the digital economy can be conducted at three levels: the macro level, the meso level (industry or regional level), and the micro level (organizational level). Approaches to assessing digital maturity have been explored in various scientific publications by Ukrainian and foreign researchers [2, 13, 15].

An analysis of the approaches to determining digital maturity at these three levels of management leads to the following conclusions, which are taken into account in the development of an economic tool for assessing the digital maturity of an organization:

- All the researched tools highlight 3-5 sub-indexes (or blocks) in different areas, mainly focusing on the development of human resources, the level of use of digital technologies, the organizational and management component, and the interaction with the external environment (clients, suppliers, the state).
- The level of employee competence is the first key component in the development of any organization. The second important component is the level of digital technology implementation, which is especially relevant for industrial enterprises. Without automation, the use of modern technologies such as robotics, "smart" factories, and digital twins in production, creating competitive products becomes impossible, as competition in the market constantly increases, necessitating a reduction in the production cycle time.
- Almost all approaches rely on calculating a composite indicator using research methods such as expert evaluations, questionnaires, normalization, statistical methods, and comparisons.

The main limitation of the analyzed approaches is that the assessment of digital maturity often takes an absolute form, evaluating organizations based on a fixed set of parameters. While this result can serve as a benchmark for comparing an organization with competitors or tracking changes over time, it provides little insight into what kind of support from authorities might be needed, given the available economic tools. Therefore, the new economic tool should address this problem in a scientific and methodological way.

Assessing the digital maturity of organizations involves considering regional factors, which represent external influences on the organization's functioning at the macro level [5]. The main regional aspects that stand out are as follows:

- Personnel Aspect: Typically, most school graduates choose institutions in their region of residence for further education, making the personnel aspect inherently regional. High-tech industrial enterprises, in particular, are usually located in or near large cities, where highly qualified specialists are concentrated. However, as the half-life of knowledge is now only 2-3 years, regularly updating employee qualifications is crucial for enterprises to effectively utilize current digital technologies. Therefore, the indicator "the share of personnel who annually improve their qualifications in the field of information and communication technologies" is proposed to evaluate this aspect.
- Financial Aspect: The financial aspect is equally important. Digital transformation is not possible without adequate financial resources (for developing new business models, purchasing equipment, etc.), and for this, the enterprise must be financially stable. The availability of internal funds enables digital transformation, and even if a loan is necessary, financial stability increases the likelihood of successfully securing it. The ratio of current assets provided by the enterprise's own funds is one of the most informative indicators of financial stability. Although the financial aspect might initially seem to lack a regional dimension, regional factors significantly affect the financial resources available to an enterprise. These factors include average salaries, service costs, and opportunities to obtain regional financial support for digitization.
- Aspect of Consumer Demand: The location of production is often determined by the demand for its products and the presence of a sales market. This is a key regional aspect in determining the location of an enterprise. Additionally, the enterprise itself may be a consumer of components and equipment. In the digital economy, businesses are expanding their ability to promote products through digital technologies, such as digital sales channels and communication tools. To evaluate this aspect in terms of digital maturity, the following indicators are proposed: "the share of contracts with external counterparties where the enterprise is a customer" and "the share of contracts where the enterprise is a consumer of products." Businesses with a higher level of digital maturity, actively using digital technologies to communicate, promote products, and find counterparties, will have more contracts and/or larger deal volumes with external partners from other regions.
- Technological Aspect of Infrastructure: Digital infrastructure refers to the set of technologies and digital products that provide computing, telecommunications, and networking capabilities on a digital basis. Since the absolute values of individual indicators determining the level of digital infrastructure development in a region may not be informative for this study, it is suggested to use the relative number of organizations in the region that use information protection tools to assess the technological aspect of the infrastructure.

To account for these aspects, the following indicators are proposed:

- The proportion of contracts with external counterparties where the company acts as a customer;

- The percentage of employees who annually improve their qualifications in the field of information and communication technologies;
- The ratio of current assets provided by the company's own funds;
- The proportion of contracts with external counterparties where the company acts as a supplier;
- The relative number of organizations in the region using information security tools.

As these indicators grow, the level of an organization’s external digital maturity increases.

The economic tool for assessing the digital maturity of an organization involves determining the readiness of its various components—subsystems, departments, or elements—to successfully operate within the digital economy. This includes evaluating the level of digital technology application in business processes to achieve strategic goals. Assessing digital maturity serves as the initial step in forming and implementing the organization's digital transformation strategy. It is a crucial prerequisite for effective system management, as success depends on first determining the current state, setting clear goals, and then developing a plan to achieve those goals. Analyzing the level of digital maturity in an organization, whether in general or in specific areas such as human resources, finance, or IT infrastructure, helps identify weaknesses that need addressing.

This economic tool assesses the organization's digital readiness based on the following categories [1]:

- Internal digital maturity, which covers the scientific, technological, and production readiness of enterprises for the adoption of digital technologies.
- External digital maturity, which reflects the organization's preparedness to operate in the digital economy.

The assessment of external maturity takes into account regional characteristics and can serve as a foundation for developing regional policies related to education, IT infrastructure, and the creation of financial tools to support organizations.

The conceptual framework for assessing the digital maturity of an organization is presented in Fig. 1. The initial data for evaluating digital maturity are outlined in Table 1 [6].

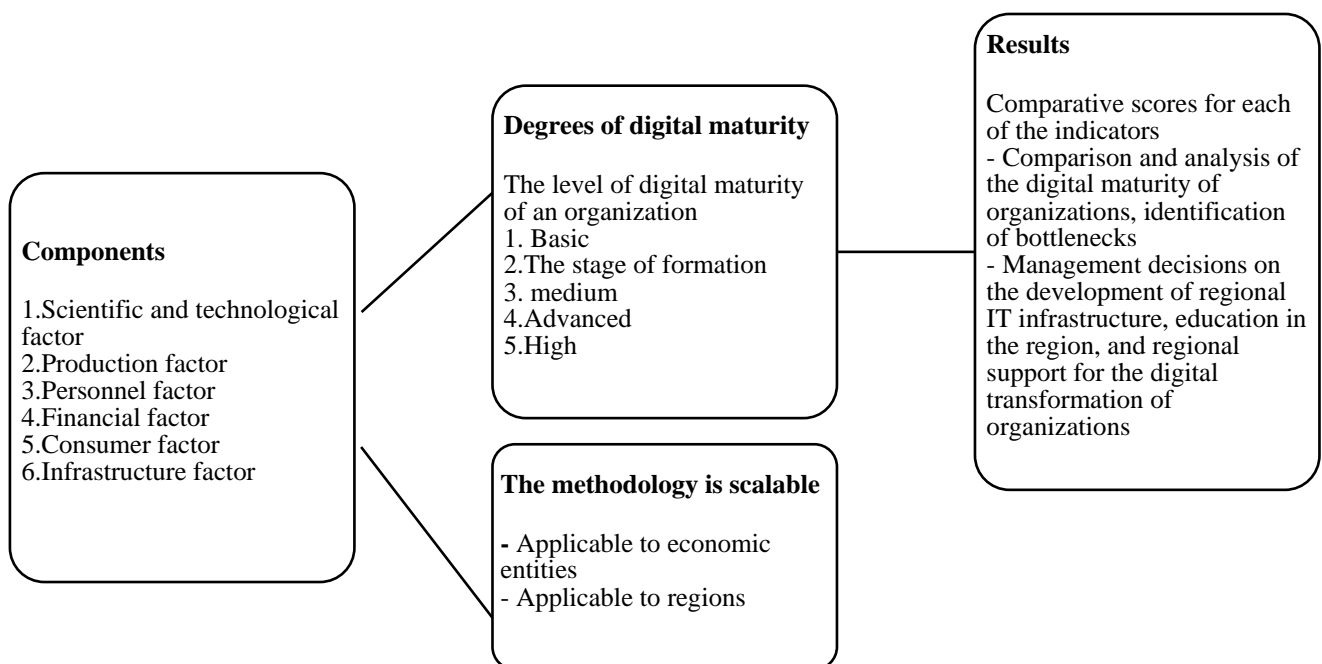


Fig. 1. Conceptual scheme for evaluating the organization's digital maturity
Source: prepared by the author

Table 1. Factors and indicators for assessing the digital maturity of an organization

Factor	Indicator	Unit of measurement
Internal digital maturity		
Scientific and technological factor	The share of expenses from revenue for R&D (Research and development works)	Interest
Production factor	Labor productivity	Conventional units (hryvnias)
External digital maturity		
Personnel factor	The share of personnel who annually raises qualification	Percentage (or fraction of a unit)
Financial factor	The coefficient of provision of current assets with own funds	Percentage (or fraction of a unit)
Consumer factor	Share of the volume of contracts with external counterparties in which the company is a supplier	Percentage (or fraction of a unit)
	Share of the volume of contracts with external counterparties in which the company is a customer	Percentage (or fraction of a unit)
Infrastructure factor	The specific weight of organizations that used information protection tools in the region	Percentage (or fraction of a unit)

Source: prepared by the author

Calculations of an organization's digital maturity are carried out with the following frequency [11]:

- During the development of a digital transformation strategy;
- Throughout the implementation of the digital transformation strategy;
- When refining (or updating) the digital transformation strategy.

The algorithm for assessing the digital maturity of the organization is presented in Fig. 2.

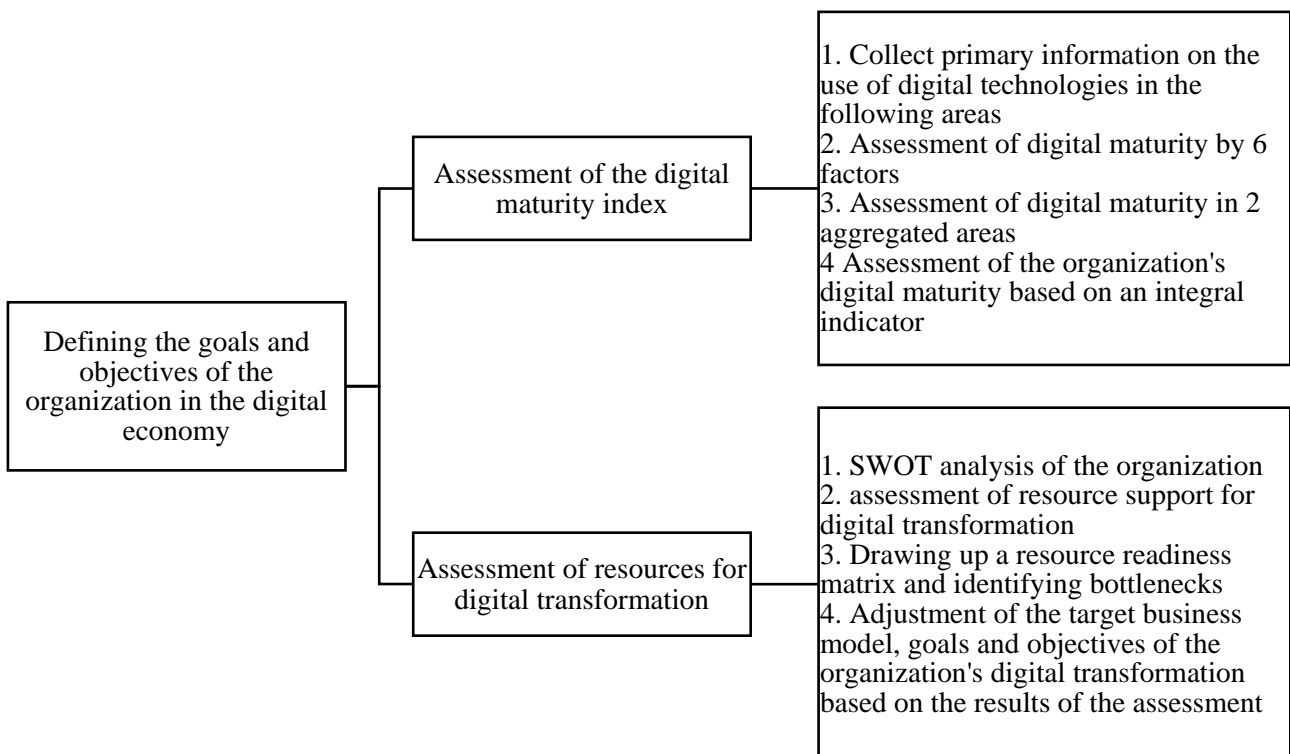


Fig. 2. Algorithm for evaluating the organization's digital maturity

Source: prepared by the author

To assess the necessary resource provision of the organization for digital transformation, a comparison of actual and necessary human resources (number of employees with the necessary professional digital competences), financial resources (taking into account own and borrowed) and capacities of the material and technical base (power of servers, number of computers) is required (computers, availability of software, etc.), as well as determining the sources of their receipt.

For this purpose, it is proposed to build a table of resource capabilities, which allows you to see critical points (i.e. lack of financial or other resources), and the use of the SWOT analysis method, which allows you to identify the strengths and weaknesses of the organization both from the point of view of resource capabilities and from the point of view of digital organizational maturity, as well as threats and opportunities.

Further, taking into account the results of the analysis, the target business model is adjusted to ensure the achievement of the goals and objectives of the organization's digital transformation.

Discussion. The findings of this study on assessing the digital maturity of organizations reveal several critical insights. One key result is the growing importance of incorporating regional factors into digital maturity assessments. This aligns with the views of Isaev [11], who emphasized that regional economic conditions can significantly influence an organization's readiness for digital transformation. The present research further reinforces the notion that effective digital transformation is not solely a technological endeavor but one deeply intertwined with regional and organizational characteristics.

Moreover, the identified challenges to digital transformation—such as insufficient employee competencies, limited financial resources, and inadequate IT infrastructure—are consistent with the findings of researchers like Gilova [8] and Timofeeva [7]. These barriers highlight that the successful implementation of digital initiatives requires more than just technological upgrades. It demands comprehensive changes in human resources, financial strategies, and infrastructural support, confirming the conclusions of Nadkarni and Prügl [18] that a holistic approach is essential for digital maturity.

The proposed economic tool for assessing digital maturity, which incorporates both internal and external factors, offers a novel contribution by introducing regional aspects such as workforce qualifications and infrastructure readiness. This aligns with the recommendations of Vladykina [6], who advocates for multi-level assessments that consider external influences. However, this study provides additional insights by integrating these factors into a unified tool that not only assesses digital readiness but also identifies areas for improvement based on regional characteristics.

While many studies primarily focus on technological metrics of digital transformation, this research emphasizes the need to address human capital and financial readiness as key components of digital maturity. Similar to the findings of Chesnokova [19], this study shows that workforce development and continuous training are crucial for enhancing an organization's ability to leverage digital technologies effectively. Furthermore, the research suggests that a more region-specific approach to financial planning, considering local economic conditions, will enhance the success of digital transformations.

Another critical finding is that the current methods of assessing digital maturity often provide absolute values, which may not sufficiently capture the nuances of regional differences. This study advances the field by proposing a more flexible, regionally adaptive model, which offers both qualitative and quantitative assessments. The proposed tool also introduces an algorithm that facilitates the continuous evaluation of an organization's digital transformation, allowing for more dynamic adjustments throughout the process. Future research could explore the effectiveness of this tool in different regions and industries to validate its generalizability and practical application.

Conclusion. This study contributes to the expanding body of literature on assessing digital maturity by developing a comprehensive tool that incorporates both internal and external organizational factors, with a focus on regional characteristics. The research highlights the importance of considering workforce qualifications, financial stability, consumer demand, and infrastructure readiness when evaluating an organization's digital maturity. These regional factors provide a clearer understanding of the potential areas for digitalization, particularly in regions where resources may be constrained.

The study confirms the hypothesis that digital maturity assessments must account for regional differences to provide a more accurate evaluation of an organization's readiness for digital transformation. This approach enhances the objectivity of decision-making processes, allowing for more targeted regional policies, such as financial support for organizations, the development of IT education, and improvements in infrastructure. The inclusion of both quantitative and qualitative indicators offers a more nuanced perspective, enabling organizations to better understand their current state and identify areas requiring strategic improvement.

From a practical standpoint, this research provides organizations with a structured tool to assess their digital maturity, identify weaknesses, and formulate strategies for improvement. Companies that focus on continuously updating their workforce's digital competencies and aligning their financial resources with digital transformation initiatives will be better positioned to thrive in the rapidly evolving digital economy. Furthermore, regional policymakers can leverage these findings to create more effective support mechanisms, ensuring that digital transformation efforts are well-funded and regionally adaptive.

In conclusion, the successful management of digital transformation requires a comprehensive approach that balances technological, financial, and human resource factors. By adopting flexible, regionally adaptive strategies, organizations can enhance their competitiveness and mitigate the risks associated with digital transformation. Future research should focus on validating this tool in various industry contexts and further refining digital maturity assessment models to support organizations in different regions.

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Розвиток методів оцінювання цифрової зрілості бізнесу

Анотація. Процес цифрової трансформації спостерігається в усіх секторах української економіки. Це підкреслює важливість оцінки цифрової зрілості підприємств, особливо з урахуванням регіональних відмінностей, що стало нагальним питанням під час повномасштабного вторгнення. Метою даного дослідження є створення економічного інструменту для оцінки цифрової зрілості організацій з урахуванням регіонального контексту. Для досягнення поставленої мети було вирішено такі завдання: проведено аналіз теоретичних підходів до оцінки цифрової зрілості, визначено систему показників, що відображають регіональні особливості, розроблено алгоритм оцінки цифрової зрілості організацій та інтерпретації отриманих результатів.

У статті запропоновано економічний інструмент оцінки цифрової зрілості організацій, який враховує як внутрішні, так і зовнішні фактори за допомогою кількісних показників. Внутрішня цифрова зрілість оцінюється за двома групами факторів: науково-технічними та виробничими, тоді як зовнішня цифрова зрілість враховує чотири регіональні аспекти: людські ресурси, фінансові ресурси, споживчий попит та інфраструктуру. Для порівняння використовуються методи нормалізації даних, а для врахування важливості кожного фактора застосовується метод аналізу ієрархій (МАІ). Оцінка цифрової зрілості дозволяє визначити рівень розвитку, а також слабкі місця, які потребують уваги для посилення цифрової трансформації. Результати можуть бути використані для розробки стратегій управління цифровою трансформацією підприємств та формування регіональної політики.

Ключові слова: цифрова трансформація, цифрова зрілість, регіональні відмінності, метод аналізу ієрархій, розвиток бізнесу.

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