Pacific Business Review (International)
Volume 19, Issue 4, October 2026

Artificial Intelligence as a Tool for the Innovative Development of Enterprises in the Region

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Abstract

The article studies the features of the use of artificial intelligence (AI) technologies as a tool for innovative development of enterprises in the region. The need to intensify the introduction of AI technologies to increase innovation activity, digital maturity and competitiveness of enterprises has been substantiated. A methodical approach to a comprehensive assessment of the readiness of enterprises to use AI technologies has been proposed, which provides for a consistent calculation of a system of statistical, analytical and integral indicators. A research algorithm has been formed, which includes an assessment of the digitalization level of business processes, the use of AI technologies, the digital intensity of innovation activity, its effectiveness and economic efficiency of digital transformation, followed by the determination of an integral index of readiness of enterprises to use AI technologies. The proposed methodology was tested based on the analysis of statistical data for 2021–2025. confirmed the steady growth of indicators of digital transformation, the use of AI technologies and innovative activity of enterprises, which indicates the positive impact of AI solutions on increasing the efficiency of innovative development of enterprises in the region.

Keywords: Artificial Intelligence, Innovative Development, Enterprise, Region, Digitalization, Digital Technologies, Information Technologies, Transformation, Financial Resources, Financial Capacity.

Introduction

Today, artificial intelligence (AI) is gradually transforming from a separate digital tool into a factor in the innovative development of enterprises. Gradually, its role is changing from automating routine operations to a tool for creating new products, improving business processes, predicting market changes and optimizing production processes. Taking into account the above, some technologies can bring different results in the regional context. The problem of studying the role of AI in the innovation activity of enterprises in the region is to determine the conditions under which the use of AI technologies increases the

innovative efficiency of the enterprise, and not only reduces operating costs. To solve such a scientific problem, it is advisable to consider technologies based on AI from the point of view of automation of operations, a tool for innovative development, a component of a regional innovation ecosystem, etc.

In the innovative activities of enterprises, AI technologies are used in research and development, which made it possible to use machine learning, predictive models, analysis of consumer behavior, text processing, etc. In this aspect, the use of the latest technologies allows you to reduce the duration of operations and identify promising areas of marketing research. In production operations, such technologies are mostly used in equipment maintenance, process automation, which has a positive effect on product quality and labor productivity. In the field of logistics, software products with AI are used to predict routes, optimize inventories, and determine demand. The use of these technologies allows you to increase the stability of supply chains and the quality of services, which in the future expands the customer base of the enterprise. In the management of innovative projects, AI allows you to assess risks, build scenario modeling of processes, which allows you to justify the choice of a project with minimal risks.

Literature review

Today, the issue of studying the use of AI technologies is the subject of research by many scientists. Thus, the team of authors I. M. Cockburn, R. Henderson, S. Stern in their works consider AI technologies as a general purpose and a new method of invention that transforms research developments (Iain M. et al., 2018). The authors A. Agrawal, J. Gans, A. Goldfarb in their works investigate the use of AI technology for forecasting and changing the structure of managerial decisions (National Bureau of Economic Research, 2019). The authors M. Ali, T. Khan, M. N. Khattak, İ. Şener investigate the impact of AI on the creativity of employees, its use in increasing the organizational and innovation capabilities of the enterprise (Ali M. et al., 2024).

Zhao K. et al. (2026), Hu Y. et al. (2026), Zhang B. et al. (2025) analyzed pilot areas for innovative use of AI and innovation in the enterprise, investigated whether AI improves the operational sustainability of enterprises. The authors provide evidence of innovative use of AI and demonstrated the impact on the development of SMS enterprises. Han S. et al. (2025), Luo L. et al. (2025), Datsenko H. et al. (2025) AI technology, organizational learning capabilities, and corporate innovation indicators are investigated through the experience of Chinese enterprises, and innovative approaches to the use of AI in business processes are presented to increase the competitiveness of enterprises.

Datsenko H. et al. (2024), Malik A. et al. (2021), Sun Y. (2026) innovative approaches to the use of AI in business processes to increase the competitiveness of enterprises are revealed, the improvement of talent experience through innovative knowledge exchange mediated by AI is analyzed, the spread of AI as a new model of enterprise development is investigated.

Lin H.-C. et al. (2026), Zhao W. et al. (2025), Nurhayati M. et al. (2026) the implementation of multimodal AI systems at the enterprise is demonstrated, a model for predicting the modernization level of the management system of enterprises managed by AI is proposed, and how self-development stimulates the sustainable activities of micro-enterprises is analyzed. Kotko Y. et al. (2026), Zhou F. et al. (2026), Zhavoronok A. et al. (2022) the role of innovation potential in ensuring sustainable development of an enterprise was investigated, whether innovation policy contributes to high-quality development of enterprises was analyzed, and the role of regulatory policy in these processes was analyzed.

Reznik, N. et al. (2026), Xinzhong, B. et al. (2026), Nikiforov P. (2022) outlines the features of public-private partnership and explores the ways in which the level of data disclosure influences qualitative development in large innovative enterprises. Prateeppornnarong D. (2026), Li L. et al. (2025), Popelo O. et al. (2025) analyzed the role of innovative entrepreneurship for sustainable development, investigated how data activation contributes to the development of high-quality entrepreneurship, and outlined global trends in the formation of regional innovative entrepreneurial ecosystems.

Ricciardi, I. et al. (2025), Kigozi, J. et al. (2025), Dubyna M. et al. (2024) revealed the features of promoting investment by industrial enterprises in the emerging conditions of the digital economy. Paredes-Chacín A. J. et al. (2025), Odrekhivskyi M. et al. (2025), Woźniak J. et al. (2025) it is proven that digitalization is the basis of innovative development and environmental sustainability in micro, small and medium-sized enterprises, the assessment and forecasting of the state of environmental sustainability of innovative enterprises in the context of sustainable development is carried out, and organizational sustainability is substantiated as a determining factor in the development of innovative enterprises in the service sector.

Petrunenko I. et al. (2025), Yan G. (2025), Iastremska O. et al. (2024) the socio-economic impact of innovative development of SMS enterprises was investigated, an innovative model of human resources management for enterprises based on the concept of sustainable development was proposed, and the features of innovative project management to ensure innovative development of enterprises were revealed.The application of AI technologies opens up new opportunities for analyzing market trends, forecasting demand, improving logistics, personnel management, and developing innovative products and services.

The purpose of the article is to study the role of AI in the innovation activity of enterprises in the region.

Methodology

The methodological basis of the study is a combination of statistical, comparative, index and integral approaches to assessing the impact of AI technologies on the innovation activity of enterprises.

The proposed methodology provides for four interrelated stages of the study: the formation of an information base, the assessment of the effectiveness, as well as an integral assessment of the readiness of enterprises to implement AI technologies.

At the first stage, a system of initial indicators is formed, which includes the share of innovatively active enterprises, costs for innovative activities, the share of enterprises using AI technologies, investments in digital transformation, the level of digitalization of business processes, labor productivity and the share of innovative products in the total volume of sales.

At the second stage, the analysis of the temporal dynamics of indicators is carried out using generally accepted statistical methods. To assess absolute changes, an absolute deviation is determined, to assess the change in indicators relative to the previous year, a chain absolute deviation is determined, the relative change in indicators is characterized by the growth rate and growth rate, and the average annual growth rate (Compound Annual Growth Rate) is used to assess long-term development trends (Anderson D.R. et al., 2023, Krampen B., 2023).

In contrast to the above statistical indicators, which are generally accepted in economic research, it is proposed to assess the effectiveness of digital transformation of enterprises through the use of a system of interrelated analytical indicators, which will comprehensively assess the intensity of digital transformation, the effectiveness of the use of AI technologies and the level of readiness of enterprises for their implementation (Verhoef P. C. et al., 2021, Dwivedi Y. K. et al., 2023).

The proposed approach combines the analysis of the resource component of digitalization. The indicator characterizing the share of digital investments in the total volume of innovation activity of enterprises is the digital intensity coefficient:

$$K_{DI} = \frac{I_{DT}}{I_{IN}}, \quad (1)$$

where IDT is an investment in digital transformation; I_{IN} – costs for innovation activities.

The economic content of the indicator is to determine the concentration level of innovation resources during digital transformation. The increase in the value of the coefficient indicates an increase in the priority of digital technologies in the structure of innovative investments of enterprises.

The coefficient of innovation efficiency determines the effectiveness of transformation of innovation activity of enterprises into final results:

$$K_{IR} = \frac{P_{IP}}{P_{IA}}, (2)$$

where PIP is the share of innovative products in the total volume of sales, %; PIA is the share of innovatively active enterprises, %.

The indicator characterizes the commercialization level of innovation activity and allows to assess how innovative activity of enterprises is transformed into the creation of innovative products.

In contrast to existing approaches, which mainly assess individual indicators of digital transformation, the study proposes an integral index of economic efficiency of the use of AI technologies. Its application will ensure that three complementary components are taken into account: changes in labor productivity, the spread of the use of AI technologies, and the economic return of digital investments.

At the first stage, the indices of individual components are determined:

Labor productivity index

$$I_{LP} = \frac{LP_i}{LP_0}, (3)$$

Artificial Intelligence Technology Utilization Index

$$I_{AI} = \frac{AI_i}{AI_0}, (4)$$

Return on investment of digital investments

$$I_{ROI} = \frac{ROI}{100}, (5)$$

where LP is labor productivity; AI – the share of enterprises using AI technologies; ROI is the return on digital investment.

The integral index of economic efficiency is defined as the geometric average of these indicators, which provides a balanced impact of all components of the integral indicator and minimizes the possibility of reassessment of individual indicators:

$$I_{EE} = \sqrt[3]{I_{LP} * I_{AI} * I_{ROI}}, (6)$$

The final stage of the proposed methodology is to determine the integral index of readiness of enterprises for the introduction of AI technologies. Unlike existing methodological approaches that assess individual characteristics of digital transformation, the proposed index combines the key components of the assessment: the level of digitalization of business processes, the scale of use of AI technologies, innovative activity of enterprises, investments in digital transformation and labor productivity. This approach will provide a comprehensive assessment of the readiness of enterprises to integrate AI technologies into innovative activities.

Before integration, all indicators are normalized according to the method of maximum value(Anderson D.R. et al., 2023, Krampen B., 2023).

$$X_i^* = \frac{x_i}{x_{max}}, (7)$$

where is the normalized value of the indicator; XX^*_i $_i$is the actual value of the indicator; X_{max} is the maximum value of the indicator for the study period.

The integral index is defined as the weighted average sum of normalized indicators:

$$I_R = \sum_{i=1}^{m} \omega_i X_i^*, (8)$$

where ? i is the weighting coefficient of the i-th indicator; m is the number of indicators included in the integral assessment.

Unlike traditional approaches, weighting factors can be determined by the expert method or taken as equivalent depending on the objectives of the study. In this study, equivalent weighting coefficients are used, which ensures the same influence of each component on the formation of an integral assessment and excludes subjectivity in the interpretation of results.

Thus, the proposed methodology combines classical statistical tools for analyzing dynamics with a system of analytical indicators. Its practical application provides the formation of an integral assessment of economic efficiency and readiness of enterprises for the introduction of AI technologies, which is the methodological basis for further analytical calculations.

Results

These technologies are widely used at all levels in the areas of cybersecurity by protecting data, detecting anomalies and threats. In general, the role of AI technologies is carried out in two directions: increasing the efficiency of existing processes and the formation of fundamentally new products and models. It is the formation of new products and processes that will ensure the competitiveness of business in the future.

If we take into account regional specifics, it is necessary to analyze the uniformity of regional access to the necessary infrastructure, the qualifications of employees, the availability of scientific and educational institutions, the branching of energy infrastructure, etc. Accordingly, the more infrastructure support there is in the region, the more it is able to accumulate resources for the innovative development of enterprises. However, it should be noted that in the regional distribution, situations of resource flow to more capable territories should be avoided, which will lead to an increase in regional development disparities.

Since technologies based on AI are implemented in various software products, technology and management systems, it is quite difficult to single out the share of AI in innovative products or services. In general, the innovative development of enterprises is determined by such groups of indicators as:

resource, which characterize the costs of AI, the number of specialists, and the amount of data;

process – the duration of product development, the speed of data analysis and the number of experiments;

effectiveness - the number of new products, patents, technologies;

economic – share of income from new products, profitability of innovations, productivity gain;

regional – employment in high-tech industries, the number of startup projects, the amount of funding, etc.

Businesses are not required to provide information to the statistics service on indicators of the use of AI and related innovative technologies, which affects the objectivity of data assessment.

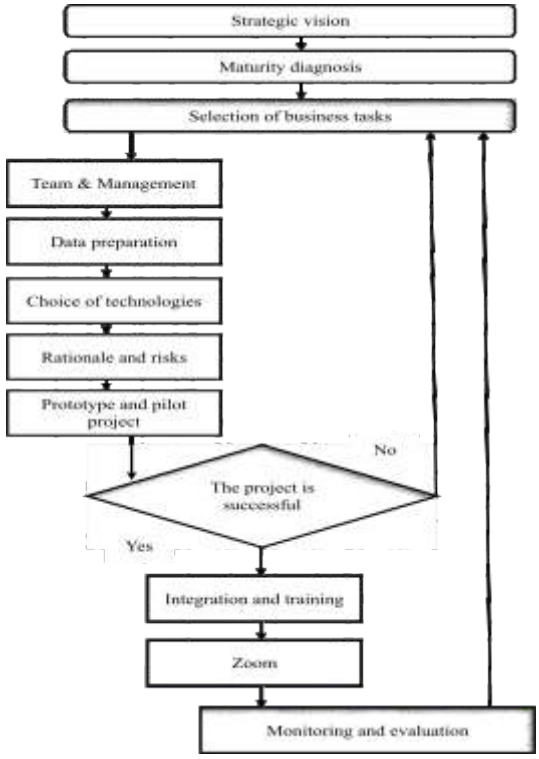
Given the current trends and the speed of development of AI technologies, in the regional distribution, this can lead to negative consequences, due to a reduction in the need for specialists in certain operational areas.

To implement innovative solutions, the company must implement a certain algorithm for the implementation of technologies based on artificial intelligence (Fig. 1).

At the first stage, an important direction is the strategic vision, which in the future will base the entire concept of its use. It should be noted that the peculiarity of the activities of enterprises today is associated with war risks, instability of energy supply, outdated technologies and the lack of a sufficient level of funding. At the stage of strategic vision, the issues of using business development strategies are solved. Taking into account such aspects will allow more effective introduction of technologies by combining digitalization and innovation. The negative consequences of the introduction of AI can be inflated expectations from the introduction of such technologies, which can lead to risks of production and financial solvency.

The next step is to diagnose the maturity of the enterprise to implement digital solutions. The maturity level of the enterprise is determined by the state of use of digitalization in production and management processes.

Figure 1. Stages of implementation of AI technologies in the activities of enterprises



Given the bureaucracy and low speed of transition to digital solutions, many enterprises have a tendency to use cloud technologies, analytical databases with simultaneous duplication of information on paper, which ultimately leads to a lack of ordering of the analytical basis and a decrease in the effectiveness of management decisions. At this stage, awareness and the level of digital literacy among staff should be taken into account, which in the future may require additional costs for improving the skills of employees as part of digitalization.

The next stage is characterized by the selection of business tasks. It is at this stage that the processes that will be automated with the help of AI are determined. The most common are supply and demand forecasting, inventory management, optimization of logistics routes, analysis of the customer base, risk forecasting, etc.

At the stage of forming a team and a management system, the participants and roles of the entire process are determined, since the implementation of AI is not only about the IT department. At this stage, the distribution of powers is carried out, the procedure for decision-making is established, and procedures for controlling models and rules of interaction are formed. It is important to ensure data cybersecurity, which requires appropriate skills and competencies from all participants in the process. Important positive developments at this stage can be considered taking into account technological and economic aspects, reducing the gap between developers and users, and clear responsibility for the result. However, to implement this stage, today there is a shortage of personnel, high labor costs, dependence on one key employee, which is caused by a significant outflow of personnel abroad. If we consider these implementations for enterprises, taking into account the costs of the project team, it is more expedient to leave the key figures of the owner and analyst in production, and outsource other technical aspects.

As you know, in the field of AI, data is the main modeling, so information requirements are a key factor in data management. Therefore, for the correct display of data, the information must meet the criteria of reliability, relevance, unification, etc. It is the quality and reliability of information in the process of its processing and modeling that allows you to more accurately form the result. Within Ukraine, if we study the activities of enterprises in the regional distribution, it is necessary to take into account the information of the pre-war, war period and post-war recovery, since in different periods different factors affect the formation of innovative activity of enterprises and the provision of human resources. After the formation of an analytical data array, the enterprise decides on the choice of technology for using ready-made cloud services, modifying existing products or creating its own model.

At the stage of feasibility study of project implementation, the volume of costs and efficiency from the implementation of technologies are taken into account to determine the payback period of projects. It should be noted that the calculation of the effectiveness of projects in the use of intangible assets has its own difficulties, which are associated with the assessment. Such complex aspects include the instability of supply and demand, uncertainty of currency and licensing costs, which can significantly affect the final assessment of the project cost, especially in conditions of uncertainty and risks.

The use of data and their subsequent processing must not contradict the current Ukrainian and international legislation, with the subsequent implementation of European standards. Adaptation of enterprises to international standards will expand the export of goods and services for innovative products. This problem is especially acute among Ukrainian enterprises during the post-war recovery, which should be introduced at the level of international standards and requirements. To test the technical capability of the project, it is advisable to develop a prototype, which is a simplified copy of the software. The use of a prototype allows you to identify technical shortcomings, correct errors, and test hypotheses with less resources.

If the project is successful, it is implemented in the activities of the enterprise with gradual training of personnel and scaling into the activities of the enterprise. In the regional aspect, attention should be paid to the processes of adaptation of technologies, taking into account the infrastructural support of territories. The implementation of projects in border regions will differ

compared to others due to the security situation, consumer behavior, infrastructure restrictions, etc.

The final stage is the monitoring and evaluation of the results, as the external environment and consumer behavior change, which requires appropriate correction.

For Ukrainian enterprises today, regional features play a key role in ensuring the innovative development of enterprises, based on the unfavorable security situation, business relocation, population migration, which led to a change in the sectoral priority of some territories.

Thus, frontline regions are characterized by a high risk of physical damage to property, threats to the lives of employees, disruption of logistics flows and limited investment funds. For enterprises, operating in such high-risk territories requires additional costs to ensure power autonomy, appropriate physical protection of production and employees, and the ability to operate online. However, not all operations and production have the ability to adapt to the conditions of remote work, taking into account the technological component of processes.

The de-occupied and restored territories are characterized by significant damage to infrastructure and territories due to mining. Therefore, in these regions, the priority today is artificial intelligence technologies, which is an important step for the economic recovery of the territories, primarily through the support and development of small businesses.

The proximity of territories to European borders allows businesses to more actively develop their foreign economic activities, attract joint projects and exchange experience. Given the territorial proximity to European borders and the security situation, it is in the western regions that new industrial and IT clusters are being formed, which focus their activities on attracting investments, developing startup projects, and introducing new technologies.

Despite the difficult security and economic situation in the country, today the Government has introduced the Strategy for the Digital Development of Innovation Activities until 2030, which has a general vector of the country's innovation policy (Cabinet of Ministers of Ukraine, 2024). Due to state and regional support for business, the creation of favorable investment conditions will further allow the recovery of Ukraine on the basis of manufacturability, innovation, energy efficiency. The areas of defense technologies (unmanned systems, data analysis), the agricultural sector, energy, industry, logistics, medicine and rehabilitation, construction, digitalization and environmental monitoring are promising for Ukraine. These areas can realize their digitalization potential both within civilian businesses and the public sector.

For the implementation of these measures, in the general aspect, it is expedient:

- creation of regional centers for the development of AI on the basis of universities and scientific institutions;
- development of regional data spaces;
- digital literacy retraining programs;
- adaptation of domestic legislation to international and European standards;
- introduction of measures to balance regional development, taking into account the security and economic situation, in order to support all territories and prevent an increase in the gap between the center and the periphery.

To confirm the validity of the proposed theoretical provisions, to check the effectiveness of the developed methodology and to assess the possibilities of its practical application, it is proposed to analyze the dynamics of key statistical indicators that characterize the innovation activity of enterprises and the development of digital transformation processes in 2021–2025. Conducting this analysis makes it possible to identify the main trends in the development of the processes under study, to assess changes in basic indicators over time and to form an empirical basis for calculating the indicators of the effectiveness of digital transformation. The summarized results of the analysis are given in Table 1.

The indicators of Table 1 indicate the formation of a stable positive trend in the development of innovation activities of Ukrainian enterprises in the context of digital transformation during 2021–2025. Despite the negative impact of war risks in 2022, most indicators have been demonstrating recovery dynamics since 2023, and in 2025

they reach maximum values for the entire period of analysis.

One of the key indicators is the share of innovatively active enterprises, which increased from 15.8% in 2021 to 18.1% in 2025, or by 2.3 pp (+14.6%), with the growth rate of 3.5%. Although the absolute increase is relatively moderate, the positive dynamics indicates a gradual recovery of business innovation activity after its reduction to 14.9% in 2022.

Table 1. Analysis of the dynamics of digitalization, the use of AI technologies and innovative activities of Ukrainian enterprises, 2021–2025

Indicator	2021	2022	2023	2024	2025	Change 2025 to		CAGR, %
						2021	2024	
Share of innovatively active enterprises, %	15,8	14,9	15,6	16,8	18,1	+2,3	+1,3	3,5
Expenditures on innovation activities, USD billion	0.36	0,32	0.39	0.5	0.61	+0.25	+0.11	14,4
Share of enterprises using AI technologies, %	4,8	6,2	9,7	14,8	20,5	+15,7	+5,7	43,8
Investments in digital transformation, USD billion	0.21	0.23	0.29	0.38	0.48	+0.27	+0.1	23,1
Share of digitalized business processes, %	37,4	40,8	46,5	53,2	60,7	+23,3	+7,5	12,9
Labor productivity, thousand tons USD /employee	17.45	18.1	19.28	20.9	22.85	+5.4	+1.95	6,9
Share of innovative products in the volume of sales, %	1,8	1,7	2,0	2,4	2,9	+1,1	+0,5	12,7

Source: calculated by the authors on the basis of State Statistics Service of Ukraine, 2026, Cabinet of Ministers of Ukraine, 2024, OECD, 2025

Financial resources aimed at innovative development grew more intensively. Thus, expenditures on innovation activities increased from 0.36 to 0.61 billion USD, i.e. by 0.25 billion USD, or by 71.3%, and the average annual growth rate was 14.4%. In 2025, their volume increased by 0.11 billion USD compared to 2024, which indicates a significant increase in investment support for innovation processes.

The most dynamic development can be traced in the use of AI technologies. The share of enterprises using AI solutions increased from 4.8 % to 20.5 %, i.e. 4.3 times (+327.1 %), and the average annual growth rate reached 43.8 %, which is the highest value among all the studied indicators. During 2025 alone, this figure increased by another 5.7 percentage points, which confirms the transition from the isolated use of AI technologies to their gradual spread among a wide range of enterprises.

A similar trend is typical for investments in digital transformation, the volume of which increased from USD 0.21 to USD 0.48 billion, or by USD 0.27 billion (+129.8%). The average annual growth rate was 23.1%, which is almost 1.6 times higher than the corresponding indicator of total spending on innovation activities. This indicates a gradual change in the structure of innovative investments in favor of digital technologies, business process automation and implementation intelligent digital solutions.

The result of these processes was a significant expansion of the level of digitalization of enterprises. The share of digitalized business processes increased from 37.4% in 2021 to 60.7% in 2025, i.e. by 23.3 pp (+62.3%), with an average annual growth rate of 12.9%. A particularly intensive acceleration of digital transformation was observed in 2024–2025, when the indicator increased by 7.5 pp at once, which is the largest annual increase for the entire period of the study.

Positive changes in digitalization were accompanied by an increase in the efficiency of enterprises. Labor productivity for the period under study increased from 17.45 to 22.85 thousand tons. USD per employee, or by 5.4 thousand.

USD (+30.9%), which corresponds to the average annual growth rate of 6.9%. The share of innovative products in the total sales increased from 1.8% to 2.9%, or by 61.1%, which indicates a gradual transformation of digital and innovative investments into real results of production activities and an increase in the competitiveness of enterprises.

In general, the results of the analysis indicate that the highest growth rates are characteristic of indicators directly related to digital transformation and the use of AI technologies. At the same time, the indicators characterizing the final results of innovation activity show more moderate dynamics, which indicates that there is a certain time lag between the implementation of digital investments, the introduction of AI technologies and the receipt of the corresponding economic effect.

The analysis of absolute statistical data does not allow to fully assess the intensity of changes in individual indicators and compare the speed of their development. In this regard, the next stage of the study is to conduct an in-depth analysis of dynamics using indicators, growth rates, growth rates and average annual rates of change (Table 2).

Table 2. Analysis of the effectiveness of digital transformation of Ukrainian enterprises, 2021–2025

Indicator	2021	2022	2023	2024	2025	Change 2025 to		CAGR, %
						2021	2021	
Digitalization factor	0,37	0,41	0,47	0,53	0,61	+0,23	+0,08	12,9
AI utilization rate	0,05	0,06	0,09	0,14	0,21	+0,16	+0,06	43,8
Digital Intensity Factor	0,59	0,71	0,74	0,77	0,79	+0,20	+0,02	7,6
Innovation efficiency coefficient	0,11	0,11	0,13	0,14	0,16	+0,05	+0,02	8,9
Digital Performance Factor	1,87	1,77	1,66	1,57	1,51	-0,36	- 0,07	-4,9

Source: calculated by the authors

The analysis, the results of which are presented in Table 2, allows us to move from assessing the absolute dynamics of statistical indicators to determining the qualitative characteristics of the digital transformation of enterprises. Unlike the initial statistical data, the proposed system of analytical coefficients provides an opportunity to quantify the intensity of digitalization.

The results of the calculations indicate a steady increase in the value of the digitalization coefficient, which increased from 0.374 in 2021 to 0.607 in 2025, i.e. by 0.233 points or 62.3%, (growth rate 12.9%). This means that in five years, the level of digitalization of business processes has increased by more than one and a half times, and the most intensive changes occurred in the last year of the study, when the coefficient increased by another 0.075 points. Such dynamics confirm the acceleration of digital transformation processes and the gradual transition of enterprises to digital management models.

The highest dynamics among all indicators is demonstrated by the coefficient of use of AI technologies, the value of which increased from 0.048 to 0.205, or 4.27 times (+327.1%), and the average annual growth rate reached 43.8%. If in 2021 AI technologies were used only by individual enterprises, then in 2025 their use became systemic, which indicates the rapid spread of AI solutions in production, logistics, financial, and management activities. It is this indicator that is characterized by the highest growth rate among all the studied indicators.

At the same time, the digital intensity coefficient, which characterizes the share of digital investments in the total volume of innovation spending, increased from 0.587 to 0.788, i.e. by 34.2%. This means that if in 2021 about 59% of all innovation spending was directed to digital transformation, then in 2025 this figure approached 79%. Thus, most of the innovative resources of enterprises are directed to digital technologies.

Positive dynamics can also be traced in the value of the innovation efficiency coefficient, which increased from 0.114 to 0.160, or by 40.4 %, so innovation activity is becoming not only more widespread, but also more effective.

Unlike other indicators, the digital productivity ratio shows the opposite trend. Its value decreased from 46.66 to 37.65

thousand. USD, or by 19.3%, with an average annual rate of change of -4.9%. Such dynamics reflects an outstripping growth in the level of digitalization of business processes compared to an increase in labor productivity, obtaining appropriate economic results, which is a characteristic feature of innovation processes.

Thus, the the proposed coefficients allow not only to detail the trends in digital transformation, but also to identify patterns that remain hidden in the analysis of absolute statistical indicators. At the same time, individual coefficients characterize only certain aspects of the digital development of enterprises and do not provide a comprehensive assessment of it. In this regard, the next stage is the integration of the results obtained into a single system of generalizing indicators by calculating the integral index of readiness of enterprises to use AI and digital transformation technologies (Table 3).

Table 3. Analysis of the economic efficiency of the use of AI technologies by Ukrainian enterprises, 2021–2025

Indicator	2021	2022	2023	2024	2025	Change 2025 to		CAGR, %
						2021	2021	
Digital Investment ROI, %	70,2	67,5	72,4	79,8	87,5	+17,3	+7,7	5,7
Labor Productivity Index (2021=1,000)	1,00	1,04	1,10	1,19	1,31	+0,31	+0,11	6,9
AI Technology Utilization Index (2021=1,000)	1,00	1,29	2,02	3,08	4,27	+3,27	+1,19	43,8
Digital Investment Payback Ratio	0,70	0,68	0,72	0,79	0,88	+0,17	+0,08	5,7
AI Cost-Effectiveness Index	1,00	1,06	1,22	1,45	1,75	+0,75	+0,30	15,1

Source: calculated by the authors

The results of the analysis of the indicators in Table 3 indicate a gradual increase in the economic return on digital investments. In particular, the ROI of digital investments increased from 70.2% in 2021 to 87.5% in 2025, i.e. by 17.3 percentage points, or 24.6%, with an average annual growth rate of 5.7%. Especially indicative is the increase of 7.7 pp. only during 2025 compared to the previous year. The results obtained confirm that digital investments gradually provide higher and higher economic returns, creating additional value for enterprises.

A positive trend can also be traced in the labor productivity index, which during the analyzed period increased from the base value of 1,000 to 1,309, or by 30.9 %. This means that labor productivity in 2025 exceeded the level of 2021 by almost a third. The average annual growth rate of the indicator was 6.9%, which confirms the stable nature of positive changes.

The most dynamic indicator remains the index of the use of AI technologies, which increased from 1,000 to 4,271, that is, more than 4 times (+327.1%), with an average annual growth rate of 43.8%. Such results indicate an extremely high rate of spread of AI solutions in the activities of enterprises and confirm that artificial intelligence technologies are a driving factor in modern digital transformations.

A similar trend is demonstrated by the payback ratio of digital investments, which increased from 0.702 to 0.875, or by 24.6%. The positive dynamics of this indicator is consistent with the growth of the ROI of digital investments and confirms the gradual reduction of the payback period for investments in digital technologies. This indicates an increase in the economic feasibility of digital investments and their ability to generate a stable economic effect.

Of particular interest is the proposed index of economic efficiency of the use of AI technologies, which integrates changes in labor productivity, the level of adoption of AI solutions and the effectiveness of digital investments. Its value increased from 1,000 in the base year to 1,753 in 2025, i.e. by 75.3%, with an average annual growth rate of 15.1%. Compared to individual partial indicators, this index provides a more comprehensive assessment of the economic effect of the use of AI technologies, as it takes into account the simultaneous impact of several interrelated factors. The steady growth of the index confirms that the expansion of the use of AI is accompanied not only by an increase in the scale of digitalization, but also by a gradual increase in the economic performance of enterprises.

The results obtained indicate that digital transformation provides a positive economic effect, but some indicators characterize only certain of its components and do not allow to form a generalized assessment of the level of digital maturity of enterprises. That is why the final stage of the study is the integration of all partial indicators into a single complex criterion by calculating the integral index of digital transformation of enterprises (Table 4).

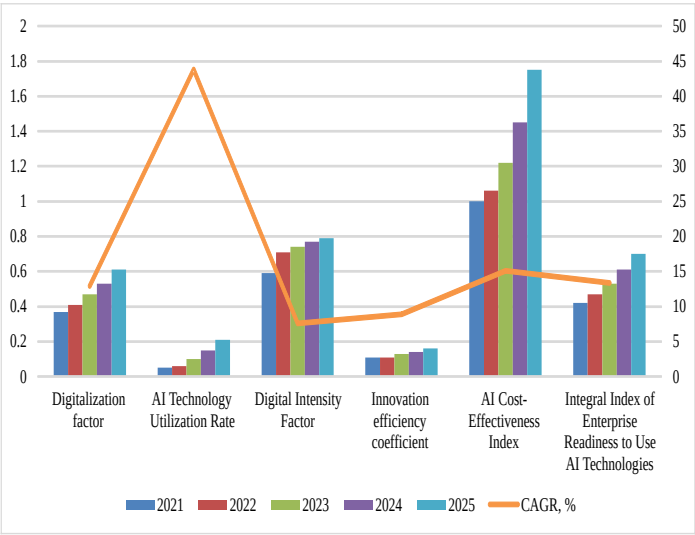
Table 4. Integral assessment of the readiness of Ukrainian enterprises to implement AI technologies, 2021–2025

Indicator	2021	2022	2023	2024	2025	Change 2025 to		CAGR, %
						2021	2021	
Digitalization factor	0,37	0,41	0,47	0,53	0,61	+0,23	+0,08	12,9
AI Technology Utilization Rate	0,05	0,06	0,10	0,15	0,21	+0,16	+0,06	43,8
Digital Intensity Factor	0,59	0,71	0,74	0,77	0,79	+0,20	+0,02	7,6
Innovation efficiency coefficient	0,11	0,11	0,13	0,14	0,16	+0,05	+0,02	8,9
AI Cost-Effectiveness Index	1,00	1,06	1,22	1,45	1,75	+0,75	+0,30	15,1
Integral Index of Enterprise Readiness to Use AI Technologies	0,42	0,47	0,53	0,61	0,70	+0,28	+0,09	13,4

Source: calculated by the authors on the basis of the proposed methodological approach

The results of the analysis of the indicators in Table 4 indicate a steady growth of the integral index throughout the entire period of the study. If in 2021 its value was 0.42, then in 2025 it reached 0.70, increasing by 0.28 points, or 65.4%, with an average annual growth rate of 13.4%. Compared to 2024, the integral indicator increased by another 0.09 points, which confirms the preservation of the positive dynamics of digital transformation of enterprises in the region and the gradual increase in their readiness for the widespread use of AI technologies (Fig. 2).

Figure 2. Integral indicators of the readiness of Ukrainian enterprises to implement AI technologies



Source: calculated by the authors on the basis of the proposed methodological approach

A characteristic feature of the proposed integral index is its ability to take into account not only the scale of the introduction of digital technologies, but also the effectiveness of their use. That is why the growth of the integral indicator reflects not a mechanical increase in individual indicators, but a comprehensive improvement in the digital maturity of enterprises, which is accompanied by an increase in the efficiency of innovation activities and economic returns from the use of AI technologies.

Thus, the results of the integral assessment confirm that the use of AI technologies is gradually turning from a separate tool for automating business processes into one of the determining factors in the innovative development of enterprises in the region. The proposed integral index can be used as a universal analytical tool for monitoring the digital readiness of enterprises, comparing the results of their digital transformation and information support for strategic management decision-making on the further implementation of AI technologies.

Conclusions

The study confirmed that AI technologies are one of the important factors in ensuring the innovative development of enterprises in the region in the context of digital transformation of the economy. Generalization of theoretical approaches is determined by the scale of its implementation.

Approbation of the methodology based on the analysis of statistical data for 2021–2025. confirmed its practical suitability and showed a steady increase in the level of use of AI technologies, digital investments, digitalization of business processes, labor productivity, and the integral index of enterprise readiness to use AI.

The practical significance of the proposed approach lies in the possibility of its use by enterprises, regional government bodies and other stakeholders to monitor the level of digital readiness of enterprises, determine priority areas of digital transformation and form a regional innovation policy. The effective use of AI technologies requires the development of digital infrastructure, the training of highly qualified personnel, the expansion of cooperation between business, authorities, universities and scientific institutions.

It is advisable to associate further research with the improvement of the proposed integral index by substantiating the weighting coefficients of individual components, adapting the methodology to the specifics of different sectors of the economy and conducting a comparative assessment of the level of readiness of enterprises in different regions of Ukraine to use AI technologies. of digital transformation.

References

- Agrawal, A., Gans, J., & Goldfarb, A. (Eds.). (2019). The economics of artificial intelligence: An agenda. National Bureau of Economic Research; University of Chicago Press. https://www.nber.org/books-and-chapters/economics-artificial-intelligence-agenda
- Ali, M., Khan, T., Khattak, M. N., & Şener, İ. (2024). Synergizing AI and business: Maximizing innovation, creativity, decision precision, and operational efficiency in high-tech enterprises. Journal of Open Innovation: Technology, Market, and Complexity, 10(3), Article 100352. https://doi.org/10.1016/j.joitmc.2024.100352
- Anderson, D. R., Sweeney, D. J., Williams, T. A., Camm, J. D., & Cochran, J. J. (2023). Statistics for business & economics (15th ed.). Cengage Learning.
- Cabinet of Ministers of Ukraine. (2024). On approval of the Strategy for the Digital Development of Innovation Activities of Ukraine for the Period up to 2030 and approval of the operational action plan for its implementation in 2025–2027, Order No. 1351-r). https://zakon.rada.gov.ua/laws/show/1351-2024-p#Text
- Cockburn, I. M., Henderson, R., & Stern, S. (2018). The impact of artificial intelligence on innovation (Working Paper No. 24449). National Bureau of Economic Research. https://www.nber.org/system/files/working_papers/w24449/w24449.pdf
- Datsenko, H., Kudyrko, O., Krupelnytska, I., Maister, L., Hladii, I., & et al. (2025). Innovative approaches to the use of artificial intelligence in accounting, control, and analytical processes to enhance enterprise competitiveness. Salud, Ciencia y Tecnología - Serie de Conferencias, 4, 663. https://doi.org/10.56294/sctconf2025663
- Datsenko, H., Kudyrko, O., Krupelnytska, I., Maister, L., Hladii, I., & et al. (2024). Innovative approaches to the use of artificial intelligence in accounting, control, and analytical processes to enhance enterprise competitiveness. Salud, Ciencia y Tecnología - Serie de Conferencias, 3, 665. https://doi.org/10.56294/sctconf2024.665
- Dubyna, M., Verbivska, L., Shyshkina, O., Los, A., & Fediai, Y. (2024). Innovative development and investment advancement of industrial enterprises in deriving conditions of digital economy. Pacific Business Review International, 17(4), 40–49. http://www.pbr.co.in/2024/2024_month/October/4.pdf
- Dwivedi, Y. K., Hughes, L., Baabdullah, A. M., Ribeiro-Navarrete, S., Giannakis, M., Al-Debei, M. M., Dennehy, D., Metri, B., Buhalis, D., Cheung, C. M. K., Conboy, K., Suess, R., Yogesh, S. K., Sharma, S. K., Tiwari, S. P., & Wamba, S. F. (2023). So what if ChatGPT wrote it? Multidisciplinary perspectives on opportunities, challenges and implications of generative conversational AI. International Journal of Information Management, 71, Article 102642.

https://doi.org/10.1016/j.ijinfomgt.2023.102642

- Han, S., Zhang, D., Zhang, H., & Lin, S. (2025). Artificial intelligence technology, organizational learning capability, and corporate innovation performance: Evidence from Chinese specialized, refined, unique, and innovative enterprises. Sustainability, 17(6), 2510. https://doi.org/10.3390/su17062510
- Hu, Y., Yan, X., Duan, C., Yang, X., & Yang, J. (2026). Does artificial intelligence improve the operational resilience of enterprises? Evidence from the AI innovative application pioneer zone policy in China. Systems, 14(4), 0377. https://doi.org/10.3390/systems14040377
- Iastremska, O., Malyarets, L., Samoilenko, V., & Budarin, O. (2024). Management of innovative projects to ensure innovative development of enterprises. Innovative Technologies and Scientific Solutions for Industries, 29, 104. https://doi.org/10.30837/2522-9818.2024.29.104
- Kigozi, J., Kalyango, M., Baidhe, E., Oluk, I., Jamison, A., & et al. (2025). Human-centered design in the development of innovative technology for the food processing medium, small and micro enterprises (MSMEs) in Uganda. Journal of Engineering Research, 13, 05034. https://doi.org/10.1016/j.jer.2024.05.034
- Kotko, Y., Levkina, R., Kulinich, O., & Levkin, D. (2026). Innovative potential in ensuring sustainable development of the enterprise. Lecture Notes on Data Engineering and Communications Technologies, Chapter 1. https://doi.org/10.1007/978-3-032-10153-2_1
- Krampen, B. (2023). Using economic indicators in analysing financial markets. Emerald Publishing Limited.
- Li, L., & Zhu, J. (2025). Can data assetization drive high-quality enterprise development?—Evidence from China's "Specialized, refined, unique, and innovative" SMEs. PLOS ONE, 20(10), e0335903. https://doi.org/10.1371/journal.pone.0335903
- Lin, H.-C., & Koong Chiou, C.-C. (2026). Enterprise implementation of multimodal AI systems: A mixed-methods study on 'Writing is Coding' framework for organizational creative and innovative intelligence. Enterprise Information Systems, 20, 2596840. https://doi.org/10.1080/17517575.2025.2596840
- Luo, L., Dong, Y., & Song, H. (2025). Artificial intelligence and the innovation quality of "specialized, refined, unique, and innovative" small- and medium-sized enterprises. Procedia Computer Science, 258, 86–92. https://doi.org/10.1016/j.procs.2025.08.086
- Malik, A., De Silva, M. T. T., Budhwar, P., & Srikanth, N. R. (2021). Elevating talents' experience through innovative artificial intelligence-mediated knowledge sharing: Evidence from an IT-multinational enterprise. Journal of International Management, 27(4), 100871. https://doi.org/10.1016/j.intman.2021.100871
- Ministry of Digital Transformation of Ukraine. (n.d.). Strategy for the Digital Development of Innovations in Ukraine. https://thedigital.gov.ua
- Nikiforov, P., Zhavoronok, A., Marych, M., Bak, N., & Marusiak, N. (2022). State policy regulation conceptual principles of public-private partnership development. Cuestiones Políticas, 40(73), 417–434. https://doi.org/10.46398/cuestpol.4073.22
- Nurhayati, M., Endri, E., Santosa, B., & Handiman, U. T. (2026). How self-development drives sustainable micro-enterprise performance: The mediating roles of entrepreneurial motivation and innovative work behavior. Problems and Perspectives in Management, 24(2), 56–67. https://doi.org/10.21511/ppm.24(2).2026.06
- Odrekhivskyi, M., Kohut, U., Kolomatskyi, V., Horbal, N., & Wołowiec, T. (2025). Assessment and forecasting of the environmental sustainability statuses of innovative enterprises in the context of sustainable development. Sustainability, 17(8), 3641. https://doi.org/10.3390/su17083641
- Organisation for Economic Co-operation and Development. (2025). OECD Economic Outlook (Vol. 2025, Issue 2). OECD Publishing.

https://www.oecd.org/content/dam/oecd/en/publications/reports/2025/12/oecd-economic-outlook-volume-2025-issue-2_413f7d0a/9f653ca1-en.pdf

- Paredes-Chacín, A. J., Melchor Cardona, M., & Mosquera-Mosquera, J. O. (2025). Digitalization as the basis for innovative development and environmental sustainability in micro, small, and medium-sized enterprises in Latin America [Digitalización como base del desarrollo innovador y sostenibilidad ambiental en micro, pequeñas y medianas empresas en Iberoamérica]. Revista de Ciencias Sociales, 31(3), 44282. https://doi.org/10.31876/rcs.v31i3.44282
- Petrunenko, I., Ustymenko, V., Dzhabrailov, R., Vozniakovska, K., & Sieriebriak, S. (2025). Socioeconomic impact of innovative development of small and medium-sized enterprises on the post-war communities of Ukraine. Heritage and Sustainable Development, 7(1), 998. https://doi.org/10.37868/hsd.v7i1.998
- Popelo, O., Ivanova, N., Ivanets, S., Perepeliukova, O., & Vasyuchenko, P. (2025). Global trends in formation of regional innovative entrepreneurial ecosystems in the context of rapid development of artificial intelligence technologies. Pacific Business Review International, 18(1), 12–38. https://www.pbr.co.in/2025/2025_month/July/2.pdf
- Prateeppornnarong, D. (2026). Innovative entrepreneurship for sustainability: A multiple case study of social innovation drivers in social enterprises for sustainable development. Sustainable Development, 34, 70951. https://doi.org/10.1002/sd.70951
- Reznik, N., Kosmidailo, I., Bobko, V., Lohinova, O., Maliarchuk, N., & et al. (2026). Strategic management of innovative development of agricultural enterprises in the modern marketing environment. Lecture Notes in Networks and Systems, Chapter 37. https://doi.org/10.1007/978-3-032-00329-4_37
- Ricciardi, I., Percuoco, M., Prisco, A., & Galmarini, E. (2025). Innovative and sustainable product development: A comparative study of influencing factors in large enterprises vs SMEs. Journal of Product & Brand Management, 34, 5571. https://doi.org/10.1108/JPBM-10-2024-5571
- State Statistics Service of Ukraine. (n.d.). Statistical information. Science, technology and innovation. https://stat.gov.ua
- Sun, Y. (2026). AI innovative dissemination of red culture in civic and political education in colleges and universities—A new model of enterprise operation participation. International Journal of Computer Information Systems and Industrial Management Applications, 18, 0102. https://doi.org/10.70917/ijcisim-2026-0102
- Verhoef, P. C., Broekhuizen, T., Bart, Y., Bhattacharya, A., Dong, J. Q., Fabian, N., & Haenlein, M. (2021). Digital transformation: A multidisciplinary reflection and research agenda. Journal of Business Research, 122, 889–901. https://doi.org/10.1016/j.jbusres.2019.09.022
- Woźniak, J., Moczydłowska, J. M., Almeida, P., & Ciocoiu, C. N. (2025). Organisational resilience as a determinant of the development of innovative service enterprises. Engineering Management in Production and Services, 17(1), 1–12. https://doi.org/10.2478/emj-2025-0001
- Xinzhong, B., & Jiahang, L. (2026). Study on the influence path of data asset information disclosure level and its high-quality development effect in large innovative enterprises. Technology Analysis & Strategic Management, 38, 2626353. https://doi.org/10.1080/09537325.2026.2626353
- Yan, G. (2025). Innovative management model of human resources for entrepreneurial enterprises under the concept of sustainable development. International Journal of Innovation and Sustainable Development, 19(2), 145966. https://doi.org/10.1504/IJISD.2025.145966
- Zhang, B., & Peng, B. (2025). Artificial intelligence and the development of "specialized, refined, unique, and innovative" small- and medium-sized enterprises.

Managerial and Decision Economics, 46, mde.4407. https://doi.org/10.1002/mde.4407

- Zhao, K., Wang, W., & Chen, X. (2026). Pilot zones for innovative application of artificial intelligence and enterprise innovation. Sustainability, 18(8), 3833. https://doi.org/10.3390/su18083833
- Zhao, W., Yu, Y., Yang, M., Zhang, G., & Cao, J. (2025). Research on the construction of a prediction model for the modernization level of the management system of AI-driven specialized, refined, unique and innovative demonstration enterprises. Proceedings of the 2025 4th International Conference on Artificial Intelligence and Intelligent Information Processing (AIIIP 2025), 3778534.3778616. https://doi.org/10.1145/3778534.3778616
- Zhavoronok, A., Chub, A., Yakushko, I., Kotelevets, D., Lozychenko, O., & Kupchyshyna, O. (2022). Regulatory policy: Bibliometric analysis using the VOSviewer program. International Journal of Computer Science and Network Security, 22(1), 39–48. https://doi.org/10.22937/IJCSNS.2022.22.1.7
- Zhou, F., Zhao, Y., Liang, R., & Zhu, S. (2026). Does the combination of low-carbon and innovative policies promote the high-quality development of enterprises?—A quasi-natural experiment based on the "dual pilot" of low carbon and innovation cities. Environment, Development and Sustainability, 28, 4979–4990. https://doi.org/10.1007/s10668-024-04979-7