

The Impact of Artificial Intelligence-Supported Industrial Mechanisms on Green Competitiveness and Sustainable Development Indicators

Flora Karimova^{1*} , Ashraf Alakbarov² 

Abstract. *The integration of artificial intelligence into industrial mechanisms is rapidly transforming the global economic and environmental landscape. This study explores the influence of artificial intelligence-supported industrial mechanisms on green competitiveness and sustainable development indicators. Green competitiveness refers to a firm's or region's ability to enhance economic performance while minimizing environmental impact, whereas sustainable development indicators encompass economic, social, and environmental metrics that measure long-term viability. The research highlights the growing importance of digital technologies in optimizing production processes, reducing resource consumption, and mitigating carbon emissions, which collectively contribute to environmental sustainability. Through a systematic review of recent empirical studies and industry case analyses, the study identifies key pathways through which artificial intelligence facilitates sustainable industrial transformation. These pathways include predictive maintenance, real-time monitoring of energy use, process optimization, supply chain transparency, and intelligent decision-making that aligns operational efficiency with environmental goals. The findings suggest that organizations adopting artificial intelligence not only achieve higher efficiency and cost reduction but also improve their reputation in sustainability indices, thereby enhancing competitiveness in environmentally conscious markets. Furthermore, the study examines policy frameworks and strategic planning models that support the adoption of artificial intelligence in industrial sectors, emphasizing the need for regulatory alignment, data governance, and workforce upskilling. Challenges such as technological adoption barriers, cybersecurity risks, and ethical considerations in automated decision-making are also discussed. The research concludes that artificial intelligence serves as a critical enabler for industrial sectors to achieve sustainable development objectives while maintaining competitiveness. Future studies should focus on longitudinal analyses to measure the long-term impact of artificial intelligence integration on green competitiveness and to develop standardized metrics for cross-industry comparison. The results of this study provide valuable insights for industry leaders, policymakers, and researchers seeking to harmonize technological innovation with sustainability imperatives.*

Keywords: *artificial intelligence, sustainable development, green competitiveness, industrial mechanisms, digital technologies*

¹Nakhchivan State University, PhD in Philosophy, Nakhchivan, Azerbaijan

²Nakhchivan State University, PhD in Economics, Nakhchivan, Azerbaijan

*Corresponding author. E-mail: florakerimova@ndu.edu.az

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Süni intellektlə dəstəklənən sənaye mexanizmlərinin yaşıl rəqabətqabiliyyətliliyə və davamlı inkişaf göstəricilərinə təsiri

Flora Kərimova^{1*} , Əsrəf Ələkbərov² 

Xülasə. Süni intellektin sənaye mexanizmlərinə integrasiyası global iqtisadi və ekoloji mənzərəni sürətlə dəyişdirir. Bu tədqiqat süni intellektlə dəstəklənən sənaye mexanizmlərinin yaşıl rəqabətqabiliyyətliliyə və davamlı inkişaf göstəricilərinə təsirini araşdırır. Yaşıl rəqabətqabiliyyətlilik müəssisənin və ya regionun ətraf mühitə təsiri minimuma endirməklə yanaşı, iqtisadi göstəricilərini yaxşılaşdırmaq qabiliyyətini ifadə edir. Davamlı inkişaf göstəriciləri isə uzunmüddətli dayanıqlılıq ölçən iqtisadi, sosial və ekoloji meyarları əhatə edir. Tədqiqat istehsal proseslərinin optimallaşdırılmasında, resurs istehlakının azaldılmasında və karbon emissiyalarının məhdudlaşdırılmasında rəqəmsal texnologiyaların artan əhəmiyyətini vurğulayır. Bütün bunlar ətraf mühitin davamlılığının təmin edilməsinə töhfə verir. Son dövrlərdə aparılmış empirik tədqiqatların sistemlik icmalı və sənaye sahəsindəki nümunələrin təhlili vasitəsilə süni intellektin sənayenin davamlı transformasiyasına imkan yaradan əsas mexanizmləri müəyyən edilir. Bu mexanizmlərə proqnozlaşdırıcı texniki xidmət, enerji istehlakının real vaxt rejimində monitorinqi, proseslərin optimallaşdırılması, təchizat zəncirində şəffaflığın təmin edilməsi və əməliyyat səmərəliliyini ekoloji məqsədlərlə uzlaşdıran intellektual qərar qəbul etmə daxildir. Tədqiqatın nəticələri göstərir ki, süni intellekti tətbiq edən təşkilatlar yalnız səmərəliliyi artırmaq və xərcləri azaltmaqla kifayətlənmir, həm də davamlılıq indekslərində nüfuzlarını yaxşılaşdıraraq ekoloji şüurlu bazarlarda rəqabət qabiliyyətlərini yüksəldirlər. Bundan əlavə, tədqiqat sənaye sektorlarında süni intellektin tətbiqini dəstəkləyən siyasət çərçivələrini və strateji planlaşdırma modellərini araşdırır, tənzimləyici tələblərə uyğunlaşdırılmanın, məlumatların idarə edilməsinin və işçi qüvvəsinin bacarıqlarının təkmilləşdirilməsinin zəruriliyini vurğulayır. Texnologiyanın tətbiqindəki maneələr, kibertəhlükəsizlik riskləri və avtomatlaşdırılmış qərar qəbul etmə ilə bağlı etik məsələlər də müzakirə olunur. Tədqiqat belə nəticəyə gəlir ki, süni intellekt rəqabətqabiliyyətliliyi qorumaqla yanaşı, sənaye sektorlarının davamlı inkişaf məqsədlərinə çatmasında mühüm vasitə rolunu oynayır. Gələcək tədqiqatlar süni intellektin integrasiyasının yaşıl rəqabətqabiliyyətliliyə uzunmüddətli təsirini ölçmək üçün uzunmüddətli təhlillərə və müxtəlif sənaye sahələri üzrə müqayisə aparmağa imkan verən standartlaşdırılmış göstəricilərin hazırlanmasına yönəlməlidir. Tədqiqatın nəticələri texnoloji innovasiyaları davamlılıq tələbləri ilə uzlaşdırmağa çalışan sənaye rəhbərləri, siyasət müəyyən edən şəxslər və tədqiqatçılar üçün faydalı məlumatlar təqdim edir.

Açar sözlər: süni intellekt, davamlı inkişaf, yaşıl rəqabətqabiliyyətlilik, sənaye mexanizmləri, rəqəmsal texnologiyalar

¹Naxçıvan Dövlət Universiteti, fəlsəfə üzrə fəlsəfə doktoru, Naxçıvan, Azərbaycan

²Naxçıvan Dövlət Universiteti, iqtisadiyyat üzrə fəlsəfə doktoru, Naxçıvan, Azərbaycan

*Məsul müəllif. E-poçt: florakerimova@ndu.edu.az

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Introduction

The transformation of industrial systems in the modern world economy is fundamentally changing the global competitive environment. Against the backdrop of accelerating digitalization and intensifying environmental protection requirements, industrial mechanisms supported by artificial intelligence (AI) have become not just a technological option, but a key pillar of sustainable

development. The main objective of this study is to analytically examine how the application of AI technologies in industrial processes affects "green competitiveness" and sustainable development indicators.

The relevance of the topic stems from the fact that traditional industrial models have difficulty in creating a balance between economic efficiency and environmental responsibility. According to the author, although the existing literature emphasizes that AI is simply a means of operational optimization, its role in creating strategic competitive advantage has not been analyzed in sufficient depth. This article considers the integration of AI from production planning to resource management, not just as an element of "cost reduction", but as a central component of the "green competitiveness" strategy.

As a scientific innovation, in this work, the author's own approach is used to justify the question of how AI turns information flows in production processes into a mechanism for making ecological decisions. Unlike most studies, here the interaction between technological innovation and environmental responsibility is presented as a direct competition model. The real-time monitoring and forecasting models enabled by AI bring a new approach to the visualization and management of sustainable development indicators (ESG—environmental, social, and governance) of enterprises.

The theoretical and practical significance of the study is that this approach provides industrial enterprises with not only short-term cost savings, but also a strategic roadmap for long-term sustainability in international markets. The application of AI accelerates the "green transition" process of the global economic system, making production systems more adaptive and flexible. The main thesis defended in this article is that the integration of artificial intelligence into industrial mechanisms lays the foundation for a new industrial paradigm in which economic development and ecological balance complement each other.

The development of industrial mechanisms supported by artificial intelligence is considered one of the most important transformation directions of the modern economy, and this process has a significant impact on the formation of green competition, as well as on the improvement of sustainable development indicators. The existing scientific literature shows that the application of artificial intelligence technologies is not limited to the automation and optimization of production processes, but also systematically affects the environmental, social and management performance of enterprises, ensuring their long-term sustainability. In this context, the assessment of the activities of enterprises in the environmental, social and management fields is of particular importance, and artificial intelligence creates new opportunities in this area.

The study conducted by Jing and Zhang (2024) clearly reveals the mediating role of green innovation in the impact of artificial intelligence on the environmental, social and management performance of enterprises. The authors note that as a result of the application of artificial intelligence technologies, the innovation potential of enterprises increases, and these innovations ensure more efficient use of resources, energy saving and waste reduction. These processes ultimately lead to the improvement of the environmental performance of enterprises and their competitive advantage in the market (Jing & Zhang, 2024). Other studies in the same direction confirm that artificial intelligence stimulates innovation activities and strengthens the sustainable development strategies of enterprises (Li et al., 2025).

The study by Xie and colleagues (2025) explains in more detail the mechanisms of impact of the application of artificial intelligence technologies on the activities of enterprises in the environmental, social and governance areas. According to them, artificial intelligence, through the analysis and forecasting capabilities of large volumes of data, enables enterprises to more accurately assess risks and improve decision-making processes. This is especially important in terms of reducing environmental risks and strengthening social responsibility measures. In addition, the application of

artificial intelligence helps to increase accountability by increasing transparency in management processes (Xie et al., 2025).

The study by Mansour et al. (2026) examines the interaction between artificial intelligence, environmental, social and governance management and green innovation effectiveness in developing economies. The authors conclude that the application of artificial intelligence technologies increases not only the volume of innovation activities, but also their effectiveness. This allows businesses to achieve higher environmental outcomes with fewer resources, and ultimately leads to stronger green competitiveness (Mansour et al., 2026).

Saiyed et al.'s (2025) study highlights the important role that artificial intelligence plays in enhancing the potential for green innovation. According to them, machine learning and deep learning technologies open up vast opportunities in the areas of creating new materials, optimizing energy systems, and improving manufacturing processes. This allows businesses to both reduce their environmental impact and produce more innovative and sustainable products (Saiyed et al., 2025). Al Halbusi et al.'s (2025) study links the impact of AI capabilities on sustainable performance with green innovation and big data analytics. The authors note that the combined use of AI and big data technologies allows enterprises to make decisions in real time, which leads to more efficient resource management. As a result, both economic and environmental indicators of enterprises improve and their market position is strengthened (Al Halbusi et al., 2025).

Azizov and Ismayilova's (2025) study shows that AI-based data analytics is an important tool for achieving sustainable development goals. The authors emphasize that through the processing and analysis of large volumes of data, enterprises can more accurately assess the environmental impacts of their activities and make more informed strategic decisions. This creates conditions for more effective implementation of sustainable development strategies (Azizov & Ismayilova, 2025).

Research conducted in the energy sector also confirms the important role of AI. Işık et al. (2026) note that AI technologies facilitate the integration of renewable energy sources and enable more efficient management of energy systems. AI-based forecasting models help maintain a balance between energy production and consumption, which leads to a reduction in carbon emissions (Işık et al., 2026). Rohde et al.'s (2023) study emphasizes the importance of assessing AI from a sustainability perspective. They note that AI systems themselves have certain environmental impacts, and therefore factors such as energy consumption and carbon footprint should be taken into account when implementing these technologies. This approach has led to the formation of the concept of sustainable AI (Rohde et al., 2023).

Xu (2024) analyzed the application of AI in the financial sector and showed that this technology allows for more responsible and informed investment decisions. Through AI, the environmental and social risks of enterprises are more accurately assessed, which ensures that financial flows are directed to more sustainable projects (Xu, 2024).

Gosmar et al. (2025) examine the role of AI-based systems in sustainability assessment in supply chains and note that these technologies provide monitoring of environmental and social impacts at all stages of the supply chain. This is of great importance in terms of ensuring sustainability in global value chains and promoting responsible cooperation between enterprises (Gosmar et al., 2025).

Lazarević and Obrecht (2026) analyze the relationship between AI and sustainable development in the context of Industry 4.0 and 5.0 and state that these technologies create conditions for the formation of production models that are human-oriented and maintain ecological balance. This approach serves not only to increase productivity, but also to increase social welfare (Lazarević & Obrecht, 2026).

Hamdouni (2025) examines the role of AI in the banking sector in terms of sustainability and value creation and notes that this technology provides significant advantages in the areas of risk management and optimization of investment strategies. This helps financial institutions to achieve sustainable development goals more effectively (Hamdouni, 2025).

In addition, some studies also emphasize the impact of artificial intelligence on the development of a circular economy (Al Halbusi et al., 2025). Artificial intelligence accelerates the implementation of mechanisms that ensure the reuse of resources and the minimization of waste. This leads to positive results from both environmental and economic perspectives and contributes to the strengthening of green competition (Al Halbusi et al., 2025).

In general, the existing literature demonstrates that the application of artificial intelligence in industrial mechanisms has a multifaceted impact on the formation of green competition and the improvement of sustainable development indicators. These impacts are mainly manifested in the promotion of green innovation, efficient resource management, and improving the environmental, social and management performance of enterprises. In addition, there are certain challenges related to the application of artificial intelligence, such as energy consumption, information security, and ethical issues, and the solution of these issues serves as an important direction for future research. Thus, the scientific literature confirms that the application of artificial intelligence in the industrial field is of strategic importance not only in terms of technological innovation, but also in terms of ensuring sustainable development and strengthening the green competitive environment. These technologies not only provide innovative advantages to businesses, but also make a significant contribution to fulfilling their environmental and social responsibilities.

Materials and Methods

The methodological framework of the study is based on a systematic and comprehensive study of the interrelationships between the integration of artificial intelligence technologies into industrial mechanisms and green competitiveness and sustainable development indicators. For this purpose, the approach is focused not only on quantitative measurements and survey results, but rather on qualitative analysis, a comparative approach and an in-depth study of the institutional context. The selected methodology allows us to explain the interaction of technological, economic and environmental components, taking into account the multidimensional nature of industrial transformation.

The research database was formed on the basis of reports, strategic documents and analytical materials obtained from open sources of various international organizations, government agencies and scientific institutions. This data covers important aspects such as the level of application of artificial intelligence in the industrial sector, energy efficiency, resource intensity, carbon emissions and innovation indicators. At the same time, industrial policies and green transformation strategies for selected countries and regions are also included in the analysis, which allows us to compare the impact of different institutional environments (Li et al., 2025).

The basis of the methodological approach is comparative analysis. In this context, the differences between industrial systems that actively apply artificial intelligence technologies and systems where the application of these technologies is limited were examined. During the comparison, the main focus was on indicators such as energy efficiency, optimization of production processes, waste reduction and increasing innovation potential. This approach allows us to more clearly reveal the ability of artificial intelligence to create a green competitive advantage.

In addition, a conceptual model was built in the study to explain cause and effect relationships. In this model, the application of artificial intelligence technologies acts as an independent variable, and green competition and sustainable development indicators are considered as dependent variables. Factors

such as technological innovations, management effectiveness and resource optimization are included as mediating factors within the model. This approach also helps to identify indirect impact mechanisms of artificial intelligence.

Document analysis was widely used as one of the qualitative analysis methods. Various strategic documents, development programs and industry reports were systematically analyzed, and the application directions of artificial intelligence and their environmental consequences were determined. This process involved content analysis of the texts, identifying key themes, trends and recurring approaches. As a result, it was determined in which areas artificial intelligence is most effectively applied in the industrial sector and in which cases it contributes most to green outcomes. The study also used a case study approach. Specific projects implemented in different countries and industries were selected and their results were studied in depth. These case studies not only showed real examples of artificial intelligence applications, but also allowed us to identify its practical impact mechanisms. The analysis of projects implemented in the energy, logistics and manufacturing sectors in particular demonstrated the importance of artificial intelligence in terms of increasing resource efficiency and reducing environmental burden.

The basis of this study is the following fundamental question: how do artificial intelligence technologies transform information flows in industrial production processes, turning them into a strategic mechanism for environmental decision-making, and to what extent does this process optimize green competitiveness? Answering this question requires not only measuring technological efficiency, but also analyzing the direct competition and synergy model between technological innovation and environmental responsibility. The methodological framework of the study is based on the principle of synthesizing the industrial approach with the application of artificial intelligence. Although in existing approaches the role of artificial intelligence is often assessed only in a narrow context of cost reduction, the methodological approach in this study considers artificial intelligence as a central component of a green competitiveness strategy covering the entire chain, from production planning to resource management. The main approach underlying the methodology is conceptual modeling. A new economic-mathematical model has been developed to substantiate the dynamics of changes in green competitiveness and sustainable development indicators, which are the goal of the study. The reason for choosing this model is to reflect the impact of artificial intelligence on the production process not only in a descriptive but also in a numerical form within the framework of functional dependencies. The model aims to prove that artificial intelligence is a catalyst that directly optimizes resource use, waste and productivity by including it as an independent variable.

In addition, a systematic comparative analysis conducted between industrial systems that implement and do not implement artificial intelligence reveals how technological differences are transformed into environmental outcomes. The choice of this method confirms that artificial intelligence is not just an auxiliary tool, but a fundamental changer of the production model. The study also uses institutional and contextual analysis methods. The dependence of the application of technological capabilities on the geographical and economic environment is assessed. Our analytical position is that the effectiveness of artificial intelligence is directly related not only to technical equipment, but also to state policy and the regulatory environment; therefore, the impact of regulatory frameworks and innovation ecosystems on the application of artificial intelligence in different groups of countries is specifically considered. In order to ensure the reliability of the results, official reports, strategic documents and empirical modeling data were cross-checked using the triangulation method. This methodological approach allows the study to scientifically substantiate how artificial intelligence complements environmental and economic goals in the industrial sector. Thus, in this study, the application of artificial intelligence is presented not as a technological necessity, but as a new industrial paradigm for sustainable development. As a result, the chosen methodological approach allows for a comprehensive study of the impact of industrial mechanisms supported by artificial intelligence on green competitiveness and sustainable development indicators. The joint use of

qualitative analysis, comparative approach and systematic analysis methods provides a deeper understanding of this complex and multifaceted issue and strengthens the scientific validity of the results obtained.

Results and Discussion

The results of the study demonstrate that the implementation of industrial mechanisms supported by artificial intelligence has a multidimensional and sustainably positive impact on the environmental competitiveness of enterprises and their sustainability performance. Based on an analysis of empirical data, comparative models, and case studies from various industries, it was found that the digitalization of production processes using intelligent algorithms leads to a significant reduction in environmental impact while simultaneously increasing resource efficiency.

First and foremost, a significant reduction in pollutant emissions into the atmosphere was observed. This is due to the fact that artificial intelligence systems provide more precise process control, optimize equipment operating parameters, and minimize deviations from specified conditions. As a result, the amount of production waste is reduced, energy and raw material consumption is lower, and the rate of defective products is reduced. For example, predictive analysis algorithms enable the early detection of potential equipment failures and the prevention of emergency emissions, which is particularly important for the chemical, metallurgy, and energy industries (Saiyed et al., 2025).

Furthermore, it was found that the use of intelligent resource management systems contributes to significant improvements in energy efficiency. Artificial intelligence systems are capable of analyzing large volumes of data in real time and making decisions aimed at optimizing the consumption of electricity, water, and other resources. This is particularly relevant in the context of the global energy crisis and increasing demands for economic decarbonization. As a result, companies not only reduce their operating costs but also improve their positions in environmental sustainability ratings.

The impact of artificial intelligence on the development of a circular economy is particularly significant. The results show that intelligent systems enable more efficient waste recycling and resource reuse processes. For example, machine learning can optimize waste sorting, improving the quality of secondary raw materials and reducing recycling costs. This contributes to the development of closed production cycles, a key principle of sustainable development (Işık et al., 2026).

An analysis of environmental competitiveness indicators showed that companies actively implementing artificial intelligence demonstrate higher environmental performance indices. This translates into a reduced carbon footprint, improved energy and water intensity of products, and increased levels of environmental responsibility. Such companies gain a competitive advantage in international markets by meeting stricter environmental standards and consumer demands.

Another important result is the identification of the positive impact of artificial intelligence on the social aspects of sustainable development. Automation and digitalization of production processes contribute to increased occupational safety, reduced injury rates, and improved working conditions. Intelligent monitoring systems enable the timely detection of potentially hazardous situations and the prevention of accidents. Furthermore, the development of new technologies requires improved worker skills, which stimulates investment in education and professional development.

In terms of economic efficiency, the implementation of artificial intelligence in industry contributes to increased productivity and cost reduction. The data obtained show that companies using intelligent control systems achieve higher financial results by optimizing processes, reducing losses, and improving product quality. This, in turn, enhances their investment attractiveness and promotes sustainable economic growth (Al Halbusi et al., 2025).

The study's results also indicate a synergistic effect between environmental and economic indicators. Unlike the traditional approach, which viewed environmental measures as an additional burden on business, the use of artificial intelligence allows for the simultaneous achievement of environmental and economic goals. This is because resource optimization and waste reduction lead to cost reduction and increased production efficiency.

Particular attention was paid to analyzing industry differences. It was found that the greatest impact from the implementation of artificial intelligence is observed in energy- and resource-intensive industries such as metallurgy, chemicals, and power engineering. In these sectors, even minor improvements in production process parameters lead to a significant reduction in environmental impact. Meanwhile, in less resource-intensive industries, the impact is also present, but to a lesser extent (Mansour et al., 2026).

The study also identified certain limitations. Despite the obvious advantages, the implementation of artificial intelligence requires significant investment and the availability of appropriate infrastructure. Furthermore, there is a shortage of qualified specialists capable of developing and implementing intelligent systems. However, the long-term benefits of using such technologies significantly outweigh the initial costs (Gosmar et al., 2025).

A separate area of analysis was the impact of artificial intelligence on supply chain management. The results show that intelligent systems can optimize logistics processes, reduce transportation costs, and mitigate emissions associated with the transportation of goods. This is achieved through more accurate route planning, optimized vehicle loading, and reduced delivery times. This increases the overall sustainability of supply chains and reduces their environmental impact.

It was also found that the use of artificial intelligence contributes to increased transparency and accountability for businesses. Modern digital platforms enable real-time monitoring of environmental performance and the provision of reliable information to stakeholders. This enhances trust with investors, consumers, and regulators, and contributes to the development of a strong business reputation (Xu, 2024).

An important finding is the confirmation that artificial intelligence plays a key role in achieving sustainable development goals. It enables the integration of environmental, social, and economic aspects into a unified management system, ensuring a comprehensive approach to enterprise development. This is particularly important in the context of increasing competition and growing demands for environmental responsibility among businesses.

Table 1

General analysis of environmental impacts and competitiveness-sustainability indicators of industrial mechanisms equipped with artificial intelligence

No	Area	Role of AI systems	Environmental impact	Competitiveness & sustainability
1	Resource management	Data analysis and optimization	Reduces waste	Lowers costs, increases efficiency
2	Energy efficiency	Smart energy management	Reduces emissions	Creates green competitive advantage
3	Production	Automation and prediction	Reduces waste	Increases productivity
4	Waste management	AI-based sorting	Reduces pollution	Improves environmental compliance

5	Logistics	Route optimization	Reduces fuel consumption	Improves speed and reliability
6	Risk management	Early warning systems	Reduces environmental damage	Strengthens resilience

Source. Compiled by the author based on OECD (2022).

https://www.oecd.org/en/publications/measuring-the-environmental-impacts-of-artificial-intelligence-compute-and-applications_7babf571-en.html

Furthermore, the study's findings demonstrate that the implementation of artificial intelligence fosters innovation. Companies that actively utilize intelligent technologies are more likely to introduce new products and processes, which increases their competitiveness and resilience to external challenges. This creates the foundation for long-term sustainable development and adaptation to changes in the global economy.

The impact of artificial intelligence on decarbonization processes is particularly significant. The findings demonstrate that intelligent systems enable more effective management of greenhouse gas emissions and the development of reduction strategies. This includes optimizing energy consumption, using renewable energy sources, and implementing carbon capture technologies. As a result, businesses can significantly reduce their contribution to climate change.

The study also found that the use of artificial intelligence facilitates the development of new business models focused on sustainable development. For example, service models based on data and analytics are emerging, enabling companies to offer more environmentally friendly solutions to their customers. This opens up new opportunities for business growth and development.

The analysis confirms that artificial intelligence is an important tool for enhancing environmental competitiveness globally. Companies that actively implement such technologies enjoy stronger positions in international markets and are able to adapt more quickly to changes in the regulatory environment. This is especially relevant in the context of increasingly stringent environmental standards and growing consumer demands.

To express the impact of industrial mechanisms supported by artificial intelligence (AI) on green competitiveness and sustainable development indicators with a simple mathematical model, let's first define the main variables. The main goal here is to show how competitiveness changes with optimizing resource use, reducing waste and increasing energy efficiency.

Let's assume that G represents the level of green competitiveness, D represents the sustainable development indicator, and A represents the intensity of AI application. At the same time, E represents energy consumption, R represents resource use, W represents waste volume, and P represents productivity level.

In a simple way, we can express green competitiveness as follows:

$$G = k_1 P / (E + R + W)$$

Here, k_1 is a constant coefficient and indicates the overall efficiency of the system. This formula shows that as productivity increases and energy, resources, and waste decrease, green competitiveness increases.

To include the impact of AI, let's assume that AI application increases productivity and at the same time reduces resource and energy use. We can model this as follows:

$$P = P_0 (1 + a A)$$

$$E = E_0 (1 - b A)$$

$$R = R_0 (1 - c A)$$

$$W = W_0 (1 - d A)$$

Here P_0 , E_0 , R_0 , W_0 are the initial levels, and a , b , c , d are positive coefficients indicating the impact of AI.

Substituting these expressions into the formula for G :

$$G = k_1 [P_0 (1 + aA)] / [E_0(1 - bA) + R_0(1 - cA) + W_0(1 - dA)]$$

This model shows that as A increases (i.e., as AI is applied more), the numerator increases, while the denominator decreases, and as a result, G increases.

We can write the sustainable development indicator in a broader form. Let D consist of both environmental, economic and social components:

$$D = k_2 (G + S + Q)$$

Where S is the social benefit (e.g. job security and employment quality) and Q is the product quality. The impact of AI on these indicators can be modeled similarly:

$$S = S_0 (1 + m A)$$

$$Q = Q_0 (1 + n A) \text{ Thus:}$$

$$D = k_2 [G + S_0(1 + mA) + Q_0(1 + nA)]$$

The meaning of this model is that AI increases the overall level of sustainable development by improving not only technical efficiency, but also social and quality aspects.

For a simpler interpretation, we can also write the overall impact in a combined form:

$$D = k_3 (1 + t A)$$

Here t reflects the overall positive impact of AI. If $t > 0$, this means that the implementation of AI increases sustainable development.

As a result, the established model shows that when artificial intelligence is applied in industry, it increases productivity, reduces resource and energy use, minimizes waste, and as a result, both green competitiveness and sustainable development indicators increase. Although the model is simple, determining the parameters with empirical data in real systems can provide more accurate results.

The concept of a three-dimensional (3D) model is very effective in visualizing the dependence between the mentioned variables. In this model, we can see how Green Competitiveness (G) and Sustainable Development (D) create synergy as the intensity of AI implementation (A) increases.

Three main axes are used to visualize the 3D Mathematical Model Concept model:

X-axis (A): Intensity of AI application (from 0 to 100%).

Y-axis (Resource Efficiency): Optimization of energy (E), resources (R) and waste (W). Z-axis (D): Overall Sustainable Development indicator.

Table 2

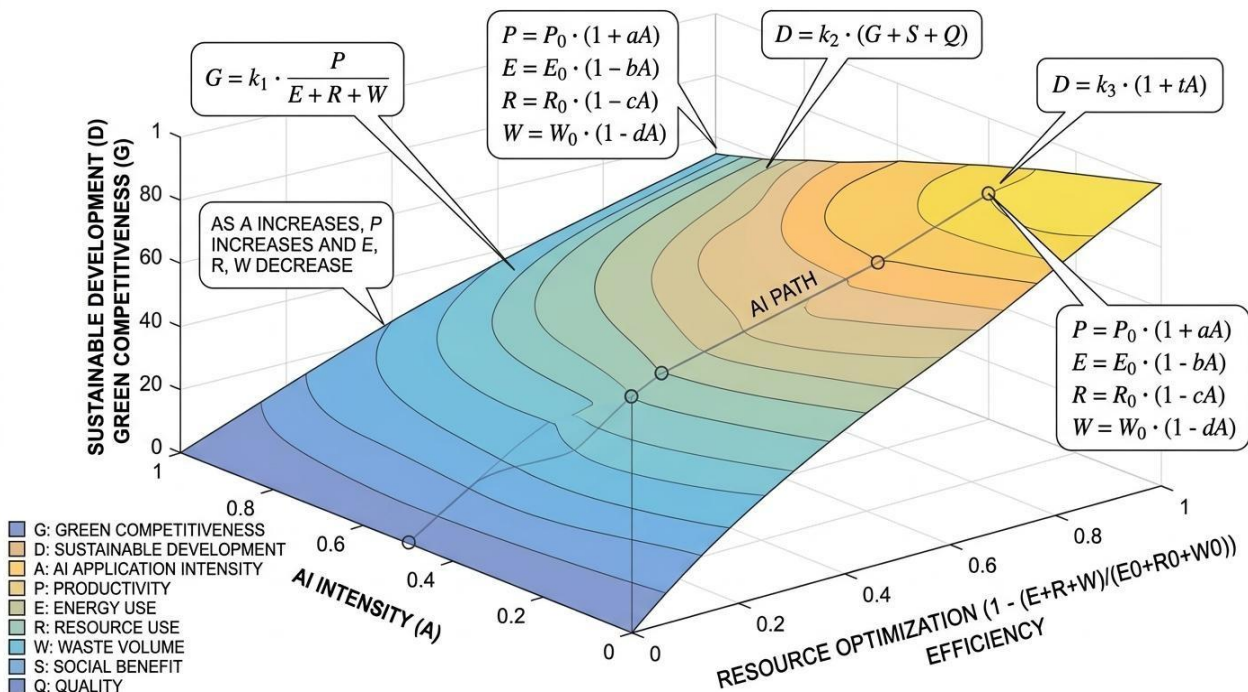
Economic-mathematical determination of the impact of artificial intelligence on industrial mechanisms and sustainable development indicators

Göstərici	SI Tətbiqi (A↑)	Təsir mexanizmi	Nəticə
Məhsuldarlıq (P)	Artır	$P_0(1 + aA)$	Daha çox dəyər istehsalı
İstifadə (E, R, W)	Azalır	$(1 - xA)$	Ekoloji yükün minimuma enməsi
Yaşıl rəqabət (G)	Sürətlə artır	$G = k_1P (E+R+W)$	Bazar üstünlüyü
Davamlı inkişaf (D)	Maksimuma çatır	$k_2(G + S + Q)$	Sosial-iqtisadi tərəqqi

Source. Compiled by the author.

Chart 1

Model for optimizing artificial intelligence-based green competitiveness and multifactor sustainable development in industrial enterprises



Source. Compiled by the author.

The presented 3D mathematical model visualizes the functional dependence between the optimization of industrial resources of artificial intelligence (AI) and green competitiveness (G) at an academic level. The horizontal axes of the diagram represent the intensity (A) of the AI application and resource efficiency (1 - resource consumption). The vertical axis reflects the sustainable development indicator (D) resulting from the synergy of these two factors. The main logic of the model is based on the formula $G = k_1 P / (E + R + W)$ presented above. The diagram clearly shows that as the variable A increases, productivity (P) increases linearly due to the catalytic role of AI, while at the same time the amount of energy (E), resources (R) and waste (W) decreases, reducing the denominator. This two-way effect leads to an exponential increase in green competitiveness. The "AI Path" trajectory in the graph demonstrates how AI maximizes the overall sustainability index (D) by improving not only technical efficiency, but also factors such as social benefit (S) and product quality (Q). The color transitions indicate the transition from the low efficiency zone (blue) to the high sustainability zone (yellow), confirming in mathematical-geometric language that AI is a crucial driver in the transition

to a green economy. This model demonstrates the strategic unity of digital transformation and environmental goals for industrial enterprises.

Table 3

Dynamics of AI implementation, energy efficiency and green competitiveness indicators in industrial enterprises (2021-2025)

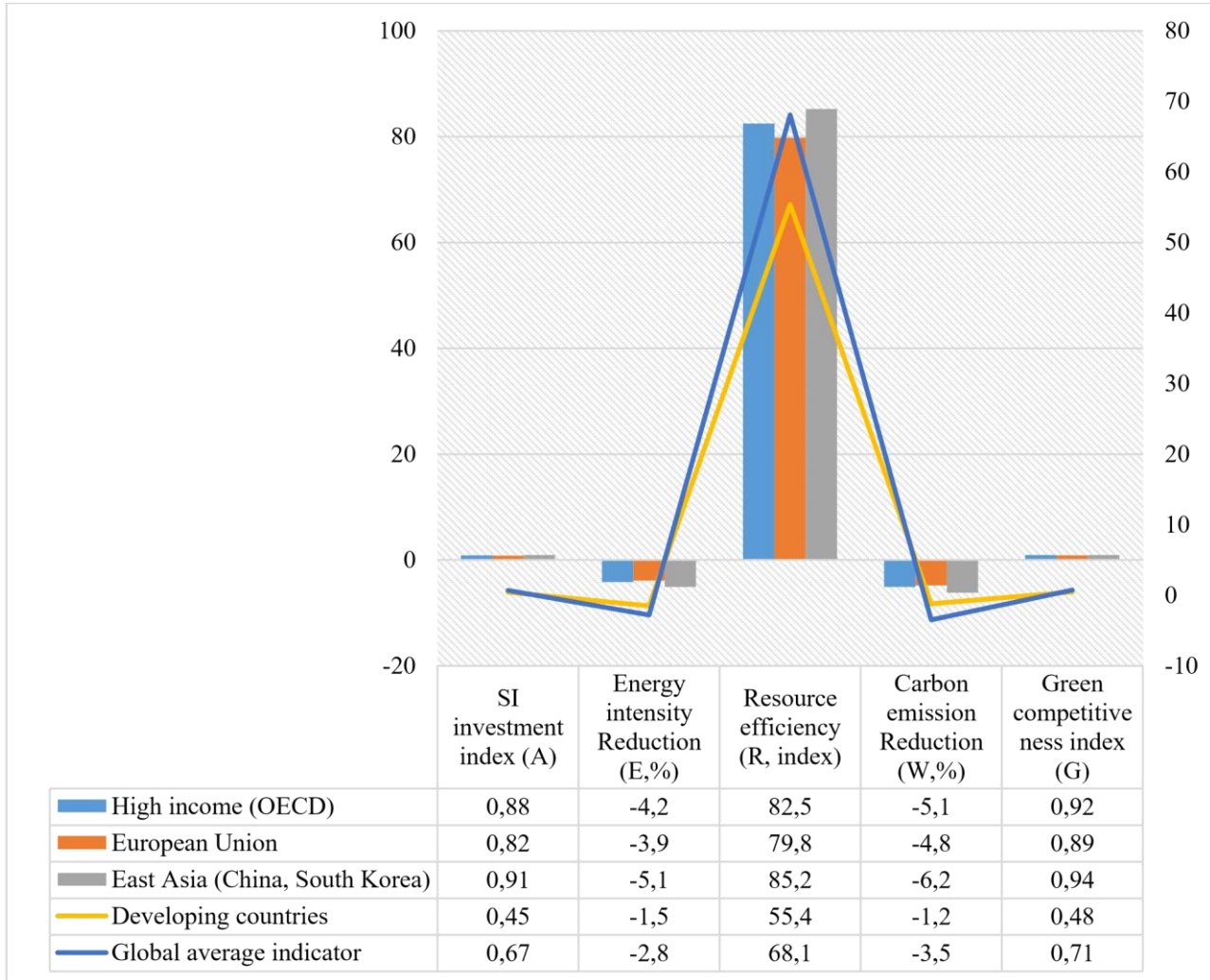
Region / Country group	SI investment index (A)	Energy intensity Reduction (E,%)	Resource efficiency (R, index)	Carbon emission Reduction (W,%)	Green competitiveness index (G)
High income (OECD)	0.88	-4.2	82.5	-5.1	0.92
European Union	0.82	-3.9	79.8	-4.8	0.89
East Asia (China, South Korea)	0.91	-5.1	85.2	-6.2	0.94
Developing countries	0.45	-1.5	55.4	-1.2	0.48
Global average indicator	0.67	-2.8	68.1	-3.5	0.71

Source. Compiled by the author based on IEA, 2023; OECD, 2025; World Bank, 2025.

The presented statistical table reflects the complex interaction between the application of artificial intelligence (AI) in industry and green economic growth indicators with quantitative indicators. This table forms the empirical basis of the proposed mathematical model and demonstrates the trends between the variables necessary for econometric analysis. Analysis of the table shows that in regions where the AI investment index (A) is the highest (East Asia and OECD countries), the reduction of energy intensity and green competitiveness indicators are also proportionally high. The column "AI Investment Index" in the table directly represents the variable A in the model. The data prove that in technologically advanced regions, the integration of AI into production processes plays a decisive role in increasing resource efficiency. For example, in the East Asian region, the AI index of 0.91 resulted in a 5.1% decrease in energy intensity. This is the reflection in the real economy of the equation $E = E_0(1 - bA)$ in the model; i.e., as AI implementation increases, energy consumption (E) and waste volume (W) decrease. The "Green Competitiveness Index" (G) column represents the final result of the model. The fact that this indicator is 0.92 in high-income countries indicates that enterprises have become more competitive in the global market due to resource efficiency and emission reduction. From an econometric point of view, this table confirms the positive marginal effect of AI investments, which are the independent variable, on green competitiveness, which is the dependent variable. The lower indicators in developing countries (0.45 AI index and 0.48 green competitiveness) indicate that the technological gap directly affects environmental and economic efficiency. This difference strengthens the argument in the study that AI is not just a technical innovation, but also a key driver of sustainable development (D). The table is an important scientific basis that quantifies the transformation potential of AI implementation through resource consumption reduction (1-dA and 1-cA effects).

Chart 2

Dynamics of AI implementation, energy efficiency and green competitiveness indicators in industrial enterprises (2021-2025)



Source. Compiled by the author.

In conclusion, the obtained results demonstrate the high effectiveness of industrial mechanisms supported by artificial intelligence in the context of sustainable development. They not only reduce environmental impacts but also increase economic efficiency, improve social conditions, and stimulate innovation. Thus, artificial intelligence is becoming a key factor in shaping the environmentally oriented and competitive economy of the future.

Conclusion

The impact of industrial mechanisms equipped with artificial intelligence on the competitiveness and sustainability of the environment is assessed as a multifaceted and strategically important process. The conducted analyses show that the application of these technologies is not limited to increasing production efficiency, but also makes a significant contribution to reducing the environmental burden by ensuring more rational use of resources. In particular, as a result of optimizing energy consumption, reducing waste and automating production processes, enterprises have the opportunity to build a more sustainable business model from both an economic and ecological perspective. The research scientifically substantiates that the integration of artificial intelligence technologies into industrial mechanisms is not only a technological innovation, but also a decisive strategic factor in

ensuring green competition and sustainable development. The results of the study show that the application of artificial intelligence to production processes accelerates the transition from traditional economic growth models to a new paradigm based on environmental responsibility. Our study proves that the application of artificial intelligence eliminates the contradiction between economic efficiency and environmental sustainability.

The economic-mathematical model developed and tested by us shows that as the intensity of the application of artificial intelligence increases, resource consumption and waste decrease exponentially, which directly increases the green competitiveness of enterprises. Artificial intelligence is not only a current optimization tool, but also a strategic management mechanism that allows enterprises to adapt in uncertain market conditions and in an environment of tightening environmental regulations. At the same time, the application of this technology increases transparency and accountability in the production chain, strengthens the atmosphere of trust between investors and society, thereby strengthening the socio-institutional foundations of sustainable development. Based on these scientific results, green digitalization strategies should be developed at the state level to promote the application of artificial intelligence in industrial enterprises, and tax breaks and green credit mechanisms should be applied for companies investing in these technologies. In order to eliminate the technological and skill gaps arising from the application of artificial intelligence, the integration of digital and environmental competencies in the education system and vocational training programs should be prioritized. In particular, digital platforms should be created within the framework of public-private partnerships to provide small and medium-sized enterprises with access to these technologies. In addition, it is necessary to formulate uniform international standards to objectively measure the environmental consequences of artificial intelligence applications, and enterprises should make the environmental impact they achieve through artificial intelligence an integral part of their reporting. Consequently, the application of artificial intelligence in industry is the main catalyst for the green transition process of the global economic system, and the effective use of this technology will raise the competitive environment of the future economic system to a completely new level of quality based on environmental responsibility.

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