Governance of Artificial Intelligence Technologies and Systems in the EU and Ukraine: Legal Foundations and Institutional Mechanisms

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Abstract

The rapid advancement of artificial intelligence (AI) is transforming economic, managerial, and legal systems, creating new opportunities and risks for sustainable development and social equity. Within global digitalisation and Ukraine's integration into the European legal and technological framework, the study of AI development management becomes a key element of national digital transformation. The topic holds significant scholarly and practical importance as it bridges law, economics, management, and sustainability. The aim of this study is to identify and systematise the legal and institutional mechanisms governing AI development in the European Union and Ukraine, and to assess their alignment with the global sustainable development agenda, based on three hypotheses: (1) the interdisciplinary nature of AI and law; (2) the integration of the UN Sustainable Development Goals into the EU AI Act (Regulation (EU) 2024/1689); and (3) the normative and institutional convergence between Ukraine and the European Union. The methodology applies a triangulated approach combining bibliometric analysis (PRISMA protocol), formal content analysis, and SWOT analysis, ensuring a comprehensive evaluation of legal and managerial aspects of AI governance. The findings show that the EU model balances innovation and accountability through ESG principles, digital ethics, and human-centred governance. Ukraine demonstrates growing alignment with EU law via strategic documents, enhanced digital governance, and participation in international harmonisation programmes. The theoretical contribution lies in conceptualising AI development management as part of a sustainable digital regulation model, reflecting the evolving roles of the state, academia, and business in responsible technology governance. The practical implications include recommendations for developing a national strategy for AI regulation and management, drafting AI legislation harmonised with the EU AI Act, and improving digital governance in the public sector.

Key words

artificial intelligence, AI development management, legal regulation, AI Act, European Union, Ukraine, sustainable development, digital governance, ESG principles, institutional convergence.

Cite as:

Kwilinski, A., & Reznik, O. (2025). Governance of Artificial Intelligence Technologies and Systems in the EU and Ukraine: Legal Foundations and Institutional Mechanisms. *Forum Scientiae Oeconomia, 13*(3), 8–52. https://doi.org/10.23762/FSO_VOL13_NO3_1

Received: 17 January 2025

Revised: 15 June 2025

Accepted: 28 August 2025

Introduction

The first conceptual foundations of artificial intelligence (AI) were established in the mid-twentieth century. A pivotal contribution came from Norbert Wiener (1948), whose work in cybernetics explored the mechanisms of control and communication in living organisms and technical systems. An equally significant milestone was A. M. Turing's (1950) publication proposing the so-called Turing Test as a method for assessing a machine's ability to exhibit intelligent behaviour. The term "artificial intelligence" was formally introduced by John McCarthy during the renowned Dartmouth Conference in 1956 (McCarthy et al., 1955), which is widely regarded as the point of origin of AI as an independent scientific discipline.

From its inception, AI was viewed not merely as a technological innovation but also as a phenomenon requiring institutional and legal governance. The management of AI development, its regulatory foundations, and its institutional design have therefore become integral components of discussions concerning the future trajectory of intelligent systems. The growing academic and policy interest in AI regulation and governance displays exponential dynamics, as evidenced by bibliometric data from leading international databases.

Contemporary scholarship conceptualises AI as a multidisciplinary phenomenon that integrates technical, economic, managerial, legal, ethical, and social dimensions, while also encompassing philosophical and cultural aspects. The present study adopts this interdisciplinary perspective, focusing on the European Union and Ukraine in the context of their European integration. This focus enables the identification of the institutional and legal specificities of AI development management in the process of convergence with the European Union's regulatory framework.

The relevance of this analysis is further reinforced by the wartime context. Since 2014, Ukraine has faced a military conflict triggered by Russian aggression, escalating into a full-scale invasion in 2022. Although such circumstances are profoundly destructive, they have historically acted as catalysts for accelerated scientific and technological advancement and as bifurcation points for systemic transformation. For instance, the First World War spurred developments in aviation, radio communications, and chemical production, while the Second World War stimulated the emergence of the first electronic computing machines (ENIAC, Colossus), nuclear energy, radar systems, and jet propulsion technologies.

The impact of wars and crises on the dynamics of scientific and technological development has been consistently examined by numerous scholars. Kondratiev (1925), within the framework of his long-wave theory, argued that wars and social upheavals act as triggers for transitions to new technological paradigms. Later, de Solla Price (1951), applying quantitative methods, demonstrated the dual effect of armed conflicts: they simultaneously stimulate the emergence of new research directions while inflicting significant losses. Mumford (1970), in developing the philosophy of technology, viewed war as a formative source of the "megamachine"– complex technological and organisational systems. In turn, Glaz'ev (1993), adapting Kondratiev's ideas to modern conditions, showed that military conflicts and global crises accelerate the diffusion of innovations and the shift of technological paradigms.

At the same time, the literature emphasises the reverse relationship: scientific and technological progress itself can radically transform the nature and methods of warfare. As early as the mid-twentieth century, Hamilton and Strausz-Hupé (1952) noted that the character of contemporary wars is largely determined by emerging technological capabilities. In subsequent decades, this topic received further attention. V. Nikitenko (2024) examines the philosophical foundations of how military actions shape social processes and technological development; Chkhikvishvili and Beridze (2024) analyse the role of technological factors in the dynamics of international conflicts; and Hasanov et al. (2024) forecast transformations in military practices under the influence of artificial intelligence, biotechnology, and nanotechnology.

Military conflicts – including those in Ukraine – although occasionally stimulating certain domains of scientific and technological advancement, are frequently accompanied by significant

constraints in academic and applied research. First, during active hostilities, a considerable number of developments become classified or confidential, limiting open knowledge exchange and access to primary data. Second, the destruction of research infrastructure, the forced migration of scientific personnel, the reallocation of public funds towards the military-industrial complex, and the suspension of civilian projects all contribute to the fragmentation of the scientific landscape. Third, heightened national security concerns and stricter secrecy regimes often restrict the dissemination of results that would otherwise be publicly available in peacetime. Collectively, these factors create asymmetries in scientific communication and hinder international cooperation – particularly in high-tech fields such as artificial intelligence – while also contributing to distortions in the information circulating within open academic and expert communities.

At the current stage, the legal regulation of artificial intelligence within the European Union is primarily based on Regulation (EU) 2024/1689 of the European Parliament and of the Council of 13 June 2024 laying down harmonised rules on artificial intelligence (Artificial Intelligence Act) (European Union, 2024). This document, representing the first comprehensive attempt to institutionalise AI governance in the EU, aims to establish a normative framework that ensures safety, transparency, and the protection of fundamental rights in the design and deployment of AI systems. In this context, the strategic guiding principle for AI development – both within the European Union and in Ukraine – is the concept of sustainable development, enshrined in the United Nations Sustainable Development Goals (SDGs).

Given the transformative potential of AI across diverse domains – including the economy, environment, healthcare, education, governance, and social policy – the governance of AI requires a systemic and holistic approach aimed at achieving all 17 Sustainable Development Goals (SDGs) without exception. Each of these goals is affected by AI either as an instrument of implementation or as a source of emerging challenges and risks. In this sense, AI development cannot be viewed in isolation from the broader global agenda, in which justice, inclusiveness, accountability, and long-term sustainability serve as defining parameters. Thus, effective AI development management entails not only regulatory and institutional support but also the deep integration of sustainability principles into strategic and operational decision-making processes.

The mathematical foundations underlying the functioning of AI systems began to take shape in the 1940s and 1950s, with the emergence of early concepts in algorithm theory, information theory, and artificial neural networks. However, it was during the 1960s–1980s that these ideas underwent systematic development. This period saw the establishment of key directions such as machine learning algorithms, optimisation methods, probabilistic models, and computational mathematics. The limited computational power available at the time significantly constrained the practical realisation of these concepts, resulting in their gradual implementation. Even today, the performance of traditional supercomputers is approaching its efficiency limits, prompting the scientific community to explore fundamentally new paradigms. Among these, the quantum computing model, based on the principles of quantum superposition and entanglement, occupies a particularly prominent place.

In contemporary conditions, artificial intelligence has moved far beyond specialised problem-solving and has become an integral component of digital infrastructure, embedded within the socio-economic fabric of modern society. With the proliferation of the internet and digital technologies, AI systems now permeate almost every sphere of human activity – from communication and medicine to transport, finance, education, and public administration. Their influence manifests both directly – – through intelligent services and decision-making algorithms – and indirectly, through smart devices, automated processes, and adaptive control systems capable of responding to user behaviour and preferences. This pervasive integration of AI gives rise to a new ontology of human–technology interaction, in which AI not only performs instrumental functions but also exerts an influence on human development, value formation, and social structures. Consequently, AI is emerging as an active agent in shaping human behaviour and development rather than merely serving as an auxiliary

tool. This evolution necessitates a reconceptualisation of AI's role from both technical and normative–ethical perspectives, emphasising responsibility, transparency, and accountability.

It is important to note that the present study does not claim to provide an exhaustive resolution of the complex issues addressed. Its purpose is to offer an analytical overview and systematisation of the material, positioning this work as an intermediate academic stage that lays the groundwork for further inquiry. The findings can serve as a foundation for both scholarly debate and practical applications, particularly in advancing AI technologies and developing the legal and institutional mechanisms required for their effective and ethical regulation.

This study follows a clearly structured framework consistent with contemporary academic standards. The Introduction establishes the relevance of the topic, outlines the research context, and defines the study's objectives. The Literature Review analyses key academic sources addressing the legal, institutional, and ethical dimensions of artificial intelligence regulation in the European Union and Ukraine. Based on the identified research gaps, the purpose and hypotheses of the study are formulated. The Methodology section presents a combined research framework incorporating bibliometric analysis (according to the PRISMA protocol), formal content analysis of the AI Act in the context of the United Nations Sustainable Development Goals, and a SWOT analysis of Ukraine's legal and institutional framework. The Results section provides empirical evidence and analytical findings confirming the interdisciplinary nature of AI and law research, the normative integration of the Sustainable Development Goals into the structure of the AI Act, and the institutional convergence of Ukraine with the European Union's legal system. The Discussion interprets these results within the broader context of sustainable digital governance, ESG principles, and ongoing processes of legal convergence. Conclusions section summarises the main findings, highlights the theoretical and practical implications, and outlines promising directions for further research in the field of regulation and management of artificial intelligence technologies.

1. Literature review

The rapid advancement of AI technologies has generated a significant surge of interest within the academic community across multiple disciplinary domains – from computer science and law to philosophy, ethics, and public administration. Particular attention is devoted to the development and implementation of both individual AI technologies and complex AI systems, as well as to the formation of effective mechanisms for managing their development.

Given AI's transformative potential, especially in the context of the digital transformation of public administration and international integration, there is an increasing need to systematise existing academic approaches and critically assess the current state of scholarly research. Within this framework, special emphasis is placed on the legal foundations of AI regulation, the institutional mechanisms governing its development, and the distinctive features of their formation under conditions of European integration.

This literature review therefore examines the conceptual underpinnings of artificial intelligence, analyses key academic publications concerning the legal and institutional dimensions of AI governance in the European Union and Ukraine, and identifies major research gaps. The section concludes with the articulation of the study's objective and the formulation of its guiding hypotheses.

1.1 Artificial Intelligence Through the Lens of Scientific Disciplines

Modern AI technologies have penetrated virtually every sphere of human activity, exerting both direct and indirect influence – through digital services, infrastructural solutions, and automated processes. Their rapid proliferation is largely driven by the exponential pace of technological progress, manifested through digitalisation, informatization, robotisation, and automation – all aimed at optimising production, managerial, and social processes. Under these conditions, AI functions not merely as a tool for enhancing efficiency in specific sectors, but as a catalyst for the profound transformation of social and institutional structures.

A key role in the development and large-scale deployment of AI technologies and systems is played by major transnational corporations – Google, Amazon, Apple, Meta, and Microsoft – as well as by next-generation research and technology companies such as OpenAI, Anthropic, XAI, Cohere, and Hugging Face. Their activities not only define the architecture of the global AI market and set the standards for its application but also exert a direct impact on the sphere of governance, contributing to the formation of institutional mechanisms and legal-regulatory approaches to AI oversight. In the Asian market, an analogous role is performed by leading Chinese corporations – DeepSeek, Baidu, Alibaba, SenseTime, Moonshot AI, and Baichuan AI – which are actively developing proprietary large language models and applied AI solutions comparable in sophistication to their Western counterparts. This dynamic further underscores the growing relevance of regulation and control over the development and use of AI technologies.

The contemporary AI industry demonstrates not only a high rate of technological advancement but also increasing concern regarding the governance of its development. Within academic and policy discourse, issues of developer accountability, algorithmic transparency, protection of human rights and freedoms, and adherence to ethical principles in AI design and deployment are being articulated with growing clarity. As the quantitative growth of research output and applied innovations enters an exponential phase, the interaction between human and artificial intelligence is becoming increasingly institutionalised – encompassing regulatory mechanisms at both national and international levels.

Under these conditions, the formation of an optimal model for artificial intelligence (AI) development acquires particular significance. Such a model must be aligned with the strategy of sustainable development and integrated into the implementation of the United Nations Sustainable Development Goals (SDGs). This approach enables the maintenance of a balanced relationship between technological innovation, legal regulation, and social responsibility, while ensuring the long-term sustainability and equity of digital transformation processes.

An analysis of publication activity on the topic of "artificial intelligence," based on data indexed in the Scopus database, revealed a total of 4,728,583 documents. The leading positions are held by China (1,109,339 publications) and the United States (881,005 publications). However, when the European Union is considered as a single research entity, it ranks first, with a cumulative total of 1,531,064 publications. Collectively, the EU, China, and the United States account for more than half of all publications, underscoring their dominant role in the global research landscape on artificial intelligence. When EU member states are considered individually, eleven of them rank among the top thirty countries by publication volume: Germany, France, Italy, Spain, the Netherlands, Poland, Austria, Sweden, Greece, Portugal, and Belgium (Figure 1). The search criteria and filters applied in this bibliometric query are detailed in *Appendix A*.

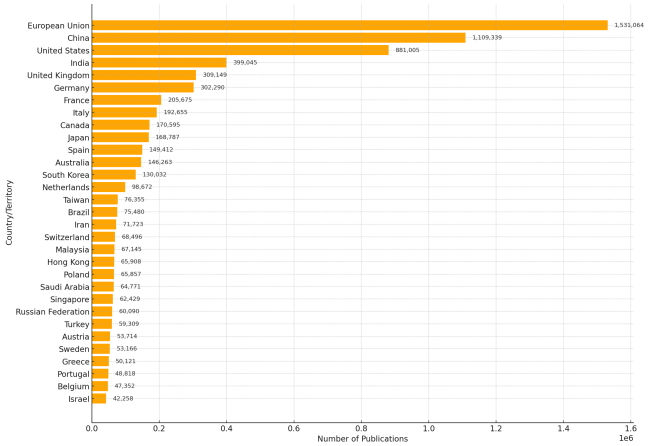


Figure 1. Distribution of publications on artificial intelligence by country/territory (top 30) and the European Union.

Source*:* Scopus database, authors' own compilation (Appendix A).

Ukraine ranks 53rd globally in terms of the number of publications, with 14,563 articles – a figure that surpasses several EU member states. In particular, Ukraine exceeds Slovakia (57th – 10,572), Slovenia (58th – 10,273), Croatia (63rd – 7,737), Bulgaria (64th – 7,703), Cyprus (66th – 7,110), Luxembourg (67th – 7,082), Estonia (70th – 6,221), Lithuania (72nd – 5,548), Latvia (78th – 3,326), and Malta (89th – 1,876). However, it is important to note that country-level indicators are based on author affiliations, which may exceed the total number of published papers. The aggregate number of affiliations equals 6,150,587, approximately 30% higher than the total number of articles. This discrepancy arises because many publications have multiple co-authors associated with different institutions and countries, meaning that a single article is counted multiple times across national statistics.

The publication dynamics exhibit an exponential growth pattern, which can be approximated using an exponential function. To construct the model, empirical data on the number of AI-related publications for the period 1961–2025 were extracted from the Scopus database according to the applied filters described in Appendix A. The approximation was performed using the least squares method, allowing for the selection of function parameters that best fit the observed values. As a result, the following functional relationship was obtained:

$$y = 3.43 \cdot 10^2 \cdot e^{0.1123 \cdot (x-1960)} - 948.10 \quad (1)$$

where y – number of publications on artificial intelligence in year x; $3.43 \cdot 10^2$ – scaling constant of the model, defining the initial level of exponential growth; 0.1123 – growth rate coefficient, reflecting the intensity of increase in the number of publications over time; (x - 1960) – time shift parameter, which sets 1960 as the reference point for exponential growth; e – exponential function; -948.10 – adjustment constant of the model, compensating for historical deviations in the data.

The visualisation of the empirical data and the results of the approximation is presented in Figure 2.

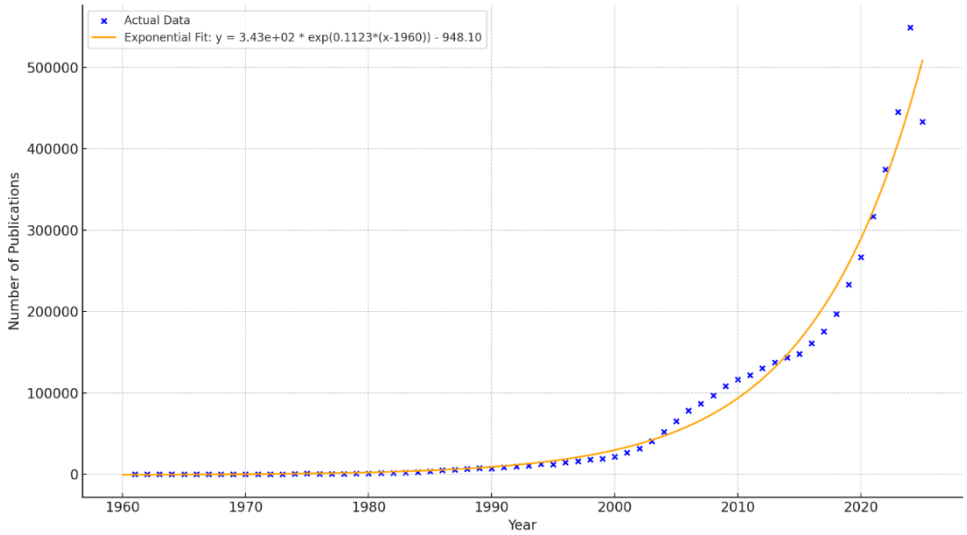


Figure 2. Exponential growth of publications on artificial intelligence (1961–2025) based on Scopus data (2025).
Source: Scopus database, authors' own calculations (Appendix A).

The interpretation of the obtained model indicates that research on artificial intelligence (AI) has entered a phase of accelerated growth, characteristic of exponential processes. This trend is reinforced by the fact that the most highly cited publications in the field of AI are associated with fundamental methodological breakthroughs: ensemble learning algorithms (Breiman, 2001), the development of deep convolutional neural networks (Krizhevsky et al., 2012), the long short-term memory architecture (Hochreiter & Schmidhuber, 1997), specialised networks for image segmentation (Ronneberger et al., 2015), and the systematisation of the deep learning paradigm (LeCun et al., 2015).

These studies have defined the trajectory of modern AI technologies and shaped the research agenda of the past decades.

The widespread dissemination of AI-related publications is confirmed not only by the overall volume of works but also by the diversity of disciplinary domains in which artificial intelligence is developing. According to Scopus, the number of articles attributed to various fields of knowledge substantially exceeds the total number of unique publications, reflecting their interdisciplinary classification and simultaneous attribution to multiple subject areas. The highest concentration of research is observed in computer science (3,262,772 publications), engineering (1,547,710), mathematics (1,321,581), social sciences (382,569), physics and astronomy (321,753), and medicine (321,160). Significant contributions are also made by applied disciplines, including business management, materials science, biotechnology, energy, environmental studies, and the humanities.

Thus, artificial intelligence has evolved into a genuinely interdisciplinary field, integrating fundamental theoretical research with a wide range of practical applications. At the same time, increasing attention within academic discourse is devoted not only to technical and applied dimensions but also to the management of AI development, encompassing institutional mechanisms and legal regulation. The legal dimension, in this regard, becomes an essential precondition for ensuring the sustainable and responsible development of AI, which, in turn, reinforces its exponential growth and defines the long-term trajectory of its integration into social and economic systems.

1.2 Legal Foundations of AI Development Governance in the European Union

For the preliminary analysis, a bibliometric search was conducted in the Scopus database to identify publications related to artificial intelligence and its legal regulation. The resulting dataset (see Appendix B) comprised 67,583 documents, covering a wide range of topics – from legislative frameworks and ethics to governance issues and human rights protection.

To focus specifically on the European Union and Ukraine within the context of European integration processes, a refined search query was developed, incorporating relevant legal categories and geographical indicators (Appendix C). This approach made it possible to identify both the scale and dynamics of research devoted to the legal aspects of managing the development of artificial intelligence technologies in these regions.

The purpose of the publication selection was to identify the scale and dynamics of research devoted to the legal regulation of artificial intelligence in the European Union and Ukraine within the framework of European integration processes. The resulting data enabled the construction of a timeline of publication activity for the period 1986–2024, clearly demonstrating the exponential growth of academic interest in this field (Figure 3).

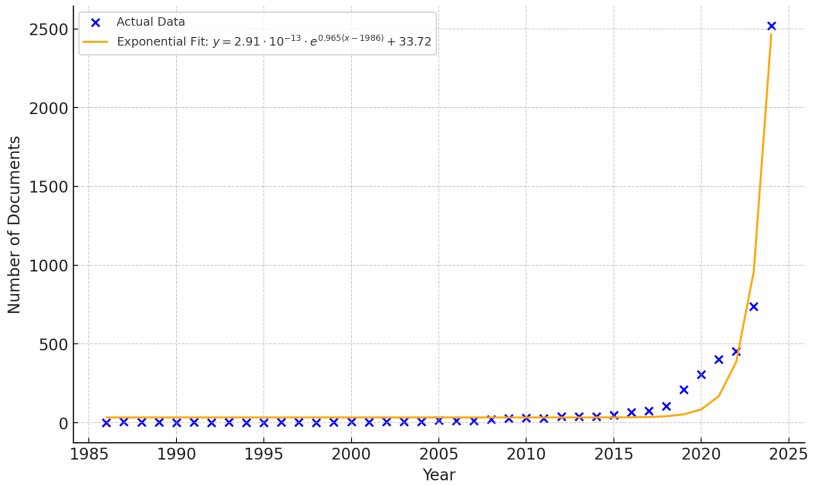


Figure 3. Exponential growth of publications on artificial intelligence and legal regulation in the European Union and Ukraine (1986–2024).

Source: Scopus database, authors' own calculations (Appendix C).

Using the least squares method, an exponential model was developed, with parameters ensuring the closest possible fit to the actual publication statistics. As a result, the following functional relationship was obtained:

$$y = 2.91 \cdot 10^{-13} \cdot e^{0.965(x-1986)} + 33.72 \quad (2)$$

where y represents the number of publications in year x; 2.91×10^{-13} is the scale coefficient of the model, defining the initial publication level; 0.965 is the growth rate coefficient, reflecting the intensity of publication increase; $(x - 1986)$ denotes the time shift, setting 1986 as the reference point; e represents the exponential function, describing the nonlinear nature of the growth process; and 33.72 is the correction constant, compensating for statistical deviations within the dataset.

Among the European Union member states demonstrating the highest levels of publication activity in the field of artificial intelligence, the top three leaders are Italy, Germany, and Spain. It is particularly noteworthy that following the adoption of Regulation (EU) 2024/1689 of the European Parliament and of the Council of 13 June 2024, which establishes harmonised rules on artificial intelligence (Artificial Intelligence Act) (European Union, 2024), Italy became the first EU country to enact its own national law governing AI. This refers to "Disposizioni e deleghe al Governo in materia di intelligenza artificiale" (Atto Senato n. 1146, XIX Legislatura), approved by the Senate of the Republic on 20 March 2025 (Senato della Repubblica, 2025). In many other EU states, similar legislative initiatives are currently under development, public consultation, or interministerial coordination, reflecting the overall trend toward the unification of AI regulation in line with pan-European standards.

It should be noted that, despite the 5,240 identified publications, the total number of country affiliations amounts to 7,958, due to the methodological specifics of the Scopus database (Appendix C). As previously mentioned, the same article may be counted for multiple countries because of multi-affiliated authors representing different research institutions and nations. While this leads to a numerical overestimation, it accurately reflects the international cooperation and networked nature of contemporary AI research.

The analysed publications exhibit a distinctly interdisciplinary profile, confirming the broad range of fields addressing the issues of artificial intelligence and its legal regulation. The most active areas include social sciences, computer science, medicine, and engineering, highlighting the dual importance of humanitarian and technological dimensions. Significant contributions also arise from economics and finance, business and management, mathematics, environmental sciences, and decision sciences. Humanities disciplines play an important role, while applied research encompasses energy, biotechnology, healthcare, psychology, and related domains.

Such an interdisciplinary character underscores the complex nature of AI and the need for integration across diverse domains of knowledge to build an effective system for managing and regulating AI development. For greater clarity, the distribution of publications by subject area is illustrated in Figure 4.

Among the most cited publications addressing the legal regulation of artificial intelligence (AI) in the European Union, several key research directions can be identified, forming the foundation of the current academic discourse. These studies reflect not only normative and ethical principles, but also institutional approaches to AI governance, including administrative and legal mechanisms that ensure transparency and accountability of algorithmic systems.

The academic community's primary focus lies in the medical, ethical–legal, and administrative aspects of AI implementation. For instance, He et al. (2019) highlight practical challenges of integrating AI into clinical workflows, emphasising the importance of legal regulation concerning data exchange, privacy, and algorithmic standardisation. Similarly, Gerke et al. (2020) provide a systematic overview of ethical and legal challenges in AI-driven healthcare, including issues of liability, cybersecurity, and personal data protection. Both studies illustrate that the use of AI in

socially sensitive domains is impossible without robust administrative–legal instruments that guarantee oversight, control, and balance between the interests of society, the state, and developers.

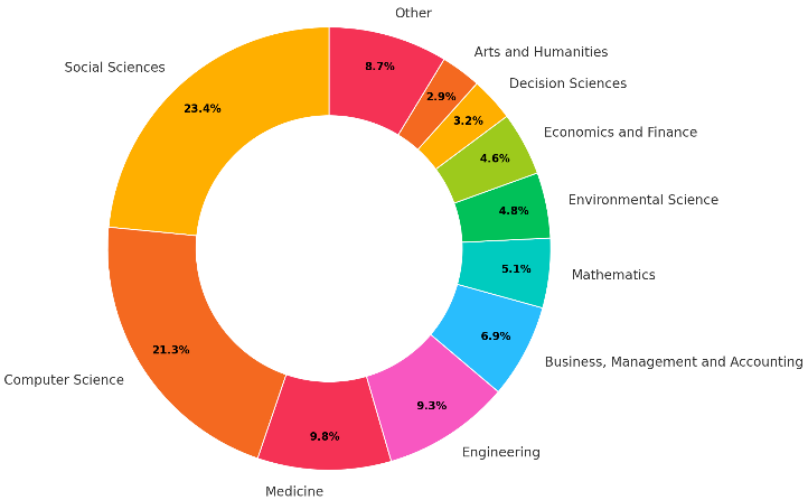


Figure 4. Distribution of publications on artificial intelligence and legal regulation by subject area.
Source: Scopus database, authors' own calculations (Appendix C).

Another crucial research area concerns legal responses to cross-border data exchange and compliance with personal data protection laws. The work of Yang et al. (2020) on federated learning demonstrates that GDPR regulations act as a catalyst for developing decentralised machine learning models, enabling compliance with data protection requirements. In this context, law functions not merely as a regulatory constraint but as a driver of technological innovation, shaping the trajectory of AI's institutionalisation.

Significant attention is also devoted to the political and legal foundations of AI regulation. In their comparative analysis, Cath et al. (2018) examine the strategies of the US, EU, and UK, concluding that despite the EU's institutional activity, it lacks a coherent long-term strategy for AI governance. This underscores the need for a unified administrative–legal framework to ensure policy consistency across the Union.

An additional dimension of the discourse focuses on the regulation of AI-based medical devices. The comparative study by Muehlematter et al. (2021) shows that Europe applies a more flexible but less stringent regulatory model than the US. While this approach facilitates faster innovation adoption, it simultaneously raises risks concerning the quality and safety of medical technologies, highlighting the necessity for legal framework refinement.

A separate research line addresses algorithmic governance in the public sector. The study by Kuziemski and Misuraca (2020) reveals that the use of algorithmic systems in public administration (based on the cases of Canada, Poland, and Finland) can reinforce power asymmetries and create new challenges for democratic institutions. This underlines the need to implement administrative control and oversight mechanisms that could balance the interests of governments, citizens, and technology developers.

Overall, the analysis of the literature on AI governance in the European Union demonstrates that the scholarly debate evolves across multiple domains–from medical and biotechnological applications to data protection and administrative regulation in the public sector. However, existing research remains fragmented, addressing isolated aspects without offering a comprehensive understanding of the interrelations between legal, institutional, and policy dimensions. The lack of systematisation and comparative analysis reveals a significant research gap, which hinders the development of an integrated model of AI regulation aligned with EU-wide priorities and European integration processes.

The AI Act (European Union, 2024) represents the outcome of an institutional consensus on the governance of artificial intelligence (AI) technologies and systems, standing out among the European Union's legal acts for its complex structure and high level of technical detail. Unlike traditional regulations or directives, it operates with technical classifications, risk levels, and certification procedures, making it comparable not to a conventional legal text, but rather to a normative–technical standard. Its interpretation therefore requires not only legal expertise, but also technological literacy, which significantly limits the document's accessibility for a broader audience.

However, the question of how well the provisions of the AI Act align with the Sustainable Development Goals (SDGs) remains open. To test this hypothesis, an extended search was conducted in the Scopus database, using keywords related to the regulation itself, its relationship with the SDGs, and its broader legal–institutional context (Appendix D). The search revealed only a limited number of publications, confirming that this area remains underexplored. The available works focus on specific aspects: the adaptation of the European model in other countries (Yap, 2025); the role of the AI Act in shaping SDG-compatible legal frameworks (Tjokro et al., 2025); comparative studies of regional AI strategies (Tun et al., 2025); and the assessment of AI risks and governance methods (Constantinides et al., 2024; Tjoa et al., 2022).

Meanwhile, studies addressing the relationship between high technology and sustainable development–particularly in the context of AI and digital transformation–highlight a growing interconnection between innovation, sustainability governance, and green economic growth. For instance, research has explored the formation of a culture of sustainable management as the foundation of green economic development (Kwilinski et al., 2025a), the role of digital literacy and ICT competencies in migration processes and human capital development (Kwilinski et al., 2025b), as well as the significance of innovation as a driver of the green economy (Kwiliński et al., 2025c) and the expansion of green financial instruments (Kwilinski et al., 2025d, 2025e).

This discourse is further complemented by empirical studies on public perceptions of AI and its socio-cultural dimensions (Lyulyov et al., 2024), alongside research into institutional and cultural factors influencing green innovation development in various countries (Thirakulwanich et al., 2025). At the intercultural level, special emphasis is placed on educational and value-based aspects of sustainability, as reflected in studies on cross-cultural communication and ethnic diversity in educational environments (Ciuladiene & Walancik, 2022; Ciuladiene et al., 2021), as well as in the monograph on multicultural education strategies (Walancik, 2024).

A separate group of works focuses on strategic management and regional models of sustainable development, identifying the role of cross-border and intercultural cooperation in achieving the SDGs (Dacko-Pikiewicz, 2019). At the macro level, attention is given to the interdependence between digitalisation, energy efficiency, and innovation as key drivers of green growth (Dzwigol et al., 2023, 2024), and to the development of environmental security indicators and risk assessment methodologies employing AI (Kharazishvili & Kwilinski, 2022; Kharazishvili et al., 2025).

An important direction of analysis concerns digital transformation as a key driver of sustainable development (Kwilinski, 2023). It manifests not only in economic efficiency gains, but also in its significant contribution to environmental goals, such as reducing CO_2 emissions (Kwilinski, 2024) and strengthening technological leadership through the relationship between GDP growth and foreign direct investment inflows (Kwilinski, 2025). A number of studies demonstrate that digitalisation is closely linked to the formation of digital governance systems and business models (Kwilinski et al., 2023a), while also enhancing the energy efficiency of EU economies (Kwilinski et al., 2023b).

The continued evolution of this research trend indicates that artificial intelligence is emerging not merely as a technological instrument, but as a core element of the institutional architecture of sustainable development. Analyses of AI's role in sustainable transformation management within the EU (Kwilinski et al., 2024a) and its influence on entrepreneurial transformation in the green economy (Kwilinski et al., 2024b) suggest that technological innovation has become an integral part of ESG

mechanisms, ensuring balanced and responsible growth. These studies reveal the institutional interplay between digital technologies, innovative financial tools, and the SDGs, directly aligning with the normative objectives of the AI Act (European Union, 2024).

At the same time, the cultural and value-based dimension of sustainability is gaining increasing attention in scholarly literature. Recent works emphasise the role of digital culture in advancing the SDGs and shaping the global sustainability agenda (Kwiliński et al., 2024c). Here, digitalisation is conceptualised not only as a technological process, but as a sociocultural phenomenon that integrates sustainability principles into the humanitarian and ethical domains, enriching their normative foundations.

In conclusion, the analysis of existing publications demonstrates that, despite a growing number of studies examining the intersection of the AI Act and the SDGs, a comprehensive approach to evaluating their alignment and institutional coherence is still lacking. This research gap largely stems from the interdisciplinary nature of the regulation itself and the multi-level structure of the SDGs. Therefore, further research is required to develop a systemic understanding of the AI Act's contribution to the implementation of the EU's sustainable development agenda and the global green transition.

1.3 Legal Aspects of AI Development Governance in Ukraine

For the analysis of the legal aspects of AI regulation in Ukraine, a bibliographic search was conducted using the Scopus database and an expanded search strategy that included keywords related to artificial intelligence, legal and institutional frameworks, and a geographical filter for Ukraine. The full search query is presented in Appendix E. The initial search, limited to titles, abstracts, and keywords, identified 262 documents, confirming a growing academic interest in the regulation of AI within the Ukrainian context. For comparison, under equivalent search parameters, the number of publications in the broader European context reaches several thousand, indicating a much higher level of academic activity within EU countries. Hence, while Ukraine's research output remains relatively modest, it demonstrates a clear upward trend, driven by European integration processes and the need to align national legislation with EU regulatory frameworks.

However, this broad dataset proved excessive for the purposes of this study, as a significant proportion of publications addressed AI regulation only indirectly. Therefore, the search was refined to include only titles containing relevant keywords (Appendix F), allowing a focus on the most pertinent works directly related to the intersection of AI and law in Ukraine. The refined selection yielded 12 publications, which formed the basis for further analysis.

The analysis of these publications reveals that the legal regulation and practical application of AI in Ukraine are characterised by a distinctly interdisciplinary approach. A substantial share of studies is concentrated in medicine and healthcare: for example, Osyodlo et al. (2025) discuss the development of an ethical code for AI use in military medical training; Putiienko et al. (2025) explore the teaching of ophthalmology during wartime; and Krasnoselskyi et al. (2025) address academic integrity and anti-plagiarism measures in medical research. Further studies examine data standardisation in healthcare systems (Kaduk et al., 2023), the application of AI in obstetrics (Zhylka et al., 2022), and precision diagnostic technologies in gastroenterology (Stepanov & Zyhalo, 2020).

Beyond healthcare, research attention extends to economics, management, energy, and agriculture. Kozlovskyi et al. (2025) investigate AI-based currency exchange forecasting, while Hudima & Kamyshanskyi (2023) analyse the digitalisation and legal regulation of foreign economic policy. Odrekhivskyy et al. (2022) examine intelligent systems for competency monitoring in innovation management. In the energy sector, emphasis is placed on interdisciplinary approaches to AI energy supply (Prazian, 2025) and the use of AI in nuclear energy (Golyonko et al., 2025), whereas in agriculture, studies focus on the integration of space technologies into agro-industrial production (Skydan et al., 2019). Collectively, these works span medicine, education, economics, energy, and agriculture, demonstrating the comprehensive and interdisciplinary nature of AI research in Ukraine.

Despite the thematic diversity, a unifying feature of Ukrainian publications is their focus on national challenges – including the consequences of war, the need for reconstruction, and adaptation to EU integration requirements. At the same time, most studies remain sector-specific, addressing individual legal or institutional aspects rather than offering a holistic understanding of AI governance mechanisms, in contrast to the systemic discourse characteristic of EU scholarship.

Thus, although the number of AI-related studies in Ukraine shows a positive growth trend, there remains a significant research gap in works comparing Ukrainian legal frameworks with European standards and exploring harmonisation prospects within the EU legal space. Bridging this gap requires a systemic approach that integrates both legal regulation and institutional governance mechanisms of AI development. A comprehensive comparative analysis of the Ukrainian and EU legal frameworks would make it possible to identify strengths, weaknesses, and priority areas for adaptation, ultimately supporting Ukraine's integration into the unified legal and regulatory architecture of the European Union.

1.4 Research Gaps, Objectives, and Hypotheses of the Present Study

The conducted literature review has revealed several significant research gaps. First, most studies addressing the legal regulation of artificial intelligence (AI) in the European Union and Ukraine are fragmentary in nature. They tend to focus either on individual sectors (such as healthcare, cybersecurity, or labour law) or on specific aspects of regulation (including ethics, data protection, or copyright), without progressing toward a systemic analysis of institutional and legal mechanisms. Second, the issue of comparing Ukraine's national legal frameworks with pan-European standards remains underexplored, which is particularly important in the context of the country's European integration. Third, although the AI Act (European Union, 2024) is a key normative document that directly affects such domains as healthcare, innovation, human rights protection, and institutional development, its connection to the United Nations Sustainable Development Goals (SDGs) has not yet been the subject of a comprehensive academic examination.

Against this background, the aim of this study is to identify and systematise the legal and institutional mechanisms governing the development of AI technologies and systems in the European Union and Ukraine, and to assess their alignment with the global sustainable development agenda, based on the verification of three hypotheses:

- the interdisciplinary nature of legal and AI research;
- the integration of the SDGs within the structure of the AI Act;
- the process of normative and institutional convergence between Ukraine and the EU.

To achieve this aim, the following working hypotheses are proposed:

Hypothesis 1: Research in the field of law and artificial intelligence constitutes a multifaceted interdisciplinary domain, encompassing areas such as data protection, medical law, labour relations, and public administration. It is assumed that this thematic and institutional diversity will be reflected in the distribution of academic publications, thereby confirming the comprehensive nature of AI regulation within the European context.

Hypothesis 2: The substantive provisions of the AI Act directly or indirectly incorporate the priorities of the Sustainable Development Goals, reflected in the alignment of regulatory objectives and instruments with ESG governance principles, digital inclusion, environmental efficiency, and ethical responsibility. It is expected that a detailed analysis of the Act's provisions will reveal a structural correlation between the European model of AI regulation and the global sustainable development agenda.

Hypothesis 3: The Ukrainian legal framework on artificial intelligence demonstrates a trend toward normative and institutional convergence with the EU legal system. This is presumed to manifest through the adaptation of national digital strategies, the harmonisation of legal norms, and the formation of regulatory institutions designed to ensure compatibility with pan-European standards and the principles of the AI Act.

2. Methodology

The study is based on a mixed methodological approach that integrates bibliometric, qualitative, and comparative legal analysis to test the three working hypotheses. The methodological framework combines the PRISMA protocol (PRISMA Guidelines, 2020) for the systematic selection of publications, bibliometric visualisation using VOSviewer (2025), formal content analysis of the Artificial Intelligence Act (AI Act) within the context of the Sustainable Development Goals (SDGs), and a SWOT analysis of Ukraine's legal and institutional framework for artificial intelligence. This multi-level approach ensures both empirical robustness and conceptual depth, integrating quantitative mapping with normative interpretation.

The bibliometric component of the study aims to test Hypothesis 1, which posits that research in the field of law and artificial intelligence constitutes a multifaceted interdisciplinary domain encompassing data protection, medical law, labour relations, and public administration.

The publication search was conducted in accordance with the PRISMA 2020 protocol, as illustrated in Figure 5. Data were extracted from the Scopus database using the search query provided in Appendix C, which included a combination of keywords such as "artificial intelligence," "law," "regulation," "governance," "policy," "compliance," "ethics," "human rights," "data protection," "privacy law", as well as geographical identifiers related to the European Union and Ukraine.

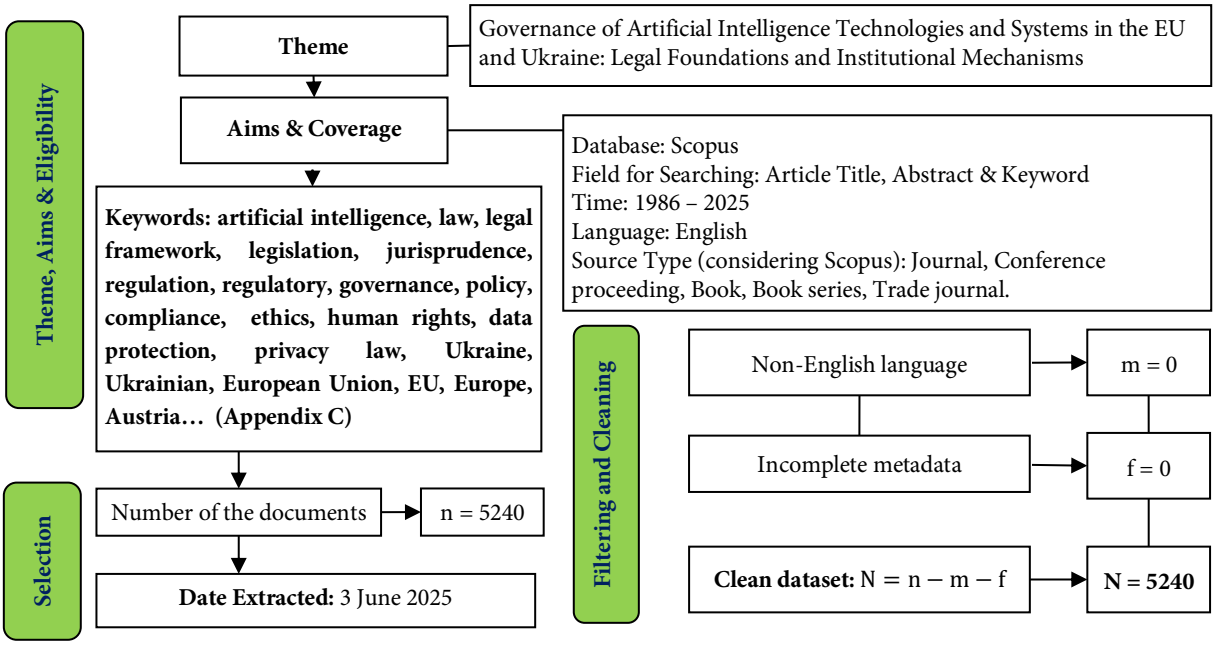


Figure 5. PRISMA Flow Diagram for Identification and Selection of Studies.
Source: Authors' Elaboration Following the PRISMA 2020 Statement (PRISMA Guidelines, 2020).

This query was selected to capture the intersection of legal, regulatory, and ethical dimensions of AI governance, while maintaining a territorial focus on the EU and Ukraine. Such an approach ensures comprehensive coverage of the academic field and provides a balanced representation of research addressing issues of law, policy, and institutional governance.

The resulting dataset comprised 5,240 documents published between 1986 and 2025, all containing English-language metadata (titles, abstracts, and keywords). The dataset was subsequently cleaned to exclude non-English and incomplete records, resulting in a final sample of N = 5,240.

To test Hypothesis 1, the study employed VOSviewer software, designed for the construction of network maps and cluster analysis of bibliometric data. The mathematical foundation of this method lies in the creation of a weighted graph, where each element (e.g., author, keyword, or publication) is represented as a node, and the relationships between elements are depicted as edges with assigned weights.

The strength of association between elements i and j is defined by the following formula:

$$S_{ij} = \frac{c_{ij}}{w_i \times w_j} \quad (3)$$

where S_{ij} represents the strength of association between elements *i* and *j*; C_{ij} denotes the number of co-occurrences of these elements; and w_i and w_j correspond to the frequency of occurrence of each element within the dataset.

Thus, the coefficient S_{ij} reflects the normalised intensity of the connection between elements, allowing for consideration not only of the absolute number of their co-occurrences but also of the relative frequency of each within the overall dataset.

The higher the S_{ij} value, the stronger the association between elements – for example, between keywords, authors, or sources – within the analysed thematic domain.

The use of this coefficient ensures the accurate weighting of connections and prevents the analysis from being biased toward the most frequently occurring elements, which is particularly important when constructing clusters and visualising scientific mapping structures in VOSviewer.

Subsequently, the VOS (Visualization of Similarities) algorithm minimises the loss function, expressed as follows:

$$V = \sum_{i<j} S_{ij} (d_{ij} - l_{ij})^2 \quad (4)$$

where *V* represents the value of the function, reflecting the overall discrepancy between the actual and ideal distances between elements; S_{ij} denotes the strength of association between elements *i* and *j*; d_{ij} is the actual Euclidean distance between nodes on the two-dimensional map; and l_{ij} is the desired (ideal) distance, proportional to the magnitude of the connection S_{ij}.

The purpose of this optimisation function is to position elements (e.g., keywords, authors, or publications) in such a way that the actual distance d_{ij} between them closely corresponds to their logical or semantic proximity l_{ij}, as determined by the strength of their association.

Minimising the function *V* ensures that the resulting map satisfies the following conditions:

- Elements with high co-occurrence frequency are positioned closer together;
- Elements with low associative strength are positioned further apart;
- The spatial structure of the map reflects the internal organisation of the research field.

This type of visualisation allows for the identification of clusters – groups of elements linked by strong thematic or institutional connections. These clusters can be interpreted as scientific domains, research schools, or subfields emerging within the interdisciplinary space of law and artificial intelligence.

The use of VOSviewer is justified by its ability to combine a rigorous mathematical model of distance optimisation with intuitive data visualisation, making it particularly effective for the exploration of complex interdisciplinary research areas.

Within the framework of the present study, this method enables the empirical validation of the cross-sectoral nature of AI governance research, while also identifying dominant thematic directions and institutional interconnections shaping the European legal model of artificial intelligence.

The second hypothesis aims to assess the degree of integration of the Sustainable Development Goals (SDGs) into the normative content of the European Union Artificial Intelligence Act (2024). To this end, a formal content analysis was conducted by comparing the textual provisions of the Act with the framework of 17 SDGs, adopted by the United Nations General Assembly in 2015 (United Nations, 2015).

Methodologically, the analysis covered all 17 SDGs, since even the absence of a direct correlation between specific provisions of the AI Act and certain goals (e.g., SDG 2 – Zero Hunger or SDG 6 – Clean Water and Sanitation) holds interpretive value, highlighting areas where the Act's influence is

indirect or minimal. This approach provides a comprehensive assessment of the normative alignment between the European model of AI regulation and the universal sustainable development agenda.

For the purposes of this analysis, a correlation matrix was constructed, mapping each article and section of the AI Act against the relevant SDGs and their target indicators. The matrix captures three categories of relationships:

- Explicit link – a direct normative correspondence between provisions of the AI Act and specific SDGs;
- Implicit link – provisions that contribute indirectly to the achievement of SDGs through complementary mechanisms or effects;
- No link – areas where AI regulation exerts no significant influence on the attainment of SDG targets.

Particular attention in this study is given to the Sustainable Development Goals (SDGs) most closely related to technological regulation, ethics, and institutional development, namely:

- SDG 4 – Quality Education;
- SDG 8 – Decent Work and Economic Growth;
- SDG 9 – Industry, Innovation and Infrastructure;
- SDG 12 – Responsible Consumption and Production;
- SDG 13 – Climate Action;
- SDG 16 – Peace, Justice and Strong Institutions;
- SDG 17 – Partnerships for the Goals (particularly in the context of international AI coordination and technology exchange).

This analytical focus made it possible to identify the structural and substantive intersections between the AI Act and the SDG framework, reflecting the European Union's commitment to building an ethical, inclusive, and sustainable model of digital regulation.

The choice of formal content analysis as the main method for assessing this relationship is justified by its ability to provide objective textual correlation between national and supranational legal norms and international regulatory frameworks. This method not only identifies semantic overlaps but also evaluates the degree of institutional integration of sustainability principles into the architecture of European AI regulation. Such an approach ensures a high level of analytical depth and interpretive rigour, which is essential for subsequent comparison with the results of the SWOT analysis of national systems.

To test the third hypothesis, which assumes the existence of a convergence trend between Ukraine's legal and institutional architecture in the field of artificial intelligence (AI) and the regulatory and governance standards of the European Union, a SWOT analysis (Strengths, Weaknesses, Opportunities, Threats) was employed.

The selection of this method is explained by its analytical versatility and its ability to account for the multi-level nature of legal regulation, where internal and external determinants are interrelated. On the one hand, internal factors (such as the legislative framework, institutional practices, and the level of digital governance) define the domestic capacity of the legal system to adapt to European requirements. On the other hand, external factors (including normative pressure from the EU, international cooperation, and the broader political and legal context) shape the direction and pace of harmonisation.

Accordingly, the SWOT framework allows not only to describe the current state of regulation but also to assess the strategic potential for legal convergence between Ukraine and the European Union.

Within the study, four analytical categories were defined:

- Strengths – the existence of national digital transformation strategies, institutionalised AI competence centres, and legislative initiatives aligned with European principles of ethics, transparency, and accountability;

- Weaknesses – fragmented legal acts, limited inter-ministerial coordination, insufficient implementation of ethical and legal AI principles, and constraints in human and financial resources;
- Opportunities – deepening integration with the EU, participation in pan-European digitalisation programmes, adoption of ESG and digital responsibility standards, formation of joint research and innovation clusters, and development of legal cooperation in AI regulation;
- Threats – geopolitical instability, uncertain legal status of certain acts, institutional inertia, regulatory duplication risks, and insufficient enforcement mechanisms.

Methodologically, the SWOT analysis serves as a qualitative framework for the strategic interpretation of institutional adaptation processes, complementing the quantitative methods (bibliometric and content analysis). Its advantage over alternative approaches, such as PESTLE (Political, Economic, Social, Technological, Legal, Environmental) or TOWS (a reverse-logic variant of SWOT), lies in its focus not merely on describing the environment but on evaluating the system's transformative potential. In this study, it enables the assessment of Ukraine's legal readiness for harmonisation with the AI Act, as well as the identification of barriers and growth points in building compatible institutional mechanisms.

The integration of PRISMA-based bibliometric mapping (VOSviewer), formal content analysis, and SWOT evaluation ensures a triangulation of methodological instruments, enhancing the reliability and validity of the findings.

At the first level, the quantitative bibliometric analysis using VOSviewer identifies empirical patterns and thematic clusters in AI law research, reflecting the interdisciplinary structure and institutional complexity of the field.

At the second level, the formal content analysis of the AI Act in comparison with the SDGs establishes the normative and ethical core of the European regulatory model, demonstrating its alignment with principles of sustainability, digital inclusion, and ESG governance.

At the third level, the SWOT analysis of Ukraine's legal framework provides a qualitative interpretation of its institutional dynamics and strategic orientation toward adaptation to European standards.

The integration of these three methodological approaches forms a comprehensive analytical framework, combining quantitative and qualitative perspectives, as well as normative and institutional dimensions, thereby allowing an assessment of the structural and substantive convergence between Ukraine and the European Union in the field of AI governance and regulatory development.

Thus, this multi-level, triangulated methodology enables both the quantitative validation of interdisciplinary trends and the qualitative explanation of governance mechanisms and institutional trajectories that define the evolution of AI legal regulation within the European context.

3. Research results

The integration of three complementary methodological approaches – PRISMA-based bibliometric analysis (VOSviewer), formal content analysis, and SWOT evaluation – made it possible to construct a coherent empirical foundation for testing the proposed hypotheses. This methodological combination ensures data triangulation and enables the institutional and normative convergence processes between Ukraine and the European Union to be examined from multiple analytical perspectives: quantitative, normative-value, and managerial-institutional.

The bibliometric analysis identified the key thematic clusters and evolutionary patterns in legal scholarship on artificial intelligence, revealing the interdisciplinary structure and conceptual diversity of this field. The content analysis of the EU Artificial Intelligence Act (AI Act) in relation to the United Nations Sustainable Development Goals (SDGs) allowed for the identification of the normative core of the European regulatory model, founded on the principles of ethics, accountability, transparency, and sustainability. Meanwhile, the SWOT analysis of Ukraine's national legal framework provided an

interpretative lens for understanding the institutional adaptation processes and assessing the strategic potential for harmonisation with EU-wide standards.

Taken together, the findings obtained at each analytical level complement one another, forming a multidimensional understanding of the nature and degree of legal convergence between Ukraine and the European Union in the field of artificial intelligence governance and regulatory development.

3.1 Bibliometric Analysis of the Interdisciplinarity of Research on Law and Artificial Intelligence

For the empirical verification of Hypothesis 1, which concerns the interdisciplinary nature of research in the field of law and artificial intelligence, a bibliometric analysis of scientific publications from 1986 to 2025 was conducted using the VOSviewer software. The resulting visualisation made it possible to map the structure and interconnections between key terms appearing in the titles, abstracts, and keywords of publications, thereby illustrating the institutional and thematic architecture of the research domain.

The term co-occurrence map (Figure 6) clearly reveals four distinct colour-coded clusters, each representing a specific research direction. The size of the nodes corresponds to the frequency of term occurrence, while the distance between nodes reflects the strength of their co-occurrence relationships within the academic corpus. At the centre of the map lies the term "artificial intelligence", around which thematic domains are organised – ranging from medical and technological aspects to ethical, legal, and institutional dimensions of AI governance and regulation.

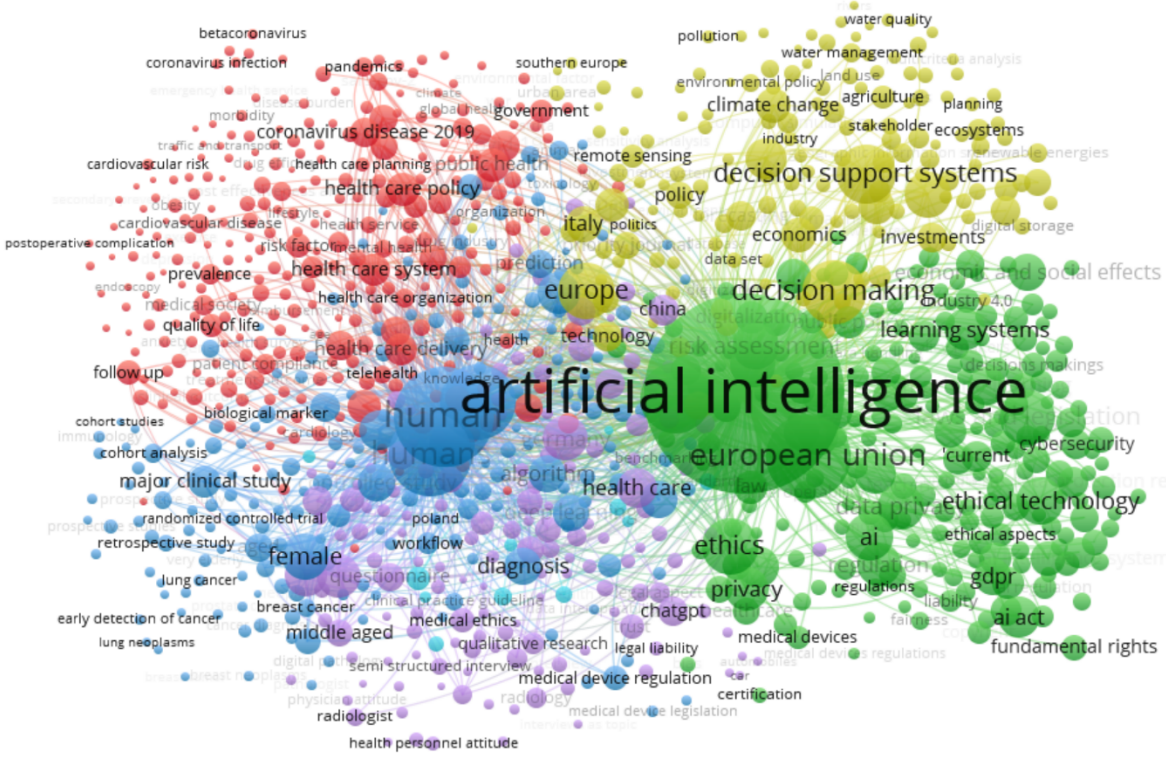


Figure 6. Term Map Visualising the Research Landscape on Law and Artificial Intelligence, Created Using Vosviewer (Version 1.6.20) from Scopus Database Records, 1986–2025.
Source: Authors' Compilation Based on Bibliometric Analysis (VOSviewer, 2025).

The visualised structure of the scientific landscape demonstrates a high degree of interdisciplinarity, integrating legal, technological, ethical, and social dimensions of artificial intelligence regulation. The bibliometric map reveals several distinct thematic clusters:

- Green cluster – "AI Law, Ethics and Governance": This cluster includes the terms European Union, regulation, ethics, privacy, fundamental rights, GDPR, AI Act, ethical technology. It reflects a strong academic focus on the institutional architecture of AI regulation within the

EU, its interaction with European law, and issues related to ethics, accountability, and human rights protection.

- Yellow cluster – "Social, Economic and Environmental Dimensions of AI": It unites such terms as decision support systems, policy, economics, sustainability, climate change, investments, industry 4.0, digitalisation. This cluster highlights the impact of AI on socio-economic processes, environmental governance, and sustainable development, emphasising the link between AI research and the UN Sustainable Development Goals (SDGs).
- Blue cluster – "Health Law and Bioethics": This group comprises health care, diagnosis, clinical study, telemedicine, medical devices, radiologist, liability, qualitative research. It captures the growing scholarly interest in the legal and ethical aspects of AI use in medicine, including diagnostics, clinical trials, liability for AI-driven decisions, and data protection in healthcare.
- Red cluster – "Biomedical and Public Health Research": Containing the terms coronavirus infection, pandemics, COVID-19, health care planning, risk factors, cardiovascular disease, cohort study, this cluster reflects the influence of the COVID-19 pandemic on the surge of publications examining the application of AI in medicine, risk prediction, and healthcare system planning.

Overall, the bibliometric evidence indicates a growing role of legal scholarship within the broader AI research field and empirically confirms Hypothesis 1, which posits the multifaceted and interdisciplinary nature of AI governance research.

The next stage in testing Hypothesis 1 involved analysing the temporal structure of publications, illustrating the evolution of the research field in AI law and regulation.

The overlay visualisation generated in VOSviewer (version 1.6.20) based on Scopus bibliometric data (1986–2025) assigns each node to a specific term, with its colour representing the average year of publication (Figure 7).

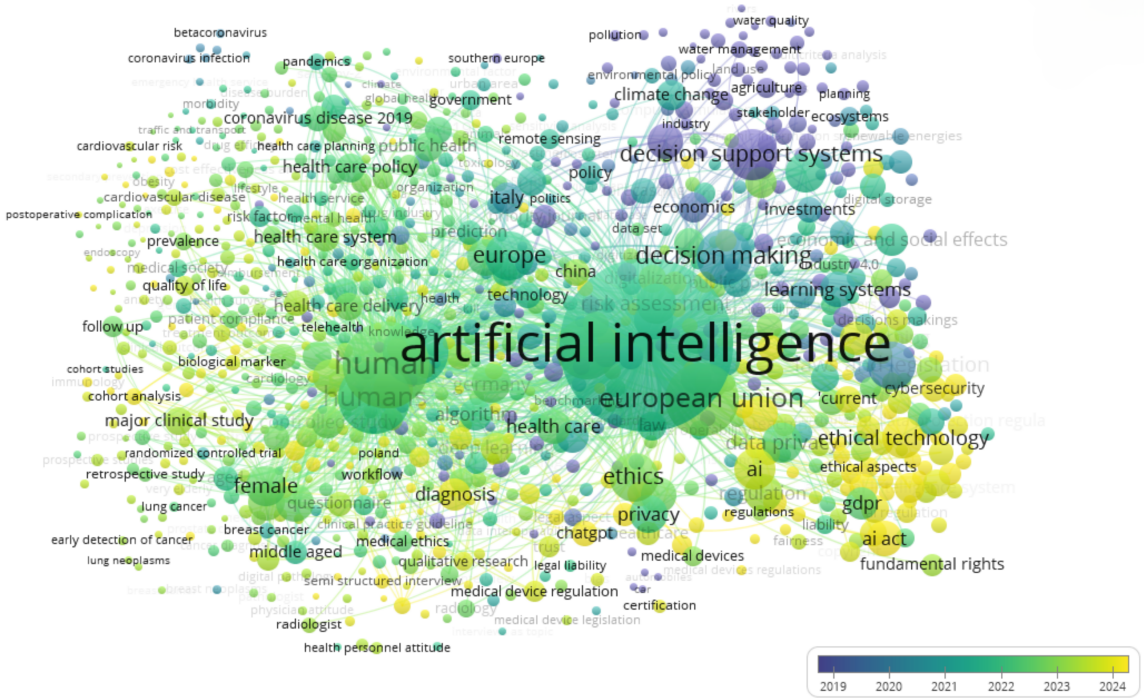


Figure 7. Overlay Visualisation of Term Co-Occurrence in Research on Law and Artificial Intelligence, Created Using Vosviewer Software (Version 1.6.20) Based on Scopus Data for the Period 1986–2025.

Source: Authors' Compilation Based on Bibliometric Analysis (VOSviewer, 2025).

The visualisation clearly shows a shift from early technological and biomedical studies to contemporary legal, ethical, and governance-oriented research, thereby confirming the institutionalisation of AI law as an independent and interdisciplinary domain of scientific inquiry.

The green cluster – "AI Law, Ethics and Governance" – includes the terms European Union, regulation, ethics, privacy, fundamental rights, GDPR, AI Act, ethical technology. This cluster remains central and stable throughout the analysed period, showing a steady growth in publications related to AI regulation in the European Union, data protection, and ethical aspects of technology. Since 2020, there has been a marked thematic expansion toward transparency, accountability, and responsible AI, reflecting the institutionalisation of ethical AI governance within the European legal framework.

The yellow cluster – "Social, Economic and Environmental Dimensions of AI" – encompasses terms such as decision support systems, policy, economics, sustainability, climate change, investments, industry 4.0, digitalisation. Its temporal dynamics reveal increased research activity between 2021 and 2023, corresponding to the growing influence of the ESG agenda, digital governance, and the UN Sustainable Development Goals (SDGs). The topics sustainability and digitalisation form a conceptual bridge between legal and technological research domains, underscoring the integrative nature of AI development and governance.

The blue cluster – "Health Law and Bioethics" – includes health care, diagnosis, clinical study, telemedicine, medical devices, radiologist, liability, qualitative research. This cluster dominated in earlier periods (prior to 2020), reflecting the initial research focus on AI applications in medicine, diagnostics, and healthcare management. Over time, these topics evolved to include the ethical and legal implications of medical AI, such as accountability, patient data protection, and algorithmic transparency.

The purple cluster – "Biomedical and Public Health Research" – contains terms such as coronavirus infection, pandemics, COVID-19, public health, risk factors, health care policy, epidemiology. Its peak activity occurred between 2020 and 2021, when the COVID-19 pandemic triggered a surge of studies examining the use of AI in epidemiological modelling, medical logistics, and risk management. After 2022, this cluster's activity gradually declined, giving way to a growing focus on normative and ethical dimensions of AI governance.

The temporal map illustrates the dynamic evolution of the research field – from applied and medical studies (2019–2021) toward regulatory and governance-oriented research (2022–2024). This transition confirms that the legal discourse on artificial intelligence has emerged as an outcome of the progressive expansion of interdisciplinary links among law, ethics, technology, and social policy.

This trend supports Hypothesis 1, demonstrating that the legal discourse on AI is developing within a stable interdisciplinary paradigm that integrates technical, legal, and governance dimensions of artificial intelligence.

To further clarify the structure and intensity of thematic directions, a density visualisation analysis was conducted (Figure 8), based on Scopus bibliometric data for the period 1986–2025. The map, created using VOSviewer (version 1.6.20), visualises the frequency of term occurrence and the strength of associative relationships within the corpus of publications on AI regulation. The colour intensity indicates the density of mentions: yellow areas represent regions of highest publication concentration, green areas show moderate activity, and blue areas mark peripheral themes.

The term density map reveals a clearly defined multi-layered structure of the research landscape, where the core area consists of concepts related to the legal, ethical, and institutional dimensions of AI regulation, while the peripheral zones are associated with medical, social, and environmental research directions.

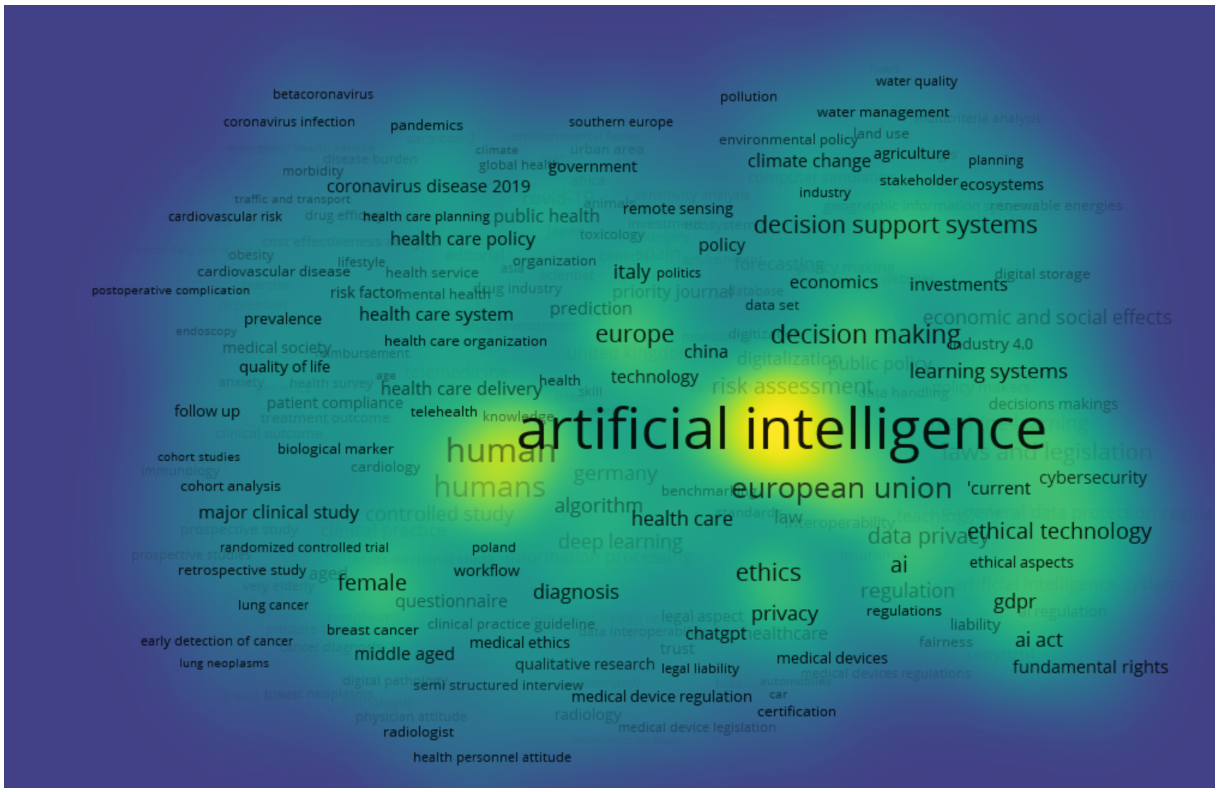


Figure 8. Density Visualisation of Term Co-Occurrence in Research on Law and Artificial Intelligence, Created Using Vosviewer Software (Version 1.6.20) Based on Scopus Data for the Period 1986–2025.

Source: Authors' Compilation Based on Bibliometric Analysis (VOSviewer, 2025).

The central zone (yellow area) includes the terms artificial intelligence, European Union, ethics, regulation, AI Act, GDPR, fundamental rights, and ethical technology. This area forms the normative-ethical core of the academic discourse, reflecting the legal mechanisms of AI regulation, European policy frameworks, and the integration of ethical principles into technology governance.

The intermediate contour (green areas) contains the terms decision making, policy, economics, sustainability, health care, machine learning, and data privacy. This zone concentrates studies that bridge technical, managerial, and socio-economic dimensions of AI, highlighting the interdisciplinary nature of the research field.

The peripheral zones (blue areas) feature terms such as coronavirus infection, public health, telemedicine, climate change, education, employment law, and social effects. These topics demonstrate the expanding scope of AI applications and the emergence of applied research directions – from healthcare and biomedicine to environmental regulation and labour law.

Overall, the visualisation exposes a hierarchical and interconnected structure of AI-law research, where legal and ethical aspects constitute the core, and technical and applied themes form the surrounding field of interdisciplinary interactions.

The results of the density map analysis confirm that the field of AI law and regulation is characterised by a high level of integration between legal, technological, and social dimensions. The dense core centred around the terms AI regulation, ethics, GDPR, and AI Act illustrates the institutional maturity and stability of the European legal discourse on artificial intelligence. Thus, this visualisation empirically supports Hypothesis 1, demonstrating that the research field of AI law is multilayered, interdisciplinary, and structurally balanced.

To further explore the geographical structure of research activity in AI law and governance, a country co-authorship network was constructed based on Scopus bibliometric data (1986–2025). The visualisation, generated using VOSviewer (version 1.6.20), depicts the intensity of international

scientific collaboration among countries. The size of each node corresponds to the number of publications associated with a given country, while the thickness of the connecting lines indicates the strength of cooperative links (Figure 9).

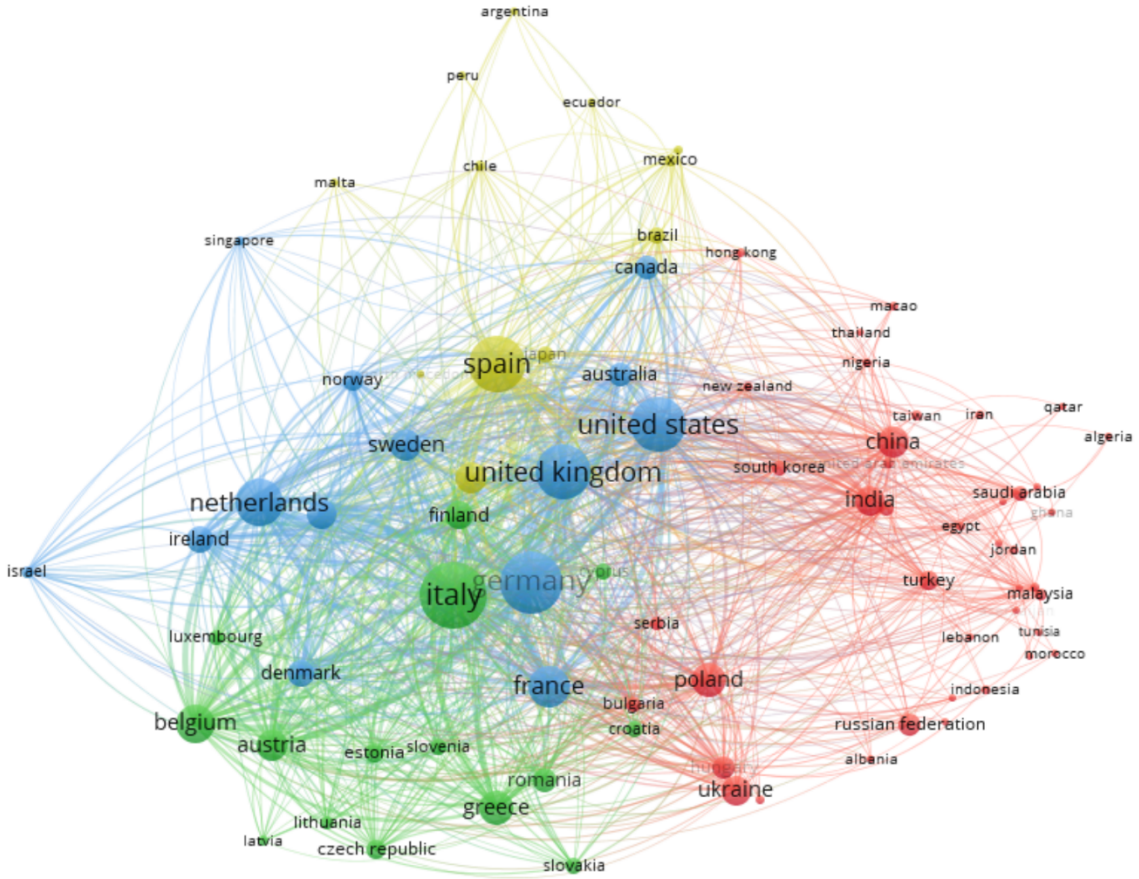


Figure 9. Country Co-Authorship Network in Research on Law and Artificial Intelligence, Created Using Vosviewer Software (Version 1.6.20) Based on Scopus Data for the Period 1986–2025.
Source: Authors' Compilation Based on Bibliometric Analysis (VOSviewer, 2025).

The co-authorship network map illustrates a high degree of international integration within the AI law research landscape and highlights several key hubs of global collaboration:

1. Blue cluster – "Anglo-American Research Core": Includes United States, United Kingdom, Canada, Australia, Netherlands, Sweden, Norway, Finland, Ireland, and Israel. This cluster represents the leading centre of research on AI law, characterised by a high level of interdisciplinarity, publication activity, and global influence. The US and UK emerge as the most productive and interconnected nodes, shaping international academic standards and discourse.

2. Green cluster – "Continental European Network": Comprises Germany, Italy, France, Belgium, Austria, Denmark, Greece, Poland, Romania, Czech Republic, Lithuania, and Luxembourg. This cluster reflects the legal and institutional specificity of the EU, marked by intensive collaboration on AI governance, GDPR, AI Act, and digital policy. The most active centres – Germany, Italy, and France – integrate legal and ethical dimensions of AI regulation, reinforcing Europe's leadership in normative governance.

3. Red cluster – "Asia-Pacific Research Cluster": Includes China, India, South Korea, Japan, Malaysia, Indonesia, Turkey, Iran, Saudi Arabia, and Qatar. These countries exhibit high publication activity and a technological orientation toward applied AI topics – algorithms, automation, and data

management – though with less normative integration. China and India act as major publication engines, especially after 2020, driving the expansion of AI research in the region.

4. Yellow cluster – "Ibero-Latin Network": Includes Spain, Portugal, Brazil, Mexico, Argentina, Chile, Ecuador, and Peru. This group represents a growing transatlantic research community, linking European and Latin American approaches to AI ethics, regulation, and sustainable development, thereby broadening the scope of global academic collaboration.

5. Ukraine and Eastern Europe: Ukraine, Poland, and Romania occupy an intermediary position between the green and red clusters, reflecting Ukraine's increasing integration into the European research ecosystem while maintaining connections with the Asia-Pacific region. This trend empirically confirms Ukraine's gradual institutional convergence with the EU in the field of AI governance.

The international collaboration network demonstrates that research on AI law and governance is global in scope yet organised around several regional centres – North America, Europe, and Asia. The structure of the network reveals strong intra-European coordination and active Ukrainian participation in the European academic space, providing further empirical support for Hypothesis 1, which posits the interdisciplinary and institutionally integrated nature of AI law research.

The bibliometric analysis conducted for 1986–2025 empirically confirms the interdisciplinary and institutional nature of research on artificial intelligence law within the European academic landscape. The identified clusters – spanning legal, ethical, medical, social, and technological domains – demonstrate that the field of AI regulation functions as a multidimensional and convergent research ecosystem, where normative, technological, and socio-economic components are tightly interlinked.

The temporal and density visualisations trace a clear trajectory: from early technological and biomedical applications to institutionalised legal-ethical frameworks and governance models aligned with European standards. This progression underscores the consolidation of AI law as an independent interdisciplinary field, integrating perspectives from computer science, ethics, data protection, and public administration.

Furthermore, the global co-authorship network reveals a high level of cross-border research integration, positioning Europe as the structural hub connecting the Anglo-American, Asian, and Ibero-Latin research clusters. Ukraine's embeddedness within this network highlights its increasing institutional alignment with EU legal and governance frameworks, particularly in ethical AI regulation and digital sustainability.

Hence, the findings of the bibliometric analysis provide robust empirical evidence for Hypothesis 1, confirming that AI legal regulation constitutes a multi-level interdisciplinary domain, uniting technological, normative, and ethical dimensions within a coherent European research and governance paradigm.

3.2 Content Analysis of the AI Act and Its Alignment with the UN Sustainable Development Goals

To test Hypothesis 2, a formal content analysis was conducted to examine the extent to which the provisions of the European Union Artificial Intelligence Act (AI Act, Regulation (EU) 2024/1689) reflect and integrate the priorities of the United Nations Sustainable Development Goals (SDGs). The analysis aims to identify the normative convergence between the EU's regulatory framework for artificial intelligence and the global sustainability agenda, particularly regarding ESG governance, ethical responsibility, and digital inclusiveness.

The hypothesis posits that the AI Act's structure and principles – including transparency, accountability, safety, fairness, and human oversight – are conceptually and functionally consistent with the sustainable development paradigm, even in areas where the Regulation does not provide explicit sectoral references.

The matrix below (Table 1) presents the correspondence between the provisions of the European Union Artificial Intelligence Act (AI Act, Regulation (EU) 2024/1689) and the 17 United Nations Sustainable Development Goals (SDGs). Each correlation is categorized as either direct, indirect, or absent, depending on the degree to which the regulatory provisions contribute to achieving the

specific SDG objectives. The structure follows the SDG numbering sequence (1–17) to provide systematic coverage of the global sustainability framework.

Table 1. Correlation Matrix between the AI Act and the Sustainable Development Goals.

SDGs	Type of Link	Description of Correlation
1. No Poverty	Indirect	The AI Act contributes to the implementation of certain principles of SDG 1 at the level of economic potential and technological inclusion, but it does not address the social dimensions of poverty eradication. Its impact may therefore be viewed as the creation of infrastructural conditions for sustainable development rather than as a direct instrument of social transformation.
2. Zero Hunger	No Link	The AI Act does not contain explicit provisions addressing food security, sustainable agriculture, or access to nutrition. The Regulation does not directly relate to agricultural innovation or hunger reduction. Its potential contribution to SDG 2 can therefore be viewed as indirect and structural, supporting innovation and sustainability frameworks that may, in the long term, enhance food systems rather than provide immediate regulatory mechanisms for hunger eradication.
3. Good Health and Well-Being	Indirect	The AI Act demonstrates an indirect yet significant correlation with SDG 3 (Good Health and Well-Being). Although the Regulation does not directly govern healthcare systems, several of its provisions–particularly Articles 9, 10 and 14, along with Annex III–establish a regulatory environment that ensures the safety, reliability, and ethical use of AI in medical and health-related contexts. By setting standards for risk management, data quality, and human oversight, the Act contributes to patient safety, responsible innovation, and overall wellbeing. Hence, its contribution to SDG 3 is best described as indirect but foundational, providing the necessary legal infrastructure for sustainable and safe health innovation.
4. Quality Education	Direct	The AI Act demonstrates a clear and direct link with SDG 4 (Quality Education). By introducing the concept of AI literacy (Recital 20) and promoting the development of skills, knowledge sharing, and innovation, the Regulation positions education as a cornerstone of the European digital transition. Its provisions support the creation of an informed and responsible society capable of using AI safely and ethically. Accordingly, the AI Act's contribution to SDG 4 can be regarded as direct and structural, reinforcing inclusive education, lifelong learning, and digital competence as essential dimensions of sustainable development.
5. Gender Equality	Indirect	The AI Act indirectly supports SDG 5 – Gender Equality by embedding principles of non-discrimination, fairness, and human oversight throughout its provisions. Articles 5 and 10 prohibit the use of manipulative or biased AI systems and require the use of representative, high-quality datasets to prevent algorithmic bias. Although gender equality is not explicitly mentioned, the Regulation strengthens the ethical and institutional foundations of equality in AI governance. Hence, its contribution to SDG 5 can be characterised as indirect but legally and ethically substantial, advancing fairness and inclusiveness in the European digital framework.
6. Clean Water and Sanitation	No Link	The AI Act does not contain any direct provisions related to SDG 6. The Regulation does not explicitly address water management, pollution control, or sanitation systems. Its contribution to SDG 6 can therefore be seen as indirect and structural, creating a regulatory environment that could support the future development of sustainable AI solutions in environmental and resource management sectors.
7. Affordable and Clean Energy	Indirect	The AI Act demonstrates an indirect yet meaningful relationship with SDG 7. While the Regulation does not specifically address the energy sector, it recognises the broader environmental and social benefits of artificial intelligence, particularly in enhancing energy efficiency and promoting sustainable technological development. The Act contributes to the creation of a legal and ethical framework that enables the safe and responsible use of AI in energy management and innovation. Its influence is therefore structural rather than sectoral, supporting the long-term transition towards clean and affordable energy through responsible digital transformation.
8. Decent Work and Economic Growth	Direct	The AI Act shows a direct and substantial relationship with SDG 8. It positions artificial intelligence as a driver of innovation, productivity, and competitiveness within the European economy. By fostering a trustworthy digital environment and supporting small and medium-sized enterprises, the Regulation contributes to sustainable economic expansion and job creation. Its framework ensures that technological progress aligns with social responsibility, making the AI Act a cornerstone for inclusive and ethical economic growth in the EU.
9. Industry, Innovation and Infrastructure	Direct	The AI Act demonstrates a strong and direct alignment with SDG 9. It provides a unified regulatory framework for the safe and ethical deployment of artificial intelligence, supporting industrial innovation and the development of trustworthy digital infrastructure. By fostering collaboration between enterprises, research institutions, and regulators, the Act strengthens Europe's capacity for responsible technological leadership. Its contribution to SDG 9 is therefore systemic, shaping the foundations of sustainable industrial transformation and innovation-driven growth within the EU.
10. Reduced Inequalities	Direct	The AI Act shows a direct and socially significant alignment with SDG 10. By prohibiting manipulative and discriminatory AI practices, ensuring transparency, and promoting fairness in algorithmic decision-making, the Regulation strengthens the protection of human rights and social justice. It fosters digital inclusiveness by creating equitable access to technology and innovation across regions and social groups. The AI Act's contribution to SDG 10 is therefore both normative

		and transformative, embedding equality as a foundational principle of the European digital framework.
11. Sustainable Cities and Communities	Indirect	The AI Act demonstrates an indirect but conceptually significant relationship with SDG 1. By defining legal safeguards for the use of AI in public spaces, transport, and critical infrastructure, the Regulation enables the responsible development of smart and sustainable cities. Its emphasis on transparency, safety, and human oversight ensures that digital innovation enhances, rather than compromises, urban inclusiveness and public trust. Hence, the AI Act contributes to SDG 11 by shaping the ethical and institutional foundations of the smart city transformation in Europe.
12. Responsible Consumption and Production	Indirect	The AI Act shows an indirect yet substantial alignment with SDG 12. By embedding transparency, accountability, and ethical design principles into the governance of artificial intelligence, the Regulation supports responsible innovation and sustainable production models. Its provisions help prevent environmental and social harm arising from unregulated technological expansion and ensure that AI development aligns with ESG-oriented practices. Therefore, the AI Act contributes to SDG 12 by establishing a framework for sustainable and accountable digital transformation within the European economy.
13. Climate Action	Indirect	The AI Act demonstrates an indirect yet strategically important link with SDG 13. Although it does not explicitly regulate climate policy, the Regulation promotes the ethical and sustainable use of artificial intelligence in ways that support environmental resilience and energy efficiency. By encouraging innovation in resource optimisation, emissions monitoring, and digital environmental governance, the Act contributes to the broader objectives of the European Green Deal. Its role in relation to SDG 13 is therefore enabling and structural, establishing the legal foundation for AI-driven climate solutions within a sustainable digital transition.
14. Life Below Water	No Link	The AI Act shows no direct link with SDG 14. However, its emphasis on environmental responsibility and ethical technology use provides an indirect framework for the application of AI in marine monitoring and resource protection. By establishing standards for safety, transparency, and accountability, the Regulation enables the development of responsible AI solutions that could support the sustainability of ocean ecosystems in the long term. Its contribution is therefore indirect and enabling, rather than normative or regulatory.
15. Life on Land	Indirect	The AI Act demonstrates an indirect but meaningful connection with SDG 15. While it does not explicitly regulate environmental protection, the Regulation establishes ethical and legal principles that enable the responsible use of AI in land monitoring, biodiversity conservation, and sustainable resource management. Its framework supports the development of "green AI" applications that align with the EU's ESG agenda, reinforcing the link between technological progress and ecological resilience. Therefore, the AI Act contributes to SDG 15 by providing a governance model for sustainable and ethical environmental innovation.
16. Peace, Justice and Strong Institutions	Direct	The AI Act demonstrates a strong and direct alignment with SDG 16. It establishes a legal framework that reinforces transparency, accountability, and the rule of law in the governance of artificial intelligence. By safeguarding human rights, prohibiting manipulative and discriminatory AI systems, and enhancing institutional oversight, the Regulation strengthens democratic governance in the digital age. The AI Act's contribution to SDG 16 is therefore structural and foundational, embedding justice and ethical responsibility into Europe's technological governance model.
17. Partnerships for the Goals	Direct	The AI Act demonstrates a direct and strategic alignment with SDG 17. As the first comprehensive legal framework for artificial intelligence, it sets a global benchmark for responsible technology governance. By promoting international cooperation, knowledge exchange, and harmonisation of regulatory standards, the Regulation strengthens cross-border partnerships between governments, academia, and industry. Its contribution to SDG 17 is therefore institutional and transformative, advancing the EU's role as a global leader in sustainable and ethical AI governance.

Source: developed by authors.

The correlation matrix presented in Table 1 provides a systematic overview of the degree of alignment between the European Union Artificial Intelligence Act (Regulation (EU) 2024/1689) and the United Nations Sustainable Development Goals (SDGs). The findings indicate that the Act demonstrates a high level of normative and conceptual consistency with the sustainable development framework, confirming the partial to strong integration of ESG principles, ethical accountability, and digital inclusion within the European model of AI governance.

Out of the 17 SDGs:

- 6 goals exhibit a direct correlation (SDGs 4, 8, 9, 10, 16, 17);
- 8 goals show an indirect correlation (SDGs 1, 3, 5, 7, 11, 12, 13, 15);
- 3 goals have no explicit linkage (SDGs 2, 6, 14).

This distribution illustrates that the AI Act primarily contributes to the institutional, ethical, and governance dimensions of sustainable development rather than sectoral or environmental domains.

The Regulation functions as a meta-governance instrument – a legal and ethical foundation enabling sustainability-oriented innovation across various policy sectors.

The AI Act indirectly supports goals related to poverty reduction, health, and gender equality (SDGs 1, 3, 5) primarily through provisions that promote fairness, non-discrimination, and human oversight of AI systems. Its direct contribution to quality education (SDG 4) – through the concept of AI literacy and the promotion of digital competences – demonstrates how the Regulation embeds the principles of empowerment and knowledge dissemination within the digital transition framework. Although no explicit connection was found with zero hunger and clean water and sanitation (SDGs 2 and 6), the Act lays the institutional groundwork for long-term technological inclusion and equality.

The AI Act makes a direct contribution to decent work and economic growth (SDG 8), industry, innovation and infrastructure (SDG 9), and reduced inequalities (SDG 10) by positioning artificial intelligence as a driver of sustainable competitiveness and inclusive growth. It is also indirectly linked to affordable and clean energy (SDG 7) through provisions promoting efficiency and sustainable technological advancement. Collectively, these interlinkages confirm that the AI Act serves as a regulatory catalyst for the digital economy and a just technological transition aligned with ESG principles.

While the Regulation does not contain explicit environmental provisions, its ethical and accountability structure indirectly supports sustainable cities and communities (SDG 11), responsible consumption and production (SDG 12), climate action (SDG 13), and life on land (SDG 15). These relationships highlight the structural contribution of the AI Act – it creates legal conditions for the development of "green" AI solutions consistent with the European Green Deal. A direct correlation with life below water (SDG 14) is absent; however, the Regulation's focus on safety and transparency may foster future innovations in marine sustainability.

The AI Act directly reinforces the goal of peace, justice and strong institutions (SDG 16) by embedding the principles of transparency, accountability, and human rights protection into the digital governance framework. Furthermore, it contributes to SDG 17 (Partnerships for the Goals) by advancing international regulatory harmonisation and knowledge exchange, thereby positioning the European Union as a global normative leader in ethical and sustainable AI regulation.

Taken together, the results of this analysis show that the AI Act institutionalises the values and objectives of sustainable development within the European model of digital governance. Although the Regulation does not encompass all thematic areas of the SDG agenda, its structure reflects systemic alignment with the social, economic, and institutional pillars of sustainability. This demonstrates that the principles of sustainability are embedded within the normative architecture of the AI Act – not through sectoral mandates, but through an overarching commitment to ethics, equity, and accountability in technology governance.

Thus, the content analysis of Table 1 provides compelling empirical support for Hypothesis 2, demonstrating that the European model of AI regulation is both conceptually and functionally integrated with the UN Sustainable Development Goals, linking digital transformation to the broader paradigm of sustainable and inclusive growth.

3.3 SWOT Analysis of Ukraine's Legal and Institutional Framework for Artificial Intelligence in the Context of EU Convergence

Hypothesis 3 posits that Ukraine's legal framework in the field of artificial intelligence demonstrates a trend toward normative and institutional convergence with the European Union's legislation. This process is expected to manifest through the adaptation of national digital development strategies, the harmonisation of legal norms, and the formation of regulatory institutions aimed at ensuring compatibility with EU standards and the principles established in the Artificial Intelligence Act (Regulation (EU) 2024/1689).

The verification of this hypothesis focuses on identifying the actual degree of institutional and normative convergence between Ukraine and the EU, as well as determining the structural factors

that either facilitate or constrain this process. To achieve this goal, a SWOT analysis is employed, allowing for a comprehensive assessment of the strengths and weaknesses of Ukraine's legal system in the AI domain, alongside the identification of external opportunities and threats shaping its strategic development trajectory.

The use of SWOT analysis is justified by the need not only to diagnose the current state of Ukraine's regulatory and institutional environment but also to evaluate the potential for harmonisation of national legislation with the European model of AI governance. This approach enables the legal framework to be examined within the context of ongoing integration processes, identifying the key directions for its adaptation to the requirements of the AI Act, and aligning it with the principles of digital responsibility, ethics, and sustainability.

In the era of globalisation and Ukraine's active inclusion in the international scientific and technological space, the establishment of an effective legal mechanism for managing the development of artificial intelligence has become increasingly vital. Contemporary global trends indicate that leading innovation centres – the EU, the United States, and China – view AI as a strategic domain of public policy, requiring legal codification, institutional oversight, and ethical control.

Ukraine is likewise engaging in these processes, progressively forming its own regulatory and organisational framework in the field of AI. However, despite the presence of conceptual documents and strategic programmes, the national legal system remains fragmented and requires institutional consolidation. This creates an objective need to examine both the strengths and weaknesses of the Ukrainian legal environment, as well as the external influences that determine the potential and risks of its convergence with EU standards.

Within this context, the SWOT analysis serves as a tool to systematise the key components of Ukraine's regulatory and institutional environment in the AI domain and to evaluate their compatibility with the European model of governance, providing an empirical basis for testing Hypothesis 3.

As previously noted, artificial intelligence represents one of the most transformative technologies of the modern era, with the potential to reshape multiple sectors of social and economic life. Public policy in this domain must ensure the responsible use of AI, balancing innovation and accountability, with the goal of enhancing public service delivery and strengthening democratic governance (Panda et al., 2025). Consequently, effective governance of AI development is becoming a strategic priority of Ukraine's national policy.

The public authorities responsible for managing AI development play a central role in shaping and implementing national policy, establishing regulatory frameworks, and supervising the introduction of innovative technologies. Each of these institutions performs specific functions and exercises distinct powers within the existing legal system, collectively contributing to the sustainable integration of AI across economic sectors and the system of public administration.

At the core of this system stands the Cabinet of Ministers of Ukraine (CMU), which is responsible for implementing state policy, drafting regulatory acts, and coordinating the activities of other executive bodies in the fields of innovation and artificial intelligence. The fundamental principles defining the legal status of the CMU are enshrined in the Constitution of Ukraine (1996). According to Article 113, the Cabinet of Ministers is the highest body in the system of executive power, which grants it a leading role in ensuring public policy across all spheres of social life, including scientific and technological development, digitalisation, innovation, and AI governance.

In this context, the CMU functions as the central coordinating authority of state policy in the AI domain, providing the regulatory, organisational, and financial foundation for the integration of intelligent technologies into the economy, national security, and public administration.

According to Article 116 of the Constitution of Ukraine (1996), the Cabinet of Ministers:

- ensures state sovereignty and economic independence of Ukraine, as well as the implementation of domestic and foreign policy (para. 1);

- conducts financial, investment, tax, educational, scientific, and environmental policy (para. 3);
- takes measures to ensure defence capability and national security (para. 7);
- organises foreign economic activity (para. 8);
- directs and coordinates the activities of ministries and other executive bodies (para. 9).

These functions encompass a wide range of responsibilities relevant to the Cabinet's role in AI development and governance. Accordingly, the government serves as the principal state authority responsible for policy implementation and regulatory support of innovation-driven development, including artificial intelligence.

The second key institution is the Ministry of Digital Transformation of Ukraine (MinCifra), whose legal status is defined in the Regulation on the Ministry of Digital Transformation of Ukraine (Kabinet Ministriv Ukrainy, 2019b). According to this document, the Ministry is responsible for shaping and implementing state policy in the areas of digitalisation, digital economy, digital innovation, robotics, e-governance, and the development of the information society.

In the context of AI technology governance, the Ministry of Digital Transformation of Ukraine (MinCifra) plays a pivotal role. Specifically, it:

- participates in the formulation and implementation of state policy in the field of artificial intelligence, including the development of strategies, programmes, and regulatory acts;
- contributes to the development of AI infrastructure, coordinating the establishment of research and technological platforms;
- plays a key role in international cooperation, facilitating Ukraine's integration into the global digital ecosystem and participation in international initiatives.

Equally significant is the State Service of Special Communications and Information Protection of Ukraine (Derzhspetszviazok), whose legal foundations are established by the Law of Ukraine "On the State Service of Special Communications and Information Protection of Ukraine" of 23 February 2006, No. 3475-IV. According to the law, Derzhspetszviazok is a central executive authority responsible for the formulation and implementation of state policy in the fields of special communications, information protection, cybersecurity, and cryptographic data security (Zakon Ukrainy "Pro Derzhavnu sluzhbu spetsialnoho zviazku ta zakhystu informatsii Ukrainy", 2006).

Derzhspetszviazok actively integrates AI technologies to enhance the effectiveness of cyber defence, and it participates in international initiatives focused on cyber resilience and innovation. In particular, its representatives took part in the NATO "TIDE Sprint 2025" Conference (Helsinki, Finland), where topics such as cyber threat forecasting, AI applications in intelligence, and information security were discussed (State Service for Special Communications and Information Protection of Ukraine, 2025).

Thus, Derzhspetszviazok performs a key function in ensuring national cybersecurity, actively integrating AI into information protection systems and contributing to the formation of digital resilience standards.

Beyond the aforementioned bodies, the system of public administration of AI development in Ukraine includes:

- the National Security and Defence Council of Ukraine (NSDC) – coordinates policy in the field of cyber and technological security (Zakon Ukrainy "Pro natsionalnu bezpeku Ukrainy", 2018);
- the Ministry of Education and Science of Ukraine – responsible for advancing research and training qualified personnel in AI;
- the Ministry of Economy of Ukraine – develops innovation policy and supports the digital business sector;
- the Ministry of Defence of Ukraine / General Staff of the Armed Forces – integrates AI technologies into the defence sector, including data analytics and UAV control systems;

- the Security Service of Ukraine (SBU) – counteracts cyber threats and safeguards critical infrastructure;
- the National Agency for Science, Innovation and Informatization – coordinates innovation projects and funds scientific research.

Hence, the system of public administration of AI development in Ukraine is multilevel and complex. The role of public authorities extends beyond setting strategic priorities and developing the legal framework; it also encompasses the practical implementation of tasks related to the development, deployment, and security of AI technologies across various sectors of public life.

Participation of the business sector in building an effective governance system for AI development is becoming increasingly significant in the context of global digitalisation and rapid technological advancement. Enterprises, start-ups, venture funds, industry associations, and other private actors not only develop and implement innovative AI solutions, but also shape the pace, direction, and ethical foundations of AI evolution (Ryan & Stahl, 2021).

Importantly, within the framework of Ukraine's European integration trajectory, the business sector's activity serves as a practical embodiment of European approaches to AI regulation, as enshrined in the AI Act, particularly concerning transparency, accountability, and non-discrimination.

Accordingly, legal regulation of business entities' status and functions in AI governance is of particular relevance. The harmonisation of national legal norms governing private-sector innovation with EU legislation constitutes one of the key indicators of normative convergence and provides additional empirical support for Hypothesis 3.

Given the importance of private-sector participation in AI development governance in Ukraine, it is appropriate to examine the legal status of its key groups.

One of the most important categories of business-sector entities playing a central role in managing AI technologies and systems in Ukraine are legal entities – enterprises. Their innovation potential is largely determined by the scale and depth of AI implementation (Jiang et al., 2024).

This group includes:

- IT companies developing or deploying AI-based solutions;
- industrial enterprises applying AI in logistics, agriculture, and manufacturing;
- research and engineering firms engaged in technological innovation;
- consulting and analytical organisations supporting AI-driven projects.

Among these, IT companies occupy a leading position. Their legal status is governed by a number of normative acts. The general rights and obligations of business entities are defined in the Commercial Code of Ukraine (Commercial Code of Ukraine, 2003) and the Civil Code of Ukraine (Tsyvilnyi kodeks Ukrainy, 2003). Issues of innovation and scientific-technical activity are regulated by the Laws of Ukraine "On Innovation Activity" (Zakon Ukrainy "Pro innovatsiinu diialnist", 2002) and "On Scientific and Scientific-Technical Activity" (Zakon Ukrainy "Pro naukovu i naukovo-tekhnichnu diialnist", 2015). The strategic principles of participation in national AI development are outlined in the Concept for the Development of Artificial Intelligence in Ukraine (Kabinet Ministriv Ukrainy, 2020).

The introduction of such comprehensive approaches into national legislation indicates a progressive convergence between the Ukrainian regulatory model and the European framework, in which digital business is regarded not merely as an economic entity but also as a carrier of ethical and socially responsible practices, fully consistent with the provisions of the AI Act.

The legal status of industrial enterprises applying AI in logistics, agriculture, and manufacturing is determined by the combined effect of the Commercial Code of Ukraine, the Laws of Ukraine "On Innovation Activity" and "On Scientific and Scientific-Technical Activity", as well as the Concept for the Development of Artificial Intelligence in Ukraine. These enterprises do not develop AI solutions independently but rather integrate them into production processes, thereby creating a sustainable demand for innovation that directly influences the national AI development strategy. Such a model

provides a legal foundation for adapting Ukrainian enterprises to the Industry 4.0 standards and digital transformation agenda defined in the strategic documents of the European Union.

Research-oriented enterprises play a crucial role in the development, testing, and implementation of innovations in the field of AI, in cooperation with universities, IT companies, and industrial organisations. Their activities are governed by the Laws of Ukraine "On Innovation Activity" and "On Scientific and Scientific-Technical Activity", as well as the Concept for the Development of Artificial Intelligence in Ukraine. These forms of public–private partnership reflect the European model of innovation collaboration, confirming Ukraine's institutional orientation toward integration with the EU.

The legal status of engineering companies is regulated by the Commercial Code of Ukraine and the Law of Ukraine "On Investment Activity" (Zakon Ukrainy "Pro investytsiinu diialnist"). Within the framework of AI development governance, these companies facilitate the adaptation and integration of AI solutions into production processes and the optimisation of enterprise infrastructure based on intelligent technologies. This aligns with European approaches to technological modernisation and sustainable development.

The legal specifics of consulting and analytical firms supporting AI-related projects are established by the Commercial Code of Ukraine, the Law of Ukraine "On Innovation Activity", and the Strategy for the Development of Innovation Activity until 2030 (Kabinet Ministriv Ukrainy, 2019a). Although their activities are not governed by a separate law, they operate within the framework of commercial, informational, and innovation legislation. These firms not only provide project support but also shape the legal, strategic, and ethical environment for AI development, directly corresponding to the principles of responsible and transparent AI governance enshrined in the AI Act.

The legal regulation of educational institutions is defined by the Laws of Ukraine "On Education" (Zakon Ukrainy "Pro osvitu", 2017), "On Higher Education" (Zakon Ukrainy "Pro vyshchu osvitu", 2014), and "On Scientific and Scientific-Technical Activity" (Zakon Ukrainy "Pro naukovu i naukovo-tekhnichnu diialnist", 2002), among others. Their role in AI governance and development in Ukraine can be characterised as follows:

- they train specialists capable of developing, implementing, and regulating AI systems;
- they design educational programmes encompassing IT, ethics, governance, and AI regulation (Bećirović & Mattoš, 2024);
- they host research laboratories and AI centres;
- they act as a link between science, business, and the state.

The second category of business-sector entities includes innovation structures – start-ups, technology parks, incubators, accelerators, venture funds, investment platforms, innovation hubs, clusters, and technology transfer centres. Their legal status is governed by the Laws of Ukraine "On Innovation Activity" and "On Scientific and Scientific-Technical Activity", as well as the Law of Ukraine "On Copyright and Related Rights" (Zakon Ukrainy "Pro avtorske pravo i sumizhni prava", 2023).

These entities form the organisational and legal infrastructure of innovation development, create favourable conditions for the deployment and commercialisation of AI technologies, and serve as intermediaries between science, business, and government. Their activities contribute to the formation of national innovation ecosystems, fully consistent with European principles embedded in the Digital Europe and Horizon Europe programmes – thus reflecting Ukraine's institutional convergence with the European Union.

A distinct category of business actors comprises industry associations and alliances, such as IT Ukraine Association, AI HOUSE, and UVCA, which function as platforms for business–government cooperation, the promotion of ethical standards, and the development of self-regulatory mechanisms in the field of AI. These associations help build an effective regulatory environment, participate in the drafting of strategic documents, concepts, and normative acts, and contribute to shaping the national

framework for AI governance. Their activities embody the European principle of multi-stakeholder governance, which is also embedded within the AI Act's institutional design.

Given the rapid advancement of artificial intelligence technologies, effective AI governance requires the participation not only of public authorities and the business sector but also of civil society and the academic and educational community.

Civil society organisations, research institutions, and educational establishments play a crucial role in shaping ethical standards, providing scientific and analytical support, developing innovative solutions, and ensuring capacity building in the field of AI.

The normative foundations of their legal status are defined in the Laws of Ukraine "On Public Associations" (Zakon Ukrainy "Pro hromadski obiednannia", 2012) and "On Scientific and Scientific-Technical Activity" (Zakon Ukrainy "Pro naukovu i naukovo-tekhnichnu diialnist", 2015).

The role of public associations in ensuring AI governance and development in Ukraine manifests in several dimensions:

- they exercise public oversight over the ethical and lawful implementation of AI technologies;
- they serve as experts and stakeholders in drafting AI-related policies, concepts, and legislation;
- they engage in public education and awareness-raising on the opportunities and risks of AI through training, lectures, information campaigns, and social initiatives;
- they promote citizen participation in discussions on the ethical, legal, and social implications of AI development.

Such involvement of civil society reflects the European approach to multi-level governance (multi-stakeholder governance) embedded within the structure of the AI Act, where the participation of public institutions in AI regulatory processes is regarded as a mandatory prerequisite for ensuring transparency and accountability. Thus, the development of the legal status of civil society organisations in Ukraine demonstrates a clear trend toward institutional convergence with the European Union and provides further support for Hypothesis 3.

In today's globalised world, the development of technologies – particularly artificial intelligence systems – is impossible without the active engagement of international organisations, institutions, and partners. International cooperation in the field of AI governance is of critical importance for Ukraine, as it underpins the formation of national policy in this domain and facilitates its integration into global and European digital development processes.

From a legal perspective, the activities of international organisations and partners within Ukraine are regulated by a number of normative acts that establish the foundations for international cooperation and legal harmonisation. These include:

- the Association Agreement between Ukraine and the European Union (Uhoda pro asotsiatsiiu mizh Ukrainoiu, z odniiei storony, ta Yevropeiskym Soiuzom, Yevropeiskym spivtovarystvom z atomnoi enerhii i yikhnimy derzhavamy-chlenamy, z inshoi storony, 2014);
- the Law of Ukraine "On International Treaties of Ukraine" (Zakon Ukrainy "Pro mizhnarodni dohovory Ukrainy", 2004);
- the Law of Ukraine "On the Legal Status of Foreigners and Stateless Persons" (Zakon Ukrainy "Pro pravovyi status inozemtsiv ta osib bez hromadianstva", 2011);
- the Resolution of the Cabinet of Ministers of Ukraine "On the Establishment of a Unified System for Attracting, Using, and Monitoring International Technical Assistance" (Kabinet Ministriv Ukrainy, 2002);
- as well as memoranda and grant agreements with international institutions such as OECD, UNESCO, USAID, and others.

The existence of these legislative instruments provides a legal infrastructure for international cooperation, which is a key element of Ukraine's institutional convergence with the legal and regulatory framework of the European Union and with global mechanisms of AI governance.

A number of international organisations, institutions, and partners are actively engaged in the development of AI technologies and systems in Ukraine. One of the most prominent is the United

Nations Educational, Scientific and Cultural Organization (UNESCO), which promotes the concept of human-centred, ethical, fair, and sustainable AI development that serves human interests, respects human rights, reduces inequality, and contributes to national development (van Norren, 2023). In Ukraine, UNESCO's activities have a significant influence on the ethical, legal, educational, and research environments within which AI platforms and governance frameworks are formed.

Another major international partner of Ukraine is the United States Agency for International Development (USAID), which actively supports digital transformation, innovation development, and technology governance, including artificial intelligence. USAID can be regarded as a key provider of international technical assistance, implementing programmes that directly or indirectly promote AI development in Ukraine, strengthen institutional and human capacities, and foster digitalisation, data governance, and innovation.

The Organisation for Economic Co-operation and Development (OECD) also plays a pivotal role. It developed and adopted the OECD Principles on Artificial Intelligence – the first intergovernmental document defining the ethical, legal, and governance framework for AI development and use. The OECD provides Ukraine with expert and methodological assistance in harmonising digital legislation and designing national AI strategies, particularly in the context of alignment with the EU AI Act.

The activities of UNESCO, USAID, and OECD are primarily directed towards supporting low- and middle-income countries, helping them bridge the technological divide through technology transfer, grant support, knowledge exchange, and professional development (Khan et al., 2024). For Ukraine, this support is of special significance, as it enhances both its scientific and technical potential and the alignment of its digital policy with international and European standards of responsible AI governance.

The international partners discussed above play a crucial role in shaping the contemporary system of AI governance in Ukraine. Their activities aim to:

- develop and implement ethical and legal standards for AI;
- strengthen the institutional and financial capacities for digitalisation and innovation;
- promote the harmonisation of Ukraine's national policies with international principles of responsible, human-centred AI, including the principles of transparency, accountability, sustainability, and non-discrimination.

Thus, it can be concluded that Ukraine's foreign policy and institutional trajectory in the field of artificial intelligence is consistently oriented toward the European model of ethical, responsible, and sustainable digital governance. This is evident both in the content of its legal acts and in the nature of its international partnerships. Such a direction of development provides further empirical confirmation of Hypothesis 3, indicating progressive normative and institutional convergence between Ukraine and the European Union's legal space in the field of AI regulation.

Based on the analysis of the legal status of state authorities, the business sector, academic and educational institutions, and international partners, it is appropriate to proceed to the systematisation of findings in the form of a SWOT analysis (Table 2). The SWOT matrix summarises the strengths and weaknesses, as well as the opportunities and threats for the development of Ukraine's national legal framework in the field of artificial intelligence. This, in turn, enables an assessment of the degree of its alignment with the principles and structure of regulation established by the EU AI Act.

The results of the conducted SWOT analysis indicate that Ukraine's legal system in the field of artificial intelligence regulation is in a stage of active formation, characterised by a combination of significant institutional potential and fragmented normative development.

Among the key strengths are the presence of strategic policy documents (notably, the Concept for the Development of Artificial Intelligence in Ukraine, 2020), a developed institutional infrastructure encompassing state bodies and academic institutions, as well as active participation in international initiatives and alignment with European approaches to ethical AI governance.

Table 2. SWOT Analysis of the Development of Artificial Intelligence Regulation in Ukraine in the Context of Convergence with the European Union Legal Framework.

STRENGTHS	WEAKNESSES
1. Existence of strategic and conceptual frameworks – the Concept for the Development of Artificial Intelligence in Ukraine (2020), as well as strategies for digital transformation and innovation development up to 2030, align with the goals of Digital Europe.	1. Fragmented regulatory framework – the absence of a comprehensive Artificial Intelligence Act; legal regulation remains dispersed across various legislative domains (innovation, science, information law, cybersecurity).
2. Institutional infrastructure – key public authorities such as the Cabinet of Ministers, the Ministry of Digital Transformation, the State Service for Special Communications and Information Protection, the Ministry of Economy and the Ministry of Defence play active roles in AI policy implementation.	2. Insufficient inter-agency coordination – no single national coordinating centre or agency for AI policy exists, which reduces policy coherence and governance efficiency.
3. Active participation in international initiatives and partnerships – cooperation with the EU, UNESCO, OECD, and USAID facilitates integration into global programmes on responsible and ethical AI.	3. Limited human and financial capacity – a shortage of highly qualified AI law and policy experts, and insufficient funding for research centres and higher education programmes.
4. Growing AI business ecosystem – development of IT companies, start-ups, technology parks, venture funds and clusters; active role of associations (AI House, IT Ukraine Association, UVCA) in promoting policy dialogue and ethical standards.	4. Undefined legal status of several actors – the roles and powers of non-governmental and private entities in AI governance remain legally uncertain.
5. Strong role of science and education – universities and academic institutes conduct AI research, design training programmes and establish dedicated AI research centres.	5. Insufficient implementation of ethical and legal principles – transparency, accountability and non-discrimination principles are not yet fully incorporated into national law.
6. Development of cybersecurity and data protection mechanisms – the State Service for Special Communications plays a crucial role, with Ukraine's participation in NATO's TIDE Sprint 2025 and the use of AI for cyber defence.	6. Weak enforcement mechanisms – despite existing conceptual frameworks, control, monitoring and liability mechanisms remain underdeveloped.
OPPORTUNITIES	**THREATS**
1. Harmonisation with the EU Artificial Intelligence Act (2024) – adoption of common risk-based regulatory principles, transparency, ESG and sustainability standards.	1. Geopolitical instability and ongoing military conflict – diversion of resources, infrastructure damage, and reduced investment in IT and AI sectors.
2. Deeper integration into the European digital ecosystem – participation in Digital Europe, Horizon Europe, and the European AI Alliance, enabling knowledge exchange and technology transfer.	2. Institutional inertia and bureaucratic resistance – slow legislative adaptation and reluctance to reform within public administration.
3. Expansion of international cooperation – access to grants, investments and technical assistance from the EU, OECD, USAID, and UNESCO.	3. Regulatory overlap risks – potential inconsistencies between national and EU legal norms, especially in cybersecurity and data protection.
4. Implementation of ESG and digital responsibility principles – advancing legal frameworks that incorporate sustainability, ethics and social inclusivity.	4. Uncertain legal status of certain policy documents and institutions – many strategies remain declarative, lacking concrete implementation mechanisms.
5. Creation of international research and technological clusters – integration of universities, start-ups and government institutions into transnational AI innovation networks.	5. Brain drain risks – migration of AI specialists and researchers abroad due to economic or security-related factors.
6. Digitalisation of public administration – using AI to enhance transparency, efficiency and accountability in public governance.	6. Insufficient data protection and ethical safeguards – risk of misuse of personal data and algorithmic bias in governance systems.

Source: developed by authors.

At the same time, the weaknesses reveal the absence of a comprehensive legislative framework, insufficient inter-agency coordination, and weak implementation mechanisms for ethical norms. These shortcomings substantially slow down the process of legal convergence with the European Union and underscore the need for institutional strengthening and systemic legislative integration.

The opportunities identified demonstrate that Ukraine possesses a wide potential for integration into the European digital ecosystem through participation in programmes such as Digital Europe and Horizon Europe, as well as through harmonisation with the EU AI Act (2024). The effective realisation of these opportunities would enhance the country's legal resilience, digital ethics, and innovation capacity, consolidating its position within the European framework of responsible technological governance.

The primary threats are associated with external political and economic factors – above all, the ongoing military conflict, institutional inertia, and human resource constraints. Nevertheless, the presence of international support, particularly from organisations such as the OECD, UNESCO, and USAID, mitigates some of these risks and contributes to maintaining Ukraine's Eurointegration trajectory.

Overall, the results of the SWOT analysis confirm Hypothesis 3, which posits that Ukraine's legal and institutional framework in the field of artificial intelligence demonstrates a steady trend toward normative and institutional convergence with the legislative system of the European Union. This convergence is manifested through the adaptation of strategic documents, participation in international partnerships, and the integration of ESG principles and ethical–legal mechanisms consistent with the requirements of the EU AI Act.

3.4 Synthesis of Findings and Confirmation of Research Hypotheses

The integrated application of bibliometric analysis, formal content analysis, and SWOT evaluation has provided comprehensive empirical evidence supporting all three hypotheses formulated within this study.

First, the results of the bibliometric analysis of interdisciplinary publications in the field of artificial intelligence and law have confirmed Hypothesis 1, demonstrating that scholarly activity in this domain indeed forms a cross-sectoral and multidimensional research field. The identified thematic clusters encompass such areas as data protection, medical law, labour relations, and public administration, reflecting the systemic and institutionally integrated nature of AI regulation in the European context.

Second, the findings of the formal content analysis of the European Union Artificial Intelligence Act (Regulation (EU) 2024/1689) have confirmed Hypothesis 2, revealing a clear integration of the United Nations Sustainable Development Goals (SDGs) into the normative architecture of this legal act. The AI Act institutionalises the principles of ethical, inclusive, and sustainable digital governance, aligning its regulatory mechanisms with the ESG paradigm and the global sustainable development agenda.

Third, the conducted SWOT analysis of Ukraine's legal and institutional environment has empirically confirmed Hypothesis 3, demonstrating the progressive convergence of the national AI regulatory system with the European model. The harmonisation of strategic, normative, and institutional components – from the Concept for the Development of Artificial Intelligence in Ukraine (2020) to digital transformation strategies and active cooperation with the EU, OECD, UNESCO, and USAID – provides evidence of Ukraine's consistent movement toward the principles and standards established in the EU AI Act.

Taken together, the results show that Ukraine's approach to AI governance and regulation is evolving in accordance with European norms of responsibility, transparency, and sustainability. This confirms that the national legal system is undergoing a process of normative and institutional alignment with the European model of ethical AI regulation.

Accordingly, all three research hypotheses have been fully validated, providing a robust empirical foundation for further analytical generalisation and the development of strategic policy recommendations aimed at improving Ukraine's national legal framework in line with European and global standards.

4. Discussion

The results of the conducted study confirm the interdisciplinary, normative–institutional, and strategic nature of the processes governing the development of artificial intelligence (AI) in the European Union and Ukraine. The analysis has revealed a sustained trend toward the convergence of legal systems, which is manifested not only in the formal adoption of regulatory approaches, but also in a deeper institutional integration of the principles of responsibility, transparency, and sustainability.

However, the confirmation of all three hypotheses does not preclude the need for a critical reflection on a number of factors that may exert a significant influence on the dynamics and interpretation of the results obtained.

4.1 Global and Technological Factors of Influence

The contemporary stage of artificial intelligence (AI) development is characterised not merely by the acceleration of computational processes, but by a qualitative transition toward new levels of interaction between computational systems and the physical and social world. The increasing speed of computation, approaching its physical limits, creates the preconditions for phenomena whose consequences cannot yet be fully assessed. Whereas in the mid-twentieth century computational velocity was measured in milliseconds, modern quantum and neuromorphic architectures are bringing us closer to regimes in which information processing occurs with near-instantaneous synchronisation–a speed of simultaneity comparable to the ultimate physical constants.

This opens unprecedented prospects, yet simultaneously calls into question the applicability of many existing principles of digital and legal regulation. The concepts of responsibility, causality, and predictability of algorithmic decisions–traditionally forming the foundations of legal systems–may require radical reconsideration. A situation is emerging in which the speed of AI-driven decision-making surpasses human capacities for control and interpretation, producing an "institutional temporal gap" between action and legal response.

At the same time, there is a growing scale and impact of malicious operations employing AI–including cyberattacks, manipulative media campaigns, and harmful software designed to destabilise social systems or undermine critical infrastructure. Contemporary AI tools can generate highly realistic fabrications, falsify data, simulate personal profiles, and even mimic managerial decisions, thereby necessitating not only technical but also legal countermeasures. Hence, the regulation of AI extends beyond the boundaries of national legal orders and becomes an element of global human security.

Under these conditions, the importance of ethical and legal oversight is significantly amplified. Traditional control mechanisms–expert evaluation, certification, and audit–must evolve into dynamic systems of monitoring and legal adaptation capable of responding in real time. This transformation implies the integration of cybersecurity, law, and the philosophy of science into a unified interdisciplinary framework.

4.2 Reconceptualisation of the Principles of AI Governance

The fundamental legal principles currently in force – transparency, accountability, respect for human rights, and non-discrimination – emerged in an era when technologies were linear, deterministic, and manageable. However, the transition to systems based on deep learning, self-learning, and quantum computation is transforming the very nature of controllability.

This shift generates the need for a new generation of digital-law principles, capable of accounting not only for causal relationships, but also for probabilistic, stochastic, and systemic interdependencies. Among such emerging principles, the following may be identified:

- the principle of probabilistic accountability, which recognises the statistical degree of AI participation in decision-making;
- the principle of cognitive symmetry, requiring that humans and machines be afforded comparable capacities to comprehend the logic of algorithmic actions;
- the principle of systemic adaptability, obliging the legal system to evolve in synchrony with technological advancement.

Such a transformation of the legal foundations necessitates a reconsideration of existing instruments, including the EU Artificial Intelligence Act, which may require further expansion to encompass the regulation of quantum computing, generative models, and autonomous systems. Consequently, any assertion of stability within the European regulatory model must be understood in the context of its inherent dynamic evolution.

4.3 Ethical and Civilisational Dimensions

Artificial intelligence is becoming not merely an instrument, but an element of an emerging anthropo-technological synthesis, in which the boundary between human and machine is progressively blurred. This convergence gives rise to profound philosophical and legal dilemmas concerning personhood, identity, and accountability. Questions regarding the rights of AI and its status as a subject or object of law remain unresolved and continue to challenge the conceptual limits of contemporary jurisprudence.

Amid the rapid development of autonomous systems, there arises a pressing need for meta-legal mechanisms–frameworks capable of regulating not only the application but also the very feasibility of creating certain categories of technologies. This issue becomes particularly acute in the military domain, where the integration of AI into weapons control systems raises the spectre of losing human oversight over decisions that directly concern life and death.

These challenges are further exacerbated by geopolitical instability, economic polarisation, and informational vulnerability. Taken together, these dynamics create the preconditions for the emergence of a new ethical contract of humanity–one that must delineate the boundaries of the permissible in the use and creation of artificial intelligence.

4.4 The Impact of Global Factors on the Interpretation of Results

The confirmation of all three research hypotheses must be interpreted through the lens of broader global contexts, encompassing:

- the military-political dimension, reflecting the role of AI in ensuring security and maintaining strategic balance;
- the technological dimension, associated with the quantum leap in computational capacity;
- the economic and ecological dimension, expressing the impact of digitalisation on sustainable development.

Each of these factors has the potential to reshape the interpretation of empirical findings. For instance, the dynamics of Ukraine's convergence with the European Union in the legal regulation of AI may accelerate not solely as a result of institutional European integration, but also under the pressure of military exigencies and technological imperatives.

Moreover, the ongoing processes of global standardisation, led by the European Union, the United States, and China, may give rise to asymmetric harmonisation, in which partner countries are compelled to adapt their legislation at a faster pace than their internal institutional capacities can sustain. This creates the risk of formal rather than substantive convergence, where harmonisation is reduced to the replication of norms without a genuine integration of ethical and value-based foundations.

4.5 Research Limitations

Despite the comprehensive and multi-layered design of this study, several limitations must be acknowledged. First, the bibliometric data are inherently dependent on the coverage and structure of the Scopus database, which may introduce a selection bias favouring English-language publications and Western research institutions. Second, the formal content analysis of the EU Artificial Intelligence Act (AI Act) is confined to a textual comparison and does not encompass the broader interpretative corpus emerging from European judicial and administrative practice. Third, the SWOT analysis of Ukraine's legal system reflects the state of affairs as of 2025, whereas regulatory developments are evolving rapidly, which may affect the short-term validity of some conclusions. Fourth, the study does not consider informal and non-institutional mechanisms of regulation, such as sectoral agreements, corporate ethics codes, and self-regulatory protocols, which also play a growing role in shaping the practical governance of artificial intelligence.

4.6 Prospects for Further Research

Future research may be directed towards several key areas:

- the development of a predictive legal methodology capable of anticipating the consequences of technological innovation before their materialisation;

- the analysis of legal regimes governing quantum AI and the unique risks associated with such systems;
- the formulation of ethical standards for generative models and autonomous systems;
- a comparative examination of national AI regulatory strategies across Asia, Europe, and North America;
- the study of AI's influence on the transformation of the very concepts of sovereignty and public governance.

Thus, the discussion confirms that the regulation of artificial intelligence requires not merely an update of existing legal frameworks, but a reconsideration of the fundamental principles of law in light of new physical and technological realities. Contemporary challenges – ranging from quantum acceleration of computation to ethical threats posed by AI-enabled sabotage – call for a comprehensive and interdisciplinary response, uniting international law, science, and philosophy.

At the same time, the present study demonstrates that Ukraine is advancing towards normative and institutional convergence with the European Union, while the broader global processes of digitalisation and computational expansion are shaping new horizons for legal evolution and the future architecture of technological governance.

Conclusions

The present study has undertaken a systematic analysis of the legal and institutional mechanisms governing the development of artificial intelligence (AI) in the European Union and Ukraine, viewed through the lens of the global sustainable development agenda.

By employing a triangulated methodological framework – combining PRISMA-based bibliometric analysis, formal content analysis, and SWOT assessment – the research achieved a multidimensional perspective that enabled the empirical confirmation of all three proposed hypotheses.

Firstly, the bibliometric analysis empirically confirmed the interdisciplinary nature of AI and law research. The formation of four stable clusters – AI Law, Ethics and Governance; Social and Environmental Dimensions of AI; Medicine and Bioethics; and Public Administration and Security – demonstrates the institutionalisation of AI law as an independent field of inquiry. This finding validates Hypothesis 1, showing that the regulation of artificial intelligence in the European context is complex and cross-sectoral, encompassing legal, ethical, managerial, and technological dimensions.

Secondly, the results of the formal content analysis confirmed the structural integration of the United Nations Sustainable Development Goals (SDGs) into the architecture of the AI Act (Regulation (EU) 2024/1689). The provisions of the Act correlate directly or indirectly with SDGs 4, 8, 9, 12, 13, 16, and 17, reflecting the transformation of the European regulatory model towards sustainable, ethical, and accountable governance. The European Union thereby advances a unique normative paradigm in which digital regulation is conceived not as a constraint, but as an instrument for promoting ESG principles, digital inclusion, and social justice. This fully confirms Hypothesis 2.

Thirdly, the SWOT analysis of Ukraine's legal and institutional framework revealed consistent signs of normative and managerial convergence with the European Union. Among the key strengths are the existence of strategic documents, a developed institutional infrastructure, and participation in international initiatives. Weaknesses include the fragmentation of legislation and insufficient inter-agency coordination. Nevertheless, significant opportunities arise through harmonisation with the AI Act, deeper integration into EU digital programmes, and the creation of joint research clusters. Despite threats posed by ongoing war and institutional inertia, Ukraine's strategic trajectory of legal transformation remains aligned with the European course. These findings confirm Hypothesis 3, affirming the progressive convergence of Ukrainian and European legal systems in the field of AI regulation.

The empirical results are further substantiated by the institutional architecture established in Ukraine to manage AI development. Governance in this domain emerges as the outcome of coordinated interaction among multiple actors at national and international levels.

At the national level, key roles are played by governmental bodies responsible for digitalisation and innovation policy, which design strategic frameworks and legislative instruments defining the direction of AI deployment.

The business sector acts as the main driver of technological progress, investing in research, development, and implementation of AI solutions, while fostering employment and digital competence.

Civil society, academic, and educational institutions provide research, ethical, and educational support, preparing skilled professionals and shaping standards for responsible AI use.

Meanwhile, international organisations and partners – including UNESCO, USAID, and the OECD – provide financial, technical, and institutional assistance, facilitating the harmonisation of standards and integration of Ukraine into the global ecosystem of ethical and sustainable AI.

The interaction among these actors constitutes an integrated governance ecosystem, combining legal, ethical, and innovation mechanisms that ensure the sustainable development of AI technologies in Ukraine.

Taken together, the findings demonstrate that the regulation of artificial intelligence transcends a narrow legal discourse and has become a central element in the transformation of public governance, economic systems, and international law. Processes of digitalisation and global integration intensify the need for a new governance paradigm – one that is adaptive, interdisciplinary, and grounded in the principles of sustainability and accountability.

The scientific novelty of this research lies in the development of a comprehensive model of legal analysis that integrates quantitative (bibliometric) and qualitative (content and SWOT) methods. It also reveals that the AI Act serves not only as a regulatory instrument but as a structural component of the European digital architecture, aligned with the goals of sustainable development.

The practical significance of the findings lies in their applicability for drafting Ukraine's national AI regulation strategy, preparing legislative proposals harmonised with EU law, and designing institutional mechanisms for managing digital transformation.

Future research perspectives include the development of a predictive legal framework capable of anticipating the effects of technological innovation; the exploration of quantum AI and its associated legal risks; the establishment of ethical standards for generative and autonomous systems; comparative analysis of national AI governance strategies across Asia, Europe, and North America; and examination of AI's impact on the evolution of sovereignty and public governance.

In conclusion, the formation of an effective system for AI governance requires not only the refinement of legal instruments but also the reconsideration of the philosophical and civilisational foundations of human–technology interaction.

Contemporary challenges – from the quantum acceleration of computation to the ethical risks of AI-enabled sabotage – demand the concerted efforts of law, science, and international institutions to shape a sustainable and secure future for the digital civilisation.

Author Contributions: Conceptualization, A.K.; methodology, A.K.; software, A.K.; validation, A.K. and O.N.R.; formal analysis, A.K. and O.N.R.; investigation, A.K. and O.N.R.; resources, A.K. and O.N.R.; data curation, A.K. and O.N.R.; writing-original draft preparation, A.K. and O.N.R.; writing-review and editing, A.K.; visualization, A.K.; supervision, A.K.; project administration, A.K.; funding acquisition, A.K. All authors have read and agreed to the published version of the manuscript.

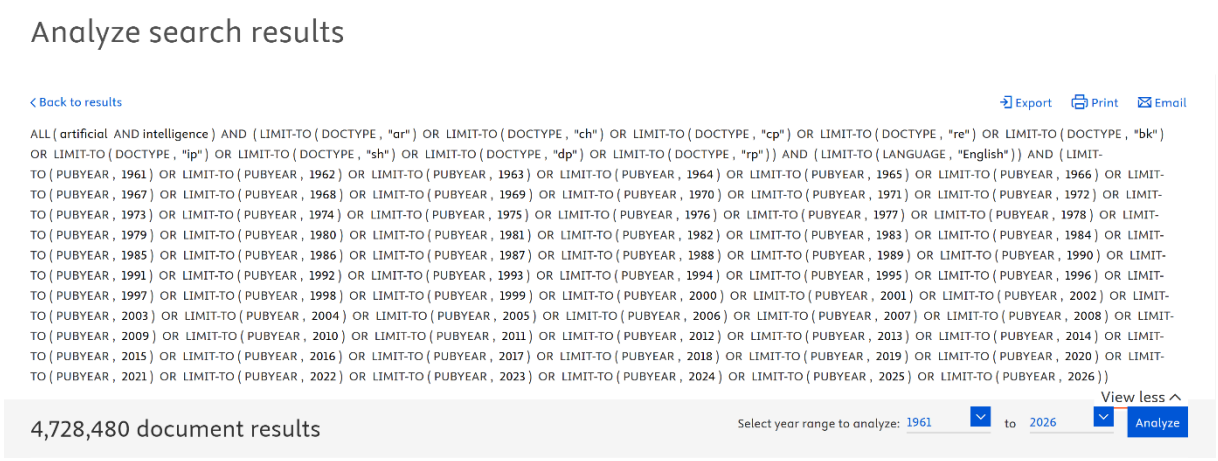
Funding: The authors declare that no funding was received for the conduct of this research or the preparation of this article.

Data Availability Statement: All datasets and materials employed in the analytical and computational processes of this study are obtained from publicly accessible sources. Comprehensive references and hyperlinks to the original materials are provided within the manuscript to ensure full transparency and facilitate reproducibility. The data supporting the findings of this research are also available from the corresponding author upon reasonable request.

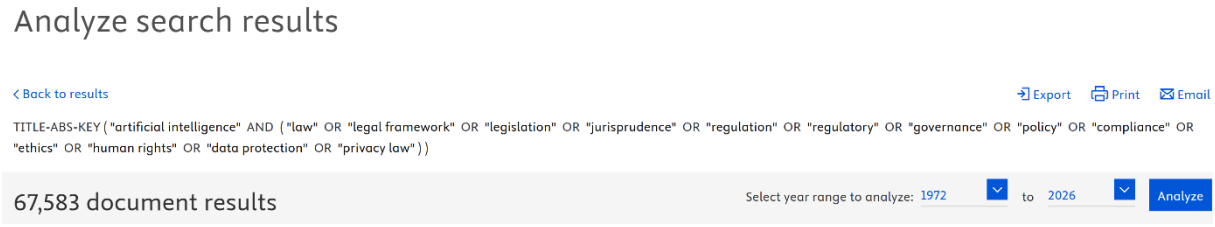
Acknowledgements: The authors would like to express their sincere gratitude to the reviewers, the academic editor, and the editorial team for their valuable comments and constructive recommendations, which have significantly contributed to improving the quality and clarity of this work.

Conflicts of Interest: The authors affirm no conflict of interest.

Appendix A

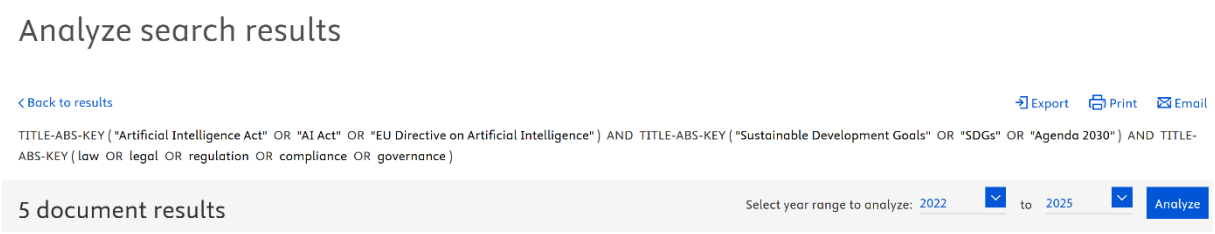


Appendix B

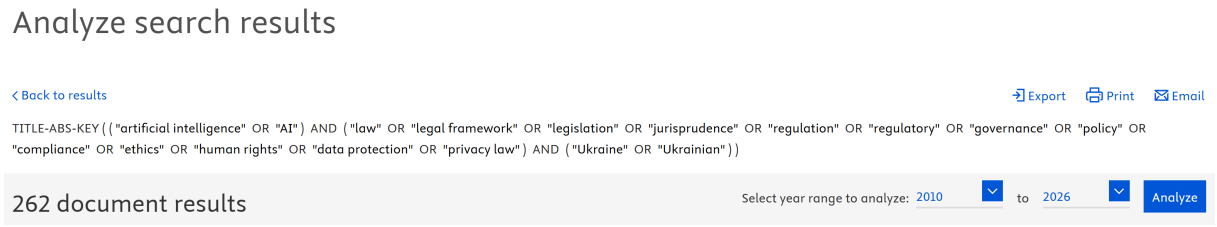


Appendix C

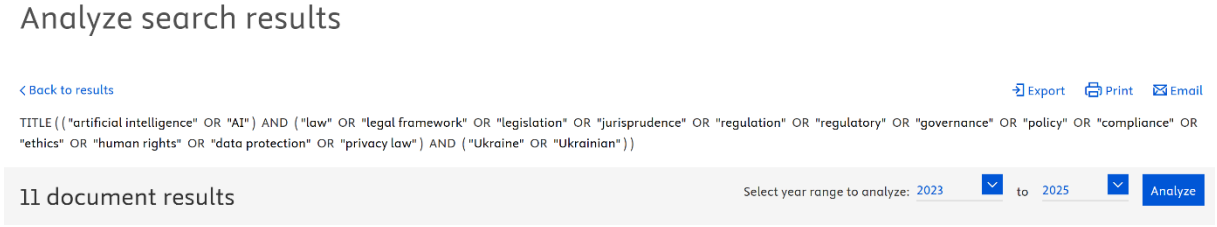
Appendix D



Appendix E



Appendix F



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