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Review

Institutional Evolution of Virtual Space under the Development of Artificial Intelligence and the Metaverse

Nataliya Dalevska, and Valentyna Khobta

Abstract. The rapid development of digital technologies, artificial intelligence, and immersive virtual space has significantly transformed socio-economic interactions in the digital economy. Virtual space increasingly functions not only as technological infrastructure but also as an emerging institutional environment in which economic, social, and informational interactions are coordinated through digital platforms and algorithmic systems. Although previous studies have examined digital transformation, artificial intelligence, and virtual space, the institutional mechanisms underlying the evolution of virtual space remain insufficiently explored, particularly regarding how technological innovations contribute to the formation of digital institutions and governance mechanisms within virtual ecosystems. The aim of this study is to analyse the institutional evolution of virtual space in the context of the development of artificial intelligence and metaverse technologies. The research is based on a bibliometric analysis of scientific publications indexed in the Scopus database. Bibliometric mapping and co-occurrence analysis using VOSviewer were applied to identify key thematic clusters and research trends related to institutional aspects of virtual space, while institutional and systemic analysis was used to interpret relationships between technological innovation and institutional evolution. The results reveal the emergence of an interdisciplinary research field linking digital technologies, virtual space, and institutional economics. Bibliometric mapping highlights central research themes related to virtual reality, artificial intelligence, digital environments, and social institutions. Based on the analysis, a conceptual algorithm of institutional evolution in virtual space is proposed, illustrating the transition from technological drivers and digital platforms to algorithmic governance and the emergence of digital institutions. The findings indicate that artificial intelligence and metaverse technologies contribute to the formation of platform, algorithmic, and network institutions regulating interactions within digital ecosystems. The study is limited by the use of bibliometric data from a single database and by the conceptual nature of the proposed model, highlighting the need for further empirical research on digital institutions and virtual economic space.

Keywords: artificial intelligence, metaverse, virtual space, digital institutions, platform economy, institutional evolution.

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1. Introduction

At the beginning of the twenty-first century, the global economy and social systems entered a period of profound transformation associated with the rapid development of digital technologies and the emergence of new models of interaction between individuals, organisations and technological systems. In the academic literature, this stage of societal development is interpreted through several theoretical frameworks describing similar processes of structural technological and socio-economic transformation. Among the most frequently discussed are the concepts of the Fourth Industrial Revolution (Industry 4.0), the post-industrial society, the digital economy and the theory of long waves of economic development. Within the latter, particular attention is given to the concept proposed by Nikolai Kondratiev [1], according to which the development of the global economy occurs through successive technological cycles accompanied by shifts in technological paradigms and institutional structures. Contemporary research increasingly associates the current stage of development with the emergence of a new technological paradigm based on digital technologies, big data processing systems, artificial intelligence and network communications.

A distinctive feature of the current stage of technological development is the exponential growth of digital capabilities and the accelerated diffusion of digital technologies across various spheres of social life. In this context, the development of Artificial Intelligence technologies plays a particularly significant role [2], gradually becoming one of the key drivers of transformations in economic, social and institutional systems. Artificial intelligence systems enable the automation of decision-making processes, the analysis of large volumes of data, the creation of new governance and regulatory mechanisms, and the development of fundamentally new forms of interaction among economic actors. At the same time, the advancement of digital technologies contributes to the emergence of new types of digital environments in which social and economic interactions occur.

One of the most significant directions in the development of the digital environment is the emergence of so-called metaverses, representing complex digital spaces that integrate virtual space, social interactions, digital markets and various forms of economic activity by users. The concept of the Metaverse involves the creation of integrated virtual ecosystems in which users can interact with one another, engage in economic activities, create and exchange digital assets, and participate in shaping new social and economic structures [3]. In contrast to traditional Internet platforms, metaverses are characterised by a higher level of immersion, the integration of multiple digital technologies and the formation of complex digital ecosystems.

The combined processes of digitalisation, the development of artificial intelligence and the emergence of metaverses give rise to a new environment of interaction that can be described as virtual space. In the academic literature, virtual space is considered a socio-digital environment in which interactions between economic agents are mediated through network technologies, digital platforms and algorithmic systems. Within this environment, new forms of economic activity, digital markets, network communities and platform ecosystems are emerging. At the same time, virtual space is characterised by several distinctive features that differentiate it from traditional economic and social systems. These include the global scope of interactions, the absence of territorial boundaries, the rapid transformation of socio-economic processes and the significant role of algorithmic mechanisms of governance and regulation.

The development of virtual space is accompanied by the emergence of new institutional structures regulating interactions among participants in the digital environment. Within the framework of institutional economic theory, institutions are understood as stable systems of rules, norms and regulatory mechanisms that determine the nature of socio-economic interactions. However, in the context of digital technologies and virtual space, new types of institutions are emerging that may be formed not only through traditional social or governmental mechanisms but also through digital platforms, algorithms and automated governance systems. Consequently, it is possible to speak of the formation of specific institutional structures within virtual space characterised by new principles of functioning, high adaptability and flexible regulatory mechanisms.

Despite the growing body of research devoted to the digital economy, artificial intelligence and virtual space, the institutional evolution of virtual space remains relatively underexplored. A considerable share of existing studies focuses on technological aspects of digital platforms, the economic effects of digitalisation or the social dimensions of virtual communities. However, the institutional characteristics of the formation and functioning of virtual space, as well as the influence of artificial intelligence and metaverse technologies on the transformation of the institutional structure of the digital environment, have received comparatively limited scholarly attention. This is partly explained by the novelty of the phenomena under consideration and the rapid pace of technological change.

In this context, there is a clear need for a systematic analysis of existing research on the institutional aspects of virtual space and for identifying the key directions in the development of this emerging field of knowledge. Accordingly, the present study conducts a bibliometric analysis of scientific publications related to institutionalism in virtual space, the development of artificial intelligence and the emergence of metaverse ecosystems using scientific data visualisation tools.

The remainder of this article is organised as follows. The next section presents a review of the literature on institutional theory, digital environments and virtual economic systems and identifies existing research gaps. The subsequent section describes the data and research methodology, including the procedures used to construct the publication dataset and the methods applied in the bibliometric analysis. The results section presents the main findings of the bibliometric mapping and identifies the principal thematic clusters within the research field. The discussion section interprets the results within the framework of institutional theory and contemporary processes of digital transformation. Finally, the conclusion summarises the main findings of the study and outlines directions for future research in this area.

2. Literature Review

The development of digital technologies, virtual space and artificial intelligence systems has led to the emergence of a new research direction focused on the institutional aspects of the functioning of digital space. In order to analyse existing scientific approaches to the study of the institutional structure of virtual space, a search for relevant publications was conducted using the Scopus database [4]. This database is one of the largest international bibliographic platforms indexing scholarly publications across various fields of knowledge, including

economics, social sciences, computer science and interdisciplinary research on digital technologies.

To construct the publication dataset, a search query based on key concepts of institutional theory and virtual space was used:

TITLE-ABS-KEY ((institutionalism OR "institutional economics" OR "institutional theory" OR institutions OR institutionalisation) AND ("virtual space" OR "virtual space" OR "virtual economy" OR "digital environment" OR cyberspace)).

This query identified 2,671 publications addressing issues of institutional analysis within digital or virtual space. The use of multiple synonymous terms in the first part of the query reflects the diversity of terminology used in institutional theory. In the academic literature, concepts such as institutionalism, institutional economics, institutional theory, institutions and institutionalisation are employed to describe different dimensions of institutional analysis, ranging from the theoretical foundations of institutional economics to processes of institutional formation and evolution. Including these terms in the search query makes it possible to capture a broader range of studies addressing institutional issues.

The second group of keywords relates to the characteristics of the digital interaction environment. The inclusion of terms such as virtual space, virtual space, virtual economy, digital environment and cyberspace reflects the absence of a unified terminology describing digital environments. Different researchers use different concepts to characterise digital spaces, including virtual space, digital ecosystems and cyberspace. The inclusion of several synonymous terms reduces the risk of overlooking relevant publications.

In order to provide a more focused analysis of studies addressing contemporary technological transformations in virtual space, the search query was further refined by including terms related to the development of artificial intelligence:

TITLE-ABS-KEY (institutionalism OR "institutional economics" OR "institutional theory" OR institutions OR institutionalisation) AND ("virtual space" OR "virtual environment" OR "virtual economy" OR "digital space" OR "digital environment" OR cyberspace OR "online environment") AND ("artificial intelligence" OR AI OR "machine learning" OR "intelligent systems" OR algorithms OR "algorithmic governance").

The application of this refined query resulted in the identification of 330 publications. The substantial reduction in the number of publications compared with the initial query can be explained by the inclusion of the third block of keywords, which restricts the dataset to studies that simultaneously address institutional aspects of virtual space and the impact of artificial intelligence technologies. This indicates that research integrating institutional theory with the analysis of artificial intelligence in virtual space remains relatively limited compared with the broader body of literature on institutionalism and digital environments.

To further refine the analysis, an even more specific search query was applied by introducing an additional block of terms related to the development of metaverses:

TITLE-ABS-KEY ((institutionalism OR "institutional economics" OR "institutional theory" OR institutions OR institutionalisation OR "institutional framework") AND ("virtual space" OR "virtual space" OR "virtual economy" OR "digital space" OR "digital environment" OR cyberspace OR "online environment") AND ("artificial intelligence" OR AI OR "machine learning" OR "intelligent systems" OR algorithms OR "algorithmic governance") AND (metaverse OR "virtual worlds" OR "digital worlds" OR "immersive environments")).

The results of this search revealed only 32 publications. Such a significant reduction in the number of studies can be explained by several factors. First, the concept of the metaverse represents a relatively recent scientific and technological paradigm that has gained prominence in academic and technological literature only in recent years. Second, studies integrating institutional theory, virtual space, artificial intelligence and metaverse technologies remain at an early stage of development and are currently represented by a limited number of academic publications. These findings therefore confirm the existence of a research gap in analysing the institutional evolution of virtual space in the context of the development of artificial intelligence and metaverse technologies.

Among the most cited studies addressing the development of virtual space and the institutional mechanisms of digital environments is the work of Yang et al. [5], which examines the concept of geospatial cyberinfrastructure. The authors describe cyberinfrastructure as a comprehensive system integrating information resources, network protocols, computing platforms and analytical tools for data processing. Within this framework, virtual space is viewed as an integrated digital environment combining various data sources and technological tools for scientific research and information analysis. Particular attention is given to the role of network technologies, cloud computing and distributed computing systems in the development of new infrastructures for scientific research. Although this study does not directly address institutional aspects of virtual space, it provides an important theoretical foundation for understanding the technological infrastructure of virtual space within which new institutional structures subsequently emerge.

One of the fundamental studies on institutional aspects of virtual space is the work of Johnson and Post [6], which analyses the formation of legal institutions in cyberspace. The authors argue that traditional legal systems based on territorial principles of regulation are insufficient for governing relations in virtual space. Unlike physical space, the boundaries of cyberspace are determined not by geographical factors but by technological mechanisms such as network protocols, digital identifiers and access control systems. Consequently, Johnson and Post emphasise the need to develop new legal and institutional mechanisms capable of regulating interactions in virtual space. This study was among the first to conceptualise cyberspace as an autonomous institutional environment requiring the creation of new regulatory frameworks.

More recent studies increasingly analyse virtual space in the context of the development of metaverse technologies. For example, Barbereau [7] examines different approaches to defining the concept of the metaverse and identifies three key components of this digital environment: users, technological solutions and the infrastructure of digital markets. The author emphasises that the development of the metaverse is driven not only by technological innovation but also by the formation of new economic and institutional structures. Within this perspective, the metaverse is interpreted as a complex digital ecosystem integrating virtual user identities,

extended reality platforms and digital markets that facilitate economic interactions within virtual space.

Institutional aspects of metaverses are also examined in the study by Wu and Hao [8], which focuses on the concept of the educational metaverse. The authors analyse the architecture of digital educational environments and the potential application of virtual and augmented reality technologies in educational systems. Within this framework, the metaverse is described as an integrated digital platform that combines educational resources, digital tools and user interaction mechanisms. The study demonstrates that the development of metaverses contributes to the emergence of new institutional models for organising educational processes based on digital platforms and network-based forms of interaction.

From the perspective of institutional theory, the research conducted by Zhukova and Mordous [9] is also of particular interest. Their study examines institutional changes in the education system resulting from the virtualisation of educational environments. The authors argue that the digital transformation of education leads to the emergence of new institutional mechanisms regulating educational processes. The use of virtual platforms and digital learning technologies results not only in technological changes but also in transformations of organisational, managerial and value-based structures within educational institutions. This research highlights the need for further institutional analysis of processes associated with the virtualisation of social systems.

The analysis of the existing literature indicates that most studies focus primarily on individual aspects of digital transformation, including technological infrastructures of virtual space, legal regulation of cyberspace and the development of specific types of digital platforms. Comprehensive studies integrating institutional theory, virtual space analysis, artificial intelligence and metaverse concepts remain relatively limited. In particular, the institutional evolution of virtual space and the transformation of regulatory mechanisms governing interactions within digital ecosystems remain insufficiently explored.

In this context, the aim of the present study is to identify the key features of the institutional evolution of virtual space in the context of the development of artificial intelligence and metaverse technologies based on a bibliometric analysis of scientific publications indexed in the Scopus database. The analysis employs visualisation tools for scientific networks implemented in the VOSviewer software [10].

H1: The development of artificial intelligence and metaverse technologies accelerates the institutional evolution of virtual space by facilitating the emergence of algorithmic governance mechanisms, platform institutions and new forms of digital interaction.

3. Data and Methods

3.1. Data Collection

To analyse the institutional evolution of virtual space in the context of the development of artificial intelligence and metaverse technologies, the international bibliographic database Scopus was used as the primary source of scientific data. The selection of this database is justified by its high level of representativeness and its extensive coverage of scholarly

publications across various scientific disciplines. The publication dataset was constructed using a search query that included key terms related to institutional theory and virtual space.

The search results indicated that 2,671 scientific publications were identified in the database based on the specified query. The resulting dataset reflects a considerable level of scholarly interest in the study of institutional aspects of digital environments. At the same time, an analysis of the publication structure shows that the majority of studies focus on individual aspects of institutional economics, digital transformation and the development of Internet platforms, while research integrating institutional analysis, virtual space and emerging technological phenomena remains relatively limited.

To enhance the systematic nature and reproducibility of the research, the process of constructing the publication dataset was organised in accordance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework [11], which is widely applied in systematic literature reviews and bibliometric studies. This framework provides a structured approach to the stages of searching, selecting and analysing scientific publications, thereby increasing the transparency and reproducibility of the research procedure. The application of the PRISMA methodology enables the systematic organisation of the dataset construction process, beginning with the identification of publications in the database and concluding with the formation of the final dataset for subsequent analysis. A schematic representation of the publication selection procedure in accordance with the PRISMA framework is presented in Figure 1.

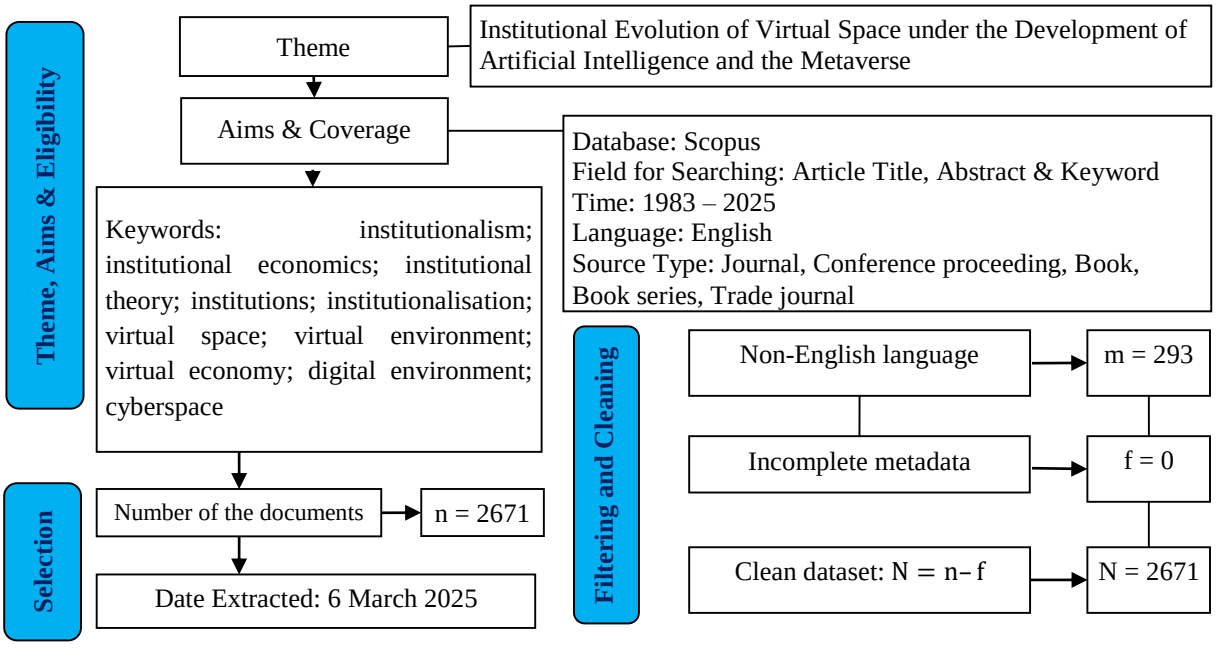

Figure 1. PRISMA Flow Diagram Illustrating the Process of Identification and Selection of Studies.
Source: Authors' Elaboration Based on the PRISMA 2020 Statement.

3.2. Bibliometric Analysis

To analyse the structure of scientific research devoted to the institutional aspects of virtual space, bibliometric analysis methods were employed. Bibliometric analysis represents a set of quantitative techniques for examining scientific literature aimed at identifying patterns in the development of research fields, the structure of scientific relationships and the dynamics of emerging research clusters.

One of the most widely used tools in bibliometric analysis is the VOSviewer software. This software enables the visualisation of scientific relationships between publications, authors, keywords and research areas. The application of VOSviewer makes it possible to identify thematic clusters of research, analyse the structure of scientific communities and determine the main directions of development within a particular field of study.

In the present study, VOSviewer was applied to analyse keywords and thematic relationships between scientific publications. The primary analytical method used was co-occurrence analysis, which identifies relationships between keywords based on the frequency with which they appear together in scientific publications. This method is widely employed in bibliometric research to determine the structure of research domains and to identify thematic clusters.

The co-occurrence analysis method is based on the assumption that keywords frequently appearing together in scientific publications represent related research themes. Visualising such relationships allows the identification of major thematic areas of scientific research and facilitates the analysis of the structure of the research field.

During the analysis, keywords extracted from the publications were grouped into thematic clusters using network analysis algorithms implemented in the VOSviewer software. Each cluster represents a particular research direction and is characterised by a high degree of interconnection among the keywords included within it.

3.3. Analytical Approach

In addition to bibliometric analysis, the study employed methods of systems analysis and institutional analysis. The systems approach makes it possible to conceptualise virtual space as a complex socio-technological system comprising multiple levels of interaction between technological infrastructures, digital platforms and socio-economic institutions.

Institutional analysis is applied to identify the mechanisms underlying the formation and evolution of institutions within virtual space. Within the framework of institutional theory, institutions are understood as stable systems of rules, norms and regulatory mechanisms that shape the nature of socio-economic interactions. The application of institutional analysis makes it possible to identify the characteristics of emerging types of institutions within digital environments, including platform-based institutions, algorithmic governance mechanisms and digital forms of coordination and control.

In addition, the study employs methods of logical and comparative analysis. Logical analysis was used to interpret the results of bibliometric mapping and to identify patterns in the

formation of research directions. Comparative analysis enabled the findings of the bibliometric study to be examined in relation to existing theoretical approaches in institutional economics and research on digital platforms.

The combined application of bibliometric methods, systems analysis and an institutional approach provides a more comprehensive understanding of the structure of scientific research devoted to the institutional evolution of virtual space. This methodological framework allows the identification of key research directions as well as the analysis of relationships between technological developments and institutional evolution within digital environments.

The results of the bibliometric analysis and the mapping of scientific publications provide a basis for examining the structure of the research field and identifying the principal thematic clusters that reflect different directions in the study of institutional aspects of virtual space.

4. Results

The results of the study are presented in three sequential analytical stages aimed at identifying the structure of scientific research devoted to the institutional evolution of virtual space and interpreting its transformation under the influence of artificial intelligence and metaverse technologies.

The first stage involved a bibliometric analysis of scientific publications indexed in the Scopus database using the VOSviewer software. The primary objective of this stage was to identify the structure of the research field, the relationships between key concepts and the formation of thematic clusters within the scientific literature related to virtual space, artificial intelligence and institutional processes. The visualisation of the keyword co-occurrence network makes it possible to determine the dominant research directions and the conceptual structure of the analysed field.

The second stage of the analysis focuses on the development of an analytical model explaining the acceleration of the institutional evolution of virtual space. Based on the results of the bibliometric mapping, an algorithmic model of institutional evolution is proposed, demonstrating how technological innovations — particularly artificial intelligence and immersive digital environments — contribute to the emergence of new institutional forms, governance mechanisms and socio-economic interactions.

The third stage of the analysis is aimed at the empirical interpretation of the results in relation to the verification of the proposed hypothesis that the development of artificial intelligence and metaverse technologies acts as a factor driving the institutional evolution of virtual space. The interpretation of bibliometric clusters and thematic relationships makes it possible to identify the emergence of new institutional mechanisms, including algorithmic forms of governance, platform-based institutional structures and new forms of socio-economic interaction within the digital environment.

4.1. Bibliometric Mapping of Research on the Institutional Evolution of Virtual Space

Bibliometric mapping of scientific publications devoted to the institutional aspects of virtual space was conducted using the keyword co-occurrence analysis method implemented in the VOSviewer software. The results of the visualisation of the scientific network are presented in Figure 2.

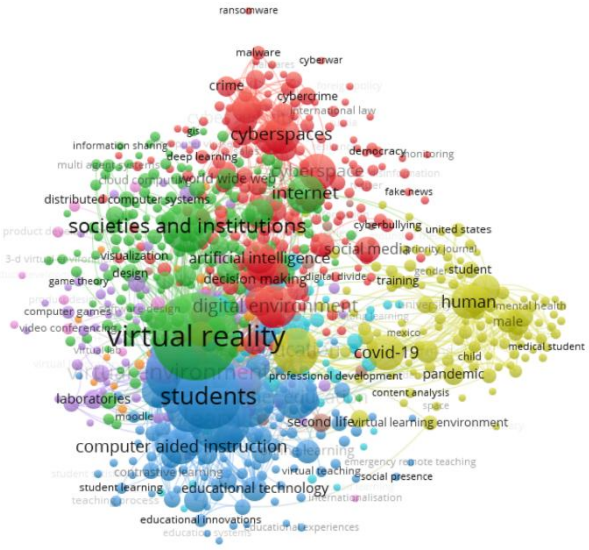

Figure 2. Network Visualization of Keyword Co-Occurrence in Research on the Institutional Evolution of Virtual Space.
Source: Authors' Elaboration Based on Scopus Data Using VOSviewer.

This map reflects the structure of the research field emerging at the intersection of studies on virtual space, artificial intelligence, digital platforms and institutional processes. The size of the nodes corresponds to the frequency of the occurrence of particular keywords in scientific publications, while the distance between them represents the degree of conceptual proximity between research topics. Colour differentiation makes it possible to identify several thematic clusters representing the main directions of scientific development.

Analysis of the network indicates that concepts such as virtual reality, cyberspace, students, societies and institutions, digital environment and artificial intelligence occupy central positions within the structure of scientific relationships. This suggests that research on virtual space is developing at the intersection of technological, social and institutional research domains. The strong concentration of keywords related to virtual reality and digital environments indicates the active formation of a research field focused on digital spaces as a new environment for socio-economic interaction.

A distinct cluster of research emerges around the concept of cyberspace, combining terms associated with security and regulatory issues within digital environments, including cybercrime, malware, ransomware, cyberwar, fake news and cyberbullying. The presence of these terms within the research network indicates significant academic attention to the institutional and legal aspects of cyberspace, as well as to issues of digital security and the regulation of information flows in network environments. This cluster reflects a research

direction associated with the development of institutional mechanisms for governing digital space and emerging forms of digital governance.

Another important research cluster relates to the development of virtual reality technologies and digital environments. At its centre lies the concept of virtual reality, around which several keywords are grouped, including digital environment, artificial intelligence, decision making, deep learning, information sharing and distributed computer systems. This cluster reflects the technological dimension of research related to the development of virtual platforms, algorithmic systems for information processing and intelligent data analysis technologies. The presence of terms associated with artificial intelligence and machine learning highlights the increasing role of algorithmic technologies in shaping the structure of virtual space.

A significant part of the research field is represented by a cluster associated with educational applications of virtual space. Central keywords within this cluster include students, computer aided instruction, educational technology, virtual learning environments and distance learning. The high concentration of terms related to educational technologies indicates the extensive use of virtual space and digital platforms within educational systems. This cluster demonstrates that education represents one of the most actively developing areas for the application of virtual technologies and artificial intelligence systems.

In addition, a cluster associated with the social dimensions of digital environments can be identified within the research structure. This cluster includes terms such as human, male, female, child, as well as keywords related to the COVID-19 pandemic. The presence of these terms reflects the influence of the pandemic on accelerating digitalisation processes and increasing interest in virtual forms of interaction. During the period of global restrictions, digital platforms and virtual space became essential tools for maintaining social, educational and economic activities, which is reflected in the growth of scientific publications addressing these topics.

Overall, the results of the bibliometric analysis demonstrate the strongly interdisciplinary nature of research on virtual space. Scientific publications integrate approaches from information technology, social sciences, economics, education and studies of digital governance. Concepts related to artificial intelligence, digital platforms and social institutions play a particularly important role within the structure of the research field, indicating the gradual emergence of a new research direction focusing on the institutional aspects of virtual space.

An additional representation of the structure of scientific research is provided by the density visualisation of keyword occurrences shown in Figure 3.

Unlike cluster visualisation, this map reflects the intensity of the distribution of key concepts within the research field. The most prominent concentration areas correspond to the concepts virtual reality, students, cyberspace, digital environment and societies and institutions, confirming their central role in the structure of scientific research. The density visualisation also shows that the main research directions emerge around the interaction between technological factors (artificial intelligence, digital environments and virtual reality) and social processes (education, institutions and human interaction), which provides the foundation for further analysis of the institutional evolution of virtual space.

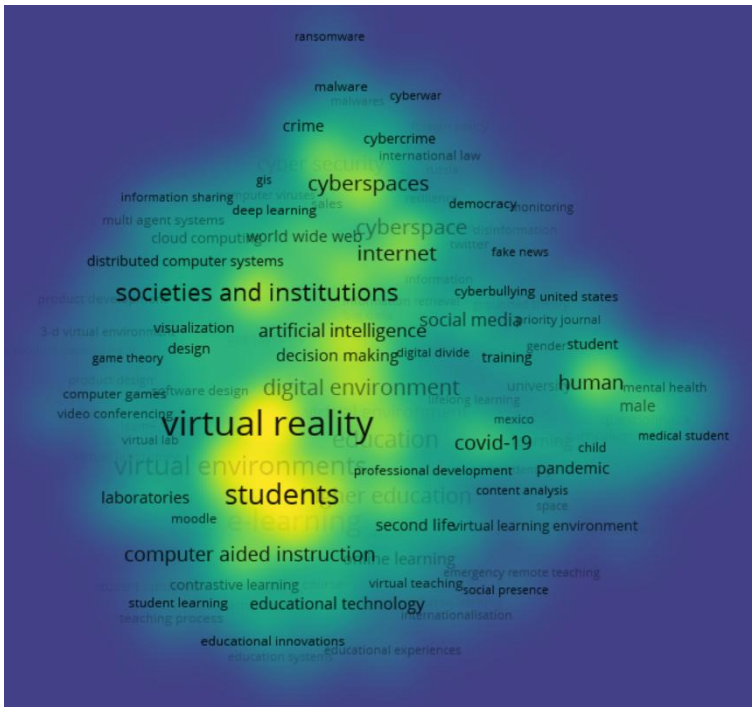

Figure 3. Density Visualization of Keyword Co-Occurrence in Research on the Institutional Evolution of Virtual Space.
Source: Authors' Elaboration Based on Scopus Data Using VOSviewer.

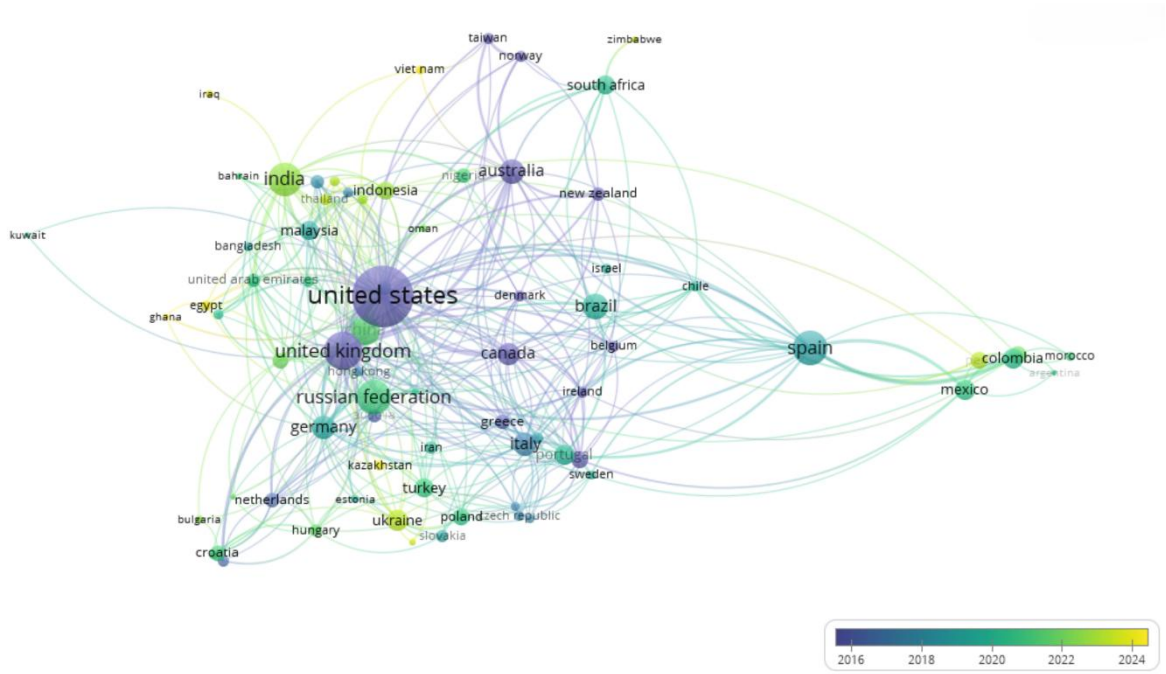

Figure 4. International Collaboration Network and Temporal Distribution of Publications on the Institutional Evolution of Virtual Space.
Source: Authors' Elaboration Based on Scopus Data Using VOSviewer.

To strengthen the analysis and identify spatial and temporal trends in the development of the research field, an additional visualisation of scientific publications by country and year of publication was conducted using VOSviewer tools. The results of this analysis are presented in Figure 4, which illustrates the network of international scientific collaboration and the dynamics of research development in the fields of virtual space, artificial intelligence and digital institutions.

The map demonstrates the geographical distribution of scientific publications and the structure of international scientific collaboration. The United States occupies a central position within the network, indicating the leading role of American research institutions in shaping the research agenda in the fields of digital technologies, virtual space and institutional aspects of the digital economy. The high density of connections between the United States and a number of other countries reflects the active development of international scientific cooperation and the formation of global research networks.

A significant role in the structure of scientific collaboration is also played by the United Kingdom, Germany, Spain, Canada, Italy and Australia, reflecting the strong involvement of European and English-speaking research centres in the development of this research field. The presence of numerous connections between countries indicates a high degree of internationalisation in research on virtual space and the emergence of transnational scientific networks connecting researchers from different regions of the world. Particular attention should also be paid to the participation of countries from Asia and developing economies, including India, Malaysia, Indonesia, Bangladesh, South Africa, as well as several countries in Latin America. The expansion of the geographical distribution of research indicates the global character of digital transformation and the spread of studies on virtual space beyond traditional research centres.

The colour scale of the visualisation also allows the temporal dynamics of publication activity to be observed. Darker colours correspond to earlier publications, whereas lighter colours represent more recent studies. The distribution of colours shows that earlier research, mainly prior to 2018, was concentrated primarily in research centres in North America and Western Europe. In subsequent years, the geographical distribution of research expanded to include countries in Asia, Latin America and other developing regions.

A particularly noticeable increase in publication activity is observed after 2020. This trend may be associated both with the acceleration of digital transformation during the COVID-19 pandemic and with the rapid development of artificial intelligence, virtual reality and digital platform technologies. As a result, research on virtual space is gradually transforming from a relatively narrow technological field into a broader interdisciplinary research domain that integrates approaches from information technology, economics, social sciences and digital governance studies.

The results complement the previously identified patterns in the formation of the research field, demonstrating that the development of studies on virtual space occurs not only at the intersection of technological and socio-institutional factors but also within global scientific networks. The expansion of the geographical distribution of publications and the growth of international collaboration confirm that processes of digital transformation and institutional

evolution within virtual space have a global character. Consequently, the analysis of the spatial and temporal structure of scientific publications supports the conclusion that a new interdisciplinary research field is emerging in which technological innovations — including artificial intelligence and virtual space — act as key drivers of the transformation of institutional mechanisms governing digital interaction. The observed dynamics of publication activity and the expansion of international scientific collaboration provide the basis for further analysis of the mechanisms accelerating the institutional evolution of virtual space, which is presented in the following section of the study.

4.2. Algorithm of Institutional Acceleration of Virtual Space

The results of the bibliometric analysis and the identified spatial and temporal trends in the development of scientific research make it possible to proceed to a deeper interpretation of the processes underlying the institutional evolution of virtual space. The findings indicate that the development of virtual space should be considered not only as a technological process but also as a process of forming new institutional structures regulating interactions among participants in the digital environment. In institutional economics, such processes are interpreted as the outcome of the interaction between technological change and the transformation of the rules governing socio-economic interactions among economic agents [12–15].

Under conditions of rapid digital technological development, traditional mechanisms of socio-economic regulation are undergoing transformation. Whereas in the industrial economy institutional structures were primarily formed by state and social institutions, within the digital environment a substantial share of regulatory mechanisms increasingly emerges at the level of digital platforms, algorithmic systems and network ecosystems. As a result, a new institutional architecture of virtual space is formed in which technological solutions and algorithmic mechanisms play a central role in organising interactions among users.

Artificial intelligence technologies and the development of virtual space, including metaverses, are of particular importance in this process. Artificial intelligence enables the automation of information processing, data analysis and decision-making, while virtual space provide the infrastructure for new forms of social and economic interaction. The combined development of these technologies leads to the formation of digital ecosystems within which new institutional mechanisms of regulation emerge.

Based on the results of the analysis, an algorithm explaining the acceleration of the institutional evolution of virtual space can be proposed. This model reflects the sequential relationship between technological innovation, the development of digital platforms and the formation of new institutional structures. The conceptual scheme of this process is presented in Figure 5. The logic of the proposed model is based on the gradual transformation of technological capabilities into new forms of coordination of interactions, which over time become institutionalised as stable regulatory mechanisms.

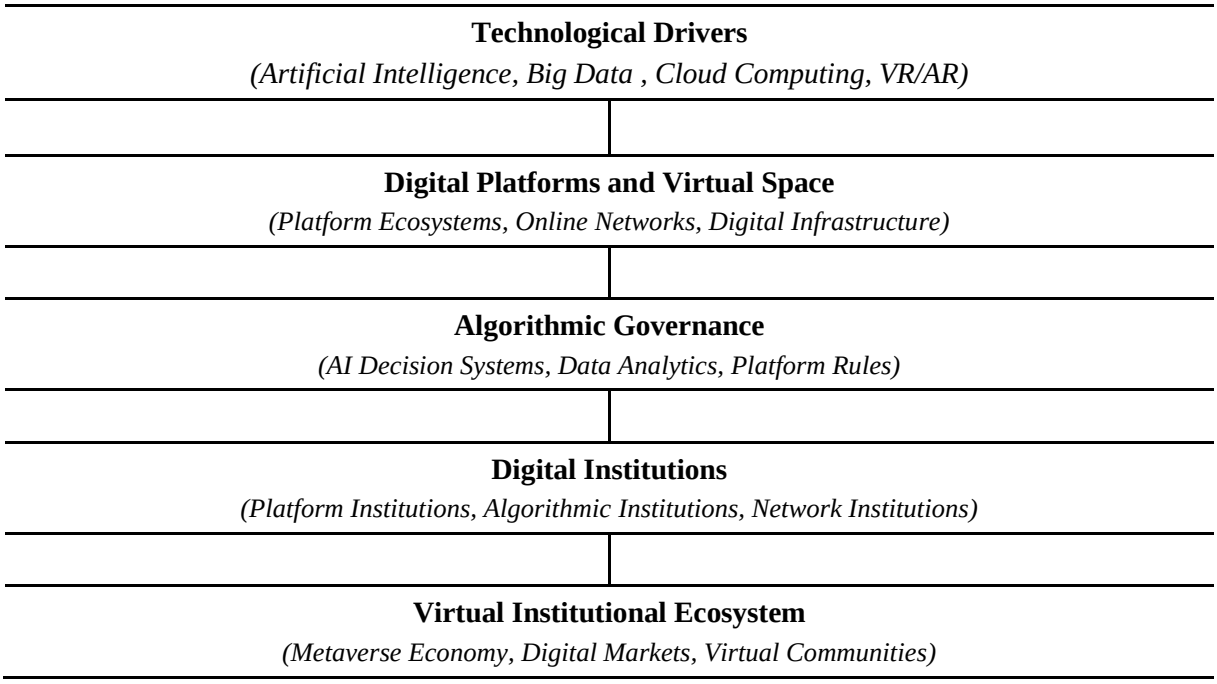

Figure 5. Conceptual Framework of Institutional Evolution of Virtual Space.
Source: Authors' Elaboration Based on Institutional Theory [12, 14, 16].

At the first stage, the technological infrastructure of the digital environment is formed, including data transmission networks, cloud computing, distributed data processing systems, virtual and augmented reality technologies and artificial intelligence systems. This infrastructure creates the basic conditions for the functioning of digital platforms and virtual interaction environments by reducing transaction costs and expanding the scalability of digital services.

At the second stage, platform ecosystems develop and begin to perform the role of intermediaries in socio-economic interactions. Digital platforms integrate users, organisations and digital services within a unified technological environment, thereby creating new models of economic interaction. Platform ecosystems gradually become key coordination nodes of digital markets and virtual communities.

At the third stage, algorithmic governance systems based on artificial intelligence and machine learning technologies acquire a central role. Algorithms are used to analyse user behaviour, manage digital services, allocate resources and regulate interactions within digital ecosystems. In this way, algorithms gradually assume functions of coordination and regulation that were previously performed by traditional governance institutions.

At the subsequent stage, new institutional mechanisms of regulation emerge, gradually complementing or replacing traditional forms of governance. These mechanisms include platform rules of interaction, algorithmic governance systems, reputation mechanisms, rating systems and digital forms of monitoring and control. From the perspective of institutional theory, these mechanisms can be interpreted as the formation of new institutions — stable "rules

of the game" that determine the structure of interaction among economic actors in the digital environment [12].

As a result, a virtual institutional ecosystem emerges in which a significant share of socio-economic interactions takes place within digital environments. Within this system, virtual space evolves into an autonomous institutional environment characterised by its own regulatory mechanisms, interaction rules and economic structures.

At the same time, the development of the institutional structure of virtual space occurs at an accelerated pace under the influence of several factors. The principal drivers of institutional acceleration include the development of artificial intelligence technologies, the rapid growth of digital data volumes, the global expansion of digital platforms, the development of cloud infrastructure and the acceleration of digitalisation processes during the COVID-19 pandemic. These factors increase the speed of technological diffusion and facilitate the faster formation of new mechanisms coordinating economic interactions.

A particularly significant role in this process is played by the development of metaverses, which create a new infrastructure integrating digital technologies, virtual communities and digital markets. Metaverses form immersive digital environments in which users can interact, engage in economic activities and create digital assets. Within such environments, institutional mechanisms emerge not only through formal rules but also through platform algorithms, digital protocols and network interaction mechanisms.

As virtual ecosystems develop, new types of digital institutions emerge that can be broadly classified into three main categories. The first category consists of platform institutions formed by digital platforms that determine the rules governing user interaction within platform ecosystems. The second category includes algorithmic institutions based on the use of algorithms and artificial intelligence systems for automated regulation and decision-making. The third category comprises network institutions that emerge within digital communities and distributed ecosystems, including virtual communities and decentralised forms of interaction. These forms of coordination are closely related to mechanisms of collective governance and self-organisation described in studies of institutional diversity and common resource governance [16].

It should also be noted that the institutional evolution of virtual space is nonlinear. Newly formed digital institutions begin to exert feedback effects on the development of technological infrastructure and platform ecosystems, stimulating the emergence of new digital services and interaction models. Consequently, feedback loops arise between technological innovation, algorithmic governance mechanisms and institutional structures, further accelerating institutional evolution within the digital environment.

Thus, the proposed algorithm of institutional evolution demonstrates that the development of artificial intelligence and metaverse technologies acts as a catalyst for the emergence of new institutional mechanisms of regulation. Virtual space gradually evolves into an autonomous institutional environment of the digital economy in which interactions among participants are increasingly governed by digital platforms, algorithmic systems and network-based coordination mechanisms.

4.3. Verification of the Research Hypothesis

The results of the bibliometric analysis and the conceptual model of the institutional evolution of virtual space developed in this study allow the obtained findings to be interpreted in terms of testing the proposed research hypothesis.

It should be recalled that hypothesis *H1* assumes that the development of artificial intelligence and metaverse technologies accelerates the institutional evolution of virtual space, facilitating the emergence of algorithmic governance mechanisms, platform-based institutions and new forms of digital interaction.

The results of the bibliometric analysis confirm the presence of stable relationships between studies on virtual space, artificial intelligence, digital platforms and institutional processes. The keyword co-occurrence analysis shows that concepts such as virtual reality, digital environment, cyberspace, artificial intelligence, and societies and institutions occupy central positions within the structure of scientific research. Such a configuration of research clusters indicates the emergence of a research direction integrating technological and institutional perspectives on digital transformation.

Additional support for this trend is provided by the density analysis of keyword distribution, which demonstrates a strong concentration of studies at the intersection of digital technologies and social institutions. This finding suggests an increasing role of artificial intelligence and virtual space in shaping new mechanisms regulating digital interactions.

The analysis of the international structure of scientific publications further confirms the global character of the studied processes. The identified network of scientific collaboration indicates that research on the institutional aspects of virtual space is actively developing within major research centres in North America, Europe and Asia. This distribution highlights the growing importance of this research area within the broader context of global digital transformation.

The algorithm of institutional evolution of virtual space developed in this study (Figure 5) demonstrates a sequential transformation of technological innovation into new institutional mechanisms of regulation. Within this framework, the development of technological infrastructure and digital platforms leads to the emergence of algorithmic governance mechanisms, which gradually become institutionalised in the form of new digital institutions.

An important outcome of the study is the identification of three types of digital institutions emerging within virtual space: platform institutions, algorithmic institutions and network institutions. Platform institutions determine the rules governing interactions within digital ecosystems, algorithmic institutions provide automated mechanisms for regulating interactions, while network institutions emerge within digital communities and distributed virtual ecosystems.

A particularly significant role in accelerating the institutional evolution of virtual space is played by the development of metaverses, which create a new infrastructure for integrating digital technologies, virtual markets and social interactions. Metaverses form immersive digital

environments in which institutional mechanisms emerge not only through formal rules but also through algorithmic governance systems and platform interaction protocols.

Thus, the results of the bibliometric analysis, the identified spatial and temporal trends in scientific research and the proposed conceptual model of the institutional evolution of virtual space allow the conclusion that hypothesis *H1* is supported. The development of artificial intelligence and metaverse technologies indeed acts as a factor accelerating the institutional evolution of virtual space, leading to the emergence of new governance mechanisms, digital institutions and forms of socio-economic interaction within the digital economy.

The findings confirm that the institutional evolution of virtual space represents an important component of the broader processes of digital transformation in the global economy and requires further theoretical and empirical investigation.

5. Discussion and Limitations

The obtained results allow the development of virtual space to be interpreted within the broader context of the institutional evolution of the global economy. The bibliometric analysis of scientific publications demonstrates that studies on virtual space, artificial intelligence and digital platforms constitute a rapidly developing interdisciplinary research field. The increasing number of publications and the expanding geographical distribution of research indicate that processes of digital transformation are acquiring a global character, generating new mechanisms for coordinating economic and social interactions.

From the perspective of institutional theory, the results confirm the proposition that technological change represents an important driver of institutional evolution. According to the classical definition of institutions as “rules of the game” structuring interactions among economic agents [12–13], the development of digital technologies and platform ecosystems leads to the emergence of new forms of institutional regulation. Within the digital environment, these rules are increasingly implemented through algorithmic governance systems and platform-based coordination mechanisms.

The findings are also consistent with the principles of new institutional economics, according to which institutional change often arises in response to transformations in mechanisms of economic coordination and reductions in transaction costs [14–15]. Digital platforms and algorithmic governance systems significantly reduce the costs associated with information search, coordination of interactions and monitoring of rule compliance, thereby facilitating the formation of new institutional structures within virtual space.

The proposed algorithm of institutional evolution of virtual space demonstrates that the development of artificial intelligence, digital platforms and virtual space contributes to the emergence of a new institutional architecture of the digital economy. Such transformations correspond to broader patterns of technological and economic cycles described in the theory of long waves of economic development [1]. Within this theoretical framework, technological innovation is considered a key factor driving structural changes in the global economy, accompanied by transformations in institutional regulatory mechanisms.

In this context, the development of artificial intelligence technologies and metaverses can be viewed as elements of a new technological paradigm shaping new forms of socio-economic interaction. Recent studies confirm that metaverses are becoming important platforms for the emergence of new types of economic and social interaction, integrating digital markets, virtual communities and platform ecosystems [7–8]. Bibliometric research also indicates that academic interest in this topic is rapidly increasing, reflecting the formation of a new research field at the intersection of digital technologies, economics and social sciences [3].

The results are also consistent with studies examining institutional aspects of digital and virtual platforms, which demonstrate that virtual space increasingly serve as instruments for transforming social institutions and educational systems [9]. Similar processes can be observed in the field of public regulation and the legal governance of artificial intelligence technologies, where new institutional mechanisms for managing digital systems and platform ecosystems are emerging [2].

The development of digital infrastructures for data processing and exchange also plays a significant role in the evolution of virtual space. Research on geospatial cyberinfrastructure shows that the development of distributed computing systems, network technologies and digital platforms creates the foundation for new forms of scientific and economic interaction within digital environments [5]. Collectively, these processes contribute to the formation of a new institutional environment in which virtual spaces become an essential component of the global digital economy.

At the same time, the results suggest that the institutional evolution of virtual space is nonlinear and accompanied by the emergence of new types of digital institutions. Within the proposed conceptual model, platform institutions, algorithmic institutions and network institutions are identified as the key mechanisms regulating interactions within virtual ecosystems. These forms of institutional coordination partially correspond to mechanisms of self-organisation and collective governance described in studies of institutional diversity [16].

Despite these findings, the study has several limitations. First, the bibliometric analysis was based on data obtained from the Scopus database [4], which may limit the completeness of the literature coverage, as some relevant publications may be indexed in other scientific databases such as Web of Science, Google Scholar or specialised disciplinary repositories. Second, the search queries employed in the study may not capture all possible terminological variations used by researchers to describe virtual space and digital institutions.

Third, the results of the bibliometric analysis reflect the structure of scientific publications but do not allow a direct assessment of the actual impact of artificial intelligence and metaverse technologies on institutional processes within the economy and society. Consequently, the proposed conceptual model of institutional evolution of virtual space has a theoretical and analytical character and requires further empirical validation.

Additional limitations relate to the use of scientific data visualisation methods. Although the VOSviewer software is widely applied in bibliometric studies [10], the results of mapping may depend on the selected analytical parameters and the structure of the underlying dataset. Similarly, the use of the PRISMA algorithm ensures transparency in the publication selection

procedure but does not eliminate potential limitations related to the interpretation of scientific sources [11].

Despite these limitations, the results of the study make it possible to identify the principal directions of research on the institutional evolution of virtual space and to propose a conceptual model explaining the acceleration of institutional evolution within the digital environment. The findings provide a foundation for further research aimed at a deeper analysis of the mechanisms underlying the formation of digital institutions and their influence on the development of the global digital economy. Future research may also focus on analysing the relationships between institutional evolution in digital environments and broader processes of structural change in the global economy [17–19].

6. Conclusions and Future Directions

This study analysed the institutional evolution of virtual space in the context of the development of artificial intelligence and metaverse technologies. The research was based on a bibliometric analysis of scientific publications indexed in the Scopus database, complemented by institutional and systems analysis used to interpret the obtained results.

The bibliometric analysis demonstrated that research on virtual space, artificial intelligence and digital platforms forms a rapidly developing interdisciplinary research field. The analysis of keyword structures and thematic clusters revealed stable relationships between technological components of the digital environment and the socio-institutional aspects of the digital economy. The most significant research directions are concentrated around the study of virtual space, digital platforms, artificial intelligence and social institutions.

The analysis of the spatial and temporal structure of scientific publications showed that studies addressing institutional aspects of virtual space have a global character and are actively developing in research centres across North America, Europe and Asia. At the same time, a gradual expansion of the geographical distribution of research can be observed, reflecting the growing international interest in digital transformation and virtual space.

Based on the results obtained, an algorithm of institutional evolution of virtual space was proposed. This framework reflects the sequential relationship between the development of technological infrastructure, the formation of digital platforms, the expansion of algorithmic governance mechanisms and the emergence of new institutional structures within the digital environment. Within the proposed conceptual model, three main types of digital institutions are identified: platform institutions, algorithmic institutions and network institutions, which shape the mechanisms coordinating interactions within virtual ecosystems.

The analysis suggests that the development of artificial intelligence technologies and virtual space acts as an important factor driving the institutional evolution of the digital economy. Technological innovations not only create new forms of economic activity and social interaction but also contribute to the formation of new mechanisms for regulating and coordinating interactions within virtual space.

The findings support the research hypothesis that the development of artificial intelligence and metaverse technologies accelerates the institutional evolution of virtual space. This process manifests itself through the emergence of algorithmic governance mechanisms, platform institutions and new forms of digital interaction.

Despite these results, the institutional evolution of virtual space remains a complex and multidimensional process requiring further investigation. Future research may therefore focus on a more detailed analysis of the mechanisms underlying the formation of digital institutions, empirical studies examining the influence of algorithmic governance systems on economic interactions and investigations into the institutional characteristics of metaverses and virtual economies.

Additional research may also examine the interaction between governmental regulatory mechanisms and platform institutions within the digital economy, as well as the role of digital institutions in shaping new models of global economic interaction.

Overall, the study contributes to the development of research on the institutional aspects of the digital economy and provides a foundation for further investigations into the processes of institutional evolution of virtual space under the conditions of the development of artificial intelligence and digital platforms.

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