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DIGITAL INFRASTRUCTURE AS AN OBJECT OF GOVERNMENT REGULATION: CONCEPTUAL AND METHODOLOGICAL ANALYSIS

Abstract

In the context of accelerated digitalization, the global economy is undergoing structural transformations in which digital infrastructure has become a key strategic resource. It functions not only as a technological foundation for innovation but also as a factor of national competitiveness, sovereignty, and security. Therefore, the issues of its state regulation acquire particular relevance, which is confirmed both by global trends and by national strategies implemented in Kazakhstan. The research results include two main directions. First, a bibliometric analysis of publications (Scopus, 2008–2024) revealed that the number of works devoted to the combination of “government regulation” and “digital infrastructure” remains extremely limited, indicating insufficient elaboration of this topic in academic discourse. At the same time, there has been a steady increase in publications on the keywords “digital” and “digitalization” since 2009, with a sharp rise of interest since 2018 in the cluster “government regulation – digitalization – sustainable development.” This confirms the formation of an independent research field that is currently in an active stage of development. Second, the analysis showed that Kazakhstan demonstrates significant progress in digitalization: a substantial share of public services is already delivered electronically, while mobile services and integration platforms are being expanded. International indices record the strengthening of the country’s position, although challenges remain, such as digital inequality, levels of trust in services, and cybersecurity issues. The scientific novelty of the article lies in the fact that digital infrastructure is conceptualized as a multilayer object of state regulation, encompassing network, platform, institutional, and social levels. This approach not only systematizes existing results but also suggests new research directions aimed at developing more comprehensive and effective regulatory strategies in the context of digital transformation.

Keywords: digital infrastructure; state regulation; digitalization; bibliometric analysis; e-government.

INTRODUCTION

In the context of the rapid digitalization of the global economy, the development and regulation of digital infrastructure have acquired strategic importance. Digital infrastructure is not only the technological foundation of modern processes but also a key determinant of national competitiveness, resilience, and security. In this regard, the President of the Republic of Kazakhstan, Kassym-Jomart Tokayev, consistently emphasizes digital transformation and artificial intelligence as long-term development priorities in his annual addresses (Akorda, 2023).

For instance, in the Address to the Nation titled “*A Just State. A Unified Nation. A Prosperous Society*” dated September 1, 2023, the Head of State highlighted the need to transform Kazakhstan into an “IT country,” identifying the development of digital infrastructure and the introduction of advanced technologies as central objectives of public policy (Akorda, 2023). In the Address of September 2, 2024, particular attention was given to the integration of artificial intelligence technologies into e-government systems and the establishment of a National Artificial Intelligence Center. According to the President, artificial intelligence in Kazakhstan should be deployed not in isolated domains but in a systematic and large-scale manner (Zakon.kz, 2024). These priorities were further specified in the Address of September 8, 2025, where it was stated: “We must modernize the economy through

large-scale digitalization and the active implementation of artificial intelligence technologies. As an initial step, it is necessary to urgently adopt the Digital Code...” (Tengrinews.kz, 2025). At the same time, particular emphasis was placed on institutional challenges, including the need to reform public administration based on the principles of transparency, efficiency, and human-centered governance (Gov.kz, 2024).

These policy statements reinforce the understanding of digital infrastructure as a critical resource requiring systematic state regulation. The strengthening of the state’s role is обусловлено several key factors:

- Digital sovereignty: control over infrastructure is increasingly becoming an integral component of national sovereignty, determining technological independence and the capacity for data governance;
- National and cybersecurity: digital infrastructure constitutes one of the core systems ensuring national security; neglecting this aspect in the digital era is tantamount to undermining sovereignty;
- Social and regional stability: without state intervention, the risks of digital inequality and regional disparities intensify;
- Institutional coherence: a unified regulatory framework helps prevent fragmentation and legal gaps in digital policy.

Against this background, the purpose of this article is to examine how state regulation of digital infrastructure is addressed within the scientific discourse through a bibliometric approach and to define the methodological boundaries of this research field.

Kazakhstan has entered this stage with a well-established foundation of e-government. The COVID-19 pandemic acted as a catalyst for the mass transition to online services, significantly accelerating digitalization processes. While the number of users of the eGov.kz portal was approximately 10 million in 2019, it reached 13.7 million by 2023 and exceeded 14 million in 2024, representing more than two-thirds of the country’s population. Moreover, in the first months of 2024 alone, the number of users increased by an additional 1.2 million (Gov.kz, 2024; Nitec.kz, 2024). This growth reflects not only the expansion of the technical infrastructure but also the gradual development of digital competencies among the population.

International rankings also confirm this positive trajectory. In the United Nations E-Government Development Index (EGDI), Kazakhstan ranked 28th globally in 2022 and entered the top ten in the “online services” component (Ranking.kz, 2024). In the IMD World Digital Competitiveness Ranking, Kazakhstan placed 34th out of 64 countries in 2023. These results demonstrate the country’s progress on the international stage, although there remains significant potential for further improvement.

Thus, the relevance of studying digital infrastructure as an object of state regulation is determined not only by global trends related to digital sovereignty and security but also by internal challenges articulated in the presidential addresses of 2023–2025 (Gov.kz, 2024). Within this context, the present study carries not only theoretical significance but also practical relevance, opening opportunities for the development of new methodological approaches and applied policy recommendations.

LITERATURE REVIEW

Over the past five years, Kazakhstani researchers have paid increasing attention to the issues of economic digitalization, considering it as an integral component of the national modernization strategy. In the domestic literature, particular emphasis is placed on the role of the state program “Digital Kazakhstan” (2018–2022), which became the starting point for the formation of a digital society. In their analytical review, Zh. Syubebayeva and co-authors identify new qualitative characteristics of the digital economy, including the transition from goods production to service provision, the emergence of network-based structures, the growing role of creative labor, and the introduction of innovative management approaches. These transformations not only influence the activities of the state and enterprises but also contribute to improving the efficiency of the national economy. Existing studies clearly demonstrate the potential of information and communication technologies to enhance productivity and competitiveness (Syubebayeva et al., 2021). These findings are directly relevant to the objective of the present study, as they demonstrate that the expansion of digital infrastructure requires coordinated state regulation capable of supporting institutional adaptation and technological modernization.

Attention to the implementation process of the program is also of considerable importance. For example, T.P. Pritvorova and R.B. Zhashkenova analyze the dynamics of financing digital initiatives, concluding that available resources are sufficient and have been utilized effectively. At the same time, according to Kazakhstani authors, the transition to “Digital Kazakhstan” is accompanied by a number of challenges and constraints, which in turn necessitate state regulation (Pritvorova & Zhashkenova, 2019). This argument reinforces the idea that digital transformation cannot be sustained solely through technological expansion and requires consistent regulatory coordination and financial oversight mechanisms.

A significant strand of the literature focuses on barriers to digital transformation. O. Denissova and co-authors note that digital business in Kazakhstan lags behind global trends. The main reasons include a weak technological base, a shortage of qualified personnel, and the insufficient readiness of small and medium-sized enterprises to adopt digital solutions (Denissova et al., 2025). These studies highlight structural constraints that

directly influence the effectiveness of digital infrastructure policies and justify the need for state intervention aimed at reducing infrastructural and technological disparities.

The regulatory and legal framework of digitalization has also attracted scholarly attention. A. Kuanaliyev and co-authors argue that the introduction of technologies in the public sector is not feasible without institutional reforms. Only an appropriate regulatory environment can ensure the sustainability of digital transformation and serve as a foundation for long-term effectiveness (Kuanaliyev et al., 2024). This conclusion is particularly important for the present study because it positions digital infrastructure not merely as a technical system but as an institutional object requiring regulatory governance.

Issues of state regulation are examined across various sectors. In the healthcare sector, A. Alimbaev and co-authors emphasize that the implementation of ICT should be considered not merely as a technological process but as a comprehensive measure requiring regulatory standards, data protection, and state guarantees (Alimbaev et al., 2021). In the agricultural sector, O. Tsapova and co-authors reach similar conclusions, demonstrating that the digitalization of agriculture is not feasible without state support and targeted regulation (Tsapova et al., 2025). These sectoral studies collectively indicate that the effectiveness of digital transformation depends on the institutional capacity of the state to regulate infrastructure, data management, and technological implementation across different branches of the economy. Studies on e-commerce and fintech likewise highlight the importance of legal and institutional conditions, viewing them as key factors in ensuring trust in digital services among businesses and consumers (OECD, 2023).

Taken together, these studies demonstrate that in Kazakhstani academic literature, state regulation of digitalization is not viewed merely as a control mechanism but as a fundamental condition for fostering innovation and ensuring institutional development. Researchers emphasize the need not only to advance technologies but also to improve human capital, the institutional environment, and legal frameworks. Therefore, the domestic literature increasingly supports the argument that digital infrastructure should be analyzed through an integrated regulatory perspective combining technological, institutional, and socio-economic dimensions.

The conclusions of domestic studies are consistent with international assessments. In its 2023 report, the Organisation for Economic Co-operation and Development characterizes Kazakhstan as a pioneer of digitalization in Central Asia, noting significant progress in the development of e-government and the regulatory framework (OECD, 2023). However, international experts also highlight challenges such as unequal access to the internet, the high cost of digital services, and gaps in cybersecurity. These challenges align with the conclusions of Kazakhstani scholars, who emphasize the need to eliminate bottlenecks, expand network infrastructure, enhance digital literacy, support small businesses, and improve legislation. This correspondence between domestic and international assessments confirms the relevance of studying digital infrastructure as an object of state regulation in Kazakhstan.

Overall, the Kazakhstani literature increasingly conceptualizes digitalization not merely as a technological modernization of the economy but as a comprehensive transformation requiring a systemic approach that takes into account national specificities. At the same time, despite the growing number of studies devoted to digitalization, insufficient attention has been paid to the conceptualization of digital infrastructure specifically as a multilayer object of state regulation. This research gap defines the relevance of the present study and determines its methodological focus.

At the same time, recent international studies examine the digital economy on a global scale, emphasizing its impact on the competitiveness of states and the formation of new regulatory models. In the global academic discourse, digital infrastructure and its regulation occupy a central position, enabling the comparison of national outcomes with international practices. To systematize the analysis, the key findings of foreign studies are summarized in Table 1.

Table 1. Foreign studies on digital infrastructure and state regulation (2019–2024)

Author(s), year	Research focus	Key findings	Contribution to the conceptual and methodological framework of this study
Anatan, L. et al. (2023)	Readiness of SMEs for digital transformation (Indonesia)	SMEs face shortages of skills and resources; support measures are required	Indicates the need for state policy adapted to Kazakhstan's context
Nassir, S. et al. (2023)	Implementation of e-tendering in developing markets	Adoption of digital solutions depends on the institutional environment	Highlights the role of regulation in developing digital infrastructure

Karacuka, M. et al. (2024)	Digitalization and productivity in Africa	The impact of digital technologies is heterogeneous; productivity paradox observed	Methodological implication: digitalization does not automatically lead to growth; regulation is necessary
Kamalu, K., Ibrahim, W. (2024)	Digitalization and social inequality	Digital technologies alone do not reduce poverty without complementary measures	State regulation must account for social dimensions
Goloshchapova, T. et al. (2023)	E-government and economic development	E-government increases efficiency and public trust	Confirms the importance of regulatory policy in digitalization
Heeks, R. et al. (2021)	Digital platforms in developing countries	"Institutional voids" hinder adaptation of global models	Relevant for Kazakhstan: need for a context-specific methodology
Yang, W. et al. (2024)	Digital infrastructure and economic growth in China	Investments in digital infrastructure positively affect growth	Demonstrates the direct link between infrastructure and public policy

Note: compiled by the authors based on Anatan & Nur (2023); Nassir et al. (2023); Karacuka et al. (2024); Kamalu & Ibrahim (2024); Goloshchapova et al. (2023); Heeks et al. (2021); Yang et al. (2024).

Thus, the analysis of recent studies indicates that the topic of the digital economy remains in the focus of both Kazakhstani and international scholars. In Kazakhstan, over the past five years, a clear understanding of the key directions of digital transformation has been formed: state programs are being implemented, electronic services are expanding, and researchers are actively examining the impact of digitalization across various sectors, from healthcare to agriculture.

METHODOLOGY AND METHODS

In accordance with the research objective, the study is based on three interrelated methods directly applied in the analysis: bibliometric analysis, analysis of national statistical indicators, and examination of regulatory and legal documents.

First, a bibliometric analysis was conducted using the Scopus database covering publications from 2008 to 2025. The search was performed using the keywords "digital infrastructure", "government regulation", "digitalization", and "digital". The dataset included research articles, review papers, and conference proceedings related to digital infrastructure and state regulation.

The bibliometric data exported from Scopus were processed using the Biblioshiny package in RStudio. After duplicate records were removed, the following analyses were conducted: annual scientific production, co-occurrence analysis of keywords, Three-Field Plot analysis, and thematic mapping.

Second, the study analyzed national statistical indicators related to digitalization in Kazakhstan, including data from the Bureau of National Statistics of the Republic of Kazakhstan and international indices such as the UN E-Government Development Index and the IMD Digital Competitiveness Ranking (OECD, 2023; KISI.kz, 2025).

Third, regulatory and legal documents related to digital transformation in Kazakhstan were examined, including the state program "Digital Kazakhstan", presidential addresses, and official policy documents concerning digitalization and artificial intelligence (Akorda, 2023; Gov.kz, 2024; Zakon.kz, 2024).

The combination of these methods made it possible to compare global scientific trends with the practical development of digital infrastructure regulation in Kazakhstan.

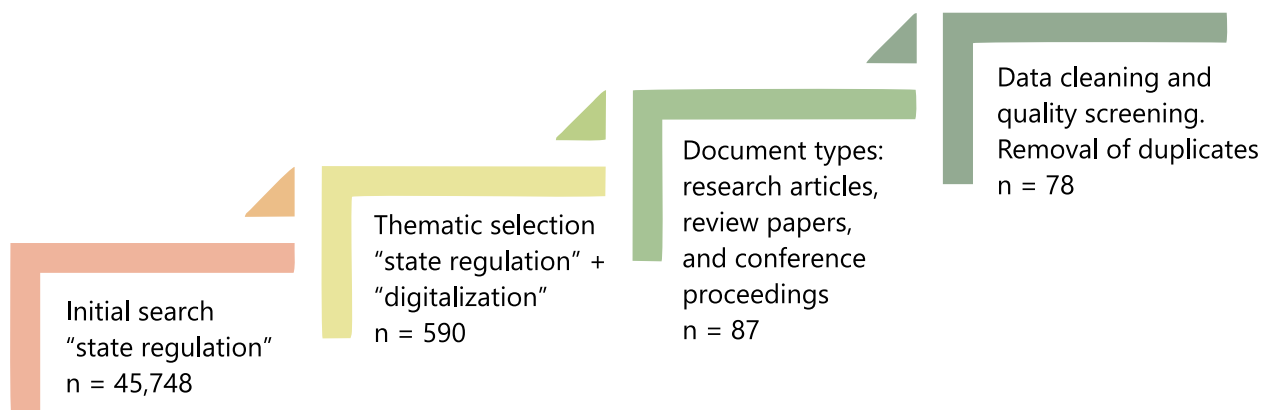
RESULTS

Based on the conducted literature review, the empirical stage of the study involved a bibliometric analysis of publications devoted to digital infrastructure and its state regulation. This step made it possible to link the qualitative findings of domestic and international scholars with the quantitative representation of global scientific activity. The application of bibliometric methods allowed not only for identifying trends in scholarly interest in this topic but also for determining the key actors shaping the discourse in this field, including authors, countries, and institutions.

The empirical stage of the study involved a bibliometric analysis of publications devoted to digital infrastructure and state regulation. The Scopus database was selected as the primary data source due to its multidisciplinary

coverage and academic relevance. The study covers the period from 2008 to 2025, enabling the analysis of both the early stages of digitalization research and recent trends in its institutional regulation. The research process consisted of several stages (Figure 1).

Figure 1. Algorithm for bibliometric data selection (in accordance with PRISMA principles)



Note: Compiled by authors

Stage One. At the initial stage, the search query "government regulation" identified 45,748 publications. Due to the broad scope of the dataset, additional refinement was required.

Stage Two. The keyword "digital infrastructure" was added to the search query, resulting in three research articles.

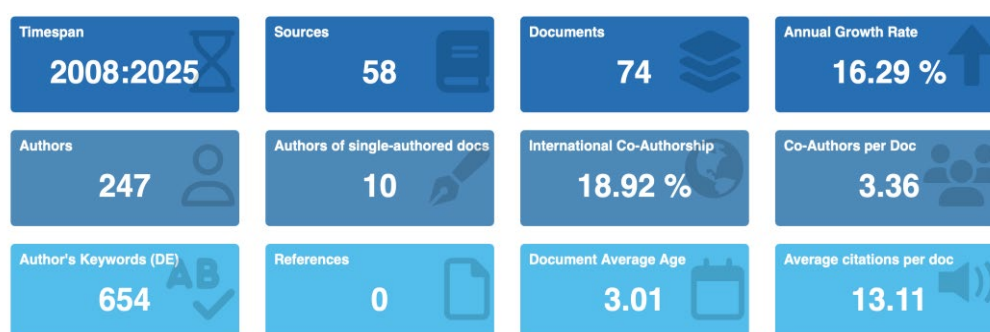
Stage Three. The broader keyword "digital" yielded 590 publications. The chronological distribution demonstrates low publication activity before 2008 and a steady increase afterward.

Stage Four. The keyword "digitalization" resulted in 87 publications covering the period from 2008 to the present.

Stage Five. The dataset was processed using the Biblioshiny package in RStudio. Duplicate and incomplete records were removed, resulting in a final sample of 74 relevant publications.

General descriptive characteristics of the dataset are presented in Figure 2. Despite its relatively small size, this sample is highly relevant to the research topic, as it clearly reflects the growing academic interest in state regulation within the context of digitalization. It is noteworthy that since 2018, publication activity has shown a sharp upward trend, which has subsequently remained at a consistently high level. General information on the study is presented in Figure 2.

Figure 2. General descriptive characteristics of the bibliometric dataset



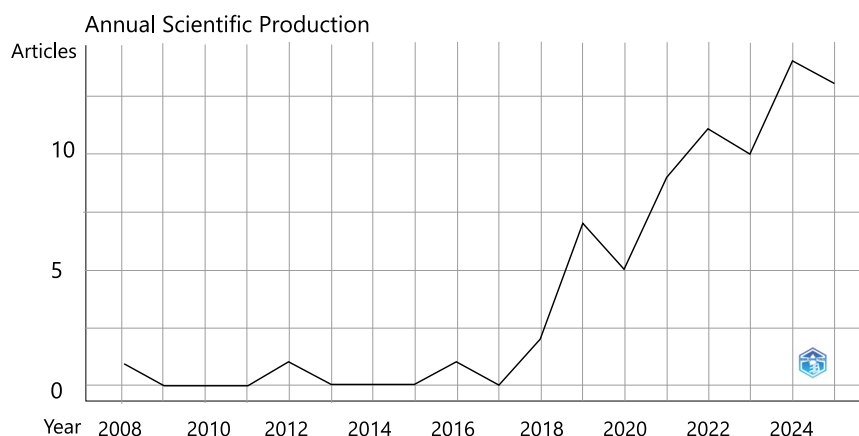
Note: compiled by the authors using the Biblioshiny package in Rstudio

Figure 2 presents the general descriptive characteristics of the bibliometric dataset. The final sample covers the period from 2008 to 2025 and includes 74 publications from 58 academic sources. A total of 247 authors were identified, including 10 single-authored publications. The average number of co-authors per document is 3.36, while the level of international co-authorship amounts to 18.92%.

The dataset contains 654 author keywords, reflecting the diversity of research topics related to digitalization and state regulation. The average age of the documents is 3.01 years, and the average number of citations per document is 13.11. In addition, the annual growth rate of publications reaches 16.29%, indicating a steady increase in scientific activity within this research field.

The data presented in Figure 3 further support this conclusion: the issue of digital infrastructure and its regulation is gradually moving beyond a marginal research area and becoming a stable focus of attention within the global scientific community. The acceleration of scientific activity corresponds with the shift of public administration practices toward digitalization, highlighting a direct link between practical transformation and academic interest.

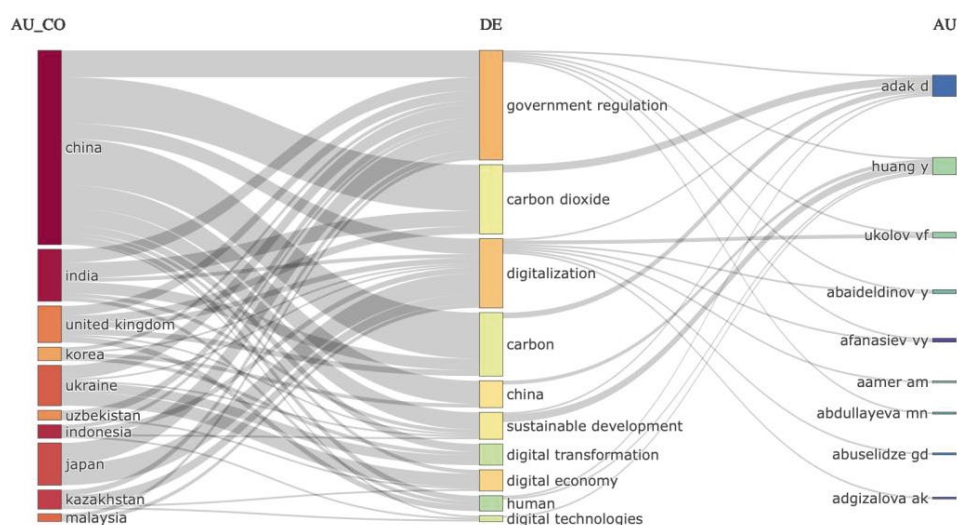
Figure 3. Annual dynamics of publications on digital infrastructure and state regulation



Note: compiled by the authors using the Biblioshiny package in RStudio

Figure 4 presents the distribution of research activity across countries, key terms, and authors (Three-Field Plot). The analysis of the obtained data indicates that the largest contributions to the study of state regulation in the context of digitalization are made by scholars from China, India, the United Kingdom, the Republic of Korea, and Ukraine. At the same time, the dataset also includes publications by authors from Central Asian countries, including Kazakhstan and Uzbekistan. This suggests the gradual formation of a regional scientific school in this field.

Figure 4. Relationships between countries, research themes, and authors in publications on digital infrastructure and regulation



Note: compiled by the authors using the Biblioshiny package in RStudio

Figure 4 presents the distribution of research activity across countries, key terms, and authors using the Three-Field Plot approach. The analysis shows that the largest contributions to the study of state regulation in the context of digitalization are made by scholars from China, India, the United Kingdom, the Republic of Korea, and Ukraine. At the same time, the dataset also includes publications by authors from Central Asian countries, including Kazakhstan and Uzbekistan.

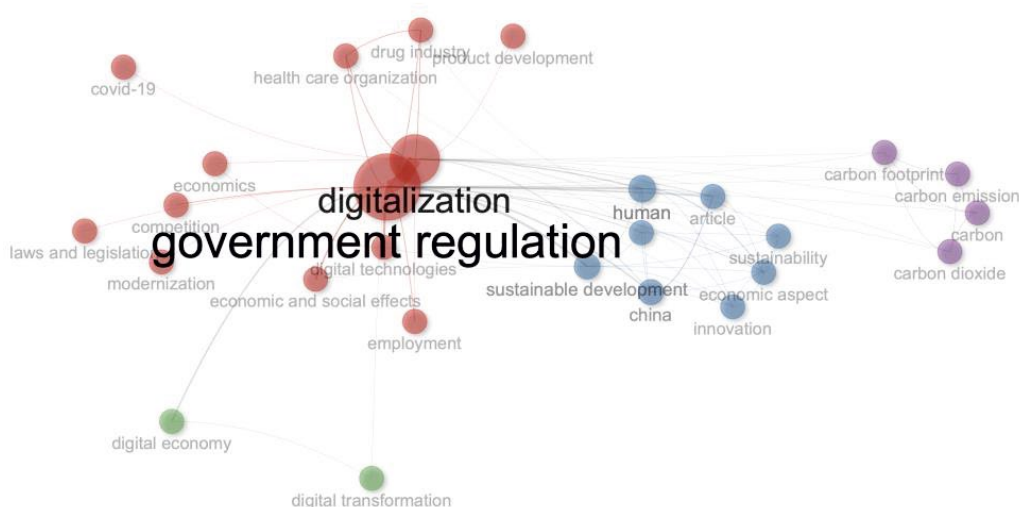
The most frequently occurring keywords include "government regulation," "digitalization," "digital transformation," and "digital technologies." Their co-occurrence with the terms "sustainable development" and "digital economy" demonstrates the close interrelation between digital transformation processes and public governance issues.

Among the most active authors identified in the dataset are D. Adak, Y. Huang, V.F. Ukolov, N. Abaideldinov, V. Afanasyev, and M. Abdullaeva. The visualization also demonstrates the growing international character of research devoted to digital infrastructure and state regulation.

The strong association of the term "government regulation" with "digitalization," "digital technologies," "sustainable development," and "digital economy" reflects the increasing dependence of public policy on digital transformation factors (Figure 5). This, in turn, necessitates a systematic scientific analysis of the interconnections between the institutional quality of the digital economy, data governance regimes, platform infrastructure, and regulatory frameworks.

The thematic concentration observed in the visualization indicates the emergence of new research directions in the field of digital infrastructure regulation. In particular, the growing prominence of topics such as climate risks, carbon emissions, sustainable development, artificial intelligence, security, and data policy reflects the expanding role of digital infrastructure. While earlier studies were largely limited to technical aspects, current research increasingly encompasses economic, social, and environmental dimensions.

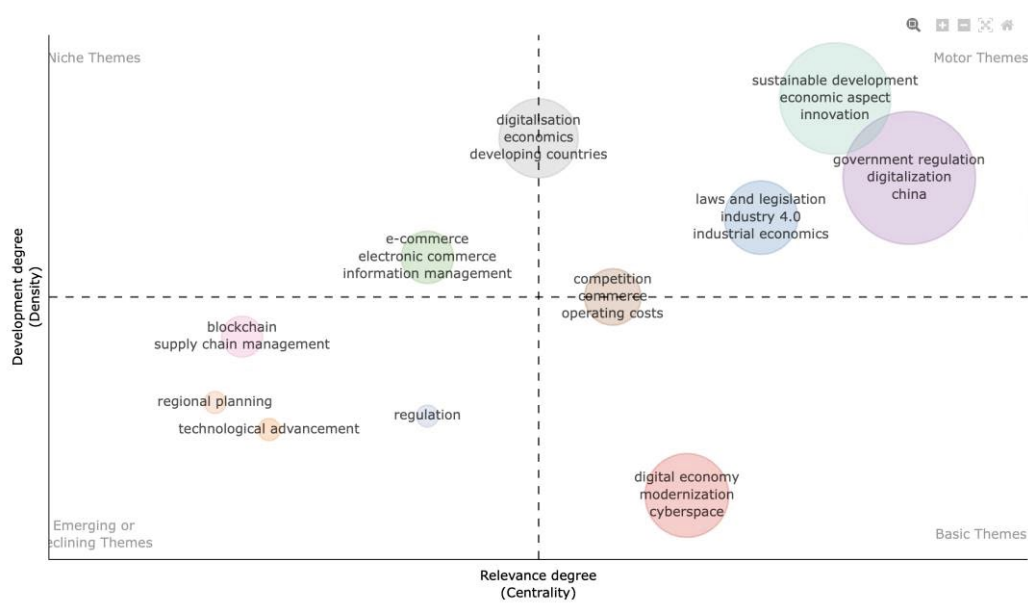
Figure 5. Co-occurrence network of keywords



Note: compiled by the authors using the Biblioshiny package in RStudio

Figure 6 presents a thematic map of the main research directions. It identifies which clusters occupy a central position in the scientific agenda and where scholarly interest is concentrated within the context of digital transformation. This approach allows not only for visualizing the structure of the current discourse but also for highlighting promising areas that require further in-depth investigation.

Figure 6. Thematic map of key research directions in the field of state regulation of digital processes



Note: compiled by the authors using the Biblioshiny package in RStudio

Figure 6 presents a thematic map of the main research directions in the field of digital infrastructure and state regulation. The visualization identifies clusters occupying central positions within the scientific discourse on digital transformation.

The motor themes (upper-right quadrant) include government regulation, digitalization, sustainable development, and innovation. These themes represent the most developed and relevant research directions within the dataset.

The basic themes (lower-right quadrant) include the digital economy, modernization, and cyberspace. These topics are frequently mentioned in the scientific literature and form an important conceptual foundation of the research field.

The niche themes (upper-left quadrant) are associated with digitalisation in developing countries, e-commerce, and information management. These areas occupy a specialized position within the overall thematic structure.

The emerging or declining themes (lower-left quadrant) include blockchain, supply chain management, regional planning, technological advancement, and regulation. The thematic positioning of these clusters suggests that their research trajectories are still evolving.

The conducted bibliometric analysis made it possible to identify general trends and delineate the boundaries of the research field. However, academic interest represents only one dimension of the issue. To fully assess the relevance and practical significance of digital infrastructure regulation, it is necessary to refer to empirical statistical data reflecting the current level of digitalization. In this regard, Table 2 presents key indicators characterizing the level of population engagement in digital processes, the development of infrastructure, and the scope of state regulation in Kazakhstan. These data complement the bibliometric analysis and allow for the comparison of theoretical conclusions with actual socio-economic processes.

Table 2. Key initiatives of digitalization of state regulation in Kazakhstan (2020–2025) and expected outcomes

Year	Document / Initiative	Brief description	Outcomes
2018–2022	“Digital Kazakhstan” State Program	First comprehensive state program aimed at digitalizing the economy, public services, education, and healthcare	Formation of basic digital infrastructure, transition of key services to online formats

2023	Digital Transformation, ICT Development and Cybersecurity Concept (2023–2029)	Development of infrastructure, human capital, and cybersecurity	100% online accessibility of public services, reduction of digital inequality, strengthening of cybersecurity
2024	Artificial Intelligence Development Concept (2024–2029)	Large-scale implementation of AI in public administration, business, and the social sector	Creation of a national AI platform, launch of supercomputers, integration of AI into e-government
2024	E-Gov.kz and eGov Mobile	Automation of over 90% of public services, growth in the number of users	Improvement of service quality, full digitization of public services, reduction of paper-based processes
2024	International indices	Improvement of Kazakhstan's position in EGD I (24th place) and IMD (34th place) rankings	Entry into the top 20 of EGD I by 2030, strengthening positions in international rankings
2022 (pilot), 2025 (scaling)	"Digital Family Card"	Integration of data on 19.4 million citizens, automated allocation of social support measures	Reduction of bureaucracy, increased efficiency of targeted social assistance
2025	"Digital Business Card"	Unified B2G platform integrating data on support measures and licenses	Improved access of businesses to public services, reduction of corruption risks
2025	"Digital Subsoil Use Map"	Geoanalytics and AI-based system for resource management	Increased transparency in subsoil use, attraction of investment in geological exploration
2025	Digital Code	Comprehensive draft law on digital regulation	Systematization of regulatory legal acts, formation of digital sovereignty, legal framework for Big Data and AI
2025	Ministry of Artificial Intelligence and Digital Development	Establishment of a new body for coordinating digital policy	Centralization of digital governance, acceleration of AI adoption in the economy and public administration

Note: compiled by the authors based on Government resolutions of the Republic of Kazakhstan (2018–2024), digital development concepts (2023, 2024), materials of JSC "NIT" (2024), UN E-Government Survey reports (2024), data from the Center for Digital Transformation, and materials of the "Atameken" National Chamber of Entrepreneurs (2025), as well as decrees of the President of the Republic of Kazakhstan and parliamentary documents (2025).

The presented data demonstrate that digitalization processes in Kazakhstan have intensified significantly in recent years. In particular, the share of public services delivered online reached 92.9% in 2023 and exceeded 90% in 2024. The expansion of eGov, eGov Mobile, and digital banking services contributed to the broader accessibility of digital public services.

The results also indicate the active institutionalization of digital governance mechanisms. Between 2020 and 2023, the number of interagency integrations increased from 426 to 1,134, while platforms such as Smart Bridge and digital access control systems for personal data were introduced. In addition, recent state initiatives include the development of AI infrastructure, the Digital Code project, the "Digital Family Card," and the establishment of the Ministry of Artificial Intelligence and Digital Development.

DISCUSSION

The application of bibliometric methods made it possible to identify the main actors shaping the scientific discourse on digital infrastructure regulation, including countries, institutions, and research clusters. This approach also allowed the integration of qualitative findings from the literature review with quantitative indicators of scientific activity.

The bibliometric analysis demonstrates that research directly examining digital infrastructure as an object of state regulation remains relatively limited within the global scientific discourse. At the same time, the rapid increase in publication activity after 2008, particularly after 2018, indicates the growing academic and institutional

importance of digitalization processes. The results also suggest the emergence of a distinct research trajectory linking digital transformation, public governance, and sustainable development.

As shown in Figure 2, the bibliometric dataset demonstrates a relatively high annual publication growth rate (16.29%) and a notable level of international co-authorship (18.92%). These findings suggest that the topic of digital infrastructure regulation is gradually strengthening its position within the global scientific discourse. At the same time, the diversity of keywords and the growing number of publications indicate the expansion of research interest toward the relationship between digitalization, public governance, and institutional transformation.

The increase in publication activity after 2018 also reflects the growing practical significance of digital transformation processes in public administration. Thus, the results confirm that digital infrastructure is increasingly being considered not only as a technological phenomenon but also as an important object of state regulation and strategic development.

As shown in Figure 4, the regulation of digital infrastructure is gradually forming as an independent and globally distributed research field. At the same time, the analysis reveals a significant geographical imbalance in scientific activity. The dominant role of China, India, Korea, and the United Kingdom contrasts with the relatively limited contribution of Central Asian countries, indicating the still emerging character of regional research in this area. The strong association between the keywords "government regulation," "digitalization," "digital technologies," "sustainable development," and "digital economy" confirms that digital infrastructure is increasingly considered within the broader context of institutional transformation and public policy modernization. This also demonstrates that contemporary studies are moving beyond purely technological interpretations of digitalization and increasingly incorporate economic, social, and regulatory dimensions.

In this regard, the obtained results support the need for a comprehensive approach to the regulation of digital infrastructure, integrating issues of governance quality, sustainability, technological modernization, and digital sovereignty.

The thematic map presented in Figure 6 demonstrates that the dominant position within the current scientific discourse is occupied by the nexus "government regulation – digitalization – sustainable development." This indicates that digital infrastructure is increasingly interpreted not merely as a technological system but as an important component of institutional transformation and public governance modernization.

At the same time, the obtained thematic structure remains uneven. While issues related to digital governance, innovation, and sustainability occupy central positions in the research field, a number of areas remain insufficiently conceptualized, including independent models of digital economy regulation and specific approaches to platform governance.

Particular attention should also be paid to the emerging thematic clusters associated with artificial intelligence, blockchain, cybersecurity, and data governance. Their growing presence within the scientific discourse reflects the transformation of digital infrastructure into a multidimensional regulatory issue encompassing technological, economic, institutional, and social dimensions.

Thus, the results of the thematic analysis confirm the need for a comprehensive methodological approach to digital infrastructure regulation, integrating issues of sustainability, governance quality, technological modernization, and digital sovereignty.

The empirical indicators presented in Table 2 confirm that digital infrastructure in Kazakhstan is gradually transforming into a strategic object of state regulation rather than remaining solely a technological instrument. The expansion of online public services, digital platforms, and interagency integrations demonstrates the increasing role of digital governance in public administration modernization.

At the same time, the obtained results indicate that digital transformation processes remain uneven. Despite the achieved progress, issues related to regional disparities, unequal access to digital services, cybersecurity, and institutional coordination continue to persist. This confirms that digital infrastructure should be considered as a multi-level regulatory system encompassing data governance, platform ecosystems, artificial intelligence, cyber-resilience, and public trust mechanisms.

The growing integration of artificial intelligence into public administration and the development of new regulatory initiatives, including the Digital Code, also indicate a transition toward more complex models of digital governance. In this regard, the findings support the need for a comprehensive regulatory approach combining technological modernization with institutional sustainability and social inclusiveness.

CONCLUSION

The study examined digital infrastructure as an object of state regulation through the integration of conceptual, bibliometric, and empirical approaches. The results demonstrate that digitalization is increasingly associated with public governance modernization, sustainable development, and institutional transformation.

The bibliometric analysis confirmed the growing scientific interest in digital infrastructure regulation and revealed strong connections between government regulation, digitalization, innovation, and the digital economy.

At the same time, the findings indicate a geographical imbalance in scientific activity, as the contribution of Central Asian countries remains limited compared to leading research centers in Asia and Europe.

The empirical analysis showed that Kazakhstan has achieved significant progress in digitalization through the expansion of online public services, eGov platforms, Smart Bridge integrations, and AI-related initiatives. However, challenges related to digital inequality, cybersecurity, and the regulation of artificial intelligence still remain.

Overall, the obtained results confirm that digital infrastructure should be considered as a multidimensional object of state regulation integrating technological, institutional, economic, and social aspects. Future research may focus on comparative regulatory models, AI governance, and the socio-economic effects of digital infrastructure development.

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ЦИФРОВАЯ ИНФРАСТРУКТУРА КАК ОБЪЕКТ ГОСУДАРСТВЕННОГО РЕГУЛИРОВАНИЯ: ПОНЯТИЙНЫЙ И МЕТОДОЛОГИЧЕСКИЙ АНАЛИЗ

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Аннотация

В условиях ускоренной цифровизации мировая экономика переживает структурные изменения, в которых цифровая инфраструктура становится ключевым стратегическим ресурсом. Она выступает не только технологической базой инноваций, но и фактором национальной конкурентоспособности, суверенитета и безопасности. Именно поэтому вопросы ее государственного регулирования приобретают особую актуальность, что подтверждается как глобальными тенденциями, так и национальными стратегиями, реализуемыми в Казахстане. Результаты исследования включают два направления. Во-первых, проведенный библиометрический анализ публикаций (Scopus, 2008–2024 гг.) показал, что число работ, посвященных сочетанию «government regulation» и «digital infrastructure», остается крайне ограниченным, что указывает на недостаточную проработку темы в академическом дискурсе. Вместе с тем наблюдается устойчивая динамика роста публикаций по ключевым терминам «digital» и «digitalization» с 2009 года, а с 2018 года резкое усиление интереса к связке «государственное регулирование – цифровизация – устойчивое развитие». Это подтверждает формирование отдельного исследовательского направления, находящегося в стадии активного развития. Во-вторых, анализ показал, что Казахстан демонстрирует заметный прогресс в цифровизации: значительная часть государственных услуг уже функционирует в электронном формате, расширяются возможности мобильных сервисов и интеграционных платформ. Международные индексы фиксируют укрепление позиций страны, хотя сохраняются и вызовы цифровое неравенство, уровень доверия к сервисам и вопросы киберустойчивости. Научная новизна статьи заключается в том, что цифровая инфраструктура рассматривается как многослойный объект государственного регулирования, объединяющий сетевой, платформенный, институциональный и социальный уровни. Такой подход позволяет не только систематизировать существующие результаты, но и предло-

жить новые направления исследований, ориентированные на выработку более комплексных и эффективных регуляторных стратегий в условиях цифровой трансформации.

Ключевые слова: цифровая инфраструктура; государственное регулирование; цифровизация; библиометрический анализ; электронное правительство

ЦИФРЛЫҚ ИНФРАҚҰРЫЛЫМ МЕМЛЕКЕТТІК РЕТТЕУДІҢ НЫСАНЫ РЕТІНДЕ: ҰҒЫМДЫҚ ЖӘНЕ ӘДІСНАМАЛЫҚ ТАЛДАУ

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Аңдатпа

Жаһандық экономиканың жедел цифрлану жағдайында құрылымдық өзгерістер орын алып, цифрлық инфрақұрылым негізгі стратегиялық ресурсқа айналууда. Ол тек инновациялардың технологиялық базасы ғана емес, сонымен қатар ұлттық бәсекеге қабілеттіліктің, егемендіктің және қауіпсіздіктің маңызды факторы болып табылады. Сондықтан да цифрлық инфрақұрылымды мемлекеттік реттеу мәселелері айрықша өзектілікке ие болып отыр, бұл жаһандық үрдістермен қатар Қазақстанда іске асырылып жатқан ұлттық стратегиялармен де дәлелденеді. Зерттеу нәтижелері екі негізгі бағытты қамтиды. Біріншіден, жарияланымдарға жүргізілген библиометриялық талдау (Scopus, 2008–2025 жж.) «government regulation» және «digital infrastructure» ұғымдарының үйлесіміне арналған еңбектердің саны тым шектеулі екенін көрсетті. Бұл аталған тақырыптың академиялық дискурста жеткілікті деңгейде ашылмағанын білдіреді. Сонымен бірге «digital» және «digitalization» негізгі терминдері бойынша жарияланымдардың тұрақты өсу динамикасы 2009 жылдан бастап байқалады, ал 2018 жылдан бері «мемлекеттік реттеу – цифрландыру – тұрақты даму» байланысына қызығушылықтың күрт артуы байқалды. Бұл осы салада дербес ғылыми бағыттың қалыптасып, белсенді даму кезеңінде екенін дәлелдейді. Екіншіден, талдау Қазақстанның цифрландыруда айтарлықтай ілгерілеуін көрсетті: мемлекеттік қызметтердің едәуір бөлігі қазірдің өзінде электрондық форматта ұсынылады, мобильді сервистер мен интеграциялық платформалардың мүмкіндіктері кеңеюде. Халықаралық индекстер елдің позициясының нығая түскенін көрсеткенімен, цифрлық теңсіздік, қызметтерге деген сенім деңгейі және кибертұрақтылық мәселелері секілді бірқатар сын-қатерлер сақталуда. Мақаланың ғылыми жаңалығы цифрлық инфрақұрылымның көпқабатты мемлекеттік реттеу нысаны ретінде қарастырылуында. Ол желілік, платформалық, институционалдық және әлеуметтік деңгейлерді біріктіреді. Мұндай тәсіл қолда бар нәтижелерді жүйелеуге ғана емес, сонымен қатар цифрлық трансформация жағдайында неғұрлым кешенді әрі тиімді реттеу стратегияларын әзірлеуге бағытталған жаңа зерттеу бағыттарын ұсынуға мүмкіндік береді.

Түйін сөздер: цифрлық инфрақұрылым; мемлекеттік реттеу; цифрландыру; библиометриялық талдау; электрондық үкімет