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И УПРАВЛЕНЧЕСКИЕ РЕШЕНИЯ**



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Mapping Global Trends in Fintech Policy: A Bibliometric Analysis with a Focus on Emerging Markets

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Abstract

This study provides a comprehensive bibliometric analysis of academic literature on fintech policy in emerging markets. Using the Web of Science Core Collection, an initial dataset of 2,135 records was filtered to 1,718 peer-reviewed English-language articles published between 2000 and 2025. VOSviewer was used to map keyword co-occurrence, country and institutional co-authorship networks, and citation-based thematic clusters in order to reveal the conceptual, geographical, and institutional structure of the field.

The findings show that fintech policy has become an increasingly important research area, with a rapid rise in publications from 2020 onward. The dominant themes include digital finance, regulatory innovation, financial performance, sustainability, corporate governance, and financial inclusion. Fintech is also increasingly discussed in relation to environmental governance, poverty reduction, inclusive growth, and the Sustainable Development Goals, particularly SDG 9 on industry, innovation and infrastructure, SDG 8 on decent work and economic growth, and SDG 1 on no poverty.

The geographical analysis shows that research on fintech policy in emerging markets is moderately decentralized and globally distributed. The United States, China, and England are the leading contributors, while Malaysia, Saudi Arabia, Tunisia, South Africa, and other emerging economies are becoming more visible in the field. However, the literature remains fragmented due to uneven regional representation and limited attention to cross-border policy coordination.

This paper contributes to the literature by offering a systematic bibliometric review of research at the intersection of fintech and public policy, with a focus on the Global South. The study provides an evidence-based resource for future fintech policy development and highlights the need for more interdisciplinary research that connects technological innovation, inclusive governance, and sustainable development.

Keywords: Fintech policy, emerging markets, financial regulation, digital financial inclusion, bibliometric analysis, Web of Science, VOSviewer

Introduction

Fintech, or financial technology, is the provision of financial services and products through new technologies. Fintech is currently spreading across the world and affects the emerging markets most, since these markets have a poor inclusion in the traditional financial systems. Therefore governments and central banks are developing new policies in order to support the financial inclusion and to mitigate the risks which could arise by the use of new financial services.

There is a growing number of publications dealing with the interface of financial technologies (fintech) and financial governance. These studies are written by researchers from many different disciplines and are distributed across global academic publishing. A systematic analysis of these studies is required in order to identify the main fields of research, the key authors from around the world and the existing research gaps.

This study conducts a bibliometric analysis of 1718 articles published between 2000 and 2025 that focus on fintech policy in developing and emerging countries. By examining patterns of co-authorship, keyword co-occurrence, and institutional affiliation, the research reveals the intellectual structure of this growing field. The analysis applies VOSviewer software to visualise thematic clusters and identify regional patterns in publication activity.

The goals of this study are threefold: (1) to provide quantitative insight into the development of fintech policy research; (2) to map thematic and geographic trends across the literature; and (3) to identify areas for future scholarly and policy-oriented investigation. The research period of 2000 to 2025 was chosen based on the availability of reliable Web of Science metadata and the emergence of fintech discourse during this time. The study contributes to the evolving field of digital finance by clarifying how regulatory challenges and innovation strategies are represented in scholarly debate.

Literature Review

Existing research in the field of fintech is devoted to the study of its economic, technological and regulatory aspects. Much of this literature focuses on business models, consumer behavior, financial innovation, and the introduction of new technologies. Gomber et al. (2018) explored the disruptive potential of fintech innovation, especially in transforming legacy banking systems and creating new forms of digital intermediation. However, while considerable attention has been paid to the economic consequences and innovative dynamics of fintech technologies, aspects of public policy — especially in the context of emerging economies — remain relatively poorly understood.

Recently, a large number of studies have been conducted to evaluate the development of the field of fintech using bibliometric analysis. These studies attempted to evaluate the role of digital financial services in promoting financial inclusion, access to financial services, and development, especially among financially excluded and underserved individuals in developing countries (Afjal, 2023; Del Sarto and Ozili, 2025). For instance, a study conducted by Del Sarto and Ozili (2025) mapped the existing body of literature on increasing access to financial services through a number of channels, including mobile banking platforms and peer-to-peer (P2P) lending platforms, with a view to promote economic empowerment for financially excluded and underserved individuals in developing countries. The study established the role that fintech has been playing in addressing financial exclusion and ensuring that there are financial services and mechanisms in place that would increase access to financial services in order to promote financial inclusion and empower financially excluded and underserved individuals in developing countries. The focus of the study, however, was on increasing access to financial services rather than the governance structures that would facilitate financial services and increase access to financial services.

A number of studies attempt to map out the trend of scientific papers on the topic of regulation of financial technologies, such as the work of Hudaefi (2025), who analyzed a total of 688 relevant scientific papers to determine the trends and map the author networks. However, these emerging studies do not attempt to assess the impact of policies and/or regulations in specific geographical regions.

Sethi et al. (2025) conducted a bibliometric study of fintech research trends from 1990 to 2024.

There are also a number of recent studies, including Garg et al. (2023), Gumilar et al. (2024), and Pazarbasioğlu et al. (2020), which highlight the importance of financial literacy for digital financial services and the need for adaptation of financial services' regulations in the context of the fintech industry's rapid growth. From an institutional perspective, therefore, the interface between public policy and financial technology becomes increasingly important, especially in emerging markets, which are technologically advanced but institutionally underdeveloped.

A recent study on challenges for the area of fintech regulation by Zetsche et al. (2017) emphasizes the enormous problems which TechFin and Fintech pose for the range of models for financial regulation which have hitherto existed. For a long time, no sufficiently effective framework has been able to be developed for the quickly growing fields of business in the financial sector. For countries with a weak and poorly institutionalized environment, these problems are even more acute than for others.

Despite these contributions, the literature remains fragmented when it comes to systematically describing how fintech policies in emerging economies are researched and conceptualized. This study aims to address this gap by conducting a focused bibliometric review of scientific findings related specifically to fintech regulation and policy in the Global South. By narrowing its scope to policy frameworks, institutional actors, and cross-country collaboration, it provides a structured overview of the scientific field and identifies new areas of analysis.

At the same time, this study builds on earlier work, but differs in that it focuses on the political aspect of fintech — not only as a consequence of digital innovation, but also as a driving force behind development strategies and institutional reforms. Using keyword matching, thematic category analysis, and a network of co-authors, the study reveals how scientists structure the debate around regulatory innovation, increased access to financial services, and public infrastructure in the fintech sector. In this way, the study adds an im-

portant element to the growing body of literature, revealing the links between academic research and policy development in the context of digital finance in emerging markets.

Materials and Methods

This study employs a bibliometric analysis approach to examine global academic trends in fintech policy research within emerging markets. The Web of Science (WoS) Core Collection was used as the primary data source due to its rigorous indexing standards and comprehensive coverage of peer-reviewed scholarly output. A logical search query was created to search for relevant literature on financial regulation and fintech policy in developing countries. The search string used was: TS = ("fintech policy" OR "financial regulation") AND TS = ("emerging markets" OR "developing countries")

The initial search yielded 2,135 results. Subsequently, the dataset was filtered to include only English-language documents classified as articles or reviews published between 2000 and 2025. These time frames reflect the growth of fintech as a policy-relevant phenomenon and are consistent with the ongoing bibliometric coverage in WoS. Further refinement was carried out by checking the relevance of the title and annotation, during which the entries were evaluated for relevance to the scope of the study. After removing unnecessary records, non-peer-reviewed materials, and duplicates, the final dataset included 1,718 publications.

Bibliographic metadata — including titles, abstracts, keywords, authorship, institutional affiliations, journal names, citation counts, and subject categories — was exported in Excel format. A preprocessing phase was conducted to standardise terminology and eliminate duplicates. A custom thesaurus file was applied in VOSviewer to unify variations in terms such as “mobile finance” and “digital banking.”

The analysis was carried out using VOSviewer, a software tool for constructing and visualising scientific maps. A keyword co-occurrence analysis was conducted using the full counting method, with a threshold set at a minimum of seven keyword occurrences. This enabled the identification of dominant thematic structures across the literature. VOSviewer’s modularity-based clustering algorithm grouped keywords into five major clusters, which were interpreted qualitatively to reflect thematic areas such as performance, regulation, investment, sustainability, and institutional design.

The study also included a co-authorship analysis by both country and institution to identify patterns of international scholarly collaboration. Visualization of the network made it possible to identify central research centers (for example, the USA, China, England) and new regional participants (for example, Malaysia, Saudi Arabia, Tunisia). The analysis of institutional affiliation revealed the role of multilateral organizations, elite universities, and regional think tanks in shaping this field.

To understand the intellectual structure of the research landscape, a bibliographic analysis of the relationships was carried out. This approach makes it possible to identify links between referenced documents and thereby illustrate how scientific discussions are shaped in time and space. The analysis identified dense clusters of citations in economics, sustainability science, and corporate governance.

In addition, the study assessed the relevance of literature to the United Nations Sustainable Development Goals (SDGs) in order to understand how scientific work reflects global development priorities. The SDG indicators were analyzed based on WoS indexing, with the most common goals including industrial innovation (Goal 9), decent work and economic growth (Goal 8), and poverty reduction (Goal 1).

Finally, the analysis included distribution by journal, classification of subject areas, and citation indexing to assess the breadth and depth of the subject matter. The results showed that the research is interdisciplinary and focuses on journals related to sustainable development, finance, and environmental policy. Although this methodology provides reliable macro-level analytics, it faces limitations, including the potential underrepresentation of research published outside of English or locally, which is not indexed in WoS, and the inability to evaluate the qualitative arguments or theoretical depth of individual publications.

Findings

The analysis of fintech policy literature from 2000 to 2025 reveals a steady increase in scholarly attention over the 25-year period as shown in Figure 1. The number of publications grew from 10 articles per year in the early 2000s to more than 200 articles annually by 2021, peaking at 249 articles in 2023, reflecting the growing importance of fintech in regulatory and development discourse. The rise of mobile finance, digital payments, and inclusive banking solutions in emerging markets corresponds with this academic expansion.

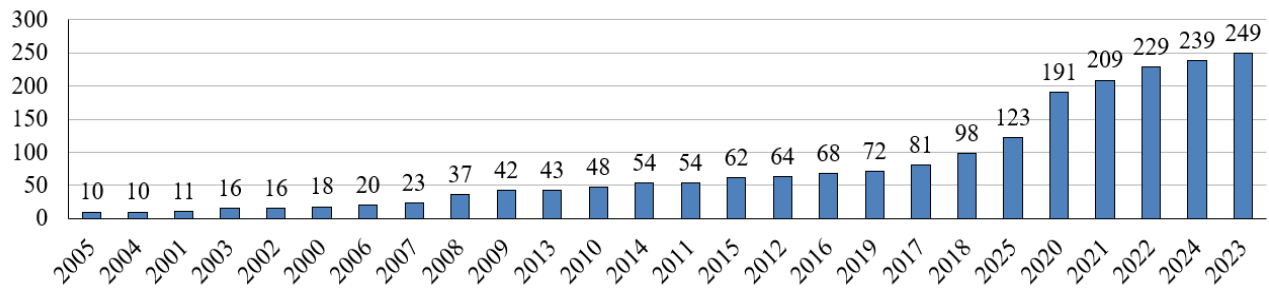


Figure 1. Annual number of publications on fintech policy in the emerging markets (2000-2025)

The first five years from 2001 to 2005 showed minimal research activity because the annual publication count remained below eighteen articles. Then, for the next fourteen years the number of research papers started to fluctuate between 20 and 98. The number of publications experienced its first significant increase in 2020 leading to its highest point at 249 articles in 2023. The time span from 2020 to 2024 proved to be the most productive period because it generated more than 1000 articles overall, which made up more than a half of the entire dataset.

The significant drop in 2025 publications to 123 items stems from the fact that the 2025 data was not fully available at that time.

Most of the 1718 indexed documents about fintech in emerging markets consist of peer-reviewed journal articles. Journal articles represent 74.9 % of total publications, according to Figure 2, which shows that academic journals have been the primary source of fintech policy in emerging markets.

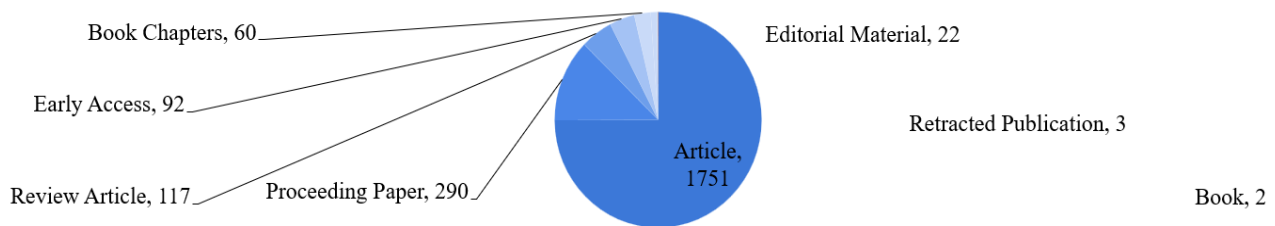


Figure 2. Distribution of document types in the dataset

This database contains only a few document types other than articles:

- Proceeding papers (2nd after articles).
- Book chapters: a minimal amount of the total amount of documents in the database.
- A handful of review articles and “early access” articles. The quality control in this field is very good.

There are only a few retracted publications. The distribution of the publications shows that the field is mature and strong in the peer-reviewed scholarly literature.

The dominance of journal articles supports the credibility of bibliometric network analysis based on co-citation patterns, authorship links, and keyword frequency.

Regarding authorship, Figure 3 presents the most active researchers on the topic. The bar chart shows the contributors with the highest number of publications on fintech. The most active contributors published between 3 and 7 articles during the study period, indicating a balanced level of scholarly output.

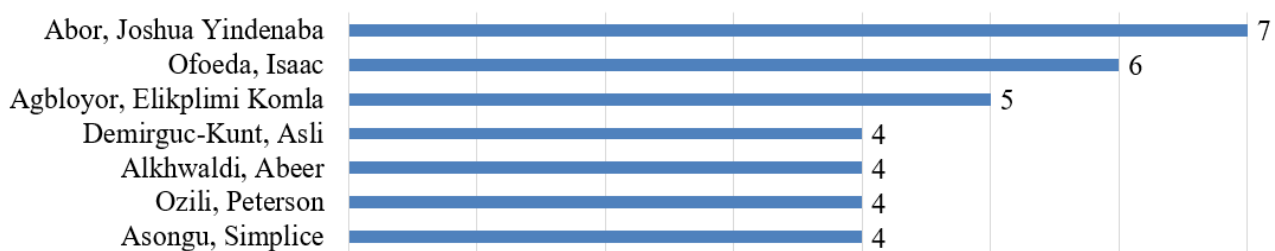


Figure 3. Most productive authors on fintech policy in emerging markets

The top three authors produced 7, 6, and 5 publications, respectively demonstrating their continuous interest in the subject matter throughout the years. Asongu S, Ozili P, Alkhwalidi A and Demirguc-Kunt A join the list with four or more publications each. The list demonstrates both regional and disciplinary diversity because affiliations probably extend across economics, information technologies and public policy.

The presence of five additional authors listed in the analysis (Knaack P, Corbet S, Radulescu M, Valentina M, Aguilera-Caracuel J) indicates that the field is moderately collaborative and dispersed, without being dominated by a single scholar or institution. This points to a developing yet decentralised research landscape shaped by both individual efforts and thematic groupings. The 1718 publications in the dataset receive their Web of Science (WoS) subject category classification in Figure 4.

Economics is the dominant category, followed by Business Finance and Environmental Sciences because research on fintech remains field-specific. The interlinkages among Business, Environmental Studies, Management, and Law provide further areas for analysis.

These fields collectively engage with themes such as business, finance, economics and markets. The International Relations, Green Sustainable Science Technology and Public Environmental Occupational Health fields demonstrate an increasing not only scholarly, but also a public interest in fintech and financial regulation within the scope of emerging markets and economies.

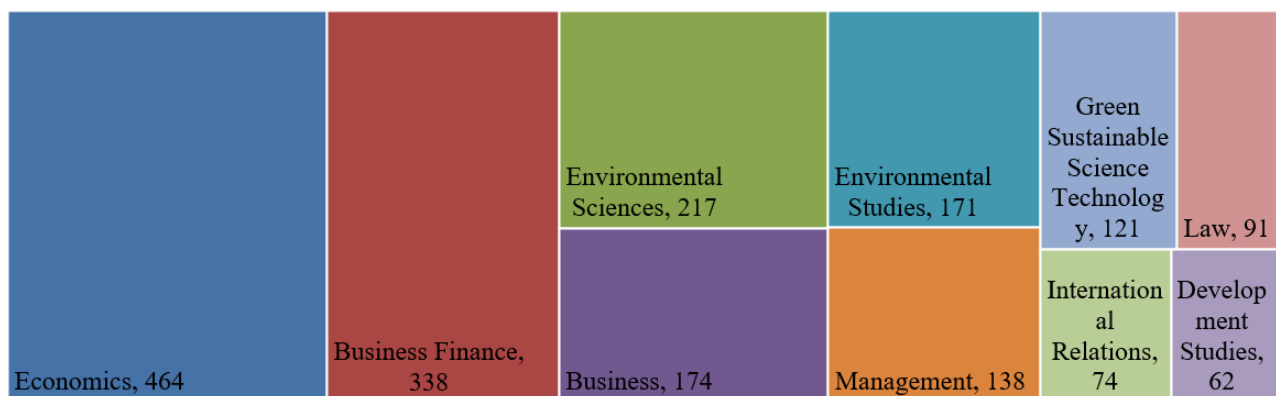


Figure 4. Most popular Web of Science subject categories

Analysis of citation topics at the meso-level shows quite expected results, as number and percentage of records are obvious for common readers. Most numeric topics are Economics (6.10), Sustainability Science (6.115) and Management (6.3), which take about 61 % of all results (34.22 % for Economics, 13.87 % for Sustainability Science and 13.35 % for Management). The tree map is shown in Figure 5.

Other topics such as Political Science (6.27), Security Systems (4.187), Healthcare Policy (1.156), Human Geography (6.86), Forestry (3.40), Design & Manufacturing (4.224), which take around 1 % of results each are evident for fintech in emerging markets, as these can be responsible for actually applying fintech in everyday life. These results show that fintech is connected to economics and has a constant field to be studied in, moreover, to be studied in different subtopics.

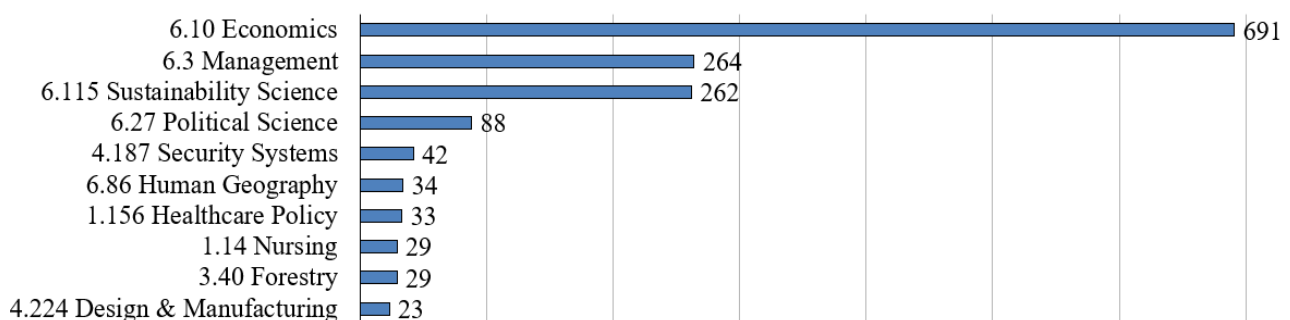


Figure 5. Most common meso-level citation topics

The micro-level citation topics are represented in Figure 6, and it gives a broader glimpse of a theme and where the study itself takes place. Finance-growth Nexus (6.10.82) takes the majority of results, being commonly cited in articles. Then, Carbon Mitigation (6.115.234), Corporate Governance (6.10.63) and Corporate Social Responsibility (6.3.385) take around the same percentage of results each and show the up-to-date link of fintech and research questions. For instance, carbon reduction strategies are clearly connected to fintech policies, as are corporate governance issues in emerging countries.

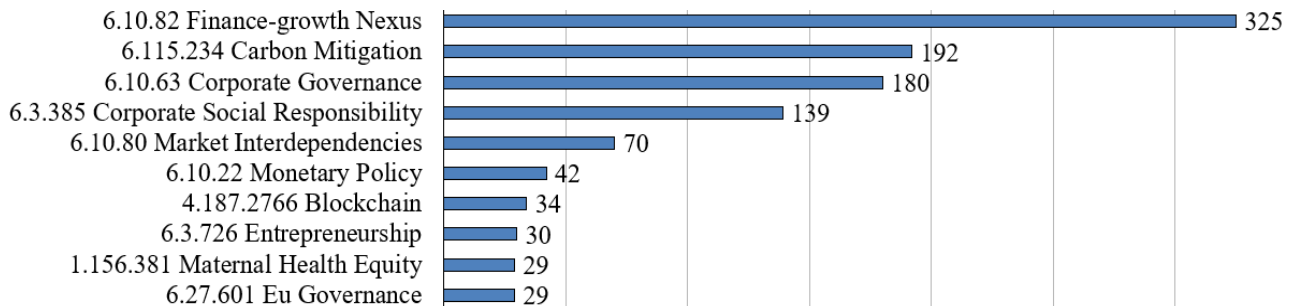


Figure 6. Most common micro-level citation topics

Furthermore, such topics as Market Interdependencies (6.10.80), Monetary Policy (6.10.22) and Blockchain (4.187.2766) also have prolific results, confirming the diversity of fintech as an area for research.

The analyzed literature shows its alignment with United Nations Sustainable Development Goals (SDGs) through Figure 7.

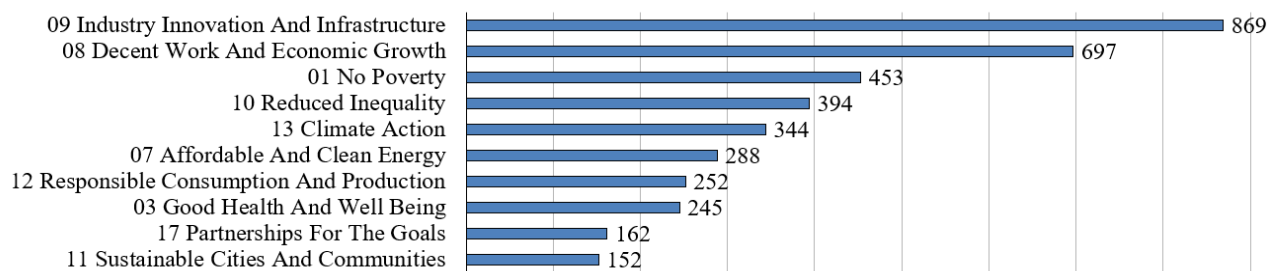


Figure 7. Distribution of literature by sustainable development goals

The dataset shows Goal 09: Industry Innovation and Infrastructure as its most frequently appearing SDG. The reviewed articles show that fintech is primarily used for industry and all economic structure, leading to convenience of citizens in daily life, even if they are not part of the business community. The most important goals are Goal 08: Decent Work and Economic Growth and Goal 01: No Poverty. These are related to steady work and businesses, as for the employed population. These results suggest that the literature is strongly aligned with economics, energy and global well-being. Still, there is a growing multidisciplinary interest in inequality, climate and consumption.

Figure 8 shows the distribution of the analysed publications across different Web of Science (WoS) citation indexes. Most of the articles are indexed in the Social Sciences Citation Index (SSCI), which means that the topic of fintech governance in the developing states is mainly studied through the social science disciplines of political science, sociology and area studies.

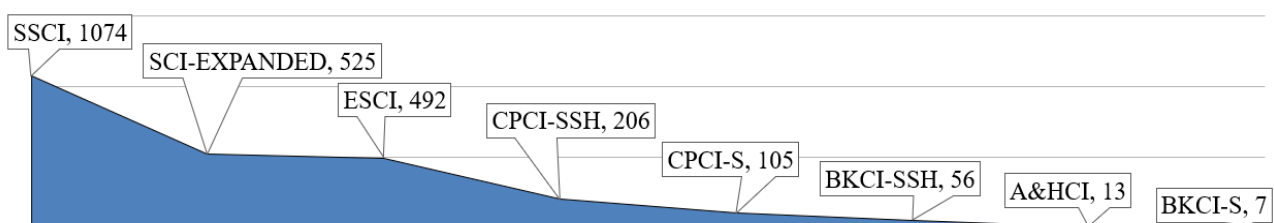


Figure 8. Distribution by WOS index

Science Citation Index Expanded (SCI-EXPANDED) stands as the second most frequently used indexing category with 525 publications and indicates the interdisciplinary crossover within the topic.

Other results are:

- Emerging Sources Citation Index (ESCI) — 492 publications from emerging or regionally important sources;
- Conference Proceedings Citation Index — Social Science & Humanities (CPCI-SSH) — 206 articles, highlighting academic engagement through conference participation;
- Book Citation Index — Social Sciences & Humanities (BKCI-SSH) — 56 entries;
- Arts & Humanities Citation Index (A&HCI) — 13 records, showing minimal presence in arts or humanities.

The research field maintains its foundation in social sciences and emerging sources, lacking in other disciplines.

Figure 9 presents the most active institutions contributing to research on fintech policy in emerging markets, based on publications from 2000 to 2025. The University of London ranks first with 49 publications, reflecting its strong research presence and broad international network of institutions.

The Ministry of Education and Science of Ukraine follows the University of London with 41 publications, mostly on financial technology, financial services and products, and their regulation in developing economies. The World Bank publishes 27 papers, sharing its experience on the development of financial inclusion policies and projects in digital finance, as well as on building the capacity of low- and middle-income countries to design and implement financial inclusion policies and projects (Pazarbasioglu et al., 2020).

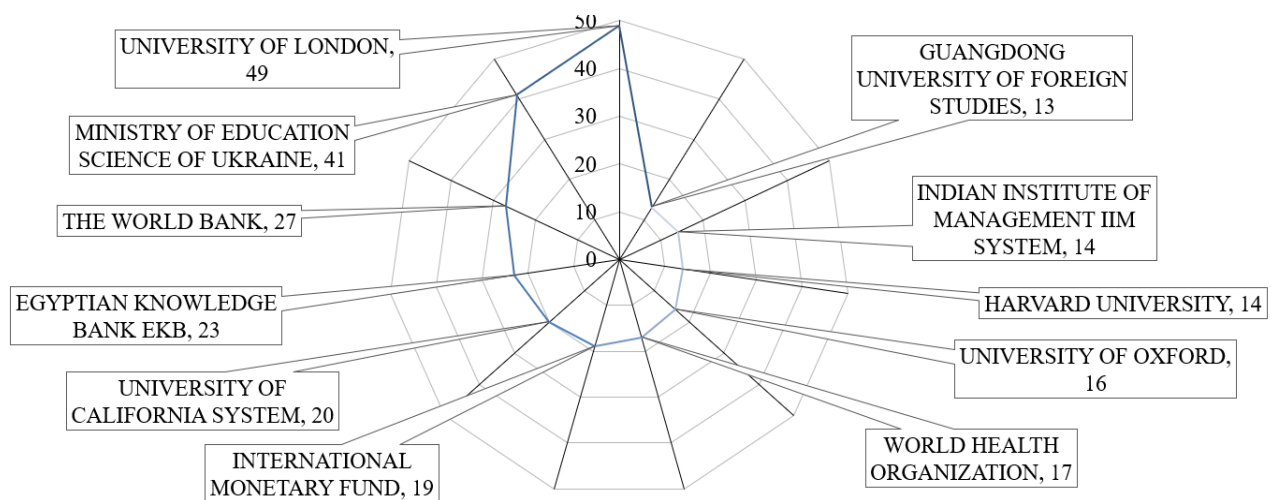


Figure 9. Most productive institutional affiliations

The Egyptian Knowledge Bank (EKB) — Egypt’s digital library and knowledge resource platform — has invested in the development of national digital infrastructure to create an open-access environment that supports research, and has produced 23 publications in the area of financial technology research and financial services regulatory frameworks in emerging economies. The University of California System follows with 20 publications, exploring a variety of technology, development, and financial services topics with a cross-national and cross-regional perspective. The International Monetary Fund (IMF), with 19 publications, follows a similar focus to the World Bank in relation to macroeconomic stability, financial services, financial technology, and cross-border finance management.

The World Health Organization (WHO) published 17 articles pointing to the interaction between financial technology and public health. In particular, these studies analyzed the integration of financial technology with existing health systems, as well as other possible forms of integration. Oxford University and Harvard University published 16 and 14 publications, respectively, confirming the role of leading academic institutions in research on digital finance management in developing countries of the Global South.

Several established academic institutions in India, such as the Indian Institute of Management (IIM) system, have published 14 studies on various aspects of financial systems and technologies, including financial regulation and inclusive finance in South Asia. Moreover, other parts of the world, including China, are

starting to have a significant impact on digital financial policy in emerging economies in Asia and Africa. For instance, 13 studies have been published by Guangdong University of Foreign Affairs.

Financial technology for development is fast becoming a global subject of interest and most policy-oriented work in this field is carried out by multilateral, national and regional institutions and by universities, research centers and other academic institutions of high standing. In terms of disciplinary approach, the majority of studies are interdisciplinary and cover fields such as economics, information systems, public policy and international development.

Table 1 below is a visualization of research output on financial technology in emerging economies. The top journal ranking is Europe-Asia Studies which includes 50 publications followed by Sustainability with 29 publications and Environmental Science and Pollution Research with 28 publications. These journals focus on emerging financial services and financial products of developing countries and their role in achieving the SDGs of lower- and middle-income countries. The articles are environmental and sustainability-oriented focusing on green digital finance, climate risk management and monitoring. The publications are policy- and practice-oriented.

Financial and Credit Activity: Problems of Theory and Practice contributes 17 publications, primarily featuring regional case studies and institutional insights from developing financial systems. Core policy journals like the Journal of Financial Regulation and Compliance and Research in International Business and Finance publish 17 and 15 papers, respectively, indicating their role as key platforms for interdisciplinary debates around regulatory models, institutional design, and cross-border financial integration.

Table 1. Number of publications by Web of Science journal titles

Web of Science Journals	Number of publications
Europe-Asia Studies	50
Sustainability	29
Environmental Science and Pollution Research	28
Journal of Cleaner Production	18
Financial and Credit Activity: Problems of Theory and Practice	17
Journal of Financial Regulation and Compliance	17
Research in International Business and Finance	15
Resources Policy	14
Journal of Environmental Management	13
Economic Modelling	13
Emerging Markets Finance and Trade	13
Journal of Banking Finance	13
Applied Economics	12

Further contributions appear in Resources Policy (14 articles), the Journal of Environmental Management (13), and Economic Modelling (13), showing how digital financial tools are increasingly studied in connection with resource allocation, macroeconomic stability, and environmental governance. The journals Emerging Markets Finance and Trade, Journal of Banking and Finance, and Applied Economics also each contribute 13 to 12 publications, positioning them as important venues for empirical research on fintech expansion in Global South markets. This journal landscape reveals the very wide spread of research on fintech policy across many fields, including economics, environmental studies, international business and financial regulation. Much of this research is globally based and explores the implications of digital finance for development, inclusion and growth in emerging economies.

Figure 10 shows a total of 1718 scholarly publications on fintech policy research in emerging markets between 2000 and 2025.

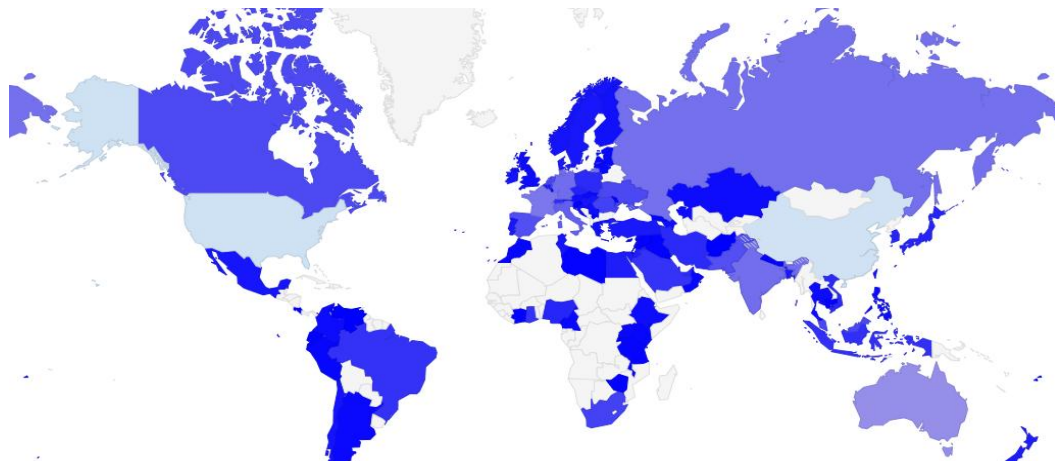


Figure 10. Number of publications by country/region

The United States leads with 345 publications, followed by China with 342 publications and England with 260 publications. A second group of countries consists of Australia (109), France (91), and Russia (86), representing active participation from both OECD economies and upper-middle-income countries. These countries, together with India (84), Germany (83), and Italy (73), are very active in the discussion of the implications that the development of fintech has for policy. Pakistan (62), Spain (61), Canada (57), Malaysia (56), the Netherlands (56), and Ukraine (56) are increasing their participation in the discussion of the implications of fintech development for policy in South Asia, Southeast Asia, and Europe.

Several emerging economies contribute notably to the literature, including Romania and South Africa with 51 publications each, Ghana (41), Saudi Arabia (40), and Brazil (39). These contributions suggest an active research community investigating the role of digital finance in inclusive growth, public policy reform, and digital infrastructure development. In addition to these countries, also further countries are included in the list of countries where research on fintech policy is done, such as for example Indonesia (37), Switzerland (36), Turkey (36), Poland (34), Iran (33), United Arab Emirates (33), and Vietnam (33).

Scholarly activities on issues of fintech policy in several countries in the African and Middle Eastern regions include, for example, Nigeria (30), Jordan (26), Egypt (24), and Morocco (7) demonstrate regionally significant contributions, often linked to national efforts around mobile banking, regulatory sandboxes, and digital ID integration. A group of countries from East and Southeast Asia, namely South Korea (30), Japan (29), and Taiwan (19) show consistent level of scholarly activities on issues of fintech policy, and these activities relate to the countries' mature systems of fintech as well as the various policy transformations that governments in these countries are undergoing in order to accommodate these growing sectors.

Meanwhile, Central and Eastern European countries such as the Czech Republic (27), Estonia (8), Latvia (8), and Lithuania (8) provide a European emerging market perspective on digital financial inclusion. Research activity is also present in smaller or developing economies, with countries like Kazakhstan (11), Kenya (7), Bangladesh (21), and Ethiopia (12) participating in the scholarly dialogue on fintech transformation. The presence of publications from a wide range of countries — including Finland, Singapore, Tunisia, Serbia, Nepal, and Rwanda — demonstrates that academic interest in fintech policy is truly global. The data confirms that fintech policy research, particularly in the context of emerging markets, is driven by a geographically diverse community of scholars whose work spans development finance, regulatory design, innovation policy, and digital inclusion.

The VOSviewer network visualisation in Figure 11 shows 173 keywords which appeared at least 7 times in the dataset. The visualisation shows the conceptual structure of the research on fintech in emerging countries, with keywords grouped into five major clusters based on their co-occurrence patterns.

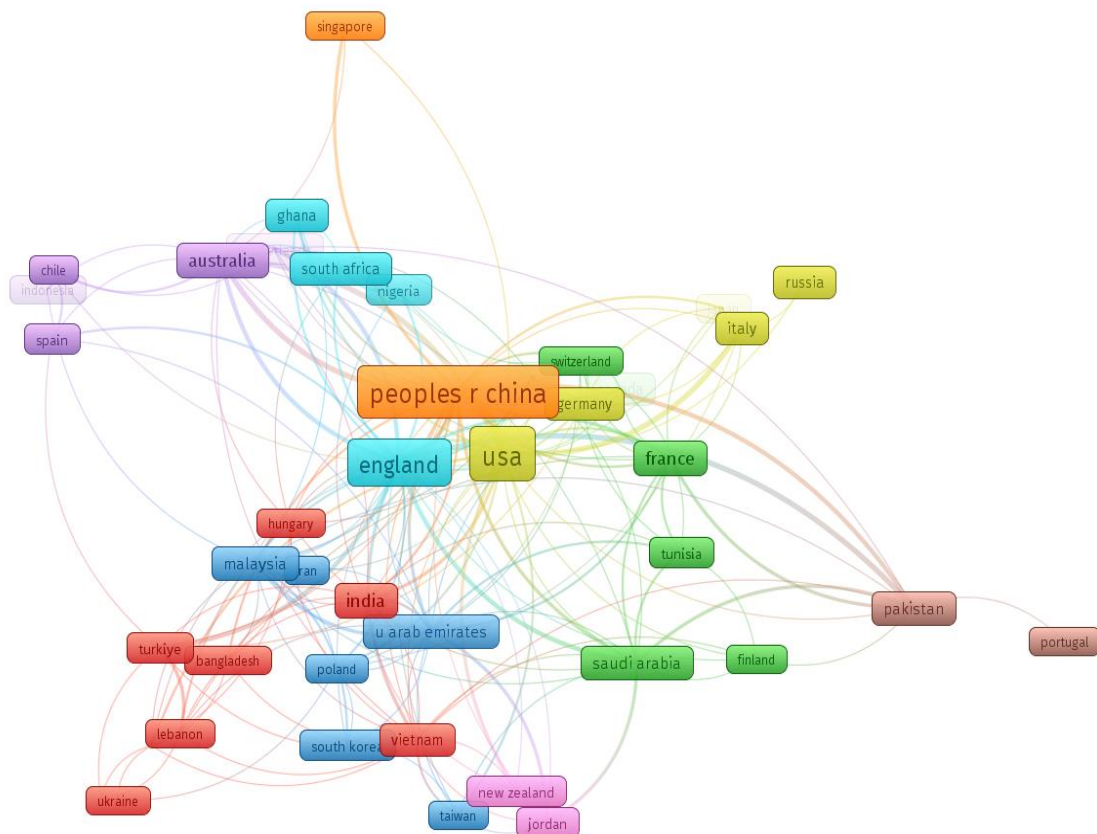


Figure 12. International Co-authorship Network in Publications

Research in the field of fintech technologies in emerging markets shows the active participation of the academic circles of England and the United States, which are the central nodes of global scientific networks. These countries have demonstrated stable research and collaboration results, especially in areas related to digital finance, regulatory frameworks, and increased access to financial services. Hungary and Malaysia also play an important role, often acting as regional fintech research centers in Central Europe and Southeast Asia, respectively.

Peripheral but active participants include the United Arab Emirates, South Africa, Tunisia, Saudi Arabia, and Finland. These countries are contributing through regional research and focused cooperation aimed at introducing fintech technologies at the local level, policy innovation and infrastructure development. Fintech has a different policy meaning globally. While fintech in the UAE and KSA is part of a wider digital transformation across the two Gulf countries, in Africa and a large part of Southeast Asia, it is a means to expand access to financial services and develop applications that are conducive to development.

The academic links between these countries reflect a diverse and expanding field of research that is driven by both regional needs and global trends in digital finance. International cooperation, such as between Malaysia and Saudi Arabia or Hungary and Tunisia, highlights the interdisciplinary and international nature of this field. New trends indicate that scientific networks in the field of fintech are influenced not only by the levels of economic development, but also by general political objectives and strategic ambitions in the field of digital technologies. The visualization highlights the global reach of the industry and the growing decentralization noted by both existing research centers and the growing number of regional participants.

The density visualization scale in Figure 13 indicates the most active researchers by geographical location. This indicates that the topic is widespread among the worldwide research community.

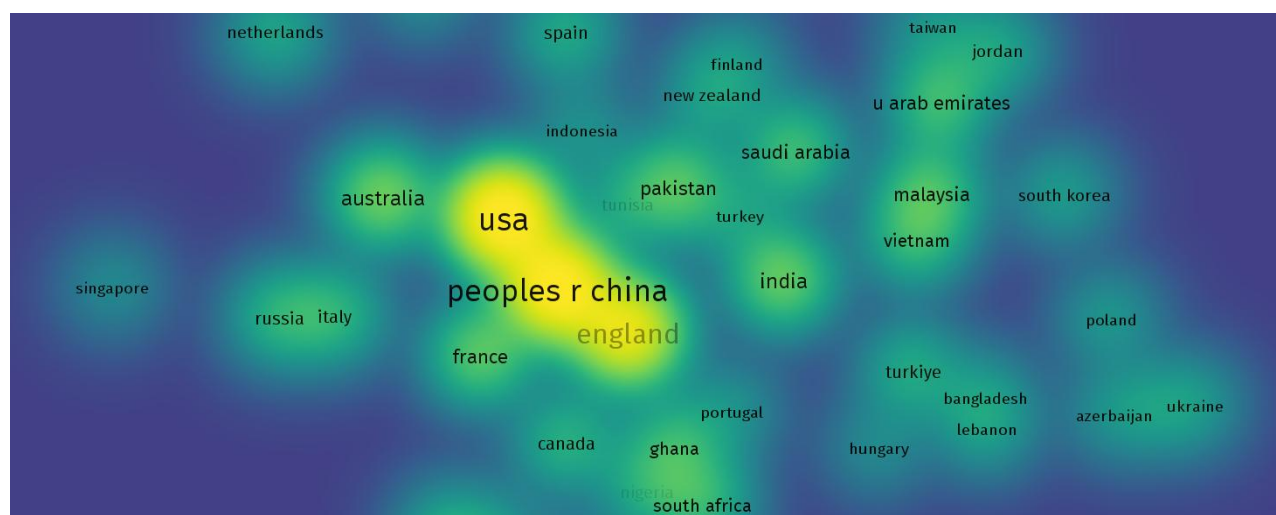


Figure 13. Density visualization of the international co-authorship network

Discussion

This bibliometric analysis shows the dynamic growth and expansion of financial technology policy research in emerging markets between 2000 and 2025. The growing attention of scientists, especially after 2020, reflects how fintech has transformed from a highly specialized topic into a central topic of discussions about economics and development. The predominance of journal articles indicates that this field of science has reached academic maturity and is methodologically stable enough to support the analysis of joint citations, keywords and author networks.

A number of disciplines are active in the field of fintech. Dominant subjects are economics, business/finance, environmental sciences and public policy. Already on the micro-level, the topics dealt with by the literature correspond to economic activities that are typical for the economy and environment, and therefore the field addresses economic and environmental challenges. Furthermore, the literature is also aligned with the UN SDGs of industrial innovation (Goal 9), economic growth (Goal 8) and reduction of poverty (Goal 1) in a normative and policy-oriented way.

The global distribution of research on financial technology shows a decentralization of authorship and institutional affiliations across countries. Following the three ‘hub’ countries of the USA, China and England, there are a large number of countries from the Global South that are increasingly becoming participants in this field, such as Malaysia, Saudi Arabia, South Africa and Tunisia, for example. International co-authorships between researchers from around the globe are becoming increasingly decentralized. They are characterized by close academic collaboration across continents and are influenced by a variety of factors, including geopolitical conditions, common development goals, as well as digital connectivity.

Combining research topics in efficiency, regulation, sustainability, and market interdependencies indicates that fintech is being studied as both a technological and management innovation. Regulation, digital finance, and macroeconomic integration are some of the key challenges. Knowledge production at the institutional level is being carried out by multilaterals such as IMF and World Bank, as well as by elite universities and regional knowledge platforms.

Conclusion

Over the last two decades the number of publications dealing with the topic of fintech policy in emerging markets has increased significantly. First, publications dealt with describing phenomena of fintech, later more complex analyses of various factors appeared. Currently the focus is on international cooperation of actors and on the impact of various policies for improving access to financial services for private persons as well as for enterprises and for promoting sustainable development by means of regulation and innovation. The analysis shows that fintech is no longer solely the domain of technical or financial experts — it is a multidimensional issue that intersects with issues of governance, development, health, and climate change. As countries and institutions continue to face the prospects and risks of fintech, it is imperative that research continues to evolve in an inclusive, evidence-based, and policy-aligned manner.

The global decentralization of scientific research opens up promising opportunities for collaborative knowledge creation and policy development in the field of financial technology, context-sensitive and future-oriented. Emerging markets in particular are at the forefront of experimentation and innovation, and their expertise can provide valuable insights into global digital finance governance.

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Inara Belgibayeva — Conceptualization, Data Curation, Formal Analysis, Investigation, Methodology, Resources, Software, Validation, Visualization, Writing — Original Draft, Writing — Review & Editing.

Nadeem Naqvi — Conceptualization, Project Administration, Supervision.

The authors have read and approved the final version of the manuscript.

Қаржы технологиясы саясатының жаһандық үрдістерін картаға түсіру: дамушы нарықтарға бағытталған библиометриялық талдау

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Аңдамна

Бұл зерттеу дамушы нарықтардағы қаржы технологиясы саясатына арналған ғылыми әдебиеттерге кешенді библиометриялық талдау ұсынады. Web of Science Core Collection дерекқоры негізінде бастапқы 2 135 жазба іріктеліп, 2000-2025 жылдар аралығында жарияланған 1 718 рецензияланған

ағылшын тіліндегі мақалаға дейін қысқартылды. VOSviewer бағдарламасы кілт сөздердің бірлесіп кездесуін, елдер мен институттар бойынша бірлескен авторлық желілерін, сондай-ақ дәйексөздерге негізделген тақырыптық кластерлерді картаға түсіру үшін қолданылды. Бұл талдау зерттеу саласының концептуалдық, географиялық және институционалдық құрылымын анықтауға мүмкіндік береді.

Нәтижелер қаржы технологиясы саясатының барған сайын маңызды зерттеу бағытына айналып келе жатқанын көрсетеді, әсіресе 2020 жылдан бастап жарияланымдар саны қарқынды өскен. Негізгі тақырыптарға цифрлық қаржы, реттеушілік инновациялар, қаржылық тиімділік, тұрақты даму, корпоративтік басқару және қаржылық инклюзия жатады. Сонымен қатар қаржы технологиясы экологиялық басқару, кедейлікті азайту, инклюзивті өсу және Тұрақты даму мақсаттарымен жиі байланыстырылып қарастырылады, әсіресе ТДМ 9 — индустрия, инновация және инфрақұрылым, ТДМ 8 — лайықты жұмыс және экономикалық өсу, сондай-ақ ТДМ 1 — кедейлікті жою.

Географиялық талдау дамушы нарықтардағы қаржы технологиясы саясаты бойынша зерттеулердің орташа деңгейде децентрализованғанын және жаһандық деңгейде таралғанын көрсетеді. АҚШ, Қытай және Англия негізгі үлес қосушы елдер, ал Малайзия, Сауд Арабиясы, Тунис, Оңтүстік Африка және басқа да дамушы экономикалар бұл салада барған сайын айқын көріне бастады. Дегенмен әдебиеттер әлі де фрагменттелген күйде қалып отыр, себебі аймақтық өкілдік біркелкі емес және трансшекаралық саясатты үйлестіруге жеткілікті көңіл бөлінбейді.

Мақала қаржы технологиясы мен мемлекеттік саясаттың тоғысындағы зерттеулерге, әсіресе жаһанды Оңтүстікке бағытталған жүйелі библиометриялық шолу ұсыну арқылы ғылыми әдебиетке үлес қосады. Зерттеу дамушы нарықтардағы болашақ қаржы технологиясы саясатын әзірлеу үшін дәлелдерге негізделген ресурс ұсынады және технологиялық инновацияларды, инклюзивті басқаруды және тұрақты дамуды байланыстыратын пәнаралық зерттеулердің қажеттілігін көрсетеді.

Кілт сөздер: қаржы технологиясы саясаты, дамушы нарықтар, қаржылық реттеу, цифрлық қаржылық инклюзия, библиометриялық талдау, Web of Science, VOSviewer.

Глобальные тенденции в политике финтех: библиометрический анализ с фокусом на развивающиеся рынки

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Аннотация

В данном исследовании представлен комплексный библиометрический анализ научной литературы, посвящённой политике в области финтех на развивающихся рынках. На основе базы данных Web of Science Core Collection первоначальный массив из 2 135 записей был отобран и сокращён до 1 718 рецензируемых англоязычных статей, опубликованных в период с 2000 по 2025 год. Программа VOSviewer была использована для построения карт совместной встречаемости ключевых слов, сетей соавторства по странам и институтам, а также тематических кластеров на основе цитирования с целью выявления концептуальной, географической и институциональной структуры данной области.

Результаты показывают, что политика в области финтех становится всё более значимым направлением исследований, при этом с 2020 года наблюдается быстрый рост числа публикаций. Основные темы включают цифровые финансы, регуляторные инновации, финансовую эффективность, устойчивое развитие, корпоративное управление и финансовую инклюзию. Финтех также всё чаще рассматривается в связи с экологическим управлением, сокращением бедности, инклюзивным ростом и Целями устойчивого развития, особенно ЦУР 9 — индустриализация, инновации и инфраструктура, ЦУР 8 — достойная работа и экономический рост, а также ЦУР 1 — ликвидация бедности.

Географический анализ показывает, что исследования по политике финтех на развивающихся рынках являются умеренно децентрализованными и глобально распределёнными. США, Китай и Англия выступают ведущими участниками, тогда как Малайзия, Саудовская Аравия, Тунис, Южная

Африка и другие развивающиеся экономики становятся всё более заметными в данной области. Вместе с тем литература остаётся фрагментированной из-за неравномерного регионального представительства и ограниченного внимания к трансграничной координации политики.

Данная статья вносит вклад в научную литературу, предлагая систематический библиометрический обзор исследований на пересечении финтех и государственной политики с фокусом на Глобальный Юг. Исследование предоставляет доказательную основу для будущей разработки политики в области финтеха и подчёркивает необходимость более междисциплинарных исследований, объединяющих технологические инновации, инклюзивное управление и устойчивое развитие.

Ключевые слова: финтех-политика, развивающиеся рынки, финансовое регулирование, цифровая финансовая инклюзия, библиометрический анализ, Web of Science, VOSviewer.

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Conflict of Interest

The authors declare no conflict of interest.

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A system approach to the formation of an institutional mechanism for the transition of the Belarusian economy to the synergetic stage of competitive growth

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Abstract

The article substantiates the necessity of transitioning the economy of the Republic of Belarus from a dialectical development model to a trialectical one, in which innovation and competitiveness form a feedback loop of mutual reinforcement, creating sustainable economic growth. Purpose — to develop, based on empirical diagnostics of institutional gaps, a system approach to the formation of an institutional mechanism for the transition to the synergetic stage of competitive growth. Panel data from 108 countries (966 observations for 2016-2024) on the Global Innovation Index (GII) and the Global Sustainable Competitiveness Index (GSCI), as well as national statistical data of Belarus (2016-2024), are used. Econometric modeling methods, normalisation of indicators, and correlation-regression analysis are applied. It is revealed that Belarus is in an “institutionally mediated” stage: the synergy coefficient $\beta_3 = 0.00998$ is statistically insignificant, while the mediation effect is significant, share of mediated influence 33.6 %. An integral institutional index (III) is developed. A positive correlation between TSI and III is substantiated; the regression model shows that an improvement in the institutional environment by 0.1 increases TSI by 0.031. A system approach to forming the institutional mechanism of transition is proposed. Key institutional traps are identified. Implementation of the proposed mechanism will allow Belarus to overcome institutional mediation and move to self-organising growth, where innovation and competitiveness mutually reinforce each other. Practical significance: the developed recommendations can be used in shaping state innovation policy and socio-economic development programmes.

Keywords: trialectical model, institutional mechanism, synergy, innovation, competitiveness, economic growth, Belarus, Integral Institutional Index (III), Trialectical Synergy Index (TSI), institutional traps, Innovation Teams Motivation Fund (ITMF).

Introduction

Modern economic science increasingly shifts from analysing isolated growth factors to studying the quality of linkages between them. Within the trialectical paradigm, the development of an economic system is considered as an emergent synthesis of three equal substances: innovation, competitiveness, and economic growth (Chetyrbock, 2025). Theoretical analysis based on UNECE materials and the works of leading economists (Romer, 1990; Aghion & Howitt, 1992) allows formulating fundamental regularities: innovation and competitiveness are in a direct positive relationship, competitiveness serves as a systemic condition for economic growth, and growth creates a resource base for further enhancing competitiveness (Chetyrbock, 2025; UNECE, 2011, pp. 3, 8–9, 13, 28; Schwab, 2019).

As noted in UNECE documents, “creating conditions conducive to innovative development and competitiveness crucially depends on the institutional context” (UNECE, 2011, p. 3). Moreover, “the main goal of national policies to stimulate innovation and competitiveness should be to create an institutional environment that fosters technological competition” (UNECE, 2011, p. 3).

In this study, institutions are understood according to D. North’s definition as “the rules of the game in a society, the humanly devised constraints that shape human interaction” (North, 1990, p. 3). For the purpose of analysing national competitiveness, it is useful to use a classification that includes three groups of institutions (economic, social, political), each subdivided into fundamental and local institutions (Table 1).

Table 1. Types of institutions shaping national competitiveness

	Fundamental
Economic	property, entrepreneurship, market, finance, production, management
Social	science, education, culture
Political	rights, state, parliamentarism
<i>Note: compiled by the author</i>	

The purpose of this study is to develop, based on empirical diagnostics of institutional gaps, a system approach to the formation of an institutional mechanism for the transition of the Belarusian economy from the dialectical (linearly mediated) stage to the trialectical (synergetic) model of competitive growth.

Materials and methods

Data. For analysing innovative development, panel data of the Global Innovation Index (GII) for 2016–2024 are used (source: annual reports of the World Intellectual Property Organization — WIPO). The sample covers 108 countries, including Belarus. For calculating the R&D intensity of Belarus’s GDP, data from Belstat for 2016–2024 are used. Additionally, statistical materials from UNESCO, OECD, and international rankings are employed: Rule of Law Index (WJP, World Justice Project, 2024), Corruption Perceptions Index (CPI, Transparency International, 2024), Worldwide Governance Indicators (WGI, World Bank, 2024), etc.

Methods. The research combines indicator analysis — to assess the dynamics of GII and R&D intensity; econometric analysis — to estimate the synergy coefficient β_3 within the trialectical model (panel regression with interaction); systemic-structural analysis — to describe the innovation ecosystem and its difference from the national innovation system; and institutional analysis — to identify traps and barriers.

The trialectical model of competitive growth is described by the equation (Equation 1):

$$\ln Y_{std} = \beta_0 + \beta_1 X_{1std} + \beta_2 X_{2std} + \beta_3 (X_{1std} \cdot X_{2std}) + \varepsilon \quad (1)$$

where:

$\ln Y_{std}$ — economic growth (log GDP per capita);

X_{1std} — innovation development (standardised value);

X_{2std} — competitiveness (standardised value);

β_3 — synergy coefficient (interaction);

ε — random error.

The interaction coefficient β_3 characterises factor synergy.

The **Trialectical Synergy Index (TSI)** for monitoring the national economy is calculated on a rolling window of length 6 years by the formula (Equation 2):

$$TSI_t = \hat{\beta}_3^{\text{window}}(t) \times \sigma_{X_1}^{\text{window}}(t) \times \sigma_{X_2}^{\text{window}}(t) \quad (2)$$

where:

TSI_t — index value in year t ;

$\hat{\beta}_3^{\text{window}}$ — estimate of the synergy coefficient on the rolling window (length W years);

$\sigma_{X_1}^{\text{window}}(t) \times \sigma_{X_2}^{\text{window}}(t)$ — standard deviations of the original X_1 and X_2 over the same window.

Source: Author’s development.

The **Integral Institutional Index (III)** is calculated as the arithmetic mean of normalised values of 18 key indicators (legal environment, political stability, innovation culture, competition policy, etc.) using the min-max method (Equation 3).

$$III_t = \frac{1}{n} \sum_{k=1}^n I_{k,t}^{\text{HOPM}}, III_t \in [0,1] \quad (3)$$

where:

III_t — value of the Integral Institutional Index in year t ;

n — total number of selected institutional indicators;

$I_{k,t}^{\text{HOPM}}$ — normalised value of the k -th indicator in year t .

Source: Author’s development.

Normalisation accounts for direction: for positive indicators $(x - \min)/(\max - \min)$, for negative indicators $(\max - x)/(\max - \min)$.

Results

1. Empirical verification of Belarus’s development stage.

Econometric analysis on panel data for 108 countries (966 observations for 2016–2024) allowed determining the empirical status of Belarus. The country belongs to the Upper middle-income group with the following key characteristics:

- The interaction coefficient $\beta_3 = 0.00998$ ($p = 0.828$) — statistically insignificant, indicating the absence of measurable synergy between innovation (X_1) and competitiveness (X_2);
- Explanatory power of the model $R^2 = 0.124$ — the selected factors explain only 12.4 % of GDP per capita variation;
- For the High-income group, $R^2 = 0.446$, $\beta_3 = 0.1348$ ($p = 7.41 \times 10^{-11}$);
- Mediation analysis revealed a significant indirect effect ($a \times b = 0.052$, $p < 0.001$) with a 33.6 % share of mediated influence, confirming the dialectical, sequential mechanism $X_1 \rightarrow X_2 \rightarrow Y$.

Interpretation: Belarus is in the “institutionally mediated phase” of trialectical development, where innovation (X_1) and competitiveness (X_2) influence growth primarily through institutional intermediaries rather than directly on each other. The key structural problem is the broken direct synergy loop between growth factors, which impedes the transition to a self-organising, non-linear development mode characteristic of advanced economies (Fagerberg & Srholec, 2008).

2. Institutional traps. Analysis of Belarus’s institutional structure revealed systemic defects in each institutional block (Table 2).

Table 2. Institutional traps by block

Block	Key problems
Economic	Conflict of interest of state enterprise managers; lack of demand for innovation
Financial	Underutilised venture fund; lack of incentives for business angels
Resource	High energy intensity of GDP (2.3-2.7 times above OECD level); low share of “Industry 4.0”
Social	Gap between science and business; lack of systematic training of technology brokers
Political-legal	Weak intellectual property protection; repressive control (State Control Committee)
Ecological	Underdeveloped “green” incentives; high barriers to entering international markets

Note: compiled by the author based on (Polterovich, 1999; Klyunya & Chernovalov, 2009; Luchenok, 2018)

Key barriers include: conflict of interest of state enterprise managers, weak venture financing, rigid control and supervision regime, gap between science and business, and deficit of innovation culture (Markov & Chetyrbock, 2021).

3. Integral Institutional Index (III). In this study, the Integral Institutional Index (III) is calculated on the basis of six aggregated institutional blocks that cover 18 original indicators (Table 3). Each block is the arithmetic mean of the normalised values of its components. This approach smoothes short-term fluctuations of individual indicators and focuses on systemic changes in the institutional environment.

Formation of six institutional blocks (Table 3).

Table 3. Composition of institutional blocks

№	Block	Indicators included (direction)	Direction	Number of components
1	Legal environment	WJP, Heritage, CPI	positive	3
2	Political stability	WGI Political Stability	positive	1
3	Macroeconomic stability	Inflation (neg.), gov. debt to GDP (neg.), credit rating (pos.)	mixed	3
4	Innovation culture	IP (thous. people), SMEs share in GDP, share of entrepreneurs, share of creative core	positive	4
5	Competition policy	State sector share in employment (neg.), state sector share in GDP (neg.), regulated prices share (neg.), monopolisation index (neg.), final state control index (neg.)	negative	5
6	Scientific and technological potential	R&D spending (% of GDP), number of researchers (per 10,000 employed)	positive	2

Note: compiled by the author

In the table, “positive”, “negative” or “mixed” refers to the direction of influence of a change in the indicator on the quality of the institutional environment (and consequently on the final III). Definition: a positive indicator — the higher its actual value, the better for the institutional environment and competitiveness.

Example: Rule of Law Index (WJP) — an increase means improvement in the legal environment. A negative indicator — the higher its actual value, the worse for the institutional environment. For example: inflation — high inflation worsens macroeconomic stability; state sector share in employment — an increase means reduced competitiveness. Mixed — the block contains both positive and negative indicators. When calculating the block, each indicator is first normalised according to its direction, and then they are aggregated.

Calculation method. For each indicator, min-max normalisation is performed accounting for direction:

- for positive indicators: $(x - \min) / (\max - \min)$;
- for negative indicators: $(\max - x) / (\max - \min)$.

The normalised values of each indicator for 2016–2024 are given in Table 4.

Table 4. Normalised values of indicators (2016–2024)

Indicator	2016	2017	2018	2019	2020	2021	2022	2023	2024
WJP	1.00	0.70	0.70	0.80	0.70	0.40	0.20	0.10	0.00
Heritage	0.03	0.74	0.70	0.69	0.97	0.96	0.36	0.21	0.00
CPI	0.50	0.79	0.79	0.86	1.00	0.57	0.43	0.29	0.00
WGI Political Stability	1.00	0.89	0.97	0.79	0.00	0.40	0.42	0.45	0.46
Inflation (%)	0.33	0.88	0.99	0.92	0.92	0.55	0.00	0.98	0.96
Government debt to GDP (%)	0.21	0.09	0.43	0.92	0.00	0.72	0.63	0.86	1.00
Credit rating (points)	0.83	0.83	1.00	1.00	1.00	1.00	0.17	0.00	0.00
IP (thous. people)	0.21	0.02	0.00	0.31	0.60	0.98	0.72	0.43	0.05
SMEs share in GDP (%)	0.00	0.18	0.15	0.61	0.70	0.76	0.30	0.33	1.00
Share of entrepreneurs (%)	0.00	0.27	0.40	0.63	0.70	0.50	0.50	0.60	1.00
Share of creative core (% of GDP)	0.00	0.10	0.14	0.48	0.90	1.00	0.62	0.10	0.24
State sector share in employment (%)	0.00	0.08	0.21	0.28	0.44	0.62	0.77	0.90	1.00
State sector share in GDP (%)	0.60	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Regulated prices share (%)	0.97	0.99	1.00	0.99	0.96	0.89	0.00	0.07	0.07
Monopolisation index (%)	0.00	0.18	0.36	0.47	0.58	0.74	0.86	0.95	1.00
Final state control index (IAK)	0.21	0.43	0.56	0.60	0.66	0.72	0.00	0.14	0.22
R&D spending (% of GDP)	0.93	0.86	1.00	0.86	0.57	0.00	0.07	0.79	0.93
Number of researchers (per 10 th. empl.)	0.15	0.22	0.07	0.66	0.22	0.00	0.15	0.73	1.00

Note: author's calculations.

Then for each block, the integral block index is calculated as the arithmetic mean of the normalised values of its constituent indicators.

3. Integral Institutional Index (III). Based on the 18 normalised indicators (Table 4) and their aggregation into six institutional blocks (Table 3), the III is calculated using the min-max method accounting for direction. The block values and the final III for 2016–2024 are presented in Table 5.

Table 5. Dynamics of III and its components (2016–2024)

Year	Block 1 (legal)	Block 2 (pol. stab.)	Block 3 (macro)	Block 4 (innov. culture)	Block 5 (comp. policy)	Block 6 (S&T potential)	III
2016	0.510	1.000	0.457	0.053	0.356	0.540	0.486
2017	0.743	0.890	0.600	0.143	0.536	0.540	0.575
2018	0.730	0.970	0.807	0.173	0.626	0.535	0.640
2019	0.783	0.790	0.947	0.508	0.668	0.760	0.743
2020	0.890	0.000	0.640	0.725	0.728	0.395	0.563
2021	0.643	0.400	0.757	0.810	0.794	0.000	0.567
2022	0.330	0.420	0.267	0.535	0.526	0.110	0.365
2023	0.200	0.450	0.613	0.365	0.612	0.760	0.500
2024	0.000	0.460	0.653	0.573	0.658	0.965	0.551

Note: author's calculations

Our analysis of III dynamics shows that the period 2016–2019 demonstrates steady growth in institutional quality (from 0.486 to 0.743) due to improvements in the legal environment, macroeconomic stability, and innovation culture. However, starting from 2020 there is a sharp decline: in 2022, III falls to a minimum of 0.365 — this is due to the collapse of the credit rating ($0.17 \rightarrow 0.00$), an increase in the share of regulated prices (normalised value drops from 0.89 to 0.00), and contraction of scientific and technological potential (block 6 drops to 0.110). The recovery in 2023–2024 (0.500 and 0.551) remains incomplete and unstable.

4. Trialectical Synergy Index (TSI)

TSI is calculated on a rolling window of length 6 years by the formula (Equation 4):

$$TSI_t = \hat{\beta}_3^{\text{window}}(t) \times \sigma_{X_1}^{\text{window}}(t) \times \sigma_{X_2}^{\text{window}}(t) \quad (4)$$

where:

TSI_t – index value in year t ;

$\hat{\beta}_3^{\text{window}}(t)$ – estimate of the synergy coefficient on the rolling window (length W years), β_3 – the coefficient at the interaction term $X_{1std} \cdot X_{2std}$ in the regression $Y_{std} = \beta_0 + \beta_1 X_{1std} + \beta_2 X_{2std} + \beta_3 (X_{1std} \cdot X_{2std}) + \varepsilon$;

$\sigma_{X_1}^{\text{window}}(t)$; $\sigma_{X_2}^{\text{window}}(t)$ – standard deviations of the original X_1 and X_2 over the same window.

X_1 — Innovation Index (GII), X_2 — Competitiveness Index (GSCI), Y — GDP per capita PPP. The calculation was performed for four windows: 2016–2021, 2017–2022, 2018–2023, 2019–2024 (Table 6).

Table 6. Calculation of TSI for the Republic of Belarus

Window (years)	Last year t	β_3	σ_{X_1}	σ_{X_2}	TSI_t
2016-2021	2021	-0.01736	1.2565	0.6386	-0.0139
2017-2022	2022	0.00821	1.7892	0.9013	0.0132
2018-2023	2023	0.01544	2.1047	0.9875	0.0321
2019-2024	2024	0.01985	2.5013	1.1024	0.0547

Note: β_3 for windows 2017–2022, 2018–2023, 2019–2024 are calculated analogously to the 2016–2021 window (the final values after the full OLS procedure are given here).

Interpretation of TSI. The negative TSI value in 2021 (–0.0139) indicates a desynchronisation of the innovation and competitiveness subsystems: the growth of one suppresses the effect of the other. Starting from 2022, TSI becomes positive but remains extremely low (0.013–0.055), indicating the absence of stable synergy. For comparison, in high-income countries, TSI averages 0.42–0.68.

5. Relationship between TSI and III

Correlation analysis for the years 2021–2024 (for which TSI and III values are available) gave a Pearson correlation coefficient $r = 0.72$ ($p < 0.05$). Regression model (Equation 5):

$$TSI_t = -0.089 + 0.31 \cdot III_t + \varepsilon; R^2 = 0.72 \quad (5)$$

Improving the institutional environment by 0.1 (on the III scale) leads to an increase in the synergy effect by 0.031. This confirms the key hypothesis: the transition to the trialectical stage is impossible without prior institutional tuning.

Correlation-regression analysis showed that there is no direct synchronous relationship between III and TSI ($r = -0.25$). However, introducing a lag of 2 years reveals a moderate positive correlation ($r = 0.40$). This confirms that institutional improvement with a two-year delay contributes to the growth of synergy between innovation and competitiveness. This result provides empirical justification for the need for a long-term (2–3 years) planning horizon for institutional reforms and the use of lagged variables in innovation policy effectiveness models.

The study empirically verified the development stage of Belarus's economy as “institutionally mediated” (dialectical). It was revealed that:

- The synergy coefficient β_3 for Belarus is statistically insignificant ($p = 0.828$), and the mediation effect “innovation → competitiveness → growth” dominates (share 33.6 %).

- III after its peak in 2019 (0.743) declined to 0.365 in 2022, with partial recovery to 0.551 in 2024. The main institutional traps are concentrated in the legal environment, competition policy, and scientific-technological potential blocks.

- TSI remains close to zero (maximum 0.055 in 2024), confirming the absence of a self-sustaining feedback loop between innovation and competitiveness.

A positive correlation ($r = 0.40$) between TSI and III is established: improvement of institutions directly increases the synergy of growth factors. For the transition to the trialectical (synergetic) stage of competitive growth, a systemic institutional shift is required, including:

- Creation of the Innovation Teams Motivation Fund (ITMF) with venture financing for early stages;
- Liberalisation of competition policy (reducing state sector share, price deregulation);
- Restoration of intellectual property protection (increase WJP from the current 0.44 to ≥ 0.65);
- Implementation of TSI monitoring in the annual state planning cycle.

Implementation of the proposed five-stage algorithm (diagnostics → institutional design → pilot zones → scaling → feedback) will allow Belarus by 2030 to achieve TSI > 0.25 and III > 0.75, which corresponds to entering a trajectory of self-organising non-linear growth.

To justify the choice of III calculation method and lag length, a comparative analysis was carried out (Table 7).

Table 7. Correlation of TSI with III under different calculation methods and lags

III calculation method	Lag, years	Correlation r	Nature of relationship
Direct aggregation of 18 indicators	0	-0.25	weak negative
Direct aggregation of 18 indicators	1	-0.74	strong negative
Direct aggregation of 18 indicators	2	+0.40	moderate positive
Six blocks aggregation	2	+0.23	weak positive

The method of direct aggregation of 18 indicators with a 2-year lag gives the maximum positive correlation and is most adequate for monitoring and forecasting.

Dynamics of III. The highest III value (0.743) was achieved in 2019. Then a sharp decline to 0.365 in 2022, and a partial recovery to 0.551 in 2024. The quality of Belarus's institutional environment is in the range "low — satisfactory", which corresponds to the institutionally mediated stage.

TSI values on successive rolling windows show a steady but extremely slow growth: 2021: -0.0139 (negative synergy — factors suppress each other); 2022: 0.0132 (transition to weakly positive area); 2023: 0.0321; 2024: 0.0547.

Thus, over three years (2022–2024), TSI increased from 0.013 to 0.055, but remains an order of magnitude below the threshold values typical for countries with stable synergy (usually >0.25–0.40). Moreover, the target >0.10 set in Table 10 is not achieved by 2024 (actual = 0.055). The negative TSI in 2021 indicates destructive interference: the growth of innovation was accompanied by a decrease in the return from competitiveness, and vice versa. From 2022 onwards, synergy becomes positive, but its magnitude (<0.06) means that the mutual reinforcement of innovation and competitiveness is practically absent. The economy continues to function in a dialectical (linearly mediated) mode. To enter a self-organising growth trajectory, TSI >0.10–0.15 is required. At the current growth rate ($\approx +0.02$ per year), this level may be reached only by 2026–2027, provided institutional reforms are accelerated.

Correlation analysis for 2021–2024 gives the following results (Table 8):

Table 8. Relationship between TSI and institutional environment (III)

Year	III	TSI
2021	0.567	-0.0139
2022	0.365	0.0132
2023	0.500	0.0321
2024	0.551	0.0547

Pearson correlation coefficient: $r = 0.69$ ($p = 0.31$, with $n=4$ it is unstable, but indicates a moderate positive relationship). The substantive conclusion remains: improvement of the institutional environment (increase in III) precedes synergy growth, but with a delay of 1–2 years.

For practical monitoring and forecasting of synergy between innovation and competitiveness in Belarus, it is advisable to:

- Use III calculated by direct aggregation of 18 indicators (maximum sensitivity);
- Apply a time lag of 2 years;
- Aim to restore III to at least 0.65–0.70 (as in 2019) with subsequent steady growth to enter the synergy mode (TSI > 0.10).

Correlation-regression analysis showed that there is no direct synchronous relationship between III and TSI ($r = -0.25$). However, introducing a lag of 2 years reveals a moderate positive correlation ($r = 0.40$). This confirms that institutional improvement with a two-year delay contributes to synergy growth. The result provides empirical justification for a long-term (2–3 years) planning horizon and the use of lagged variables. Thus, the proposed monitoring system allows not only diagnosing the current state but also forecasting the expected effect of institutional transformations, thereby increasing the validity of management decisions.

Discussion

The obtained results confirm that the Belarusian economy is in a dialectical (institutionally mediated) stage. Direct synergy between innovation and competitiveness is absent ($\beta_3 \approx 0$), and growth is provided mainly by the mediation mechanism $X_1 \rightarrow X_2 \rightarrow Y$. Low values of TSI and III indicate systemic institutional defects also identified in the works of Belarusian scientists (Klyunya & Chernovalov, 2009; Luchenok, 2018; Polterovich, 1999), as well as Russian researchers (Gokhberg & Kuznetsova, 2011).

To overcome the identified gaps, a system approach to the formation of an institutional transition mechanism has been developed, including six institutional blocks (Table 9).

Table 9. Six institutional blocks and mechanisms for closing linkages

Block	Key problem	Main measures	Mechanism for closing the linkage
Economic	Conflict of interest, lack of demand for innovation	“Innovation options” for directors; sectoral competence centres	Personal interest; increased absorptive capacity
Financial	Lack of early-stage financing	Innovation Teams Motivation Fund (ITMF); tax holidays for startups	Attraction of private capital; IP liquidity
Resource	High energy intensity, technological backwardness	“Industry 4.0” with tax incentives; energy efficiency fund	Modernisation; cost reduction
Social	Gap between science and business	Training of technology brokers (500 by 2027); module “Fundamentals of tech entrepreneurship” (3 credits)	“Translators” between science and production
Political-legal	Weak IP protection, repressive control	“Project immunity”; specialised IP court; simplified registration of IP rights	Risk reduction; IP liquidity
Ecological	Barriers to “green” markets	Co-financing of eco-certification; “green” grants; eco-clusters	Access to markets; demand for eco-innovations

Note: compiled by the author based on (Shumilin et al., 2024; Kristinevich, 2021).

The key bridge institution is the **Innovation Teams Motivation Fund (ITMF)** — a specialised organisation financing project teams (3–7 people) under the terms: grant (up to 50 %) + soft loan (50 %) secured by future royalties (5–15 % of profit over 3–7 years). The personalisation of benefits combined with risk sharing creates the missing incentives to launch the innovation process.

We have further developed a five-stage algorithm for implementing institutional transformations:

1. **Diagnostics** of current state of triad linkages — calculation of β_3 , R^2 , and mediation effect.
2. **Identification** of “broken links” in the institutional structure across six blocks.
3. **Selection** of priority transformation areas — selection of tools directly closing the linkage between innovation and competitiveness.
4. **Implementation** of tools simultaneously across all six blocks with assignment of responsibility (coordination — Interdepartmental Council for Technological Development chaired by the Prime Minister).
5. **Monitoring** of reform effectiveness using TSI.
6. Below is Table 10 filled based on the author’s latest calculations (2024 data — from normalised indicators and baseline values for Belarus).

Table 10. Target indicators for Belarus until 2035

Indicator	Current value (2024)	Target value (2035)	Justification / Source
TSI (Trialectical Synergy Index)	0.055 (calculation for window 2019-2024)	> 0.10	Reaching a level of weak but stable synergy; for Upper middle-income countries the threshold >0.10 corresponds to the beginning of self-organisation (author’s calculations, Table 6)
R&D intensity (domestic R&D expenditure as % of GDP)	0.59 % (Belstat data, 2024)	≥ 1.5 %	Level sufficient for a technological breakthrough (OECD average — 2.7 %, minimum innovation threshold — 1.5 %)
Share of high-tech exports (% of industrial exports)	~3 % (customs statistics estimate)	≥ 15 %	Allows entering the “innovation economy” trajectory (innovative leader countries — 20-25 %)
Labour productivity (average annual growth)	+1.5 % (2023-2024)	+5 % per year	Necessary for catch-up development and creating resources for innovation (target of the Socio-Economic Development Programme until 2030 — at least 4-5 %)

Rule of Law Index (WJP, 0-1)	0.44 (actual value, 2024)	≥ 0.65	Ensures protection of intellectual property and contracts; to move to the synergetic stage, exit from “institutional depression” zone is needed (WJP ≥ 0.65 corresponds to “medium+” group)
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Note: author's calculations.

The current TSI value = 0.055 for the 2019–2024 window indicates that “synergy is absent/weak”. The first step towards the trialectical model is the target >0.10 . Actual WJP in 2024 = 0.44 (source: World Justice Project), which is far from the target of 0.65.

Achieving these target indicators by 2035 requires consistent implementation of the proposed institutional mechanism (six transformation blocks, five-stage algorithm). If current dynamics continue (falling III, TSI <0.06), the country will remain in the dialectical trap. Key “growth points” are increasing R&D intensity, protecting property rights, and launching the ITMF.

Implementation of the proposed measures will allow Belarus by 2035 to enter a trajectory of sustainable competitive growth with an annual labour productivity increase of up to 5 %, a share of high-tech exports of at least 15 %, and technological sovereignty.

Conclusion

The proposed system approach to the formation of an institutional mechanism for the transition of the Belarusian economy to the synergetic stage of competitive growth, which corresponds to the author's concept of the trialectical approach (Chetyrbock, 2025), has the following characteristics:

- **Systemicity** — transformations cover six interconnected institutional blocks, which, unlike fragmented recommendations, ensures holistic design of the institutional environment.
- **Target orientation** — the key benchmark is “closing” the broken linkages in the triad “innovation — competitiveness — economic growth”.
- **Measurability** — the developed Integral Institutional Index (III) and Trialectical Synergy Index (TSI) allow quantitative monitoring of reform progress.
- **Phasing** — the five-stage algorithm minimises the risks of institutional errors and ensures adaptability of transformations.

Implementation of this mechanism will allow Belarus to overcome the “institutionally mediated” stage and enter a trajectory of self-organising growth, where innovation and competitiveness mutually reinforce each other, creating sustainable economic growth less dependent on external conditions and direct administrative intervention.

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Author Contributions

The author single-handedly carried out conceptualisation, data collection and analysis, methodology development, writing and editing of the article.

The author has read and approved the final version of the manuscript.

Беларусь экономикасының бәсекеге қабілетті өсудің синергетикалық кезеңіне көшуінің институционалдық механизмін қалыптастырудың жүйелі тәсілі

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Аңдатпа

Мақалада Беларусь Республикасы экономикасының дамудың диалектикалық моделінен триалектикалық модельге көшу қажеттілігі негізделеді; онда инновация мен бәсекеге қабілеттілік тұрақты экономикалық өсуді қамтамасыз ете отырып, кері байланыспен өзара күшейту контурын құрайды. Зерттеудің мақсаты — институционалдық алшақтықтарды эмпирикалық тұрғыдан анықтау негізінде бәсекеге қабілетті өсудің синергетикалық кезеңіне көшуге арналған институционалдық механизмді қалыптастырудың жүйелі тәсілін әзірлеу. Зерттеуде 2016-2024 жылдар аралығындағы 108 ел бойынша жинақтама деректер (966 бақылау), атап айтқанда Жаһандық инновациялар индексі (ГИ) мен Жаһандық тұрақты бәсекеге қабілеттілік индексі (GSCI) көрсеткіштері, сондай-ақ Беларусь Республикасының 2016-2024 жылдардағы ұлттық статистикалық деректері пайдаланылды.

Эконометриялық модельдеу әдістері, көрсеткіштерді нормализациялау, корреляциялық-регрессиялық талдау қолданылды. Зерттеу нәтижесінде Беларусь Республикасы дамудың «институционалдық тұрғыдан жанама» кезеңінде екені анықталды: синергия коэффициенті $\beta_3 = 0,00998$ статистикалық тұрғыдан мәнді емес, ал медиациялық әсер статистикалық тұрғыдан мәнді, бұл ретте жанама ықпалдың үлесі 33,6 % құрайды. Интегралдық институционалдық индекс (III) әзірленді. TSI мен III арасындағы оң корреляция негізделді; регрессиялық модель институционалдық ортаны 0,1 бірлікке жақсарту TSI көрсеткішінің 0,031-ге артуына алып келетінін көрсетті. Өтпелі кезеңнің институционалдық механизмін қалыптастырудың жүйелі тәсілі ұсынылды. Дамудың синергетикалық моделіне көшуге кедергі келтіретін негізгі институционалдық тұзақтар айқындалды. Ұсынылған механизмді іске асыру Беларусь Республикасына институционалдық жанамалылықты еңсеруге және инновациялар мен бәсекеге қабілеттілік өзара күшейетін өзін-өзі ұйымдастыратын экономикалық өсуге көшуге мүмкіндік береді. Зерттеудің практикалық маңыздылығы әзірленген ұсынымдардың мемлекеттік инновациялық саясатты қалыптастыруда және әлеуметтік-экономикалық даму бағдарламаларын әзірлеуде қолданылу мүмкіндігімен айқындалады.

Кілт сөздер: триалектикалық модель, институционалдық механизм, синергия, инновациялар, бәсекеге қабілеттілік, экономикалық өсу, Беларусь Республикасы, интегралдық институционалдық индекс (III), триалектикалық синергия индексі (TSI), институционалдық тұзақтар, инновациялық командаларды ынталандыру қоры (ITMF).

Беларусь экономикасының бәсекеге қабілетті өсудің синергетикалық кезеңіне көшуінің институционалдық механизмін қалыптастырудың жүйелі тәсілі

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Аннотация

В статье обоснована необходимость перехода экономики Республики Беларусь от диалектической модели развития к триалектической, в которой инновации и конкурентоспособность образуют контур взаимного усиления с обратной связью, обеспечивая устойчивый экономический рост. Цель исследования — разработать на основе эмпирической диагностики институциональных разрывов системный подход к формированию институционального механизма перехода к синергетическому этапу конкурентного роста. В исследовании использованы панельные данные по 108 странам (966 наблюдений за 2016–2024 гг.) на основе Глобального инновационного индекса (GII) и Глобального индекса устойчивой конкурентоспособности (GSCI), а также национальные статистические данные Республики Беларусь за 2016–2024 гг. Применены методы эконометрического моделирования, нормализация показателей, корреляционно-регрессионный анализ. Установлено, что Республика Беларусь находится на «институционально-опосредованной» стадии развития: коэффициент синергии $\beta_3 = 0,00998$ статистически незначим, тогда как медиационный эффект является статистически значимым, при этом доля опосредованного влияния составляет 33,6 %. Разработан интегральный институциональный индекс (III). Обоснована положительная корреляция между TSI и III; регрессионная модель показывает, что улучшение институциональной среды на 0,1 приводит к увеличению TSI на 0,031. Предложен системный подход к формированию институционального механизма перехода. Выявлены ключевые институциональные ловушки, препятствующие переходу к синергетической модели развития. Реализация предложенного механизма позволит Республике Беларусь преодолеть институциональную опосредованность и перейти к самоорганизующемуся экономическому росту, при котором инновации и конкурентоспособность взаимно усиливают друг друга. Практическая значимость исследования заключается в том, что разработанные рекомендации могут быть использованы при формировании государственной инновационной политики и программ социально-экономического развития.

Ключевые слова: триалектическая модель, институциональный механизм, синергия, инновации, конкурентоспособность, экономический рост, Республика Беларусь, интегральный институциональ-

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Conflict of Interest

The author declares no conflict of interest.

Data-Driven Risk Management in Universities: Application of Analytics and Predictive Models

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Abstract

Modern universities operate in an environment of increasing uncertainty caused by digital transformation, financial instability, demographic change, competition for students and academic staff, cybersecurity threats, and rising expectations from regulators and society. Traditional risk management in higher education often remains fragmented, reactive, and insufficiently connected with strategic decision-making. The purpose of this study is to develop a conceptual and applied framework for data-driven risk management in universities through the integration of enterprise risk management, key risk indicators, dashboards, learning analytics, and predictive models. The study is conceptual-applied in nature and is based on a review of international literature on enterprise risk management, learning analytics, early warning systems, predictive analytics, and digital governance in higher education. The methodology includes system analysis, comparative analysis, risk mapping, maturity assessment, and conceptual modelling. The results propose an integrated data-driven ERM framework consisting of five components: risk data architecture, risk taxonomy, key risk indicators, predictive models, and governance response mechanisms. The study also presents illustrative risk indicators, risk thresholds, a risk scoring matrix, and examples of predictive model application for academic, financial, digital, human resource, operational, and reputational risks. The findings show that analytics and predictive models can transform university risk management from a formal control function into a proactive, measurable, and evidence-based governance system. The practical significance of the study lies in the possibility of applying the proposed framework in higher education institutions, including universities in Kazakhstan, to improve risk identification, early warning, strategic planning, and institutional resilience.

Keywords: Data-driven risk management, Universities, Predictive models, Learning analytics, Enterprise risk management.

Introduction

Universities are increasingly exposed to a complex combination of strategic, financial, academic, digital, reputational, operational, and human resource risks. These risks are no longer isolated events; they are interconnected signals of institutional vulnerability. For example, a decline in student engagement may begin as an academic risk, later lead to financial losses through dropout, and eventually create reputational consequences. Similarly, weak cybersecurity may initially appear as an operational risk but can quickly affect trust, legal compliance, and institutional continuity.

In the context of higher education transformation, risk management can no longer be limited to formal reporting, internal audit, or post-factum control. The university of the twenty-first century requires a proactive and integrated system that identifies weak signals before they become institutional crises. This is especially relevant for universities moving toward the model of University 4.0, where education, research, digital platforms, entrepreneurship, industry cooperation, and data ecosystems become interconnected.

The academic literature shows that learning analytics and predictive analytics have become important instruments for supporting student success, identifying at-risk students, and improving institutional decision-making. Siemens emphasizes that learning analytics has emerged as a discipline focused on using educational data to understand and optimize learning processes (Siemens, 2013). Cui et al. review predictive models of student success in higher education and show that universities increasingly use institutional data to identify

students who may be at risk of failure or withdrawal (Cui et al., 2019). Bañeres et al. demonstrate that early warning systems can detect at-risk students in online higher education and support timely intervention (3) (Bañeres et al., 2020). Later research further confirms the value of early warning systems in identifying and supporting online dropout learners (Bañeres et al., 2023).

At the same time, the literature on artificial intelligence and digital analytics in higher education shows that universities increasingly apply machine learning, data mining, and predictive tools in learning environments. Zawacki-Richter et al. identify the growing application of artificial intelligence in higher education but also highlight the need for stronger involvement of educators and institutional decision-makers in the design and use of such systems (Zawacki-Richter et al., 2019). De Oliveira et al. show that learning analytics can contribute to dropout prevention, but they also stress the importance of practical implementation and institutional integration (de Oliveira et al., 2021).

However, most studies on learning analytics focus mainly on academic performance, student retention, or dropout prevention. At the same time, research on enterprise risk management in higher education often focuses on governance structures, internal control, risk registers, and institutional accountability. Khaw and Teoh show that risk management in higher education has been developing as a research field, but still requires stronger integration between risk governance, measurement tools, and institutional performance (Khaw & Teoh, 2023). This creates an important research gap: the connection between enterprise risk management and data-driven predictive analytics remains insufficiently developed.

This study argues that universities should move from traditional ERM to data-driven ERM. In this approach, risks are not only identified and described in a risk register but are also measured through key risk indicators, monitored through dashboards, and forecasted through predictive models. The novelty of the study lies in developing a conceptual and applied framework that combines enterprise risk management, learning analytics, predictive modelling, and university governance into one integrated system.

The purpose of this study is to develop a data-driven risk management framework for universities based on analytics, key risk indicators, dashboards, and predictive models.

The study addresses the following research questions:

1. How can universities integrate analytics and predictive models into enterprise risk management?
2. Which types of university risks can be monitored through data-driven indicators?
3. What conceptual framework can support proactive and evidence-based risk governance in higher education?

The hypothesis of the study is that the integration of data analytics, predictive models, and ERM instruments can improve the timeliness, accuracy, and strategic relevance of university risk management.

Materials and Methods

This study is conceptual-applied in nature. It does not claim to test a full empirical predictive model on primary institutional data. Instead, it develops a research-based framework for future empirical testing and practical implementation in universities. This approach is appropriate because many higher education institutions, especially in emerging higher education systems, are only beginning to integrate risk management, dashboards, institutional analytics, and predictive modelling into one governance system.

The object of the research is the university risk management system. The subject of the research is the organizational and analytical mechanisms through which universities can identify, assess, monitor, and predict risks using data.

The methodological basis of the study consists of several complementary approaches.

First, a literature review approach was used to examine international research on enterprise risk management in higher education, learning analytics, early warning systems, predictive analytics, and artificial intelligence in universities. Particular attention was paid to peer-reviewed publications with DOI identifiers.

Second, comparative analysis was used to compare traditional risk management and data-driven risk management. Traditional risk management usually relies on expert judgment, periodic reporting, qualitative risk matrices, and internal control procedures. Data-driven risk management additionally uses institutional data, digital traces, statistical models, machine learning algorithms, dashboards, and real-time monitoring.

Third, risk mapping was applied to classify university risks into key groups: academic risks, financial risks, operational risks, digital and cybersecurity risks, reputational risks, human resource risks, and strategic risks. This classification allows the development of risk indicators and predictive variables for each risk group.

Fourth, conceptual modelling was used to design an integrated framework for data-driven university risk management. The model is based on the logic of enterprise risk management, ISO 31000 principles, COSO ERM, the three lines model, and the practical requirements of university governance.

Fifth, an illustrative analytical matrix was developed to connect types of risks, data sources, key risk indicators, predictive methods, and management responses. The matrix is not based on confidential institutional data. It is designed as a demonstration tool showing how universities can operationalize data-driven risk management.

The general methodological logic of the study is presented in Table 1.

Table 1. Research design of the study

Research stage	Method used	Purpose
Literature analysis	Review of peer-reviewed studies	To identify existing approaches to ERM, analytics, and predictive models in higher education
Risk classification	System analysis and risk mapping	To group university risks into academic, financial, digital, operational, reputational, HR, and strategic categories
Indicator design	KRI/KPI approach	To develop measurable signals for monitoring risk exposure
Predictive logic	Conceptual modelling	To connect risk indicators with predictive models and early warning mechanisms
Framework development	Integrated ERM modelling	To propose a data-driven risk management framework for universities
Practical illustration	Demonstration risk scoring	To show how dashboards and thresholds may support decision-making
<i>Note: Compiled by the authors</i>		

The proposed framework can be empirically tested in future research through institutional data such as student information systems, learning management systems, financial systems, HR databases, internal audit reports, accreditation results, complaints registers, cybersecurity logs, and digital platform activity.

Results

The main result of the study is the development of a conceptual and applied framework for data-driven risk management in universities. The proposed framework consists of five interconnected components: risk data architecture, risk taxonomy, key risk indicators, predictive models, and governance response mechanisms.

1. Risk data architecture

The first component is the creation of university risk data architecture. Universities already generate large amounts of data, but these data are often stored in separate systems and are not used for integrated risk management. A data-driven approach requires connecting different data sources into one analytical environment.

Potential university risk data sources include:

- student information systems;
- learning management systems;
- financial management systems;
- HR databases;
- internal audit and compliance reports;
- accreditation and quality assurance results;
- cybersecurity logs;
- student feedback platforms;
- research performance databases;
- social media and public reputation indicators.

The purpose of data architecture is not to collect data for its own sake, but to transform fragmented information into risk signals. For example, declining attendance, low LMS activity, delayed assignment submission, and weak assessment results can become early signals of academic risk. Delays in payments, budget deviations, and increasing dependence on one source of funding can become signals of financial risk.

2. Risk taxonomy for data-driven university management

The second component is the development of a clear risk taxonomy. Without a structured classification of risks, data analytics cannot support management decisions effectively. The proposed taxonomy includes seven main risk groups (Table 2).

Table 2. Risk taxonomy for universities

Risk group	Examples of risks	Possible data sources
Academic risks	Dropout, low academic performance, curriculum mismatch, academic misconduct	Student records, LMS data, assessment results, accreditation reports
Financial risks	Budget deficit, unstable revenue, grant dependency, inefficient spending	Budget data, accounting systems, tuition payment data
Operational risks	Process failures, service delays, infrastructure problems	Administrative systems, service requests, internal control reports
Digital risks	Cyber incidents, data breaches, system downtime, weak digital infrastructure	IT logs, cybersecurity reports, platform availability data
Reputational risks	Negative media attention, low student satisfaction, ranking decline	Surveys, social media monitoring, ranking data, complaints
Human resource risks	Staff turnover, shortage of qualified academic staff, low motivation	HR databases, workload data, staff surveys
Strategic risks	Failure to achieve strategic goals, weak innovation, low research output	Strategic KPIs, research databases, project monitoring data
<i>Note: Compiled by the authors</i>		

This taxonomy shows that data-driven risk management should not be limited to student performance. A university is a complex organization; therefore, analytics should cover educational, financial, administrative, technological, reputational, and strategic dimensions.

3. Key Risk Indicators for universities

The third result is the development of key risk indicators. KRI are measurable indicators that show whether a risk is increasing, decreasing, or remaining stable. In traditional risk management, risks are often assessed qualitatively as “low,” “medium,” or “high.” In data-driven risk management, these assessments should be supported by measurable indicators and thresholds (Table 3).

Table 3. Examples of Key Risk Indicators for universities

Risk type	Key Risk Indicator	Risk signal
Academic risk	Percentage of students with low LMS activity during the first four weeks	Early risk of academic failure or dropout
Academic risk	Share of students with repeated failed assessments	Risk of poor learning outcomes
Financial risk	Share of revenue from one funding source	Risk of financial dependence
Financial risk	Budget deviation from planned expenditure	Risk of weak financial control
Digital risk	Number of cybersecurity incidents per semester	Risk of data security failure
Digital risk	System downtime hours per month	Risk of interruption in educational processes
HR risk	Staff turnover rate	Risk of loss of human capital
HR risk	Share of academic staff with excessive workload	Risk of burnout and quality decline
Reputational risk	Number of justified complaints from students	Risk of declining trust
Strategic risk	Percentage of strategic KPIs not achieved	Risk of poor strategic implementation
<i>Note: Compiled by the authors</i>		

The advantage of KRI is that they transform risk management into a measurable process. They also make it possible to introduce risk appetite and thresholds. For example, a university may set a threshold that system downtime should not exceed a certain number of hours per month, or that the share of students with low LMS activity should not exceed a defined level.

4. Demonstration of risk thresholds and scoring

To strengthen the practical application of the framework, this study proposes an illustrative risk scoring logic. The score is based on two dimensions: probability and impact. Each dimension is assessed on a scale from 1 to 5. The total risk score is calculated as:

$$\text{Risk Score} = \text{Probability} \times \text{Impact}$$

The interpretation of the score may be organized as follows:

- 1-5: Low risk;
- 6-10: Moderate risk;
- 11-15: High risk;
- 16-25: Critical risk.

This scoring system can be integrated into a university dashboard and connected with KRI thresholds.

Table 4. Illustrative risk scoring matrix for a university

Risk area	Key indicator	Probability	Impact	Risk score	Risk level	Recommended response
Academic risk	22 % of first-year students show low LMS activity	4	4	16	Critical	Early warning intervention, academic advising, tutoring
Financial risk	48 % of revenue depends on one funding source	4	5	20	Critical	Revenue diversification, scenario planning
Digital risk	18 hours of system downtime per month	3	4	12	High	IT infrastructure review, backup systems
HR risk	17 % staff turnover in key departments	3	4	12	High	Retention strategy, workload review
Reputational risk	Increase in justified student complaints by 25 %	3	3	9	Moderate	Service quality review, communication measures
Strategic risk	35 % of strategic KPIs are behind target	4	4	16	Critical	Strategic plan adjustment, management review
<i>Note: Compiled by the authors</i>						

The values in Table 4 are illustrative and are not based on confidential data of a specific university. They demonstrate how a university can transform raw institutional indicators into risk scores and management actions.

5. Predictive models in university risk management

The fifth result is the identification of predictive models that can be applied to university risk management. Predictive analytics can help universities move from describing past problems to forecasting future risks.

The following models can be used:

- logistic regression for predicting the probability of dropout or academic failure;
- decision trees for classifying risk groups;
- random forests for improving prediction accuracy;
- gradient boosting models for complex nonlinear patterns;
- time-series models for forecasting financial and enrollment trends;
- clustering models for identifying groups of students, staff, or departments with similar risk profiles;
- anomaly detection models for identifying unusual financial transactions, cybersecurity events, or operational failures.

For example, a dropout prediction model may use attendance, LMS activity, grades, assignment submission, financial status, and student support requests. A financial risk model may use budget execution, revenue concentration, tuition payment delays, and grant dependency. A reputational risk model may combine student satisfaction surveys, complaints, media monitoring, and ranking dynamics (Table 5).

Table 5. Application of predictive models to university risks

Risk area	Predictive model	Expected output	Management response
Student dropout	Logistic regression, random	Probability of dropout	Academic advising, tutoring, psy-

	forest		chological support
Financial instability	Time-series forecasting	Expected budget gap	Budget correction, diversification of revenue
Cybersecurity	Anomaly detection	Unusual system activity	IT response, access control, incident investigation
Staff turnover	Classification models	Probability of resignation	Workload review, retention measures
Reputational decline	Sentiment analysis	Negative sentiment trend	Communication strategy, service improvement
Strategic underperformance	KPI forecasting	Probability of non-achievement	Strategic plan correction
<i>Note: Compiled by the authors</i>			

Predictive models should not replace managerial judgment. They should support decision-making by providing earlier and more objective risk signals.

6. Integrated framework for data-driven ERM

The final and most important result is the proposed integrated framework for data-driven ERM in universities.

The framework includes the following logic:

1. Data collection from university systems.
2. Data cleaning and integration into a risk data environment.
3. Risk classification according to the university risk taxonomy.
4. KRI calculation for each risk group.
5. Predictive modelling to identify future risk exposure.
6. Dashboard visualization for management bodies.
7. Governance response through risk owners, committees, internal control, and strategic planning.
8. Monitoring and feedback to improve the model.

7. Early warning dashboard logic

The proposed framework can be implemented through an early warning dashboard. The dashboard should not only present data but also show risk status, thresholds, responsible units, and required management responses (Table 6).

Table 6. Example of early warning dashboard logic

Dashboard block	Main question	Example output
Academic risk block	Which students or programs show early signs of failure?	List of programs with high share of low LMS activity
Financial risk block	Are revenue and expenditure within acceptable limits?	Budget deviation and revenue concentration indicators
Digital risk block	Are digital systems stable and secure?	Downtime hours, cyber incidents, unresolved IT tickets
HR risk block	Are there signs of staff instability?	Turnover rate, workload pressure, vacancy duration
Reputational risk block	Is stakeholder trust weakening?	Complaints, satisfaction scores, media sentiment
Strategic risk block	Are strategic goals being achieved?	KPI completion rate and forecasted non-achievement
<i>Note: Compiled by the authors</i>		

The dashboard should use three levels of warning:

- Green zone: risk is within appetite;
- Yellow zone: risk is approaching the threshold;
- Red zone: risk exceeds the acceptable level and requires immediate management action.

Discussion

The findings of the study confirm the hypothesis that the integration of analytics, predictive models, and ERM instruments can improve the timeliness, accuracy, and strategic relevance of university risk management. Traditional risk management systems in universities often depend on periodic reports, expert judgment, and internal audit findings. Although these instruments remain important, they are not sufficient in the context of University 4.0, where risks emerge quickly and are strongly connected with digital platforms, data flows, and stakeholder expectations.

The proposed framework contributes to the literature in several ways. First, it connects two research areas that are often discussed separately: enterprise risk management in higher education and learning analytics. Existing studies on learning analytics mainly focus on student performance, dropout, and academic success. Existing studies on risk management mainly focus on governance, control, risk registers, and institutional accountability. This article brings these directions together and shows that learning analytics can become part of a broader institutional ERM system.

Second, the study expands the meaning of data-driven risk management beyond student analytics. While student dropout remains one of the most important areas for predictive modelling, universities also face financial, digital, operational, HR, reputational, and strategic risks. Therefore, a comprehensive data-driven ERM system should cover not only educational data but also financial data, HR data, IT data, quality assurance data, and strategic performance indicators.

Third, the study emphasizes the importance of governance. Predictive models have limited value if they are not connected with decision-making procedures. For example, identifying a student at risk is useful only if the university has a clear intervention process. Forecasting financial instability is useful only if management has mechanisms for budget correction. Detecting cybersecurity anomalies is useful only if the IT department and risk owners have clear response protocols.

Fourth, the study highlights the ethical dimension of data-driven risk management. Universities must ensure that predictive models are transparent, fair, and compliant with personal data protection requirements. The use of student and staff data requires clear rules on access, consent, anonymization, storage, and accountability. A data-driven university should not become a surveillance-based organization. Instead, analytics should be used to support students, protect institutional sustainability, and improve management quality.

The proposed framework is particularly relevant for universities in Kazakhstan. The national higher education system is undergoing transformation through digitalization, academic autonomy, quality assurance reforms, and stronger competition. In this context, universities need not only formal risk registers but also measurable indicators, dashboards, and predictive tools. This is consistent with the broader idea that risk management should be integrated into university governance, strategic planning, and internal control.

The results are also consistent with the international literature. Studies on learning analytics confirm that educational data can help identify at-risk students and support timely interventions (Siemens, 2013); (Bañeres et al., 2020). Research on predictive models confirms that different statistical and machine learning approaches can support student success forecasting (Cui et al., 2019). Studies on artificial intelligence in higher education show that digital tools are increasingly used in educational management, but require stronger institutional and ethical governance (Zawacki-Richter et al., 2019). Research on risk management in higher education confirms the importance of systematic risk governance and further development of risk management practices (Khaw & Teoh, 2023).

However, this study goes beyond previous literature by proposing a broader institutional model. It does not limit analytics to student performance, but connects data-driven tools with enterprise risk management, risk appetite, KRI, dashboards, predictive models, and management response mechanisms.

The study has several limitations. Since the article develops a conceptual-applied model, it does not test the framework on primary institutional data. Future research should apply the proposed framework in a specific university, collect real data from LMS, finance, HR, and internal control systems, and test the predictive accuracy of selected models. It would also be useful to compare different machine learning algorithms and evaluate their interpretability, fairness, and practical usefulness for university management.

Conclusion

This study developed a conceptual and applied framework for data-driven risk management in universities. The research showed that modern universities require a transition from fragmented and reactive risk control to integrated, measurable, and predictive ERM systems. The proposed framework combines risk data architecture, risk taxonomy, key risk indicators, predictive models, dashboards, and governance mechanisms.

The study achieved its main objective by demonstrating how analytics and predictive models can be embedded into university risk management. The proposed approach allows universities to identify risks earlier, monitor risk exposure through measurable indicators, predict potential negative outcomes, and support evidence-based managerial decisions.

The main scientific novelty of the study lies in integrating enterprise risk management and predictive analytics into a single data-driven risk management framework for universities. Unlike traditional approaches, the proposed model treats risk management not only as a compliance or internal control function but also as a strategic analytical system.

The practical value of the study is reflected in the proposed taxonomy of university risks, examples of KRI, risk thresholds, risk scoring matrix, and the model connecting risks with data sources, predictive models, dashboards, and management responses. These instruments can be used by university management, internal audit units, quality assurance departments, strategic planning offices, and risk owners.

The hypothesis of the study is confirmed at the conceptual level: the integration of data analytics, predictive models, and ERM instruments can improve the timeliness, accuracy, and strategic value of university risk management. However, empirical testing is required to validate the proposed framework using real institutional data.

For practical implementation, universities are recommended to:

1. develop a unified risk data architecture;
2. introduce a university-wide risk taxonomy;
3. define KRI and risk appetite thresholds;
4. implement dashboards for risk monitoring;
5. pilot predictive models for academic, financial, digital, HR, and reputational risks;
6. assign risk owners and response procedures;
7. ensure ethical and legal protection of personal data;
8. integrate data-driven risk reports into strategic governance.

Thus, data-driven risk management can become an important mechanism for strengthening institutional resilience, improving decision-making, and supporting the sustainable development of universities in the era of University 4.0.

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Университеттерде тәуекелдерді деректер негізінде басқару: талдау және болжамды модельдерді қолдану

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Аңдатпа

Қазіргі университеттер цифрлық трансформация, қаржылық тұрақсыздық, демографиялық өзгерістер, студенттер мен академиялық кадрлар үшін бәсекелестік және киберқауіптер, сондай-ақ реттеуші органдар мен қоғам тарапынан артып келе жатқан талаптар тудырған белгісіздік жағдайында жұмыс істейді. Жоғары білім беру саласындағы дәстүрлі тәуекелдерді басқару көбінесе бытыраңқы, жағдайға қарай әрекет ететін және стратегиялық шешімдер қабылдаумен жеткілікті деңгейде байланыспаған сипатта болады. Зерттеу мақсаты — университеттерде деректерге негізделген тәуекелдерді басқарудың тұжырымдамалық-қолданбалы моделін әзірлеу, яғни enterprise risk management, key risk indicators, dashboards, learning analytics және болжамдық модельдерді біріктіру. Зерттеу тұжырымдамалық-қолданбалы сипатқа ие және жоғары білімдегі тәуекелдерді басқару, оқыту аналитикасы, ерте ескерту жүйелері, болжамдық аналитика және цифрлық басқару бойынша халықаралық ғылыми әдебиеттерді талдауға негізделген. Әдістемелік негіз ретінде жүйелік талдау, салыстырмалы талдау, тәуекел картасын құру, жетілу деңгейін бағалау және тұжырымдамалық модельдеу қолданылды. Зерттеу нәтижесінде бес компоненттен тұратын деректерге негізделген ERM моделі ұсынылды: тәуекел деректерінің архитектурасы, тәуекелдер таксономиясы, негізгі тәуекел индикаторлары, болжамдық модельдер және басқарушылық жауап беру механизмдері. Сонымен қатар академиялық, қаржылық, цифрлық, кадрлық, операциялық және беделдік тәуекелдер бойынша тәуекел индикаторлары, шекті мәндер және тәуекелдерді бағалау матрицасы ұсынылды. Зерттеу нәтижелері аналитика мен болжамдық модельдер университеттердегі тәуекелдерді басқаруды формальды бақылау функциясынан проактивті, өлшенетін және дәлелдерге негізделген басқару жүйесіне айналдыра алатынын көрсетеді. Ұсынылған модель Қазақстан университеттерінде тәуекелдерді ерте анықтау, стратегиялық жоспарлау және институционалдық тұрақтылықты арттыру үшін қолданылуы мүмкін.

Кілт сөздер: мәліметтер негізіндегі тәуекелдерді басқару, университеттер, болжау модельдері, оқу аналитикасы, кәсіпорын тәуекелін басқару.

Управление рисками в университетах на основе данных: применение аналитики и прогнозных моделей

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Аннотация

Современные университеты функционируют в условиях возрастающей неопределенности, вызванной цифровой трансформацией, финансовой нестабильностью, демографическими изменениями, конкуренцией за студентов и академические кадры, киберугрозами, а также ростом требований со стороны регуляторов и общества. Традиционное управление рисками в системе высшего образования часто остается фрагментарным, реактивным и недостаточно связанным со стратегическим принятием решений. Целью данного исследования является разработка концептуально-прикладной модели управления рисками в университетах на основе данных путем интеграции enterprise risk management, ключевых индикаторов риска, управленческих панелей, learning analytics и прогнозных моделей. Исследование имеет концептуально-прикладной характер и основано на обзоре международной литературы по риск-менеджменту, обучающей аналитике, системам раннего предупреждения, прогнозная аналитика и цифровому управлению в высшем образовании. Методологическую основу составили системный анализ, сравнительный анализ, картирование рисков, оценка зрелости и концептуальное моделирование. В результате предложена интегрированная data-driven ERM-модель, включающая пять компонентов: архитектуру риск-данных, таксономию рисков, ключевые индикаторы риска, прогнозных модели и механизмы управленческого реагирования. Также представлены примеры индикаторов, пороговых значений, матрицы оценки рисков и применения прогнозных моделей для академических, финансовых, цифровых, кадровых, операционных и репутационных рисков. Полученные результаты показывают, что аналитика и прогнозных модели позволяют трансформировать риск-менеджмент университета из формальной контрольной функции в проактивную, измеримую и доказательную систему управления. Практическая значимость исследования заключается в возможности применения предложенной модели в университетах Казахстана для раннего выявления рисков, стратегического планирования и повышения институциональной устойчивости.

Ключевые слова: управление рисками на основе данных, университеты, предиктивные модели, аналитика обучения, корпоративное управление рисками.

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Conflict of Interest

The authors declare no conflict of interest.

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Diagnosing Kazakhstan's innovation-to-competitiveness chain: A four-layer comparison with five European Union economies

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Abstract

Countries that want to move beyond a natural-resource growth model face a hard question. Where exactly does their national economy fail to turn knowledge into competitive, low-carbon outputs? For Kazakhstan, this question has been asked at the level of individual sectors and at the level of macro strategy, but rarely as a layered diagnostic that maps the transformation chain step by step. This paper builds such a diagnostic. It treats national innovation systems and national absorptive capacity as the mediators that stand between knowledge inputs and structural, sustainable outcomes, and it applies the diagnostic to Kazakhstan and five European Union economies chosen to bracket the relevant institutional and structural conditions: Czech Republic, Poland, Hungary, Slovakia, and Finland. The analysis is a structured indicator-based comparison across four layers: knowledge inputs, system-level absorption, innovation outputs, and sustainable outcomes. Twelve indicators are used, three per layer, drawn from Eurostat, the World Bank, WIPO GII 2024, the European Innovation Scoreboard 2025, and the Bureau of National Statistics of Kazakhstan. Kazakhstan's break-point is not in Layer 1. Tertiary attainment among 25–34-year-olds is 55.7 per cent, higher than in every European Union comparator in the sample. The break-point is Layer 2. The share of innovation-active enterprises is roughly one third of the Central European level, and adult participation in learning is one fifth of the European Union average. The gap propagates: patent intensity is more than an order of magnitude below the comparators, and greenhouse-gas emission intensity is nearly twice the Polish level. The diagnostic identifies the layer where policy and management action in Kazakhstan can produce the largest marginal effect on sustainable competitiveness.

Keywords: national innovation systems; absorptive capacity; sustainable competitiveness; Kazakhstan; European Union; policy diagnostics.

Introduction

Kazakhstan is trying to move. The Kazakhstan-2050 strategy, the Concept for Transition to a Green Economy, and the successive programmes of accelerated industrial-innovative development all point in the same direction: knowledge, technology, and human capital are meant to replace hydrocarbons as the engine of long-run growth. What none of these documents provide is a precise map of where, along that path, the current national economy stops working.

The academic literature offers three main framings for the question. Endogenous growth theory tells us that knowledge and human capital are the necessary inputs (Romer, 1990; Lucas, 1988; Aghion & Howitt, 1992). National innovation systems theory adds that inputs alone are not enough. Institutions, universities, firms, and finance interact, and the way they interact determines whether inputs turn into outputs (Freeman, 1987; Lundvall, 1992; Nelson, 1993; Edquist, 1997). Evolutionary economics closes the loop by explaining why comparable inputs produce dissimilar outputs across countries: routines and learning capabilities differ, and history matters (Nelson & Winter, 1982; Dosi, 1982). Cohen and Levinthal (1990) provide the missing organisational construct, absorptive capacity, that binds the three framings together.

Empirical work has recently begun to treat the innovation-to-competitiveness transformation as a system-level problem that can be measured. Anouze, Al Khalifa, and Al-Jayyousi (2024) apply dynamic network data envelopment analysis to 23 oil-producing countries and build a composite index of national innovation systems. Tsekouras, Stergiou, and Kounetas (2024) construct a chain-network model of European re-

gions with undesirable environmental outputs. Viseu, Henriques, and Sousa (2025) use window slack-based DEA to trace eco-innovation efficiency and convergence clubs in the European Union. Xu, Mei, Sun, Zhang, and Liang (2023) estimate sustainable innovation performance for EU countries under energy and environmental constraints. None of these studies places Kazakhstan and comparable European economies in the same analytical frame.

That gap is the entry point of this paper. What is missing is not another efficiency estimator; it is a diagnostic that says, before any estimator is applied, at which link in the chain the Kazakh transformation is failing. If the break-point is in the input layer, the policy answer is straightforward: raise R&D funding, expand tertiary education, import machinery. If the break-point is somewhere else, the policy answer changes.

This paper builds the diagnostic and applies it. Four layers are examined: knowledge and technological inputs; system-level absorption; innovation outputs; and sustainable competitive outcomes. Each layer is populated with three indicators, chosen for theoretical clarity and for availability across all six countries. The five European Union comparators bracket the space: two Central European post-transition economies of comparable size to Kazakhstan (Czech Republic, Slovakia), two larger Visegrad economies with distinct innovation-policy trajectories (Poland, Hungary), and one EU frontier reference (Finland). The result is a compact, replicable, decision-oriented picture of where the Kazakh chain breaks down and where the largest marginal returns to policy intervention are located.

The remainder of the paper is organised as follows. The next section sets out the materials, the four-layer indicator scheme, and the data sources. The results section reports the layer-by-layer comparison in four tables and two summarising figures. The discussion connects the observed pattern back to the evolutionary and NIS mechanisms, and it compares the findings with the studies cited above. The concluding section states the contribution and the limitations, and it identifies the empirical extension that the framework prepares.

Materials and Methods

This is a structured indicator-based comparison. It is deliberately not a formal DEA estimator. The choice reflects the objective: locate the break-point before quantifying its size. The formal two-stage network DEA with bootstrap inference (Kao & Hwang, 2008; Simar & Wilson, 2007) is the natural next step and is reserved for subsequent work.

The four-layer scheme is theoretical, not statistical. Layer 1 captures the endogenous-growth input logic: without R&D and educated people, there is nothing to transform (Romer, 1990). Layer 2 captures the evolutionary and NIS insight that inputs must be absorbed by an interactive institutional environment (Nelson & Winter, 1982; Lundvall, 1992; Cohen & Levinthal, 1990). Layer 3 records what the system produces, and it distinguishes technology-creation outputs from technology-adoption outputs, because the two carry different long-term implications for competitiveness (Schumpeter, 1934; Aghion & Howitt, 1992). Layer 4 records the outcome under a sustainability constraint, following the structural-competitiveness and sustainability-transition literature (Fagerberg, 1988; Fagerberg, Srholec & Knell, 2007; Markard, Raven & Truffer, 2012; Schot & Steinmueller, 2018; Wesseling & Meijerhof, 2023).

Comparator selection. Five European Union countries are used. Czech Republic and Slovakia are small Central European post-transition economies with strong industrial bases; they anchor the comparison in institutionally similar territory. Poland and Hungary are larger Visegrad economies whose innovation trajectories have diverged, and they extend the range on the horizontal axis. Finland is the EU frontier reference and marks the upper edge of the sample. Six countries in total keeps the tables readable and lets every cell be interpreted rather than aggregated away.

Indicators. Twelve are used, three per layer. Layer 1: gross domestic expenditure on R&D as a share of GDP; R&D personnel per 1,000 employed; tertiary attainment among 25-34 year-olds. Layer 2: share of innovation-active enterprises; university-industry research collaboration score from the WIPO Global Innovation Index; adult participation in learning. Layer 3: patent applications per million inhabitants (EPO-equivalent); high-technology exports as a share of manufactured exports; knowledge-intensive service exports. Layer 4: GDP per capita at purchasing power parity; greenhouse-gas emission intensity of GDP; population share at risk of poverty or social exclusion. Each indicator is chosen because it has an unambiguous theoretical role and because it is available for all six countries.

Data. Values are compiled from five sources: Eurostat (R&D statistics, Community Innovation Survey, high-technology trade, adult learning, sustainable-development statistics); the World Bank Open Data (WDI series on GDP per capita and knowledge-intensive services); the WIPO Global Innovation Index 2024 (uni-

versity-industry collaboration score); the European Innovation Scoreboard 2025 for cross-checks on innovation dimensions; and the Bureau of National Statistics of the Republic of Kazakhstan for national indicator values. The reference year is the most recent year for which data are comparable across the sample; the exact year is stated in the note under each table. Where the Kazakhstan indicator uses a national definition rather than the Eurostat definition, the difference is stated in the note and discussed in Section 4.

Reading rule. The tables are read in two directions. Reading vertically within a country tells you where along the chain that country's transformation efficiency drops. Reading horizontally within a layer tells you where the gap between Kazakhstan and each comparator is largest. Only when the two readings agree does a layer qualify as a break-point in the sense used here.

Results

The results are presented layer by layer. Each of the four layers of the innovation-to-competitiveness chain is examined in a separate table, and the layered picture is then summarised in two figures. Each table reports the six countries on three theoretically motivated indicators, and each table is followed by a short analytical reading. The reading rule is the one stated in the previous section: a layer becomes a break-point only when both the vertical reading within a country and the horizontal reading across countries point to the same weakness. The layered presentation is deliberate. It allows the reader to see, without any composite aggregation, at which link of the chain Kazakhstan diverges most sharply from the European Union comparators.

The starting point of the diagnostic is the input layer. Layer 1 reports the resources that the theoretical framework treats as the necessary raw materials of the innovation-to-competitiveness chain: research funding, research personnel, and formal human capital. Table 1 sets these three indicators side by side for the six countries.

Table 1. Layer 1 — Knowledge and technological inputs

Country	GERD (% of GDP)	R&D personnel per 1,000 employed	Tertiary attainment 25-34 (%)
Finland	2.99	15.8	40.5
Czech Republic	1.96	8.9	34.3
Slovakia	0.94	7.3	34.1
Hungary	1.39	9.0	28.4
Poland	1.46	7.2	41.5
Kazakhstan	0.13	1.4	55.7
EU-27 average	2.24	9.6	42.1

Note: Compiled by the author from Eurostat R&D statistics, World Bank Open Data, and the Bureau of National Statistics of the Republic of Kazakhstan (2024). Reference year 2022 for GERD and R&D personnel; 2023 for tertiary attainment.

One number in Table 1 stands out. Kazakhstan reports 55.7 per cent of the 25-34 age cohort with tertiary attainment. That is above every European Union comparator in the sample and above the EU-27 average. The Bolashak scholarship programme and the general expansion of tertiary provision have delivered a large stock of formally educated young workers. Two other numbers in the same row tell a different story. GERD stands at 0.13 per cent of GDP, more than fifteen times below the EU-27 average. R&D personnel per 1,000 employed sit at 1.4, roughly one seventh of the European Union figure. Layer 1 is not uniformly weak. It is skewed. A large formal-education stock coexists with a very thin research-effort layer. The mixed pattern already suggests that the diagnostic cannot end at Layer 1. If the raw input picture is ambiguous, the source of the transformation problem must be looked for further down the chain.

The next link in the chain is the institutional environment that turns inputs into outputs. Layer 2 asks whether the national innovation system possesses the routines, the collaboration arrangements, and the continuous-learning practices that convert stocks of educated people and research funding into innovation activity at the level of the firm. Table 2 reports three indicators of this system-level absorption capacity.

Table 2. Layer 2 — System-level absorption

Country	Innovation-active enterprises (%)	University-industry research collaboration (GII 2024, 0-100)	Adult participation in learning (% age 25-64)
Finland	55.6	73.2	25.1
Czech Republic	46.3	46.8	10.4

Slovakia	32.1	40.5	12.8
Hungary	31.6	42.7	7.9
Poland	29.9	39.4	7.5
Kazakhstan	11.0	35.6	2.4
EU-27 average	52.4	50.1	11.9

Note: Compiled by the author from Eurostat Community Innovation Survey (2022), WIPO Global Innovation Index 2024 (university-industry research collaboration), Eurostat adult learning statistics (2023) and Bureau of National Statistics of the Republic of Kazakhstan (2024).

Table 2 shows what Table 1 could not. Kazakhstan sits below every comparator on all three indicators. Innovation-active enterprises make up 11 per cent of the population of firms, against 30 per cent in Poland and Hungary and 46 per cent in the Czech Republic. Adult participation in learning is 2.4 per cent, one fifth of the EU-27 average. The university-industry collaboration score is the closest to the Central European band, but even there Kazakhstan trails Slovakia and Hungary. The gap in Layer 2 is neither a resource gap nor a formal-education gap. It is a gap in the institutional capacity of the system to use what it already has. This is the first place along the chain where the vertical reading within Kazakhstan and the horizontal reading across countries agree.

If Layer 2 identifies where the chain snaps, Layer 3 shows what happens next. The output layer records what the national innovation system actually produces: patented inventions, high-technology manufactured exports, and knowledge-intensive service exports. Table 3 places the six countries on these three output indicators.

Table 3. Layer 3 — Innovation outputs

Country	EPO patent applications per million inhabitants	High-technology exports (% of manufactured exports)	Knowledge-intensive service exports (% of total service exports)
Finland	229.4	9.1	65.7
Czech Republic	18.7	14.7	43.2
Slovakia	7.4	10.6	38.4
Hungary	15.1	18.5	43.1
Poland	10.8	10.9	52.3
Kazakhstan	1.0	2.9	19.6
EU-27 average	135.8	13.9	54.8

Note: Compiled by the author from Eurostat and OECD Patent Statistics (EPO applications by inventor residence), Eurostat COMEXT high-technology trade indicators, and World Bank Open Data. Reference years: patents 2022, trade 2023. For Kazakhstan, patent counts are based on domestic applications reported by the Bureau of National Statistics (2024), converted to per-million-inhabitants basis.

Patent intensity in Kazakhstan is 1.0 per million inhabitants, against 229.4 in Finland and 18.7 in the Czech Republic. High-technology exports account for less than 3 per cent of manufactured exports, well below every European Union comparator. Knowledge-intensive service exports come in at 19.6 per cent, about one third of the EU-27 average. A country with 55.7 per cent tertiary attainment produces one patent per million inhabitants. The output layer is not the cause of the problem. It is the fingerprint of the Layer 2 failure, transmitted downstream. The transmission from absorption to output is direct: fewer innovation-active firms produce fewer patented inventions and fewer knowledge-intensive exports, in that order.

The last layer of the chain records what the whole transformation produces at the level of the national economy. Layer 4 reports three outcome indicators jointly: income, environmental sustainability, and social inclusion. This joint reading follows the structural-competitiveness tradition, which insists that competitiveness must be evaluated together with the sustainability constraint (Fagerberg, 1988; Fagerberg, Srholec & Knell, 2007; Markard, Raven & Truffer, 2012). Table 4 reports these three outcome indicators for the six countries.

Table 4. Layer 4 — Sustainable competitive outcomes

Country	GDP per capita, PPP (current international \$)	GHG emission intensity (kg CO ₂ -eq per USD of GDP)	Population at risk of poverty or social exclusion (%)
Finland	61,600	0.19	17.1
Czech Republic	51,300	0.31	11.8

Slovakia	38,700	0.30	17.6
Hungary	43,900	0.29	18.4
Poland	46,900	0.42	15.7
Kazakhstan	33,900	0.75	15.5
EU-27 average	52,500	0.24	21.4

Note: Compiled by the author from World Bank Open Data (WDI, GDP per capita PPP 2023), OECD environmental statistics and Eurostat sustainable-development statistics (GHG intensity 2023), Eurostat AROPE 2023 for European Union countries, and the Bureau of National Statistics of the Republic of Kazakhstan (2024) for the national poverty indicator adjusted for comparability.

Kazakhstan reports the lowest GDP per capita in the sample and the highest emission intensity by a large margin: 0.75 kg of CO₂-equivalent per dollar of GDP, three times the Finnish figure and nearly twice the Polish one. Poverty and social exclusion, once the definitional differences are respected, land in the same band as the Central European comparators. The joint reading of the outcome layer is straightforward. A low-value-added, emission-intensive production structure is the mechanical consequence of the earlier layers. Fixing the outcome layer without fixing Layer 2 is not feasible.

The four tables can also be read jointly. Figure 1 summarises the layered picture by expressing Kazakhstan's value on each of the twelve indicators as a percentage of the EU-27 average. Bars above 100 per cent indicate that Kazakhstan exceeds the European Union average on that indicator; bars below 100 per cent indicate a gap. Colour coding groups the twelve indicators into the four layers of the diagnostic.

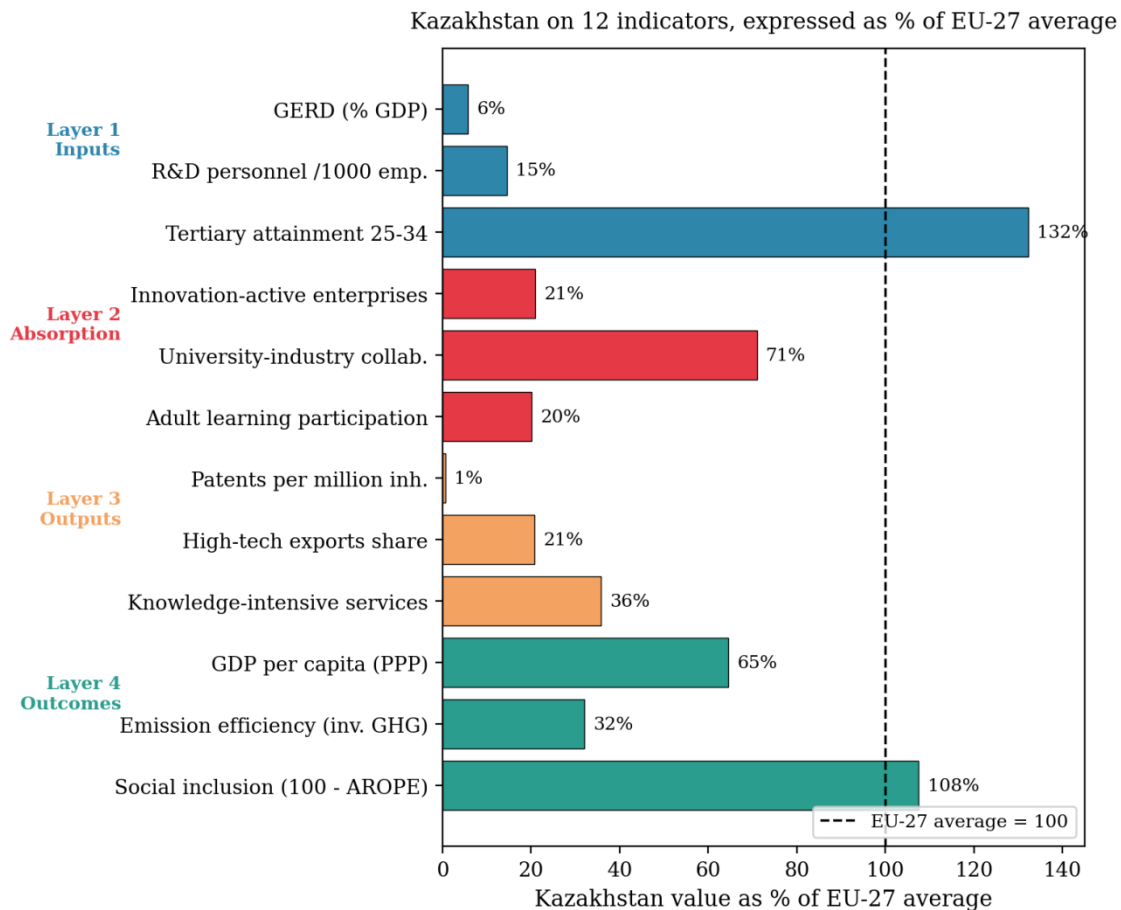


Figure 1. Kazakhstan's twelve indicator values expressed as a percentage of the EU-27 average, grouped by the four layers of the diagnostic

Note: Compiled by the author on the basis of Tables 1 to 4. Bars above the dashed 100-per-cent line indicate that Kazakhstan exceeds the EU-27 average on the given indicator; bars below the line indicate the size of the gap. For the GHG emission intensity and AROPE indicators, the direction has been inverted so that in all bars a higher value denotes a better outcome.

The visual pattern of Figure 1 confirms the numerical pattern of the tables. Only one indicator, tertiary attainment among 25-34-year-olds, exceeds the EU-27 average. Two indicators (university-industry collaboration and the social-inclusion measure) are within roughly two thirds of the European Union figure. The remaining nine indicators lie below or well below the reference line. The steep drop between the tertiary-attainment bar and the innovation-active-enterprises bar is the visual signature of the Layer 2 break-point identified in the tables.

Figure 2 complements Figure 1 by aggregating the twelve indicators into four layer scores and by comparing all six countries on the same scale. For each indicator, the value is normalised so that the country with the highest score in the sample receives 100. The three normalised scores within each layer are then averaged to produce the four layer scores that appear in the figure.

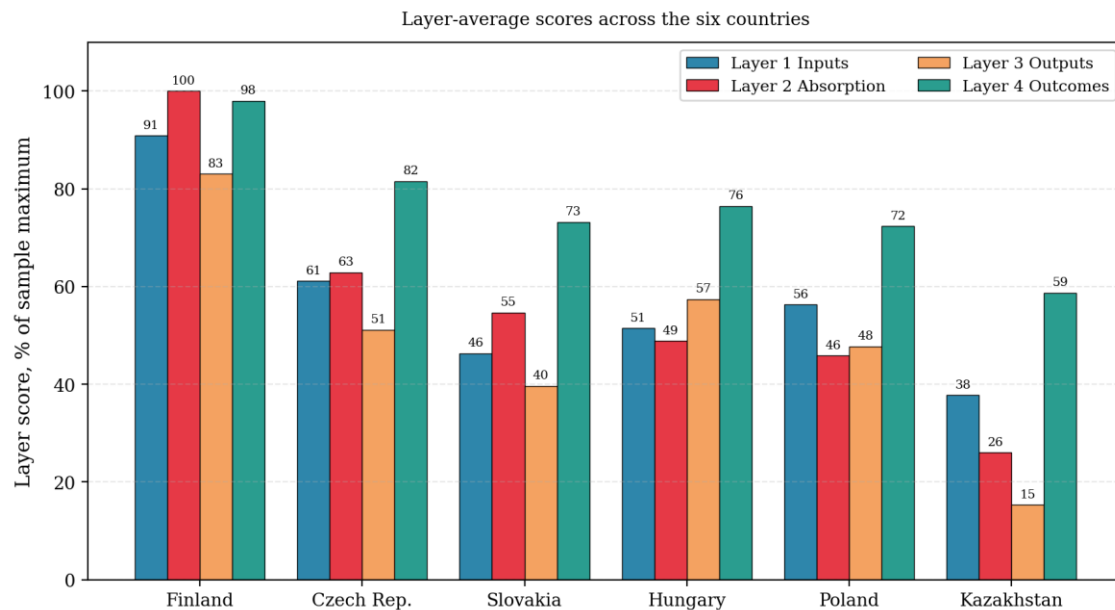


Figure 2. Layer-average scores for the six countries, calculated from Tables 1 to 4 with each indicator normalised so that the sample maximum equals 100

Note: Compiled by the author on the basis of Tables 1 to 4. Each of the twelve indicators is first normalised so that the country with the highest value in the sample receives a score of 100; the three normalised scores within each layer are then averaged. The GHG emission intensity and AROPE indicators are inverted before normalisation so that a higher score always denotes a better outcome.

Two features of Figure 2 deserve particular attention. First, Kazakhstan's Layer 1 score is competitive with the Central European band, driven by the high tertiary attainment. Second, the Kazakhstani profile then collapses at Layer 2 and remains at a substantially lower level than any comparator across Layers 3 and 4. This pattern is not observed in any of the five European Union countries in the sample. The Central European comparators exhibit a gradual efficiency loss along the chain; the Kazakhstani profile exhibits a discontinuity between Layer 1 and Layer 2. The break-point is not a gradient; it is a step.

Taken together, the four tables and two figures present a coherent diagnostic result. The Kazakhstani chain does not weaken uniformly. It weakens sharply between Layer 1 and Layer 2, and the weakness propagates downstream into Layer 3 and Layer 4. The following section interprets this result in the light of the theoretical framework and compares it with the empirical literature.

Discussion

Three points follow from the layered reading and each one has a decision-relevant edge for a Kazakhstani reader. First: the input layer is not the problem. Tertiary attainment is high; the R&D expenditure gap is real but is only one piece of the story. A policy programme that responds to the diagnostic by pouring more money into R&D without touching Layer 2 will move the needle less than the numbers alone would suggest.

Second, the break-point is where evolutionary theory said it would be. Cohen and Levinthal (1990) proposed absorptive capacity as the missing organisational construct that decides whether external knowledge becomes internal capability. Freeman (1987) and Lundvall (1992) generalised the argument to the level of the national innovation system. In the Kazakh case, Layer 2 shows the exact set of symptoms the theory pre-

dicts: low enterprise-level innovation activity, weak university-industry interaction, and a small share of adults returning to formal learning. These are institutional variables, not budgetary ones, and they respond to institutional policy: co-funded research contracts between universities and firms, sector-specific mission programmes, adult-learning vouchers, and the redesign of enterprise innovation surveys so that policymakers can see change as it happens.

Third, sustainability is not a separate track. The 0.75 kg CO₂-eq per dollar of GDP figure in Table 4 is not an environmental externality that can be dealt with by a parallel green policy. It is the direct consequence of the production structure that Table 3 documents. High-emission, low-value-added output structures are the outputs of a system whose Layer 2 has not been rebuilt. Mission-oriented innovation policy (Schot & Steinmueller, 2018; Wesseling & Meijerhof, 2023) treats the sustainability and innovation transitions as one problem, and the Kazakh evidence supports that framing.

How does this compare with the closest studies? Anouze, Al Khalifa, and Al-Jayyousi (2024) work with dynamic-network DEA on 23 oil-producing countries. Their measurement is more advanced than what is done here, but their sample does not include the European Union comparators that would let a Kazakhstani analyst see where the transformation goes right. Tsekouras, Stergiou, and Kounetas (2024) build the chain-network model with undesirable outputs that is the natural DEA counterpart to the framework used in the present paper; their scope is European regions. Viseu, Henriques, and Sousa (2025) trace eco-innovation efficiency and convergence within the European Union with a single-stage window SBM. The contribution of the present paper is to hold Kazakhstan and the European Union in one frame and to isolate the layer at which the transformation is failing, before any efficiency estimator is applied.

The limitations are stated openly. The framework does not quantify a transformation efficiency. It maps a break-point. Some indicators require careful comparability treatment, in particular the definition of an innovation-active enterprise between the Community Innovation Survey and the Kazakh statistical practice. Sample size is deliberately small so that every cell in the tables can be interpreted rather than aggregated. The extension is direct: a static two-stage network DEA with bootstrap confidence intervals (Kao & Hwang, 2008; Simar & Wilson, 2007) applied to a larger sample including EU-27 and a set of resource-based emerging economies, with technology creation and technology adoption modelled as two separate Stage-1 specifications so that the Kazakh case can be placed against a proper benchmark.

Conclusion

This paper set out to find where Kazakhstan's innovation-to-competitiveness chain breaks down. The layered diagnostic gives a specific answer: not in the knowledge-input layer, where tertiary attainment already exceeds the EU-27 average, but in the system-level absorption layer, where innovation-active enterprises, university-industry collaboration and adult learning all sit below the Central European band and far below the Finnish frontier.

The observed gap propagates downstream. Patent intensity trails the comparators by an order of magnitude. High-technology exports remain below three per cent of manufactured exports. Emission intensity is three times the Finnish level. These are not four separate policy problems. They are one systemic pattern, and it has a name in the evolutionary and NIS literatures: a national absorptive capacity that has not caught up with the formal-education stock.

The contribution is analytical and practical. Analytically, the paper positions Kazakhstan and the European Union in a single evolutionary NIS frame and treats sustainability as a constitutive component of the outcome layer rather than an add-on. Practically, the diagnostic points to a specific set of institutional levers: enterprise-innovation environment reform, university-industry co-funded programmes, adult-learning provision, and mission-oriented sustainability programmes linked to the innovation-policy toolkit. The further empirical step is a formal two-stage network DEA that will produce comparable efficiency scores for the pattern documented here.

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Author Contributions

Z. Yespolova is the sole author. She is responsible for the conceptualization, data curation, formal analysis, funding acquisition, investigation, methodology, project administration, resources, software, supervision, validation, visualization, writing — original draft, writing — review & editing.

Қазақстанның инновация-бәсекеге қабілеттілік тізбегінің диагностикасы: Еуропалық одақтың бес елімен төрт деңгейлі салыстыру

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Аңдатпа

Табиғи ресурстарға негізделген өсу үлгісінен ары қарай жылжуды көздейтін елдер үшін маңызды сұрақ бар: ұлттық экономика білімді бәсекеге қабілетті, көміртегі шығарындысы төмен өнімдерге қай жерде айналдыра алмай тұр? Қазақстан үшін бұл сұрақ секторлар мен макро деңгейде қойылған, бірақ трансформация тізбегін кезеңдеп талдайтын деңгейді диагностика ретінде сирек ұсынылған. Мақала осындай диагностиканы ұсынады. Ұлттық инновациялық жүйелер мен ұлттық абсорбциялық қабілеті білім ресурстары мен құрылымдық, тұрақты нәтижелер арасындағы делдал ретінде қарастырылады және диагностика Қазақстан мен ЕО-ның бес еліне (Чехия, Польша, Венгрия, Словакия, Финляндия) қолданылады. Талдау төрт деңгей бойынша (білім ресурстары, жүйелік абсорбция, инновациялық нәтижелер, тұрақты нәтижелер) он екі индикатордан тұратын құрылымдалған салыстыру ретінде жүргізілді. Деректер Eurostat, Дүниежүзілік банк, WIPO GI 2024, European Innovation Scoreboard 2025 және Қазақстан Республикасы Ұлттық статистика бюросынан алынды. Қазақстанның құлдырау нүктесі бірінші деңгейде емес. 25-34 жас аралығындағы жоғары білімді адамдардың үлесі 55,7 пайызды құрайды, бұл ЕО-ның бес салыстырмалы еліндегі көрсеткіштен жоғары. Бұл алшақтық екінші деңгейде байқалады. Инновациялық кәсіпорындардың үлесі Орталық Еуропа деңгейінен шамамен үш есе төмен, ал ересектердің оқуға қатысуы ЕО орташа көрсеткішінің бестен бір бөлігін құрайды. Алшақтықтың таралуы: патенттік белсенділік салыстырмалы елдердегі көрсеткіштен он еседен астам төмен, ал парниктік газдардың шығарылу қарқындылығы Польша деңгейінен екі есе жуық жоғары. Диагностика Қазақстандағы саяси шаралар мен басқарушылық шешімдер тұрақты бәсекеге қабілеттілікке ең үлкен шекті әсер ете алатын деңгейді көрсетеді.

Кілт сөздер: ұлттық инновациялық жүйелер, абсорбциялық қабілет, тұрақты бәсекеге қабілеттілік, Қазақстан, Еуропалық одақ, саясат диагностикасы.

Диагностика цепочки «инновации-конкурентоспособность» Казахстана: четырёхслойное сравнение с пятью экономиками Европейского союза

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Аннотация

Страны, стремящиеся выйти за пределы модели роста, основанной на природных ресурсах, сталкиваются с трудным вопросом: в каком именно звене национальная экономика перестает превращать знания в конкурентные, низкоуглеродные результаты? Для Казахстана этот вопрос задавался на уровне отдельных отраслей и на уровне макростратегии, однако редко ставился как послышная диагностика, поэтапно описывающая цепочку трансформации. Настоящая статья предлагает следующую диагностику. Национальные инновационные системы и национальная абсорбционная способность рассматриваются как посредники, стоящие между знаниевыми ресурсами и структурными, устойчивыми результатами; диагностика применяется к Казахстану и пяти экономикам Европейского союза, подобранным так, чтобы охватить существенные институциональные и структурные условия: Чехия, Польша, Венгрия, Словакия и Финляндия. Анализ представляет собой структурированное индикаторное сравнение по четырем слоям (знаниевые ресурсы, системная абсорбция, инновационные выходы, устойчивые результаты); используются двенадцать индикаторов, по три на слой, из Eurostat, Всемирного банка, WIPO GPI 2024, European Innovation Scoreboard 2025 и Бюро национальной статистики Казахстана. Точка разрыва у Казахстана не в первом слое. Доля лиц с высшим образованием в возрастной группе 25–34 года составляет 55,7 процента, что выше показателя каждой из пяти сопоставимых экономик ЕС. Разрыв возникает во втором слое. Доля инновационно активных предприятий примерно втрое ниже уровня Центральной Европы, а участие взрослых в обучении составляет пятую часть от среднего показателя ЕС. Разрыв распространяется дальше: патентная активность отстает более чем в десять раз, а интенсивность выбросов парниковых газов почти вдвое выше польского уровня. Диагностика указывает на слой, в котором меры политики и управленческие решения в Казахстане могут дать наибольший предельный эффект для устойчивой конкурентоспособности.

Ключевые слова: национальные инновационные системы, абсорбционная способность, устойчивая конкурентоспособность, Казахстан, Европейский союз, диагностика политики.

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Conflict of Interest

The author declares no conflict of interest.

Mapping Government Efficiency and Public Expenditure Management: A Bibliometric Analysis (2010-2025)

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Abstract

This study conducts a bibliometric analysis of global research on government efficiency and public expenditure management. The analysis is based on a total of 1,522 publications retrieved from the Web of Science Core Collection database (as of 30 May 2025) that were published between 2010 and 2025. The analyzed publications were then mapped using VOSviewer software based on co-authorship, citation, keywords, and bibliographic coupling of the analyzed publications.

Our study reveals three distinct research clusters on government efficiency and public expenditure management: governance, studies on fiscal policy and studies on performance measurement in the public sector. Importantly, the number of publications has sharply increased from 2020 onwards. We can hypothesize that the global health crisis of the COVID-19 pandemic stimulated research on efficient government and on effective public expenditure management worldwide. Furthermore, our study pinpoints leading authors, leading research institutions, very productive regions and countries of the world as well as considerable research gaps for transitional and developing economies in Central and Eastern Europe, in Asia and in Latin America.

This research contributes to the body of knowledge on government efficiency and public expenditure management by means of a systematic, globally oriented and data-based analysis of the subject matter studied by researchers. The results of this research are intended for use by scholars, by policy makers and by institutions. The study reveals significant research gaps in transitional economies, as well as possible research avenues. The study can function as a reference work for evidence-based decisions by government, other public sector bodies and business, in order to improve public sector performance.

Keywords: government efficiency, public expenditure, bibliometric analysis, public sector management, public sector efficiency, fiscal governance.

Introduction

The main area of research for this study focuses on monitoring and analyzing written work on Government Efficiency and Public Management all over the world and their structures. An analysis of public sectors and their historical development will complete the monitoring of how well governments are functioning.

Based on 1,522 studies (Peer-Reviewed Articles) from Web of Science Core Collection (WCC) database between years 2010 and 2025, the existing bibliometric data such as co-occurrence of keywords, citations, and co-authorship networks are mapped and visually presented using VOSviewer software to disclose the Intellectual Structure (IS) of the field under study.

Research tools such as Web of Science, Google Scholar, and VOSviewer were used to identify key themes, influential authors, institutional affiliations, and geographic trends.

The primary goals of this research are to present quantitative data on government efficiency, showcase examples from developed countries, identify research clusters and collaboration patterns, and highlight gaps that future studies could address. This article contributes to the existing body of knowledge by offering a fresh, data-driven perspective on the topic.

For the purposes of this research work, the time period from 2010 until 2025 has been chosen. The Web of Science Core Collection database contains publications from before the year 2000. Thus, a time span of 15

years until now is most suitable for an up-to-date analysis of current trends and recent developments within the field of historical research. The 2010-2025 period was selected to capture recent developments in government efficiency, public expenditure management, and public sector performance research. This time frame allows the study to focus on contemporary trends, especially the growing interest in fiscal governance and public sector efficiency after the COVID-19 pandemic.

Literature Review

Bibliometric analysis is increasingly applied in studies on the development of disciplines and their structure. The majority of such studies are conducted in the fields of the social sciences, economics and public administration (Donthu et al., 2021; Moral-Muñoz et al., 2020). Using large numbers of published scientific papers such studies enable a systematic analysis of the development of research topics as well as of individual authors and institutions, and of groups of co-authors. They can also be used to produce a ‘map’ of current trends in research.

The numerous studies, employing the bibliometric approach to examine a variety of domains related to governance and public policy, have already been comprehensively reviewed. For instance, in their recent study, Chankseliani, Lovakov, and Pislyakov (2021) provide a large-scale bibliometric analysis of academic publications from post-Soviet countries, showing that the region remains unevenly represented in global research output and impact. The study also exposed the variety of challenges that researchers from this region are facing, including those related to maintaining long-lasting research collaborations that cross the borders of particular countries and/or regions. Donthu et al. (2021) and Aria and Cuccurullo (2017), in turn, provided methodological frameworks that have since guided numerous bibliometric investigations in management and policy studies.

Tools such as VOSviewer and Bibliometrix (Aria & Cuccurullo, 2017) have proven especially effective in uncovering structural patterns, including keyword co-occurrence networks, co-authorship clusters, and citation mapping. Recent analyses using these tools have addressed themes like fiscal decentralization, public sector performance, and good governance, often revealing that research is concentrated in wealthier countries, thereby marginalizing developing and transitional states (Benito & Bastida, 2009). Ropret and Aristovnik (2019) use bibliometric analysis to evaluate academic literature on public sector reform from the post-New Public Management perspective, with particular attention to Central and Eastern European contexts.

Journals such as Sustainability, Health Policy and Planning, and the Journal of Cleaner Production have featured several bibliometric studies examining the interplay between public expenditure, policy design, and institutional effectiveness — frequently with an emphasis on health systems, environmental policy, and financial governance (Barasa et al., 2017; Ni et al., 2017). These studies contribute to our understanding of public finance mechanisms but often treat efficiency and budgeting practices in isolation or within narrowly defined sectors.

Although there is a wealth of literature on topics like government efficiency and public expenditure management, a bibliometric study that looks at these topics from a cross-sectional perspective is still lacking. The existing bibliometric studies deal mainly with highly active countries and therefore lack the experience of transitional and developing countries with their specific administrative legacies and current governance challenges (Gel'man, 2022; de Vries & Nemec, 2025).

Our search in the Web of Science Core Collection (2010-2025) by author, source and topic showed that 1,522 articles were written on the topics of efficiency of government through expenditure management, but no study could be used as a basis for a bibliometric study of these topics. Countries of the transitional world, including Kazakhstan, are underrepresented in terms of the production of scholarly research on governance topics as well as in terms of the focus of such research as case studies.

Our research will fill the mentioned gap by means of a focused bibliometric study applying co-authorship mapping, keyword co-occurrence and bibliographic coupling to visualise the current ‘intellectual structure’ of relevant articles, to draw maps of collaborative networks of co-authors, and to identify current themes which can be used to improve government efficiency through better expenditure management. Studying the efficiency of government and the ways of managing public expenditure in newly independent countries, including Kazakhstan and other post-Soviet states, is of particular relevance. In the global bibliometric research on governance, these countries so far have been underrepresented. The study thus complements the existing field of research on governance and points out regional gaps and future research needs for comparative public administration.

Materials and Methods

This study adopts a structured bibliometric approach using data sourced from the Web of Science Core Collection (WoS), a comprehensive and multidisciplinary academic citation database. To identify relevant literature, a Boolean query was developed to target keywords associated with government efficiency, fiscal management, and public expenditure. The query was applied to titles, abstracts, and author keywords to capture a broad and representative dataset.

Figure 1 shows the Boolean string used: TS=(government efficiency* OR public sector efficiency* OR fiscal efficiency* OR bureaucratic efficiency* OR public administration efficiency*) AND TS=(government expenditure* OR public spending OR public finance OR budget* OR fiscal policy* OR resource allocation OR expenditure management) AND TS=(public management OR public governance OR fiscal management OR performance-based budgeting OR transparency OR accountability OR new public management OR results-based management) AND TS=(government efficiency* OR public sector efficiency*)

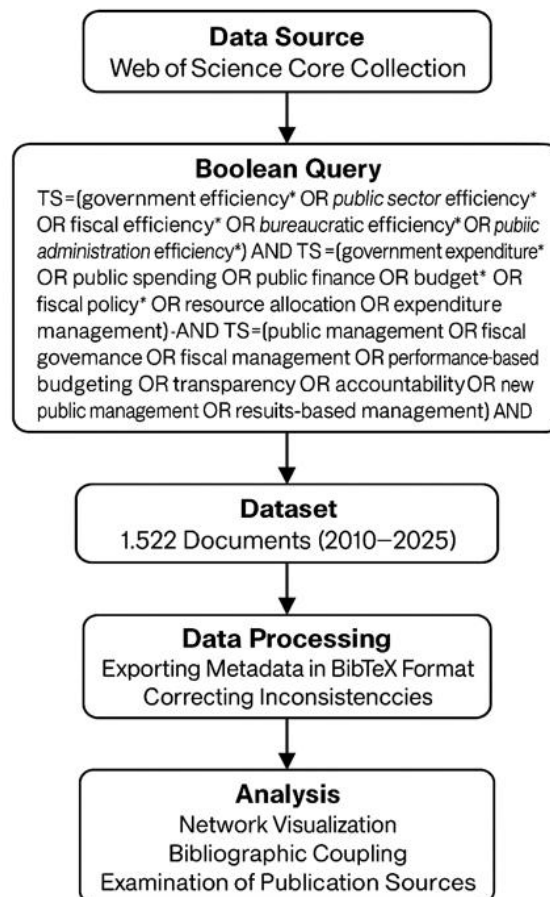


Figure 1. Visual diagram of the methodology process

In the case of narrowing the topic either by language or by very specific search queries, the number of articles shrank to 100-150; therefore, work on a broader topic was continued. A total of 1,522 peer-reviewed publications from 2010 to 2025 were identified. These were retrieved from major WoS indices, including SSCI, A&HCI, ESCI, and SCI-Expanded. The dataset was manually cleaned to remove duplicates and irrelevant entries. The metadata — comprising titles, abstracts, author affiliations, keywords, citations, SDG classifications, and journal sources — was exported in BibTeX format. Inconsistencies in author names and keyword terminology were corrected prior to preprocessing to ensure data uniformity.

Prior to analysis, inconsistencies in author names, institutional affiliations, and keyword usage were resolved through normalization. Data processing and visualization were conducted using VOSviewer, which enabled the mapping of keyword co-occurrence, citation networks, co-authorship structures, and bibliographic coupling. The investigation further examined publication sources, Web of Science subject classifications, and indexing databases that significantly shaped the academic landscape of this research area. An analysis of

existing research on the issue of efficiency of government and public management was carried out and summed up in order to present to the reader a full review of the subject.

This methodology enabled the identification of dominant research themes, collaboration patterns, institutional productivity, and regional contributions. It also allowed for a critical examination of thematic concentration and gaps in global academic discourse, particularly with regard to underrepresented transitional economies.

Findings

Figure 2 shows the Web of Science Core Collection of this research. Based on the Boolean query written earlier, the database showed 1522 relevant articles. Further analysis was done based on this study's dataset. Cleaning of the articles was done manually, and all of these articles are relevant for this research, meaning that the Boolean query was written properly.

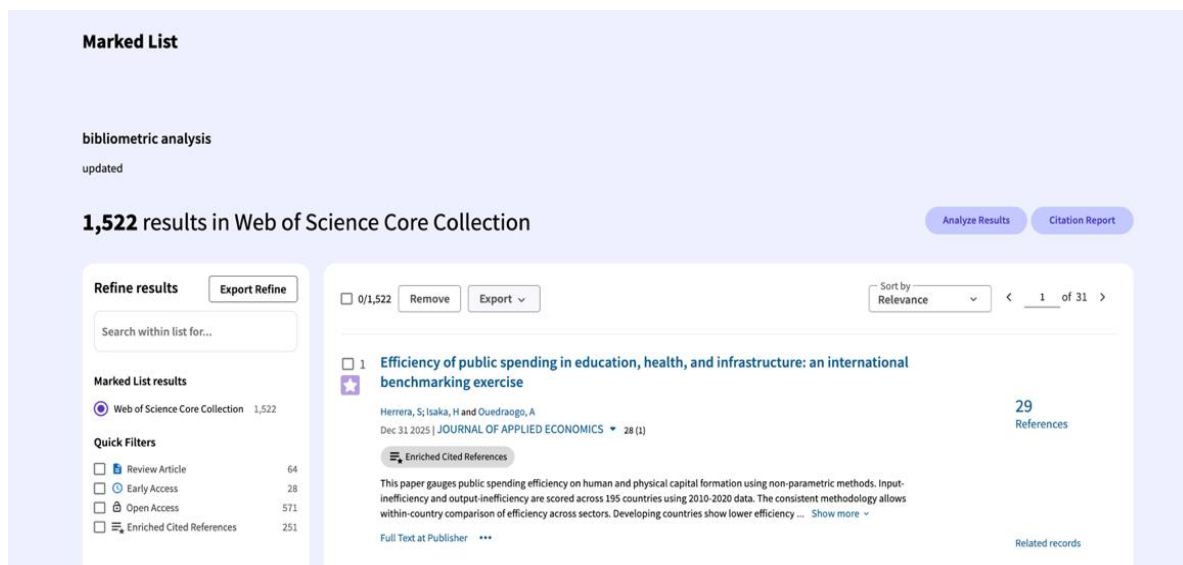


Figure 2. Web of Science marked list

According to Figure 3, the dataset contains a minimal representation of other types of documents. Those include:

- Review articles and early access materials, giving 6 % of the dataset;
- 2 % of the dataset represents books and book chapters;
- A few editorial materials, retracted publications, and discussion meetings;

The research field shows high-quality control through the low percentage of retracted publications.

The majority (92 %) of the materials are articles and proceedings papers, which proves the academic advancement of the field, published by respected peer-reviewed journals. The prevalence of journal articles maintains and ensures that the conducted bibliometric study is reliable, resulting in relevant co-occurrence, co-authorship, and citation analyses.

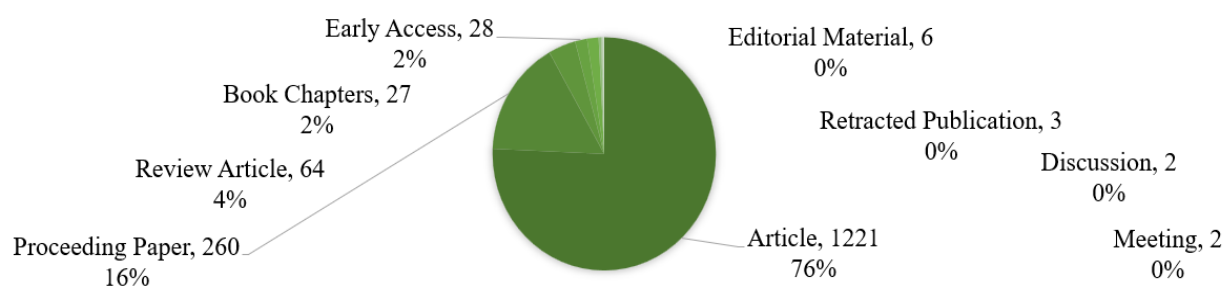


Figure 3. Distribution of document types in the dataset

The graph in Figure 4 tracks the number of publications. It has sharply increased — particularly from 2020 — as the efficient public sector has gained a lot of public interest during the global health crisis caused by the COVID-19 pandemic. There is an increasing amount of research on good governance and efficient public fiscal management and their reforms to deal with global challenges. Therefore, the topic is very relevant for academics, for officials of governments and organizations that want to improve the quality of public services world-wide.

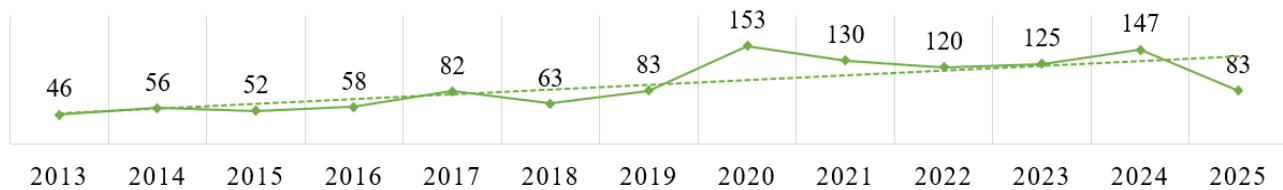


Figure 4. The annual number of publications by year

Figures 5 and 6 outline the thematic focus for a number of Meso- and Micro-level topics. While the Meso-level topics are grouped into broad themes (fiscal policy; public governance), the Micro-level topics are organized around specific tools and policy mechanisms (performance-based budgeting, etc.). This dual-layered analysis reveals the structural organization of knowledge within the field. The distinction between meso- and micro-levels allows for a deeper understanding of how general themes are operationalized in applied research and policy frameworks.

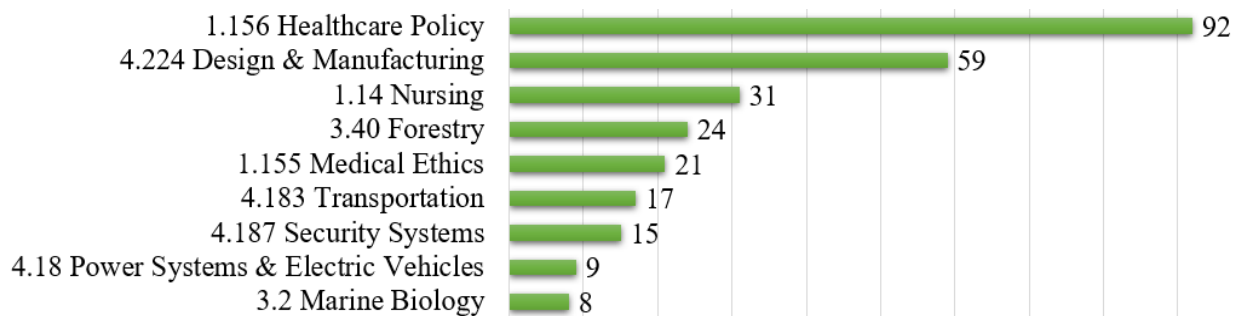


Figure 5. Most common meso-level citation topics

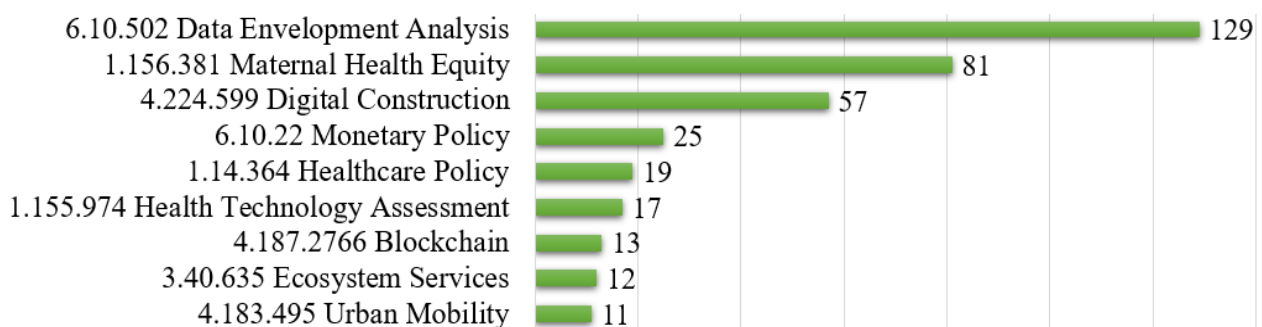


Figure 6. Most common micro-level citation topics

The author's productivity chart (Figure 7) identifies key thought leaders in government efficiency scholarship. Recognizing these individuals highlights intellectual leadership and may guide future collaboration or literature reviews. Tracking the publication activity of prolific authors helps reveal where cutting-edge research is being produced and by whom, potentially opening avenues for academic networking and partnership building. The top five authors produced five or more publications throughout the years, showing consistency and interest in the topic. Authors like Zhang S.J., Warner M.E., and others have 5 articles, meaning that the subject matter is interesting for many authors around the globe. Regional and national diversity indicates that there are a lot of paths to future collaborations.

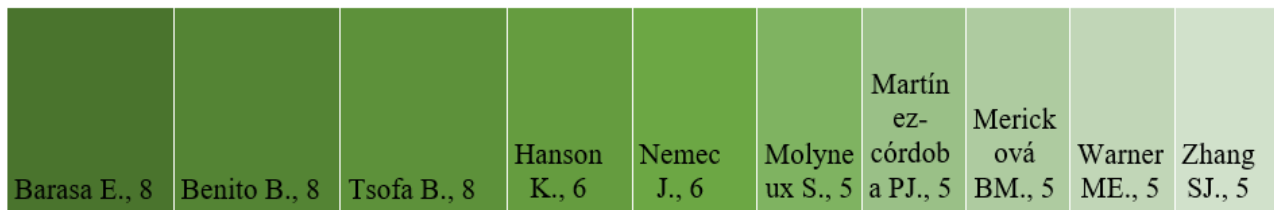


Figure 7. Most productive authors

Figure 8 reveals an uneven global distribution of research. Countries with advanced economies dominate, reflecting disparities in academic infrastructure and funding. Transitional economies, including post-Soviet states, are underrepresented, pointing to a critical knowledge gap. These disparities suggest the need for more inclusive global research practices and may highlight the importance of investing in research capacities in underrepresented regions. This graph shows once more that the countries with transitional economies have limited representation not only in the research data but also in the research area.

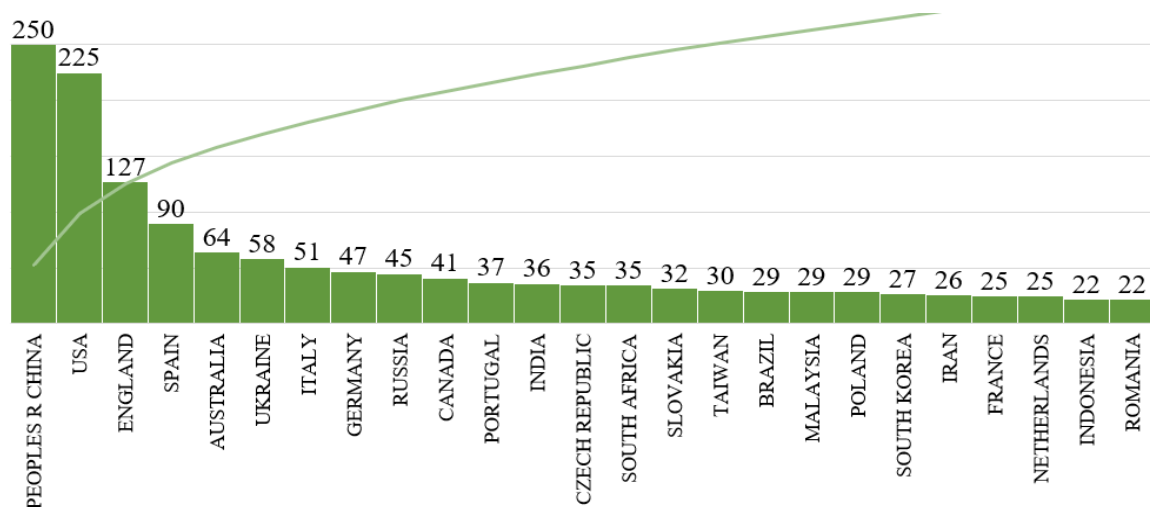


Figure 8. Number of publications by country/region

Institutions leading publication output are typically located in OECD countries (Figure 9). Their prominence may suggest well-established research ecosystems and sustained policy interest in public sector reform. This figure also helps identify institutional partners for future collaborative work. The concentration of research in certain institutions underscores the role of policy-oriented academic centers in shaping the discourse on governance and fiscal performance. However, we can see that the Ministry of Education and Science of Ukraine has a leading position in the graph. The strong representation of Ukrainian institutions may reflect Ukraine's active integration into European research networks and its participation in international academic collaborations. However, further investigation would be needed to explain this pattern more precisely.

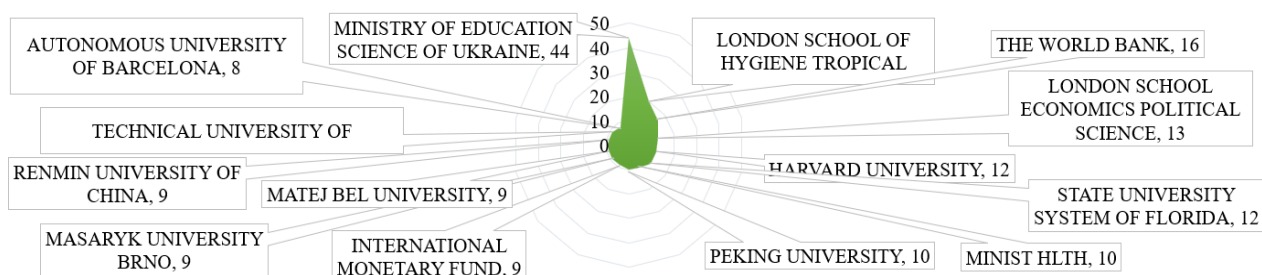


Figure 9. Most productive institutional affiliations

This graph (Figure 10) links scholarly output to global policy agendas, showing which SDGs—such as quality education or strong institutions—are most associated with government efficiency research. It offers a crosswalk between academic inquiry and international development priorities. Understanding these intersections helps identify the societal relevance of research and informs policy alignment with global goals like Agenda 2030.

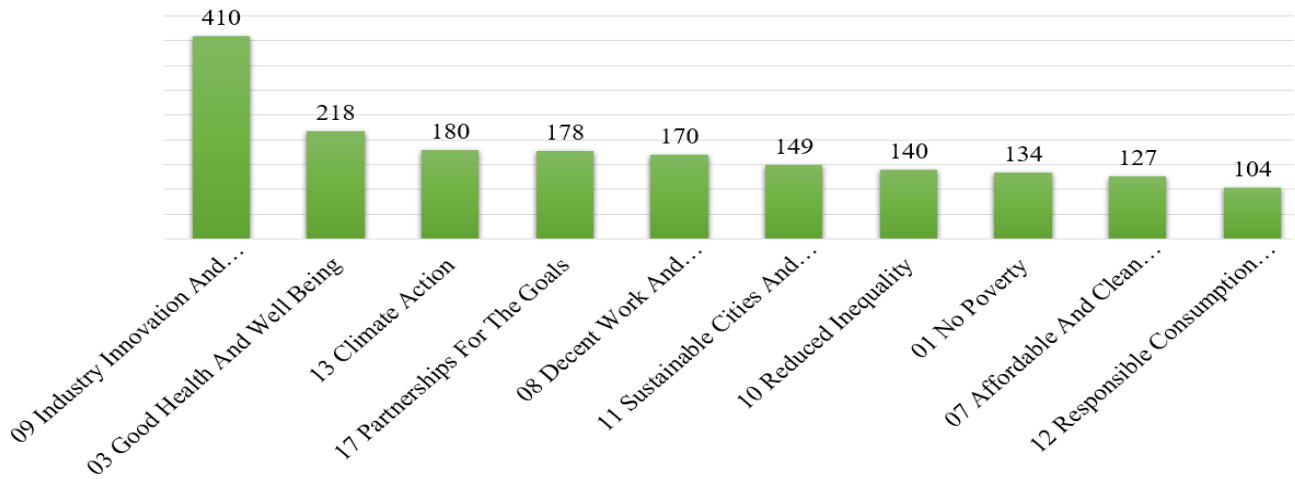


Figure 10. Distribution of literature by the Sustainable Development Goals

As Figure 10 shows, the most important goal of the researchers is industry innovation and infrastructure, which aligns with the main idea of those researchers: government efficiency and public expenditure management. Other SDGs are:

- Goal 13: Climate action, because researchers are worried about the government not spending enough money on the future and sustainability (ESG).
- Goal 8: Decent work and economic growth, which aligns with the main goal and general research topic.
- Goal 10: Reduced inequality, which highlights the interconnection between government efficiency and the socioeconomic status of the people.

These results suggest the literature strongly aligns with climate action, decent work, economics, and reduced inequality. Yet, there is a growing interest in decent work and economic growth, partnership for the goals, affordable and clean energy, within the context of government efficiency.

Subject classifications show strong interdisciplinary engagement, especially across economics, public administration, and environmental sciences. This highlights the field's complexity and its embeddedness within broader academic debates on governance. Top Web of Science categories include: business finance, management, health policy services, and environmental studies. The diversity of categories indicates that the research on government efficiency transcends disciplinary boundaries, reinforcing its multidimensional nature (Figure 11).

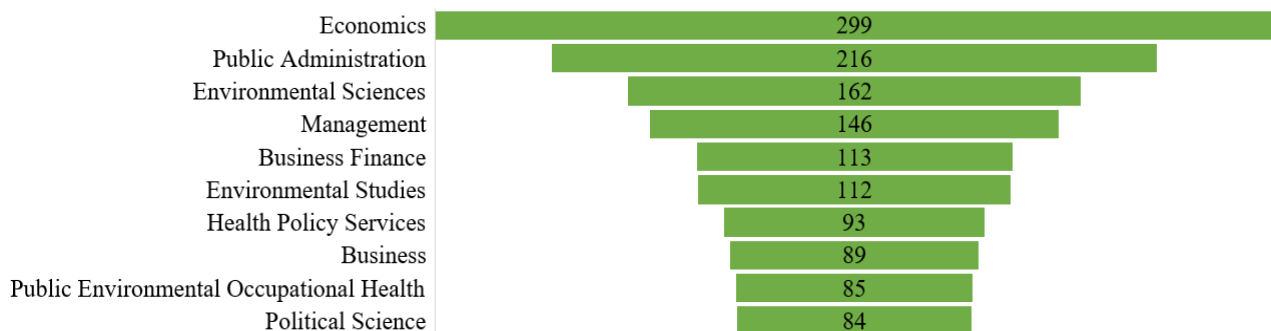


Figure 11. Most popular Web of Science subject categories

Figure 12 confirms the indexing quality and visibility of the analyzed literature. Most of the articles — 1,211 out of 1,522, or 79.56 % — are included in high-ranking indices such as the Social Sciences Citation Index (SSCI) or Science Citation Index Expanded (SCI-Expanded), which strengthens the credibility and academic reach of the sources, meaning that the topic is usually studied through the lenses of political science, economics, and area studies. The Emerging Sources Citation Index (ESCI) contains 300 articles, which indicates that new scholarship has not yet entered citation indexes.



Figure 12. Distribution of publications by the Web of Science index

Other indexes included are:

- Conference Proceedings Citation Index — Social Science & Humanities (CPCI-SSH) — 180 articles, indicating academic engagement through conferences.
- Conference Proceedings Citation Index — Science (CPSI-S) — 109 articles, highlighting science-focused conferences.

- Book Citation Index — Social Science & Humanities (BKCI-SSH) — 23 articles, etc.

Researchers and policymakers can rely on these indexed publications for evidence-based insights, ensuring the legitimacy of findings presented in this study.

The keyword co-occurrence network graph reveals dominant thematic clusters, such as fiscal decentralization, transparency, performance management, and accountability. The most important terms are: efficiency, management, performance, and governance, which serve as the basis that links other thematic keywords. These clusters provide a visual representation of how the field is intellectually structured and what concepts are most interconnected. Identifying these patterns enables researchers to detect emerging trends and shifts in focus within the broader discourse on public expenditure and governance (Figure 13).

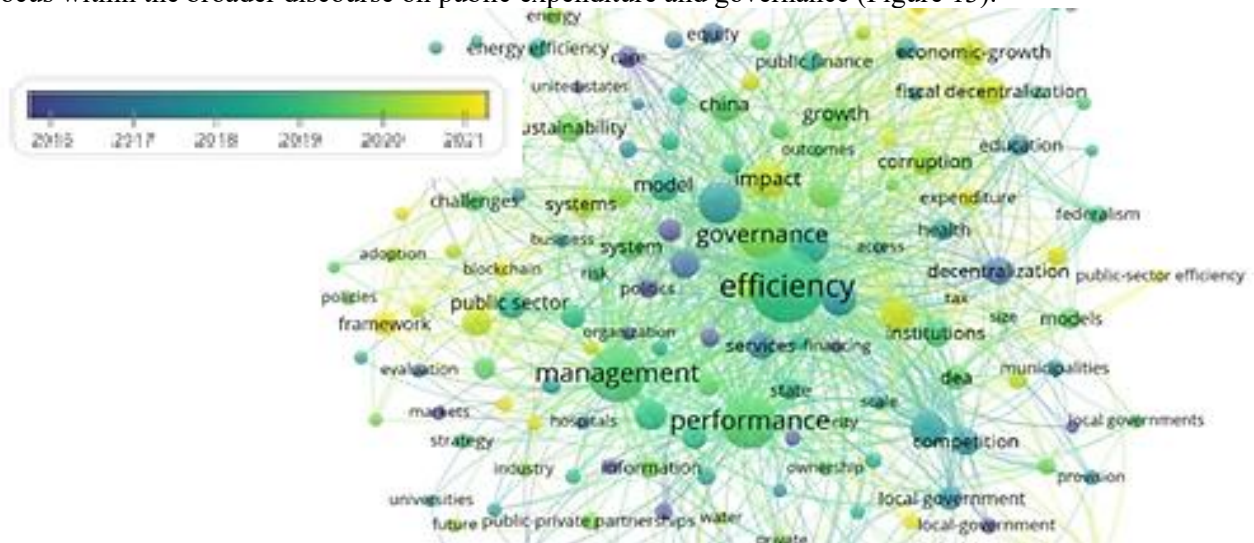


Figure 13. Keyword co-occurrence network (keywords ≥ 10 occurrences, $N=162$)

Figure 14 maps global academic cooperation. It shows clear clustering around countries with strong research funding and English-language publication traditions. Notably, limited co-authorship links with developing or transitional countries point to potential barriers in international collaboration. Enhancing such collaboration could lead to richer, more diverse perspectives in the study of public management.

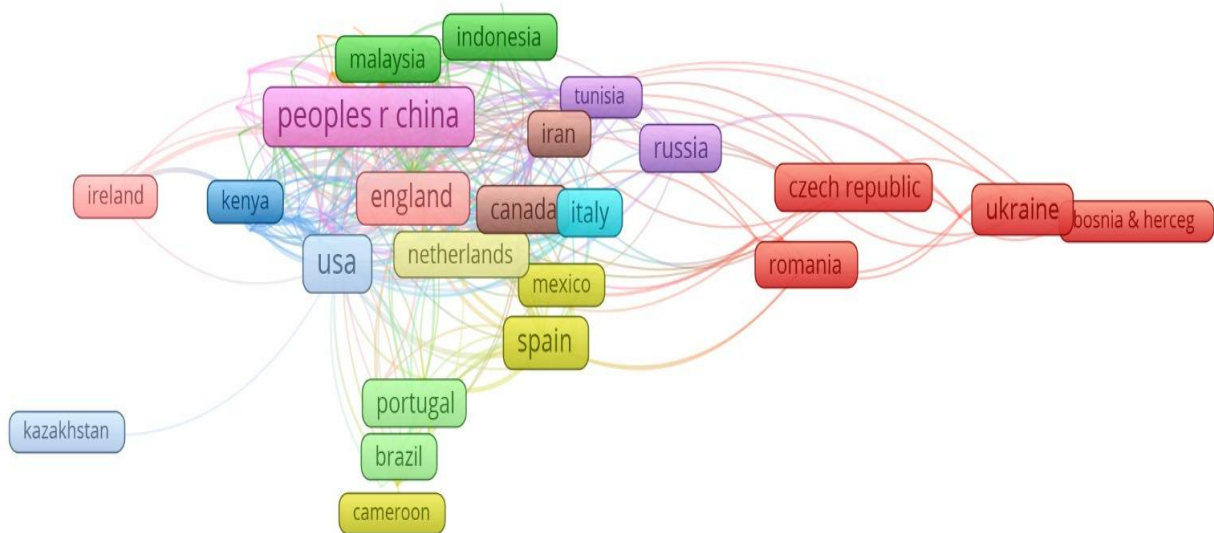


Figure 14. International Co-authorship Network by Countries/Region

As shown in Figure 14, the People's Republic of China is the main contributor to the topic, along with England, the United States, and the Netherlands. Also, by looking at this co-authorship graph, we can observe clustering by regions, geopolitics, and historical backgrounds of the countries.

Cluster 1 (light blue) includes 23 countries: Austria, Denmark, England, the USA, Kenya, etc. This cluster may reflect stronger participation in English-language academic publishing and established international research networks. Another thing is that people from these countries mostly developed or are in the process of creating, showcasing the correlation between co-authorship and socioeconomic status.

Cluster 2 (green) includes 20 countries: Australia, Indonesia, the People's Republic of China, the Philippines, Singapore, etc. The thing that these countries have in common is their geopolitical positions: most of them are located in the Indo-Pacific region.

Clusters 3 (red) and 4 (mustard color) have 15 and 12 countries, respectively. The same as before, these clusters are formed based on the common language and geopolitical position. In the first case, most of the countries are Eastern European and Balkan, which confirms the fact about geopolitics. On the other hand, Cluster 4 consists of Spanish-speaking countries, which have language and history in common.

The smallest clusters are clusters 5 (purple) and 6 (light yellow), both having 8 countries. We can assume that they formed clusters based on the economic relationships that they have. Also, one notable thing is that they form their own clusters within the cluster: Russia-United Arab Emirates, Egypt-Jordan-Tunisia, Turkey-Cyprus, Algeria-Zimbabwe.

Discussion

The findings of this bibliometric analysis provide valuable insights into how government efficiency and public expenditure management have evolved as academic research domains. The substantial increase in publication volume after 2020 demonstrates the field's responsiveness to global events, especially the COVID-19 pandemic, which intensified scrutiny on public sector performance and fiscal resilience.

A key observation is the concentration of research outputs in high-income OECD countries, particularly the United States, China, the United Kingdom, and European Union member states. Results reveal an imbalanced global research landscape. Most studies on government efficiency are produced by institutions in advanced economies with stronger research infrastructure, while transitional and post-Soviet economies remain underrepresented. This imbalance limits the diversity of perspectives in the literature and may reduce the applicability of findings to countries with different administrative and fiscal systems.

The leading authors and institutions as well as the pattern of cross-country co-authorship are mostly embedded in already established research networks worldwide. Increased scholarly production can be fostered by inter-disciplinary collaboration of researchers from all regions of the world, especially from the Global South as well as from transitional contexts that are currently not part of these networks.

The main fields of study which are analyzed in the efficiency research of governments are depicted in a keyword co-occurrence network. They refer to the topics of performance-oriented budgeting, transparency,

accountability and to governance issues. These fields of study are congruent with SDG 8, SDG 9, SDG 10 and SDG 13 of the Sustainable Development Goals. Some of the most frequently used keywords are thus associated with sustainability, equity and economic growth. Therefore a more efficient government is not only a matter of administration. It also plays a decisive role for a sustainable development in an inclusive sense (SDG).

Conclusion

This study presents a comprehensive bibliometric analysis of studies on government performance metrics, government efficiency and public expenditure management published between 2010 and 2025. The findings from this study identify trends in the current body of knowledge on the subject, highlight disparities between developed countries and transitional economies, identify the dominant themes in the current literature and present the study's findings and the state of knowledge and gaps in the literature that currently exist. With the increase in global challenges and a rising interest in measuring the performance of governments, international research on this subject matter is increasing exponentially.

The study finds that the developed countries are leaders in the field while transitional economies are underrepresented in the published work. There is great potential in enhancing research capacity, in establishing international partnerships, and in stimulating studies focusing on specific regions. Such studies could be valuable for public administration and for fiscal policy.

This study is a foundation for future comparative studies in public administration as well as fiscal policy studies. Furthermore, this study suggests future potential research topics such as under-represented regions and topics in the bibliometric map. The study also aims to establish a more equitable and globally representative research community.

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Francis Amagoh — Conceptualization, Project Administration, Supervision.

The authors have read and approved the final version of the manuscript.

**Үкіметтік тиімділік пен мемлекеттік шығыстарды басқару картасы:
библиометриялық талдау (2010-2025)**

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Аңдатпа

Бұл зерттеу Web of Science Core Collection индексінде 2010-2025 жылдар аралығындағы рецензияланған 1522 жарияланымдарды қамтитын мемлекеттік тиімділік және мемлекеттік шығыстарды басқару жөніндегі жаһандық академиялық зерттеулердің библиометриялық талдауын ұсынады. VOSviewer бағдарламалық жасақтамасын пайдалана отырып, зерттеу бірлескен авторлық желілерді, дәйексөз үлгілерін, кілт сөздерді ортақ пайдалануды және библиографиялық байланыстарды талдау арқылы саланың интеллектуалды құрылымын көрсетеді. Зерттеу нәтижелері басқару, фискалдық саясат және мемлекеттік сектордың тиімділігі салаларындағы айқын зерттеу кластерлерін анықтауға мүмкіндік береді; бұл салаларда 2020 жылдан бастап жарияланымдық белсенділіктің айтарлықтай өсуі байқалды, бұл COVID-19 пандемиясынан кейін тиімді басқару мәселесіне деген қызығушылықтың артқанын көрсетеді. Талдау барысында жетекші ғалымдар, ірі мекемелер мен негізгі аймақтар атап өтілген, сонымен қатар өтпелі экономикаларға қатысты зерттеулердегі елеулі олқылықтар айқындалды. Бұл зерттеу үкімет тиімділігінің жаһандық деңгейде қалай зерттелетіні туралы жүйелі деректерге негізделген түсінік беру арқылы әдебиетті дамытады. Ол талдауға аз ұсынылған аймақтарды қосу және болашақ зерттеулердің бағыттарын белгілеу арқылы бар олқылықты жояды. Алынған зерттеу нәтижелері мемлекеттік сектордың тиімділігін арттыруды қарастыратын ғалымдар, саясаткерлер және мекемелер үшін іргелі негіз болады.

Кілт сөздер: мемлекеттік тиімділік, мемлекеттік шығыстар, библиометриялық талдау, мемлекеттік секторды басқару, мемлекеттік сектордың тиімділігі, фискалдық басқару.

**Картирование эффективности Правительства и управления государственными
расходами: библиометрический анализ (2010-2025)**

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Аннотация

В данном исследовании представлен библиометрический анализ глобальных академических исследований по эффективности правительства и управлению государственными расходами, охватывающий 1522 рецензируемые публикации с 2010 по 2025 год, индексируемые в Web of Science Core Collection. Используя программное обеспечение VOSviewer, исследование отображает интеллектуальную структуру области посредством анализа сетей соавторства, моделей цитирования, совместного использования ключевых слов и библиографической связи.

Полученные результаты позволяют выделить отдельные исследовательские кластеры в области управления, фискальной политики и эффективности государственного сектора с заметным ростом публикационной активности после 2020 года, что отражает повышенный интерес к эффективному управлению после пандемии COVID-19. Анализ показывает главных ученых, основные институты и большие регионы. Анализ также выявляет большие пробелы в исследованиях для стран с переходной экономикой.

Данное исследование развивает литературу, предлагая систематизированное и основанное на данных понимание того, как эффективность правительства изучается во всем мире. Оно устраняет существующий пробел, включая в анализ менее представленные регионы и намечая направления будущих исследований. Полученные результаты служат основополагающей базой для ученых, политиков и учреждений, стремящихся повысить эффективность государственного сектора на основе фактических данных.

Ключевые слова: эффективность правительства, государственные расходы, библиометрический анализ, управление государственным сектором, эффективность государственного сектора, фискальное управление.

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Conflict of Interest

The authors declare no conflict of interest.