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Development of the innovation ecosystem in the Republic of Kazakhstan

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Abstract. Significant work is currently being carried out in Kazakhstan to develop innovations and build an innovative ecosystem, create a knowledge-based economy. The creation of favorable conditions for the development of innovations, directly or indirectly, has a broad legislative basis and is provided for by various regulatory legal acts and documents of the state planning system. So, on February 26, 2021, by Decree of the President of the Republic of Kazakhstan No. 520, National Priority No. 8 was established "Building a diversified and innovative economy". Tasks to support innovation are also provided for in the National Development Plan of the Republic of Kazakhstan, the Concept of Digital Transformation, development of the information and communication technologies and cybersecurity industry for 2023-2029.

This article hypothesizes that effective state support mechanisms are crucial for fostering innovation and digitalization in Kazakhstan's economy.

It provides a comparative analysis of the digitalization of certain sectors of the economy of Kazakhstan, which make up their ecosystems in innovative companies, the number of innovative projects in some countries of the world over the past three years starting in 2021, the model of Western European countries for state support of this activity of an innovative company, and a ten-year experience in providing innovative grants in Kazakhstan.

Keywords: innovations, digital economy, innovative activity, index of digitalization of the economy, indicators of innovative development, rating of digital competitiveness of countries.

Introduction

One of the forms of competition in the international economic space is the digital economy [1]. The digital economy in Kazakhstan acquires specific features and is amenable to comprehensive analysis [2]. It is possible to assess the state and level of development of the digital economy in Kazakhstan using various statistical and rating indicators [3]. An indicator of the level of development of the digital economy is also the level of digitalization of certain sectors of the economy of Kazakhstan.

Kazakhstan's journey towards innovation and digitalization began in earnest following its independence in 1991. The early 2000s saw the introduction of key legislative measures aimed at fostering a knowledge-based economy. Notable among these were the 2003 "Strategy for Industrial and Innovation Development" and the subsequent "Kazakhstan-2050 Strategy," which set ambitious goals for transforming Kazakhstan into one of the world's top 30 economies by 2050.

In the mid-2010s, the government intensified its efforts, recognizing the crucial role of digital transformation. The "Digital Kazakhstan" program, launched in 2017, marked a significant milestone, aiming to modernize various sectors of the economy and improve the quality of life through digital technologies.

The global landscape of innovation and digitalization offers valuable lessons for Kazakhstan. In the late 20th and early 21st centuries, several countries set precedents in developing robust innovation ecosystems:

- United States has long been a leader in fostering innovation through substantial investments in research and development (R&D). The establishment of Silicon Valley as a hub of technological innovation in the late 20th century was bolstered by government policies, venture capital, and a culture of entrepreneurship.

Initiatives like the Small Business Innovation Research (SBIR) program, launched in 1982, have been pivotal in providing funding to early-stage technology ventures.

- European Union has made significant strides in innovation policy, particularly with the Lisbon Strategy of 2000, which aimed to make the EU the most competitive and dynamic knowledge-based economy in the world by 2010.

The Horizon 2020 program, initiated in 2014, represented the EU's largest R&D funding program, emphasizing collaborative research across member states.

- South Korea's transformation into a high-tech economy is a prime example of successful innovation policy. In the late 20th century, the government played a crucial role in fostering industrial R&D and supporting high-tech industries through initiatives such as the "5-Year Economic Development Plans" starting in the 1960s.

The establishment of the Ministry of Information and Communication in 1994 further accelerated digital transformation efforts, making South Korea a global leader in ICT by the early 2000s.

- China has rapidly emerged as a global innovation powerhouse. The government's strategic policies, such as the "National Medium- and Long-Term Program for Science and Technology Development (2006-2020)," have significantly boosted R&D investment and technological advancements.

The "Made in China 2025" initiative, launched in 2015, aims to transform China into a leading manufacturing power, emphasizing innovation in high-tech industries.

Against the background of the spread of a new coronavirus infection in Kazakhstan, the regions found themselves in a difficult extraordinary situation. The burden on the ICT infrastructure has grown significantly due to the transfer of employees of many organizations to remote work and the self-isolation of citizens. The regions also urgently needed to transfer tens of thousands of schoolchildren to distance learning.

Improving the efficiency of innovation activities should be aimed at:

- Increased investment by the state, and as a result, ensuring the development of the industry in the country and the payment of taxes, which will make it possible after some time of the project's existence to return the invested money;
- Support for the social orientation of innovative projects;
- Strengthening the intellectual property regime;
- Strengthening information opportunities for innovators to participate in international programs.

This research provides a fresh perspective on the evolving landscape of innovation in Kazakhstan by highlighting recent legislative and strategic initiatives. Unlike previous studies, which primarily focused on early-stage development and policy formulation, this article delves into the practical impacts and effectiveness of these policies in the current digital age.

By comparing Kazakhstan's progress with that of Western European countries, this study identifies unique challenges and opportunities within the Kazakhstani context. The inclusion of recent data from 2021 onwards allows for an up-to-date analysis, reflecting the latest trends and developments in the global digital economy.

Furthermore, the examination of a decade of innovative grant provision in Kazakhstan offers valuable insights into the long-term sustainability and outcomes of state support mechanisms. This longitudinal approach distinguishes the study from previous works that often lacked comprehensive temporal analysis.

Overall, this research underscores the critical importance of state support in fostering a robust and dynamic innovation ecosystem in Kazakhstan, aligning with global digitalization trends and contributing to the nation's economic diversification and growth.

Methodology

Data for this study was collected from multiple sources to ensure comprehensive coverage and accuracy. These sources included government reports, official statistics, industry publications, and databases that track innovation metrics and digital economy indicators. Specifically, data on the digitalization of various economic sectors in Kazakhstan was obtained from national statistical agencies and relevant government departments. Information on the number of innovative projects in different countries was sourced from international databases such as the Global Innovation Index and StartupRanking. Additionally, legislative documents and policy reports provided insights into the state support mechanisms for innovation in both Kazakhstan and other countries.

The systematic approach provided a structured framework for the study, ensuring that all aspects of the research were interconnected and aligned with the central research question. This method facilitated a holistic analysis of the innovation ecosystem by integrating various elements such as policy measures, economic indicators, and innovation outcomes.

Factorial analysis was employed to identify and examine the underlying factors that influence innovation and digitalization in Kazakhstan. By analyzing multiple variables simultaneously, this method helped in understanding the complex interplay between different factors such as government policies, economic conditions, and technological advancements. This analysis directly contributed to identifying key drivers and barriers to innovation.

Comparative analysis involved comparing Kazakhstan's innovation performance and digitalization efforts with those of other countries, particularly in Western Europe and the USA. This method allowed for benchmarking Kazakhstan's progress and identifying best practices from other nations. By highlighting differences and similarities, the comparative analysis provided insights into how Kazakhstan could improve its innovation strategies and policies.

Correlation analysis was used to determine the strength and direction of relationships between different variables related to innovation and digitalization. For instance, it helped in identifying the correlation between government spending on innovation and the number of innovative projects. Regression analysis further quantified these relationships, allowing for predictions and identifying causative factors. This method was crucial for assessing the effectiveness of state support measures in fostering innovation.

Empirical generalization involved synthesizing findings from the data and drawing broader conclusions applicable to the research questions. This method helped in generalizing the results from specific case studies or datasets to the overall context of Kazakhstan's innovation ecosystem.

Graphical techniques were used to visually represent data and analytical results. Charts, graphs, and diagrams helped in illustrating trends, relationships, and patterns in the data. These visual tools made it easier to communicate complex information and support the study's findings with clear, visual evidence.

Discussion and Results

Innovation is the introduction of new ideas into life. The concept of technological innovation generates new technological knowledge, they do not require to be complicated [4]. We believe that technological innovation is something new that correlates with the use of technology and its implementation in almost the workflow [5]. The importance of this topic continues to attract the attention of both business and scientists, but understanding of the consequences of this kind of innovation in business remains limited [6].

The functioning of the ecosystem of innovative activity of an innovative company is conditioned by the action of a number of economic, logistical, market and socio-cultural factors that determine the specifics of the environment of innovative activity, which imposes certain restrictions on the actions of ecosystem entities (Figure 1).

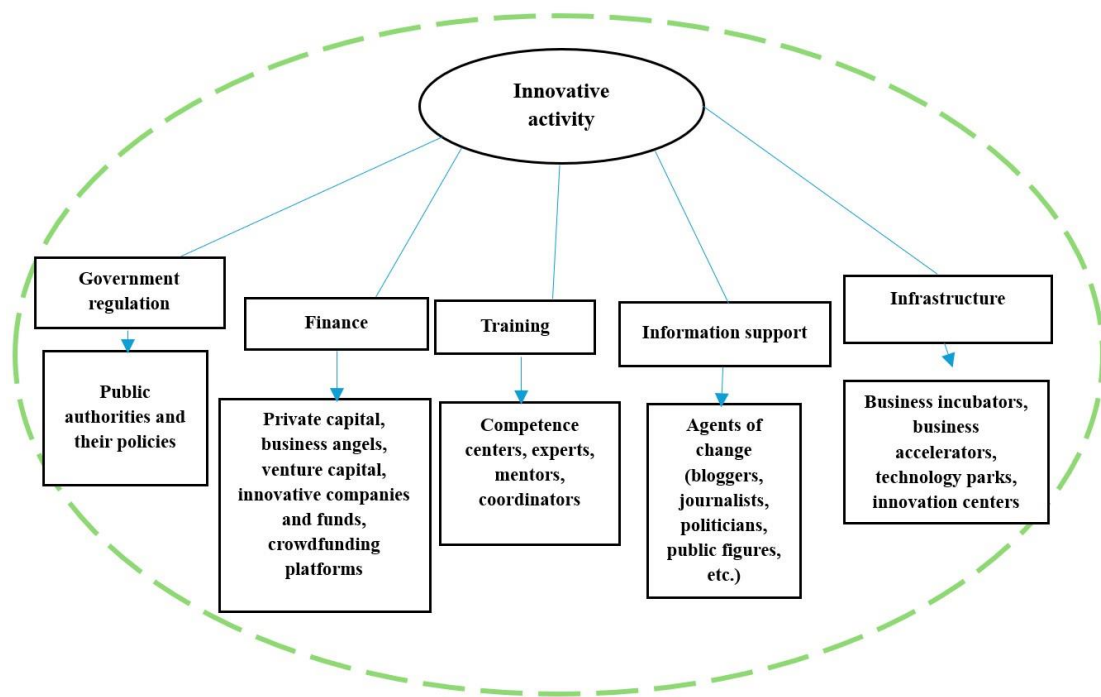


Figure 1. The structure of the ecosystem of innovative activity of an in-novative company

At the macroeconomic level, the state, represented by state authorities, forms the legal foundations of entrepreneurship and protection of intellectual property rights [1]. The place of successful innovative projects in the global economy is quite high and honorable. Thus, venture innovation funds and "business incubators" are actively being created in the markets of Europe, the USA, Japan, and Belarus, the focus of which is precisely financing and supporting innovative projects in order to capitalize on income [7]. In 2022 and 2023, the largest number of innovative projects were in developed countries (Figure 2).

The absolute leader is the USA – 45976 innovative projects according to the international StartupRanking rating. The USA is considered the leader among the countries where successful startups can be created. This is due to the fact that in the USA there are more well-known and proven channels for finding financial support, even those that could help at the very beginning of the path [2]. The Government provides legislative support to young entrepreneurs. By founding a project in America, there is a better chance to enter the international market faster [2].

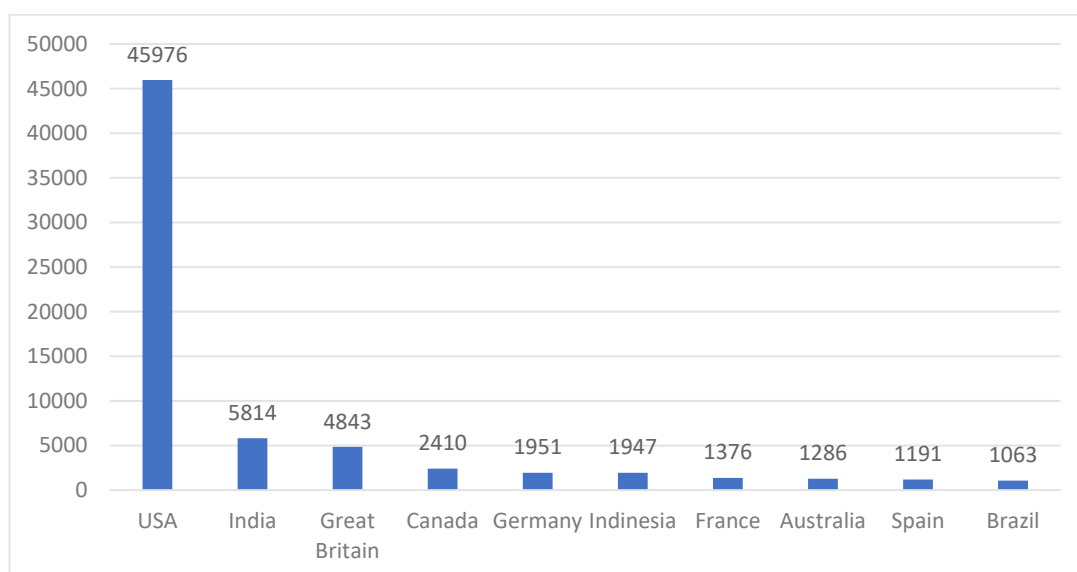


Figure 2. The number of innovative projects in some countries of the world in 2021-2023, units

World experience shows that government support for innovative projects plays a key role in their growth and successful development. The leadership of the EU and the governments of its member states [7].

The Scandinavian model of the state support mechanism is implemented through a developed institutional environment in which the state and the private sector cooperate in equal parts of financing the innovative activities of an innovative company based on the university sector. The state provides incentives for innovative projects in high-, medium- and low-tech industries.

The Western European model of the state support mechanism is implemented through a constantly improving institutional environment in which the development of innovative activities of an innovative company takes place through financing the private sector and direct stimulation of the public sector.

The Central European model of the state support mechanism is implemented through a developing institutional environment in which the development of innovative projects takes place by 90% at the expense of foreign capital attracted by the state on the basis of the low-innovation business sector and the public sector [3].

Innovative projects are focused on medium-tech industries in which large multinational corporations operate.

Since the USA is the leader among the trans in terms of the number of innovative projects, let's consider the stages of the mechanism for the development and financial support of innovative projects in this country: an innovative project goes through 6 stages from the initial grant stage, when the initiator of the project begins its implementation to the protected stage, at which the project product enters mass production [8]. The mechanisms of state support are based on direct and indirect methods.

In all countries, the state is the guarantor of legality and support for the development of innovative projects [9].

The level of innovative activity of enterprises in Kazakhstan by the end of 2022 showed an increase of 11%. For comparison, in 2021, the figure was 10.5%.

Compared to 2021, in 2022, the volume of innovative products in Kazakhstan increased and amounted to 1.9 trillion tenge.

In the ranking of the Global Innovation Index, Kazakhstan out of 132 countries of the world improved its position to 81st place (83rd place in 2022). According to the Global Competitiveness Index of the World Economic Forum, Kazakhstan ranked 95th in 2019 in terms of the "Innovation Potential" factor (no assessment has been conducted since 2020).

At the same time, the most comprehensive and appropriate rating is the Global Innovation Index (GII), which the Government is currently focusing on. The GII consists of 81 sub-factors affecting all areas, ranging from R&D, intellectual property, patent law, education, trade, green technologies, industry to printing activities. The indicator is organized into two main groups – Input (innovation environment and investment in innovation) and Output (effectiveness and efficiency of innovation).

At the same time, Kazakhstan ranks 68th in Input and 87th in Output. That is, with relatively good input data, it is necessary to strengthen the work on effectiveness.

A new approach to conducting a focused innovation policy based on the foreign experience of advanced technological countries and organizations was supported.

The essence of this approach is to prioritize certain technological areas of MedTech, AgriTech, GreenTech, which are cross-sectoral in nature, and their implementation allows you to get an "anchor" effect of the development of all related sectors of the economy.

This approach is based on the internationally proven idea of concentrating the country's key efforts on individual points of development, which in the long term has a positive multiplier effect on the economy. The mechanism of the approach is as follows:

- conducting technological forecasting to identify promising and key technologies and innovations required for the development of technological directions MedTech, AgriTech, GreenTech;
- on the basis of technological forecasting, a targeted technological program will be formed, which specifies all the required technologies and innovative products, measures to obtain them, sources of financing and implementers, as well as specific deadlines;
- orientation of measures of state support of innovations to the implementation of the developed target technological program;
- all activities of the targeted technology program will be implemented to obtain specific innovations;
- constant monitoring of the implementation of the developed target technology program.

Within the framework of the budget program "Provision of innovative grants" in the period from 2011 to 2021, 324 agreements on the provision of innovative grants totaling more than 13.3 billion tenge were concluded.

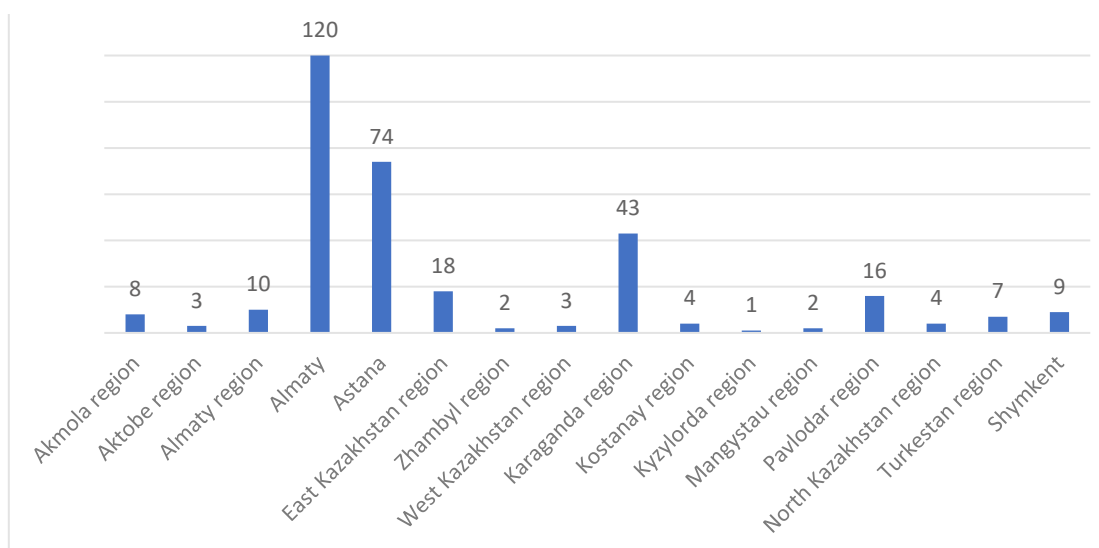


Figure 3. Supported projects by region from 2011 to 2021

To establish the fundamental and desired levels of the innovation ecosystem, the authors propose aligning two evaluation methodologies:

- At the macro level, the authors suggest integrating the Boston Consulting Group's (BCG) approach for assessing the structure and scale of the innovation pyramid in each country.
- At the meso-level, specifically within the Russian Federation regions, the authors advocate for employing the Higher School of Economics (HSE) methodology, which calculates a consolidated innovation index. This method relies on indicators reflecting socio-economic conditions, scientific and technical potential, innovation activity, and regional innovation policy quality [10].

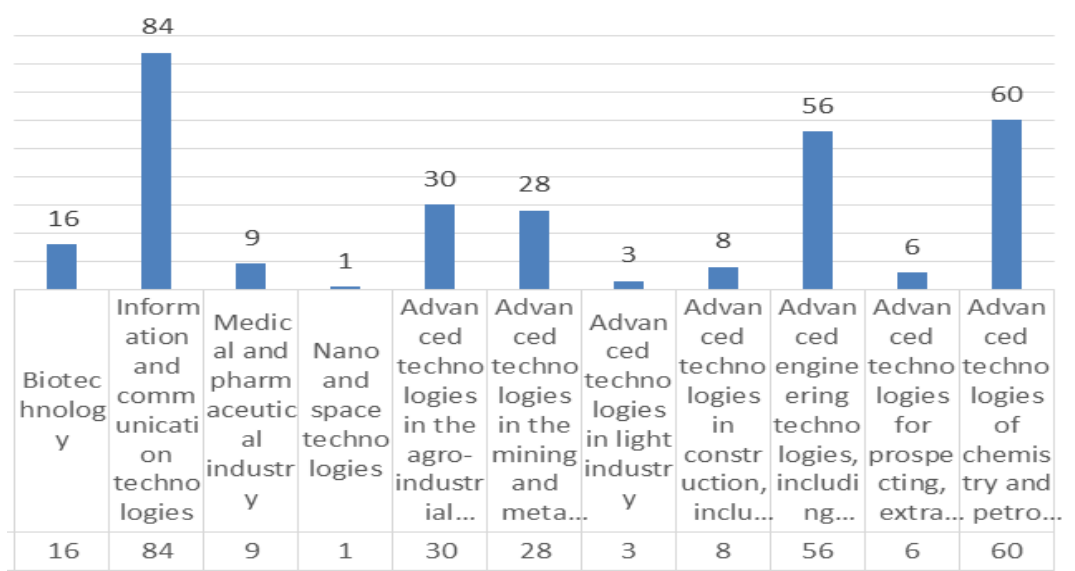


Figure 4. Supported projects by industry from 2011 to 2021

These adjustments lead to two sets of indicators with overlapping but not identical components. Assessing each methodology's strengths and weaknesses reveals disparities. For instance, the HSE methodology overlooks the "culture" layer and excludes labor productivity evaluation. Moreover, infrastructure indicators, aside from ICT, receive scant attention. Intellectual property evaluation is absent in the institutional layer.

The authors attribute these omissions to several factors. Firstly, measuring many BCG innovation pyramid layer indicators is challenging, often relying on surveys with limited accuracy and objectivity. Secondly, assigning responsibility for these indicators to specific individuals with direct control is often impractical. In contrast, HSE methodology's indicators offer a notable advantage: they are quantifiable without relying on survey data.

Moving forward, managing an enterprise's innovative environment in the digital economy requires a systematic approach. This entails: balancing the involvement of four key management entities: driver – business, customer – the state, consumer of results – society, partners – global alliances; focusing management efforts on the development, transformation, and enhancement of the enterprise's innovation environment amid digitalization; implementing a management mechanism that actively influences factors crucial to the enterprise's innovation environment's development.

A model illustrating the management mechanism for an enterprise's innovation environment could be outlined as follows [11]:

$$\text{MUIS} = f(\text{BGT}, \text{CU}, \text{KU}, \text{FU}, \text{MU}, \text{RU}, \text{LO}, \text{PT}, \text{EP}, \text{IP}) \quad (1)$$

where

MUIS – a mechanism for managing the innovative environment of an enterprise;

BGT – uncontested global trends;

CU – administration goals;

KU – administration criteria;

FU – administration factors;

MU – methods of influencing administration factors;

RU – administration resources;

LO – locomotive industries;

PT – priority end-to-end technologies;

EP – the evolutionary limit;

IP – the involution limit.

Correlation analysis was used to assess the impact of innovation process management on the level of digital transformation of the economy. The resulting variable is the Index of Digitalization of the economy (Y), proposed by HSE specialists.

This Index is comprehensive and covers the following aspects of digital development:

- development of information and telecommunication systems;
- availability of publications and patents in the field of information and communication technologies;
- the level of development of network interaction;
- the system of training modern personnel;

– accessibility of digital technologies for the population.

The construction of a correlation model allowed us to obtain the following conclusions regarding the relationship between various indicators of innovation activity and the results of digitalization of the Kazakh economy. The results of the correlation analysis are presented in Table 1.

As can be seen from the data in Table 1, the study revealed strong correlations of the digitalization index with such variables as the proportion of innovative goods in the total volume of goods shipped (X2); the volume of innovative works and services (X3); the proportion of the population with Internet access (X7) and publications in the field of information and communication technologies (X9). At the same time, such an important indicator as the internal costs of research and development of information and communication systems (X5) showed a strong negative dependence.

As for the high indicators of the relationship between the digitalization index and the availability of publications in the field of information and communication technologies (X9), they indicate that the more popularized new technologies are in society and the economy, the higher the index itself.

Table 1. The correlation matrix

	Y	X1	X2	X3	X4	X5	X6	X7	X8	X9
X1	0,42	1								
X1	0,96	0,24	1							
X1	0,85	0,016	0,94	1						
X1	0,26	0,10	0,08	-0,09	1					
X1	-0,89	-0,49	-0,86	-0,64	-0,81	1				
X1	0,26	-0,15	0,17	0,20	-0,50	-0,08	1			
X1	0,87	0,39	0,90	0,90	-0,58	-0,70	0,05	1		
X1	0,62	0,37	0,43	0,26	-0,89	-0,56	0,50	0,23	1	
X1	0,95	0,23	0,95	0,93	-0,84	-0,75	0,43	0,89	0,55	1

The correlation analysis made it possible to determine the smallest dependencies of the Digitalization Index with variables. As can be seen from the data in Table 1, the weakest dependence value was found between the Digitalization Index and the indicator of exports of goods and services in the field of information and communication technologies - the correlation coefficient is 0.26. However, it should be borne in mind that the indicator of exports of goods and services is complex and represents the sum of two components: exports of goods in the field of information and communication technologies and exports of services in the field of information and communication technologies.

As already noted, the indicator of the share of innovative goods and services in the total volume of shipped goods and services has a close and direct relationship with the index of digitalization of the economy – the correlation coefficient between the index of digitalization of the economy and

the share of shipped innovative goods is 0.95. It can be assumed that the innovative products produced go to the domestic market and generally contribute to the digital development of the domestic economy. As for the relationship of the index of digitalization of the economy with such variables as the innovative activity of subjects (X1) and patent applications for inventions in the field of information and communication systems (X6), it is direct, but weak (0.42 and 0.26, respectively). Previous studies have shown that the focus of innovative research activities carried out by Russian enterprises and organizations (including scientific organizations) are primarily industrial and technological, and patented inventions and discoveries are related to industry-specific production aspects, and not to the field of information and communication technologies. This determines the weak correlation of indicators.

Conclusion

Based on the use of correlation analysis methods, direct and inverse relationships were established between the level of digitalization of the country's economy as a whole, the expressed Index of Digitalization of the economy, indicators of innovation activity, and such a socio-economic indicator of digitalization of society as the proportion of the population with access to the Internet. To ensure the successful development of the digital economy, the state should adapt the legislative framework to new realities and create favorable conditions for the activities of firms that follow the path of digitalization of production.

The government should continuously update and refine the legislative framework to keep pace with rapid technological advancements. This includes enacting laws that support digital innovation, protect intellectual property rights, and ensure cybersecurity.

Policymakers should create a conducive environment for businesses to thrive in the digital economy. This involves reducing bureaucratic barriers, providing tax incentives for digital innovation, and facilitating access to financing for startups and SMEs in the tech sector.

Significant investment in digital infrastructure, such as high-speed internet and broadband access, is crucial. This ensures that the digital divide is minimized, allowing more citizens and businesses to participate in the digital economy.

The government should invest in education and training programs to enhance digital literacy and skills among the workforce. This includes integrating digital skills into the education system and offering retraining programs for workers affected by digital transformation.

Foster collaboration between the public and private sectors to drive innovation. Public-private partnerships can help leverage resources, expertise, and innovation from both sectors to achieve common goals in digital transformation.

Increased funding and support for R&D in digital technologies and innovation are essential. This can be achieved through grants, subsidies, and partnerships with research institutions and universities.

Implementing these recommendations will enhance Kazakhstan's competitiveness in the global digital economy, attracting foreign investment and fostering the growth of homegrown digital enterprises.

By creating favorable conditions for innovation, the volume and quality of innovative projects are likely to increase, contributing to economic growth and diversification.

Greater digital inclusion and literacy will lead to improved socio-economic outcomes, including higher employment rates in tech sectors and increased access to digital services for citizens.

The study relies on available data, which may not capture all aspects of digital innovation and economic activities. Some data sources may be outdated or lack comprehensiveness.

The findings and recommendations are based on the specific context of Kazakhstan and may not be directly applicable to other countries with different economic and regulatory environments.

The study focuses on macro-level indicators and may not fully capture micro-level dynamics and sector-specific challenges in the digital economy.

Future research should conduct in-depth analyses of specific sectors within the digital economy, such as fintech, e-commerce, and digital health, to identify tailored strategies for each sector.

Conduct longitudinal studies to track the impact of policy changes and digital initiatives over time. This will provide insights into the long-term effects of digital transformation strategies.

Comparative studies involving multiple countries can provide a broader perspective on best practices and innovative approaches to digital economy development.

Investigate the impact of emerging technologies, such as artificial intelligence, blockchain, and the Internet of Things, on the digital economy and innovation landscape.

By addressing these limitations and exploring new research avenues, policymakers and researchers can better understand and navigate the complex dynamics of the digital economy, ultimately fostering a more innovative and competitive environment in Kazakhstan.

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Author contributions:

Nauryzbaeva A.A. – Conceptualization, software, formal analysis, investigation, writing—original draft preparation, writing—review and editing, visualization.

Nepshina V.N. – Conceptualization, validation, formal analysis, data curation, writing—review and editing, supervision, project administration.

Muratova D.B. – methodology, validation, resources, supervision, funding acquisition.

All authors have read and agreed to the published version of the manuscript.

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Қазақстан Республикасында инновациялық қызметтің экожүйесін дамыту

Аннотация. Бүгінгі таңда Қазақстанда инновацияларды дамыту және инновациялық экожүйені құру, ғылымды қажетсінетін экономиканы құру бойынша айтарлықтай жұмыстар жүргізілуде. Инновацияларды тікелей немесе жанама түрде дамыту үшін қолайлы жағдайлар жасау кең заңнамалық негізге ие және мемлекеттік жоспарлау жүйесінің әртүрлі нормативтік құқықтық актілері мен құжаттарында көзделген. Мәселен, 2021 жылғы 26 ақпанда Қазақстан Республикасы Президентінің № 520 Жарлығымен №8 жалпыұлттық басымдық «Әртараптандырылған және инновациялық экономика құру» болып белгіленді. Инновацияларды қолдау жөніндегі міндеттер Қазақстан Республикасының ұлттық даму жоспарында, цифрлық трансформация

тұжырымдамасында, 2023-2029 жылдарға арналған ақпараттық - коммуникациялық технологиялар мен киберқауіпсіздік саласын дамытуда да көзделген.

Мақалада инновациялық компанияларда олардың экожүйелерін құрайтын Қазақстан экономикасының белгілі бір салаларын цифрландыруға салыстырмалы талдау жүргізілді, 2021 жылдан бастап әлемнің кейбір елдеріндегі инновациялық жобалардың саны, инновациялық компанияның осы қызметін мемлекеттік қолдау бойынша Батыс Еуропа елдерінің моделі, Қазақстанда инновациялық гранттар берудің он жылдық тәжірибесі ұсынылды.

Түйін сөздер: инновациялар, цифрлық экономика, инновациялық қызмет, экономиканы цифрландыру индексі, инновациялық даму көрсеткіштері, елдердің цифрлық бәсекеге қабілеттілік рейтингі.

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Развитие экосистемы инновационной деятельности в Республике Казахстан

Аннотация. В Казахстане на сегодняшний день проводится значительная работа по развитию инноваций и построению инновационной экосистемы, созданию наукоемкой экономики. Создание благоприятных условий для развития инноваций прямо или косвенно имеет широкую законодательную основу и предусмотрено различными нормативными правовыми актами и документами системы государственного планирования. Так, 26 февраля 2021 года Указом Президента Республики Казахстан № 520 Общенациональным приоритетом №8 установлено «Построение диверсифицированной и инновационной экономики». Задачи по поддержке инноваций также предусмотрены в Национальном плане развития Республики Казахстан, Концепции цифровой трансформации, развития отрасли информационно-коммуникационных технологий и кибербезопасности на 2023 - 2029 годы.

В статье проведен сравнительный анализ цифровизации определенных отраслей экономики Казахстана, составляющих в инновационных компаниях их экосистем, количество инновационных проектов в некоторых странах мира за последние три года начиная с 2021 года, модель западноевропейских стран по государственной поддержке данную деятельность инновационной компании, представлен десятилетний опыт предоставления инновационных грантов в Казахстане.

Ключевые слова: инновации, цифровая экономика, инновационная деятельность, индекс цифровизации экономики, показатели инновационного развития, рейтинг цифровой конкурентоспособности стран.

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