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A Framework for Assessing Regional Innovation and Digital Capacity

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Abstract. Kazakhstan has demonstrated specific progress in the innovation and digital development of regions and cities. Nevertheless, the level of digitalization and innovation varies significantly depending on the region's territoriality. This study presents a comprehensive framework for assessing Kazakhstan's regions' innovation and digital potential through a novel Innovation and Digital Potential Index. The proposed index evaluates five key dimensions: digital infrastructure, innovative activity, human resource potential, business digitalization, and cybersecurity. The authors employed a multi-criteria analysis approach using the Analytic Hierarchy Process for weighted indicators. The results obtained make it possible to analyze the territorial prospects of innovative and digital development based on indicators of regional innovation activity and digital infrastructure. The Republic of Kazakhstan's overall index of innovation and digital potential is 0.55 (from 0 to 1), the average indicator for the main criteria of innovation and digital development. The empirical findings highlight significant regional disparities in digital and innovation capacity, with major urban centers exhibiting the highest index scores. At the same time, less-developed regions lag behind due to gaps in infrastructure and policy. The results underline the need for targeted policy interventions, including enhanced broadband accessibility, fiscal incentives for digital transformation, and stronger cybersecurity measures. The results of this research contribute to the broader discourse on digital economy development and provide actionable insights for policymakers to drive inclusive and sustainable innovation ecosystems to realize the innovative and digital potential, considering the territorial characteristics of the country.

Keywords: innovation, digitalization, index, Smart cities, regional development, sustainability, cybersecurity

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Introduction

Increasing objective challenges of the external environment, both political, economic, and environmental, are global in nature, which determines the need to consolidate the efforts of all countries to implement the 17 UN Global Sustainable Development Goals. Many developed countries are working to integrate the 17 UN Sustainable Development Goals into strategic growth plans of national economies: laws are adopted, state programs are developed, road maps are approved, and platforms are created at the international level. The ongoing process of globalization, with its increasingly paradoxical nature, has brought to the forefront not only the need for Kazakhstan's national economy to move away from its reliance on raw materials but also the urgency to address the country's social and environmental challenges, considering the new challenges of the external environment and trends of innovative and digital development. Such countries as Germany, France, Great Britain, Japan, the USA, Sweden, and Denmark have started to actively promote policies aimed at the realization of sustainable development based on the application of the principles of a closed-cycle economy [1, 2, 3]. At the same time, all countries felt the increasing uncertainty of the external environment caused by the pandemic and lockdowns, which exacerbated social problems such as hunger, poverty, and inequalities in health and education services. This necessitated consolidated efforts to qualitatively transform development concepts, considering the continuous need to integrate innovation and digital policies.

The state policy in sustainable development was conceptualized in the Strategy of Kazakhstan - 2050 and partially defined by the Concept for the transition to a “green economy” issued in 2013. The Strategy for Achieving Carbon Neutrality in Kazakhstan until 2060, issued in 2023, which aims at low-carbon development and achieving carbon neutrality using an efficient low-carbon model [4], has a fundamental role in the path to sustainability. The decarbonization strategy consists of decarbonizing the heating systems sector, which includes transport, buildings, electricity, and industry. The existence of the mentioned sectors (transport and buildings) and their prioritization are significant for building sustainable smart territories in the country. Despite the progress achieved, it is insufficient, has a focal and mosaic character, and is characterized by the lack of systemic implementation. Moreover, the innovative and digital development of the country is based on two different directions: “Concept of digital transformation, development of information and communication technologies industry and cybersecurity for 2023-2029” and the State Program “Digital Kazakhstan” [5, 6].

It should be noted that to improve the efficiency of urban services and integration of smart technologies in Kazakhstan, the concept of “Smart City” was developed, which is an initiative aimed at improving the management of urban resources and services, as well as improving urban infrastructure through the introduction of innovative solutions to create comfortable living conditions for citizens. The Reference Standard of Smart Cities of the Republic of Kazakhstan was approved in 2019 to standardize approaches to building smart cities. Priority areas of smart city organization include security, transport, housing and utilities, education, healthcare, and city management.

All the above initiatives are aimed at developing smart areas of the country, which will allow us to identify and apply innovative and digital potential while incorporating elements of sustainability and achieving carbon neutrality. Thus, the current transportation system is based

predominantly on petroleum products, while the goal is to move to a carbon-neutral system based on using electricity, hydrogen, and biofuels.

Buildings, in turn, are one of the components of the smart city “smart buildings” and one of the most significant sources of greenhouse gas emissions, playing a key role in emission reduction strategies. Decarbonizing this sector is planned by shifting from fossil fuel-based heating to renewable energy heating systems and more efficient technological solutions. In contrast, at present, the use of coal and gas in heating systems is predominant. Measures are needed to introduce systems for monitoring, reporting, and verifying building energy efficiency, and to set strict requirements for the energy performance of new residential, public, and industrial buildings [7]. Thermal modernization of buildings and the introduction of new heating technologies are necessary to reduce the energy demand for heating significantly [3, p. 26]. In turn, the Strategy for Achieving Carbon Neutrality of the Republic of Kazakhstan until 2060 (2023), which aims at low-carbon development and achieving carbon neutrality using an efficient low-carbon model, plays a fundamental role in achieving sustainability.

Literature review

Analysis and appropriate assessment of the innovative and digital potential of territories and regions of the country requires a comprehensive approach. According to the research of the authors Kireyeva A. et al. (2020), Arkhipova E. (2024), Kamnev V. (2021), and Chkonia A. (2020), the index of the innovative and digital potential of territories and regions is the primary approach, which can be supplemented by the Pentalspiral (5-Helix) approach to identify and assess regional digitalization [8–10].

Furthermore, evaluating a region's innovative and digital potential is essential for comprehending its ability to promote economic expansion, technological progress, and social development. Numerous indices and frameworks have been devised to assess these potentials, each presenting distinctive methodologies and insights. This literature review explores prominent indices and critical considerations in appraising regional innovative and digital capacities. One well-established index is the Regional Innovation Index, which assesses a region's innovation performance based on factors such as human resources, research systems, innovation and entrepreneurship, and economic effects [11].

Several global indexes evaluate the innovation and digital perspectives of countries and regions. One of the complex indexes is the Global Innovation Index, published yearly by the World Intellectual Property Organization, which comprehensively assesses countries' innovation capabilities. It evaluates 132 economies based on research and development spending, intellectual property filings, and education metrics. In its 2023 edition, the GII noted a slowdown in innovative investments, a shift from the previous year's growth. It highlighted the resilience of top-performing countries such as Switzerland, Sweden, and the United States [12].

Another one, the Digital Economy and Society Index, developed by the European Commission, evaluates the digital maturity of EU member states. DESI examines four key areas: human capital, connectivity, integration of digital technologies, and digital public services. The 2022 DESI report highlighted substantial variations in digital competitiveness across member states, emphasizing the necessity for tailored policies to address this digital divide [13].

Assessing a region's innovative and digital potential involves navigating challenges such as data availability, rapidly evolving technological landscapes, and diverse regional contexts. The

Global Innovation Index 2023 report underscores a significant decline in innovative investments in 2023, marking a notable shift from previous years' growth. To address these challenges, future research should focus on developing flexible assessment frameworks that accommodate the unique characteristics of different regions and technological advancements. Furthermore, fostering robust public-private partnerships and integrating sustainability considerations will be vital in shaping resilient and forward-looking innovative ecosystems. In summary, evaluating a region's innovative and digital potential requires a multifaceted approach considering investment levels, infrastructure, policy environments, human capital, and collaborative networks. By addressing these key elements, regions can strategically enhance innovation capacities, driving sustainable economic growth and societal progress.

Thus, this article aims to present the index developed for the regions of Kazakhstan, the innovation and digital potential based on the measurement of the availability and progress of digital technologies, innovation activity, the potential of digitalization personnel, innovation and digital activities of business enterprises, as well as ensuring cybersecurity in the regions.

Methodology

The methodology of the research is based on the development of the authors' index of innovative and digital potential of Kazakhstan's regions (Innovative and Digital Potential Index), which measures the provision and development of digital technologies, innovation activity, potential of digitalization personnel, innovative and digital activities of business enterprises, as well as the provision of cybersecurity in the regions. Analysis and appropriate assessment of the innovative and digital potential of territories and regions of the country requires a comprehensive approach, which includes quantitative and qualitative assessment methods. A normalized multi-criteria methodology calculates this index, which allows ranking regions depending on their innovative development and digital transformation. This study's authors propose applying the authors' index to assess the innovative and digital potential of the territory.

Thus,

$$IDPI_r = \sum_{i=1}^{n} w_i * X_{i,r} \quad (1)$$

where:

$IDPI_r$ – r region's innovation-digital potential index;

$X_{i,r}$ – normalized value of i indicator for the region r;

w_i – indicator weighting coefficient;

n – number of indicators.

When selecting the indicators to calculate the index of innovation-digital potential of regions, the study's authors divided them into five main groups (Table 1).

Table 1. Indicators of the region's innovation-digital potential index

№	Indicators Group	Designation	Meaning
1.	Digital Infrastructure	X_1	Internet availability (access) as a percentage of the population (%)

2.	Innovative activity	X_2	The share of enterprises with innovations in the total number of enterprises (%)
3.	Human resources potential	X_3	Information and communication technology specialists, percentage of the total employed population (%)
4.	Business digitalization	X_4	Enterprises using technologies such as AI, Big Data, and cloud technologies share in the total number of enterprises (%)
5.	Cybersecurity	X_5	Cybersecurity incidents on the number of network users

Note: compiled by authors [15]

The next stage of territorial assessment of innovative and digital and calculation of the author's index is normalizing groups of indicators to a single scale from 0 to 1. In this case, Min-Max Scaling is used for normalization, which is based on bringing indicators to a single scale. This method helps to eliminate the difference between different indicators, normalizing the comparability of analysis. Thus,

$$X_{i,r} = \frac{\left(X_{i,r}^{fact} - X_i^{\min}\right)}{\left(X_i^{max} - X_i^{\min}\right)} \quad (2)$$

The next step in calculating the index of innovation and regions' digital potential is to determine each indicator's weighting coefficients. In this study, the authors applied the Analytic Hierarchy Process (AHP) based on paired expert comparisons of factors on the Saaty scale from 1 to 9, where one defines the equal value of the compared criteria and nine the absolute superiority of the basic criterion from the comparable one [14, 15]. The matrix obtained was analyzed, and the weights of each criterion were normalized to determine the average value, which is the criterion's weight (Table 2).

Table 2. Weight coefficients of the region's innovation and digital potential index

X_1	X_2	X_3	X_4	X_5
Digital Infrastructure	Innovative activity	Human resources potential	Business digitalization	Cybersecurity
0.46	0.23	0.16	0.09	0.5

Note: compiled by authors [15]

Using all the data obtained for indicators and weight coefficients, the authors obtained the following formula for the index of innovation and digital potential of regions.

$$IDPI_r = 0.46\,X_1 + 0.23\,X_2 + 0.16\,X_3 + 0.09\,X_4 + 0.05\,X_5 \quad (3)$$

Thus, regions are ranked according to the index of territorial innovation and digital potential, which ranges from 1 to 0, where 1 defines a region with a high potential level and 0 with a low level.

Results and Discussion

When analyzing the trends in Kazakhstan's innovation and digital potential, it should be noted that the country has demonstrated specific progress in the innovation and digital development of regions and cities. Nevertheless, the digitalization and innovation implementation level varies significantly depending on the region's territoriality. The territory's uneven economic performance, investment injections, and social structure dictate this difference. It should be noted that the state program "Digital Kazakhstan" has influenced the development of the country's digital infrastructure. Moreover, the country's total population has a digital literacy level of 87.3% (Table 3).

Table 3. Digital infrastructure of the country's regions (X_1)

Region	Papulation	Internet users	Digital infrastructure, in %
Republic of Kazakhstan	20033842	17870187	89,2
Abai	607589	496400	81,7
Akmola	787981	563406	71,5
Aktobe	939405	581492	61,9
Almaty	1 531167	1211153	79,1
Atyrau	704074	630850	89,6
West Kazakhstan	693262	512688	80,2
Zhambyl	1 222593	1124786	92
Zhetysu	697987	552108	79,1
Karaganda	1 135351	917364	80,8
Kostanay	829984	728726	87,8
Kyzylorda	841931	559042	66,4
Mangystau	1786841	657012	83,5
Pavlodar	753934	701913	93,1
North Kazakhstan	530089	464888	87,7
Turkestan	2 142 171	1949376	91
Ulytau	221584	177267	80,8
East Kazakhstan	727053	594002	81,7
Astana city	1 430105	1301395	91
Almaty city	2 228675	2023637	90,8
Shymkent city	1 222066	954434	78,1

Note: compiled on the basis of data from [16,17]

The digital gap between regions persists despite a reduction in this gap by about 4% annually. Systematic and purposeful work is underway to provide high-quality Internet to urban and rural populations. The Internet provision rate for the population and users is 89.2% of the country's total population. The highest indicator of digital infrastructure is in the Pavlodar region, which amounts to 93.1%, followed by the Zhambyl region – 92%, the Turkestan region and Astana city − 91% and Almaty city – 90.8%. The Aktobe region has the lowest index of digital infrastructure – 61.9%.

Table 4. Innovative activity of enterprises in regions

Region	Enterprises	With innovations	Innovative activity of enterprises, in %
Republic of Kazakhstan	30 750	3 390	11,0
Abai	593	48	8,1
Akmola	1 173	70	6,0
Aktobe	1 176	159	13,5
Almaty	1 259	67	5,3
Atyrau	1 119	75	6,7
West Kazakhstan	828	39	4,7
Zhambyl	774	42	5,4
Zhetysu	564	61	10,8
Karaganda	1 993	300	15,1
Kostanay	1 353	125	9,2
Kyzylorda	651	86	13,2
Mangystau	1 062	53	5,0
Pavlodar	1 127	149	13,2
North Kazakhstan	1 054	160	15,2
Turkestan	899	81	9,0
Ulytau	179	15	8,4
East Kazakhstan	1 292	114	8,8
Astana city	4 264	633	14,8
Almaty city	7 826	1 031	13,2
Shymkent city	1 564	82	5,2

Note: compiled on the basis of data from [16,17]

As can be seen from Table 4, out of 3,390 innovation-active enterprises, 1,031 enterprises fall in Almaty city. At the same time, the territorial leaders in terms of activity level in the field of innovation are the North-Kazakhstan region (15.2%) and Karaganda region (15.1%), as well as Astana city with 14.8%, which is 633 innovation-active enterprises. In turn, the West-Kazakhstan region has the lowest indicators, representing 4.7% of enterprises with innovation.

Mangystau region, Shymkent city, Almaty region, and Zhambyl region also have a low level of innovation activity of enterprises, 5.0%, 5.2%, 5.3%, and 5.4%, respectively.

The analysis of territorial innovation activity shows that the highest rates are observed in the country's main cities – Almaty and Astana – while industrial regions such as Karaganda and East Kazakhstan regions also have high innovation activity. These regions have well-developed industrial bases, research institutes, and higher education institutions, which contribute to the development of innovation and digitalization.

To calculate the innovation and digital potential index, it is necessary to assess the human resource potential of Kazakhstan's regions based on the share of the employed population in the information and communication technologies field in the total employed population (Figure 1).

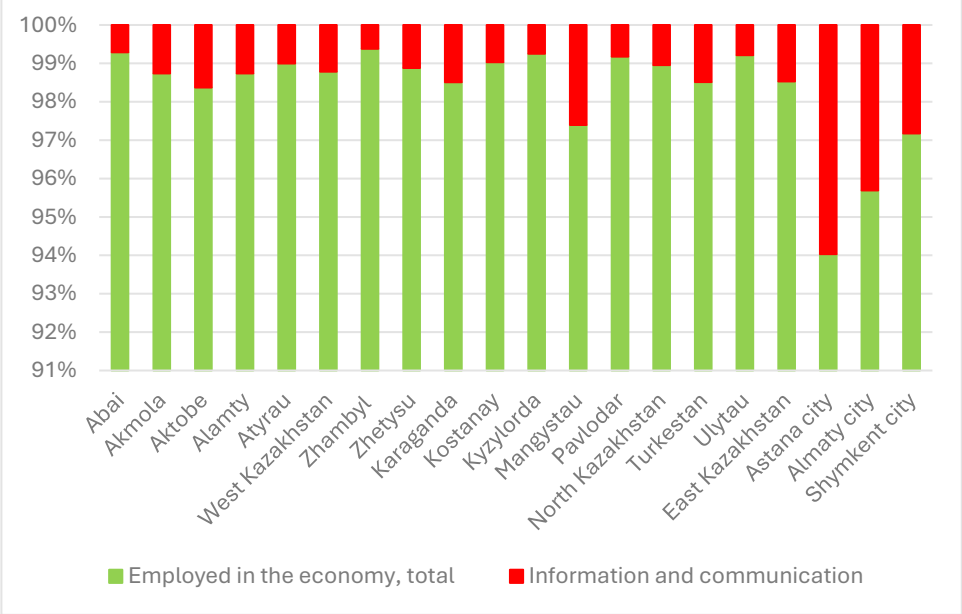

Figure 1 Human resource potential by region (X_3)

Note: compiled on the basis of data from [16,17]

The number of people employed in information and technology in the context of economic activities is 187.8 thousand people, which is more than 2% of the country's employed population. In the regional context, the highest value of this indicator falls on the cities of Astana - 6.3%, Almaty - 4.5% and Shymkent - 2.6%. Among the regions, the highest index falls on the Mangystau region - 2.7%, while the lowest value is observed in the Zhambyl region - 0.6%, Abay - 0.7%, and the Kyzylorda and Pavlodar regions - 0.8%.

Further, data on the degree of digitalization of businesses by region are applied to calculate the index of innovation and digital potential of the regions. The leading indicator in this category is the share of enterprises and companies that use digital technology tools, such as artificial intelligence, Big Data, and cloud technologies, in their activities.

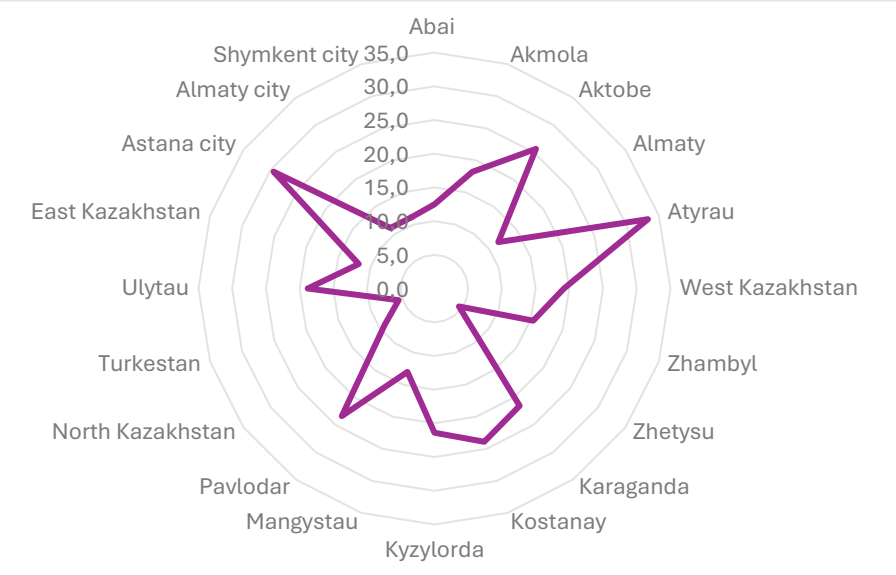

Figure 2 Digitalization of business by region (X_4)

Note: compiled on the basis of data from [16,17]

Analysis of this indicator for Kazakhstan revealed that the digitalization of business throughout the country is 16.4%. The highest level of business using digital technologies is in the Atyrau region, with an indicator of 33.3%, while the lowest value is in the Zhetisu region, with an indicator of 5.4%. Despite the increase in the share of digitalization of business in the regional context, there is a significant gap between regions, which affects the overall innovation and digital potential of the territory.

Data on cybersecurity and the level of protection of information systems in the country's regions must be assessed and collected to calculate the index of innovation and digital potential. The authors used the ratio of the number of cybersecurity incidents to the number of network users in each region.

Figure 3 Global Cybersecurity Index 2024

Note: compiled based on data from [18]

According to the Global Cybersecurity Index, Kazakhstan holds reasonably high positions in all five areas among Central Asian countries. Data from the State Technical Service revealed that the regions of the country most susceptible to cyber-attacks are Astana city, the North Kazakhstan region, the Kostanay region, Akmola, and Zhambyl regions. Almaty city is also the most susceptible to cyber-attacks by netizens.

Table 5. Cybersecurity of regions

Region	Internet users	Cyber attacks (million)	Cybersecurity indicator
Republic of Kazakhstan	17870187	57	3,2
Abai	496400	0,3	0,6
Akmola	563406	3,3	5,9
Aktobe	581492	1,7	2,9
Almaty	1211153	3,6	3
Atyrau	630850	2,2	3,5
West Kazakhstan	512688	1,2	2,3
Zhambyl	1124786	3,3	2,9
Zhetysu	552108	0,5	1
Karaganda	917364	9,2	9,9
Kostanay	728726	3,8	5,2
Kyzylorda	559042	0,4	0,7
Mangystau	657012	1	1,5
Pavlodar	701913	0,4	0,7
North Kazakhstan	464888	3,8	8
Turkestan	1949376	1	0,5
Ulytau	177267	0,1	0,6
East Kazakhstan	594002	0,7	1,2
Astana city	1301395	7,8	6
Almaty city	2023637	10	5
Shymkent city	954434	2,9	3

Note: compiled on the basis of data from [16,17]

According to the results illustrated in Table 5, the highest cybersecurity index is in the Karaganda region, which amounts to 9.9 with 917,364 Internet users. This region is followed by the North Kazakhstan region with an indicator of 8. Based on the data from five groups of indicators for each country's region, the authors calculated the indices of the Innovation and digital potential of the regions, which have a value from 0 to 1. Using the method of normalization of each group of indicators of the regions, the following indices were derived, which allowed the country's territory to be ranked depending on the innovative and digital potential.

Table 6. The index of innovation and digital potential of the regions

Region	Ranking	IDPI
Abai	14	0,44
Akmola	20	0,25
Aktobe	19	0,32
Almaty	18	0,34
Atyrau	6	0,59
West Kazakhstan	15	0,37
Zhambyl	9	0,53
Zhetysu	13	0,45
Karaganda	7	0,58
Kostanay	8	0,589
Kyzylorda	17	0,38
Mangystau	12	0,453
Pavlodar	3	0,76
North Kazakhstan	4	0,65
Turkestan	5	0,60
Ulytau	11	0,46
East Kazakhstan	10	0,47
Astana city	1	0,91
Almaty city	2	0,77
Shymkent city	16	0,37

Note: compiled on the basis of data from [16,17]

The results obtained make it possible to analyze the territorial prospects of innovative and digital development based on indicators of regional innovation activity and digital infrastructure. The Republic of Kazakhstan's overall index of innovation and digital potential is 0.55 (from 0 to 1), the average indicator for the main criteria of innovation and digital development. Eight regions of the country have an index higher than the general index, as shown in Figure 4, compared with twelve regions with an index lower than the country index.

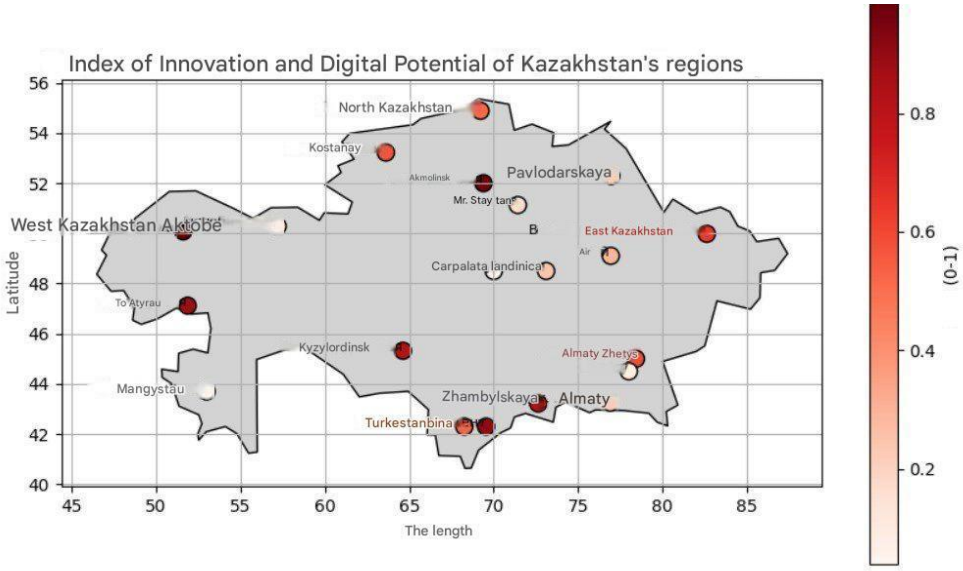

Figure 4 Innovative-digital potential index of the regions of Kazakhstan

Note: compiled on the basis of data from [16,17]

Thus, the region with the highest index of innovative and digital development is Astana city (0.91) due to a combination of factors such as the concentration of government institutions that use digital technology tools and specialists in information technology and communications. This is followed by Almaty city, which has the most significant number of enterprises with innovative activity and Internet users, with an indicator of 0.77. Pavlodar region is in the third position in the ranking of indicators of innovation and digital potential due to the relatively high level of innovation activity of the region's enterprises and digital infrastructure, as well as above the average level of business digitalization – 0.76. In turn, the Akmola, Aktobe, and Almaty regions have the lowest innovation and digital potential index of the regions – 0.25, 0.32, and 0.34, respectively. The result is due to the low innovation activity of enterprises at the level of 6% in the Akmola region, 5.3% in the Almaty region, and 11% throughout the republic. Even though the Aktobe region has a higher level of innovation activity than the Republican one (13%), a rather low level of digital infrastructure (61.9%), and business digitalization determined the innovation and digital potential index.

Kazakhstan is actively stimulating digital transformation and the introduction of innovative technologies. However, the author's analysis of the index of innovation and digital potential of the regions demonstrates significant differences in innovation and digital development between the country's regions. According to the results of the index calculation, 12 regions have a level below the national average. In this regard, addressing the identified problems in innovation and improving the level of digital infrastructure in the country's regions requires implementing a comprehensive strategic policy [19]. The proposed policy should include developing the digital environment, promoting innovation, stimulating the growth of information technology professionals, digitalizing business processes in organizations, and ensuring cybersecurity.

Conclusion

According to the results of this study, the main factor with the greatest weight in the index, which determines the level of innovative and digital development in the regions, is the level of digital infrastructure development. As the analysis showed, there are regions with a low level of Internet access for the population compared to the national indicator, and a low density of telecommunications infrastructure in these regions. The solution to this problem lies in the accelerated deployment of broadband Internet and 5G networks in all regions, including rural areas. There is a need for additional investments in developing digital and communication infrastructure in remote regions. In solving this problem, it is necessary to expand the role of public-private partnership practices to jointly finance digital projects. As the analysis and calculation of the innovation and digital potential index showed, the innovative activity of enterprises plays a significant role. Accordingly, some problems need to be solved for the further development of innovation and digitalization in Kazakhstan's regions. The report on the Global Innovation Index of 2024 ranks Kazakhstan in the top 3 innovative economies by region, along with India and Iran [20]. The innovation activity of enterprises in the country is 11%, which is considered low because the country ranks 78th in the overall innovation ranking. The solution to this problem lies in expanding the network of technology parks and hubs in the regions. This expansion will lead to increased accessibility of infrastructure for startups and enterprises with innovative technologies.

An essential aspect of solving the problem is the application of tax incentives for information technology and digital solutions companies. Following the Law of the Republic of Kazakhstan, "On Investment and Venture Funds," the Tax Code, and the Business Code, it is necessary to exempt enterprises with innovative activities, the production of innovative products, from VAT and corporate income tax. The National Entrepreneurship Development Project for 2021-2025 requires extension and expansion to increase the competitiveness of innovative IT companies.

The analysis showed the importance of human resources employed in the information and communication environment in developing an economy with high innovation and digital components. The slow pace of innovative and digital development in some regions of the country is due to a lack of information technology specialists and a low level of digital literacy. This problem can be solved within the framework of a joint project of the Ministry of Science and Higher Education and the Ministry of Labor and Social Protection – Atlas of Professions, where it is necessary to actualize the demand for personnel in the field of communications and modernize educational programs following the priorities of innovative and digital development in organizations of higher and postgraduate education and in colleges. In this atlas, it is necessary to develop a section "Digital professions" by region, considering the needs of the regions. Moreover, digital literacy courses in the region, including in rural areas, also contribute to developing the country's digital human resources potential. Cooperation between universities and businesses in preparing and implementing educational programs, internships, and employment of students at information technology enterprises will positively impact the level of staffing in the economy, which is aimed at innovative and digital development.

Business digitalization at large enterprises, in the banking sector, and in the field of public services is carried out at a high level. It provides high indicators of digitalization in global rankings. However, regional, medium, and small businesses face problems adapting to the economy's digitalization. To solve the problem of digitalization in regional business, it is

necessary to develop and implement tax incentive tools for enterprises that implement digital and information technologies, as well as AI and cloud technologies. The authors suggest that a single "national standard for digital business transformation" will allow for the unification of requirements for digital processes and encourage businesses to adopt innovative digital tools. The system of government grants and subsidies for SMEs and quotas for enterprises in regions with low rates of business digitalization contributes to improving the overall situation.

An essential aspect of the development of both an innovation-oriented and a digital economy is the issue of ensuring the cybersecurity of Internet users. The analysis of cyber threats and cyber-attacks by region revealed the presence of cybercrime in some of the studied regions of the country, as well as a high level of cooperation and cybersecurity. 132 of the world's economies have a national cybersecurity strategy, and only 85 of them contain a strategy implementation plan. A national strategy with a clearly defined action plan that meets international standards will improve cybersecurity. The solution to cybersecurity problems is expanding the KZ-CERT centers' network within the National Computer Incident Response Service Место для ввода текста.. It is necessary to continuously improve the digital security system through government measures and programs such as the Government Decree "On Approval of the Concept of Digital Transformation, development of the information and Communication Technologies and Cybersecurity industry for 2023-2029" and others. An analysis of international experience shows that the key factors of technological and innovative development of leading countries in the digital age are maximum liberalization, de-bureaucratization, and demonopolization of the ICT market, combined with a parallel, timely, and sometimes even advanced legislative and regulatory framework . Considering a unified compliance system with information system security requirements for government educational institutions and enterprises within the Law "On Informatization" framework is necessary. In addition, regular cyber training for both public and private structures will enhance cybersecurity.

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Authors' contribution.

L.A. Kuanova – theoretical substantiation, interpretation of results, data collection and processing, goal setting, and literature review.

R.D. Doszhan – preparation of conclusions and final provisions.

N.Shirazi – estimation of the index according to the methodology of the research, analysing and interpreting the results of the study.

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Қазақстан аймақтарының инновациялық және цифрлық әлеуетін бағалау

Аңдатпа. Қазақстанның өңірлері мен қалаларының инновациялық және цифрлық дамуында айтарлықтай прогресс байқалады. Алайда, цифрландыру мен инновация деңгейі аймақтың аумақтылығына байланысты өзгеріп отырады. Осы зерттеу инновациялық және цифрлық әлеуеттің индексі арқылы Қазақстан аймақтарының инновациялық және цифрлық әлеуетін бағалаудың кешенді негізін ұсынады. Ұсынылған индекс бес негізгі бағыттағы көрсеткіштерді бағалайды: цифрлық инфрақұрылым, инновациялық белсенділік, кадрлық әлеует, бизнесті цифрландыру және киберқауіпсіздік. Авторлар аймақтық көрсеткіштерді бағалау барысында аналитикалық иерархия процесс әдісі мен көп критерийлі талдау әдістемесін қолданды. Зерттеу нәтижесіне сәйкес, Қазақстан Республикасының инновациялық және цифрлық әлеуетінің жалпы индексі 0,55 (0-ден 1-ге дейін) құрайды, аталған көрсеткіш инновациялар мен цифрлық дамудың негізгі критерийлері бойынша орташа болып табылады. Мақаланың эмпирикалық нәтижелері цифрлық технологиялар мен инновациялардың әлеуетіндегі айтарлықтай аймақтық айырмашылықтары бар екенін айқындады, яғни ірі қалалық орталықтардың индекстері жоғары көрсеткіштерге ие екендігі белгілі болды. Сонымен қатар, инфрақұрылым кемшіліктеріне байланысты аз дамыған аймақтардың көрсеткіштері сәйкесінше төмен нәтижелерге ие. Зерттеу нәтижелері кең жолақты интернет желісінің қол жетімділігін арттыруды, цифрлық трансформацияны қаржылық ынталандыруды және қатаң киберқауіпсіздік шараларын қоса алғанда, мақсатты саяси шаралардың қажеттілігін айқындады. Зерттеудің нәтижелері цифрлық экономиканы дамыту мәселелерін кеңінен талқылауға ықпалын тигізіп қана қоймай, мемлекеттік реттеуші органдарға инклюзивті және тұрақты инновациялық елдің аумақтық ерекшеліктерін ескере отырып, инновациялық және цифрлық әлеуетті іске асыру мақсатында экожүйелерді құру мақсатында жүзеге асыруға болатын ақпаратты ұсынады.

Түйін сөздер: инновация, цифрландыру, индекс, smart қалалар, аймақтық даму, тұрақтылық, киберқауіпсіздік

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Оценка инновационно-цифрового потенциала регионов Казахстана

Аннотация. Казахстан продемонстрировал определенный прогресс в инновационном и цифровом развитии регионов и городов. Тем не менее уровень цифровизации и инноваций существенно различается в зависимости от территориальности региона. В данном исследовании представлена комплексная система оценки инновационного и цифрового потенциала регионов Казахстана с помощью индекса инновационно-цифрового потенциала. Предлагаемый индекс оценивает пять ключевых аспектов: цифровую инфраструктуру, инновационную активность,

потенциал человеческих ресурсов, цифровизацию бизнеса и кибербезопасность. Таким образом, в данной статье авторами был применён многокритериальный подход анализа и был использован метод процесса аналитической иерархии для нормализованных показателей индекса. Согласно результатам исследования, общий индекс инновационного и цифрового потенциала Республики Казахстан составляет 0,55 (от 0 до 1), что является средним показателем по основным критериям инновационного и цифрового развития. Полученные эмпирические данные свидетельствуют о значительных региональных различиях в цифровом и инновационном потенциале, при этом крупнейшие городские центры демонстрируют самые высокие показатели по индексу. В то же время менее развитые регионы отстают из-за недостатков инфраструктуры. Полученные результаты подчёркивают необходимость целенаправленных политических мер, включая повышение доступности широкополосной сети интернет, финансовые стимулы для цифровой трансформации и более строгие меры кибербезопасности. Результаты данного исследования способствуют более широкому обсуждению вопросов развития цифровой экономики и, более того, предлагает государственным регулирующим органам полезную информацию для создания инклюзивных и устойчивых инновационных экосистем с целью реализации инновационного и цифрового потенциала с учётом территориальных особенностей страны.

Ключевые слова: инновации, цифровизация, индекс, умные города, региональное развитие, устойчивое развитие, кибербезопасность.

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