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State and Prospects of Development of Kazakhstan Innovative Infrastructure

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Abstract:

Creation of the national innovation system and development of innovative strategies and programs have become the key tasks for the Republic of Kazakhstan in the context of establishment of the knowledge-based economy. With the purpose of defining the state and priority areas of development of the innovative infrastructure of the republic, it was analyzed based on the data collected through a questionnaire survey, study of the scientific literature and policy documents, as well as analysis of statistical data. The situational SWOT analysis was the methodical research tool.

It was found during the study that the existing Kazakhstan innovative infrastructure was in imperfect state. Its operation was prevailed by economic factors, while the factors contributing to enhancing its effectiveness were noted as prevailing in its external environment. Its weaknesses have a high influence among the internal factors. 7 strategic recommendations on overcoming the existing weaknesses at the expense of the environment capabilities were offered in order to minimize the effects of weaknesses and threats of the innovation system of Kazakhstan.

The findings of the study can be used to determine the state and priority areas of development of innovative infrastructure – in particular, in the development of the state policy in the field of science, innovation and technology.

Key words: *Republic of Kazakhstan, national innovation system, innovative infrastructure, infrastructure elements of innovation system, SWOT analysis, SWOT matrix, internal factors evaluation (IFE) matrix, external factors evaluation (EFE) matrix, strategic position and action evaluation (SPACE) matrix, quantitative strategic planning matrix (QSPM).*

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1. Introduction

Knowledge, creativity and innovation take on great importance in the current context and become the core of the innovation-driven economy. Creation of national innovation systems (NIS) and development of innovative strategies and programs are considered as key priorities for many countries today, being one of the main areas of their economic growth. Shaping an efficient and fully functioning innovation system is of paramount importance in the context of establishment of a knowledge-based economy. Measures aimed at shaping and development of the national innovation system has been taken in Kazakhstan since the early 2000s. At the moment, the republic has an active policy of development and promotion of innovation, and the individual elements of the national innovation system are being created.

However, the creation of infrastructure links of the Kazakhstan innovation system has not led to a significant growth in innovative activity. The Kazakhstan innovation system remains fragmented. It is described by poor development of individual divisions, a small number of created infrastructure facilities and a concentration of their larger part in Astana and Almaty. The existing Kazakhstan innovative infrastructure is not efficient as a system: its elements are isolated from each other and lack a required level of cooperation between each other – in particular, they lack synergy between science and industry. To date, the Kazakhstan innovative infrastructure is not a system of complex organizations that provide the entire range of services required during the operation and interaction between the members of the national innovation system (Al-Hakim & Chen, 2014).

Inefficient functioning of innovative infrastructure does not allow Kazakhstan to move towards the creation of the innovation-driven economy. According to the Global Competitiveness Index for 2016-2017, Kazakhstan ranks 53rd out of 138 countries and is in the process of transition from the factor-driven economy to the efficiency-driven economy (WEF, 2016; UN, 2012). According to the Global Innovation Index, Kazakhstan was ranked 75th out of 128 countries in 2016 and 82nd out of 141 countries in 2015. As we can see, the Kazakhstan rank has grown, but the innovation efficiency ratio is very low in the country – it ranked 108th in 2016 and 124th in 2015 (WIPO, 2016).

In the context of establishment of the knowledge-based economy in Kazakhstan and in the light of implementation of the Concept of Innovation Development of Kazakhstan till 2020 and the State Program of Industrial and Innovation Development of Kazakhstan for 2015-2019, the development of the existing innovative infrastructure becomes very important. The situational SWOT analysis is planned in order to determine the state of the priority areas of development of innovative infrastructure.

2. Literature Review

2.1. Theoretical aspects of the study of innovative infrastructure

The concept of a national innovation system emerged in the second half of the 1980s (Lundvall, 2005). It is aimed at studying the relationship between technological development and institutional involvement of innovative companies (Kaiser and Prange, 2004). The essence of this concept lies in the fact that the technological differences coming from differences in national innovation systems can act as a model of technological specialization that expresses the country's competitiveness. As long as the NIS strengthening is equivalent to improvement in the innovation climate, the increase in the possibility of the emergence of innovation is the main source of economic growth (Arocena and Sutz, 2000). The central assumption of the concept is that the rate of technological change in any country and the performance of its firms in competitiveness with foreign countries in trade in goods and services do not only depend on the scale of R&D and other technical measures, but also on the way the available resources are managed and arranged at the enterprise and national level. At the same time, institutional differences between the countries have impact on the rate and direction of innovative activity (Walsh and Le Roux, 2004). This concept underlines the importance of a national focus, since the innovation systems will differ by the specifics of the "national" factors, including national history, language and culture, as well as the time taken by industrialization. For example, the national innovation system will be defined by such factors as size, availability of resources and labor market. Besides, technological capabilities of the national system are rooted in the processes of interactive training conditioned by the economic structure and the institutional system of the country (Molina and Kinder, 2001).

In addition, despite the fact that the NIS does not take the production factors into account in its conceptual framework (Al–Saleh, 2009), it is considered within 6 subsystems: policy in the field of science and technology, innovation strategy, technical support services, mobilized financial resources and international cooperation (Kayal, 2008). Innovative infrastructure is a vital element of the national innovation system, since it contributes to the provision of economy with services and facilities necessary for the transfer of knowledge and its transformation in the final product. Rich innovative infrastructure offers more opportunities for innovators in access and dissemination of new knowledge. However, the creation of innovative infrastructure does not guarantee its efficient functioning. Too weak or too strong interaction between its elements is able to contain the whole subsystem, while the isolation of its elements from each other prevents good functioning of the innovative infrastructure (Al-Hakim and Chen, 2014).

Infrastructure is an important resource for the efficient functioning of innovative and economic activity. Innovation and efficiency of infrastructure are a source of economic growth and productivity, as well as international competitiveness (Frenz and Lambert, 2012). Innovative firms as major players in the innovation economy first of all require physical infrastructure (roads, electricity, water, etc.), then incentive infrastructure (incentive investment payments, venture companies, scientific and technical information, technology transfer centers) and infrastructure of cooperation (state R&D institutes, universities and design and engineer units) (Ramanathan, 2010). Infrastructure of technology and innovation support, i.e. infrastructure of innovative activity in any national innovation system can be divided into three key subcomponents (Edquist, 2013):

1) traditional basic infrastructure, which includes organizations performing soft functions (e.g. patent authorities) and hard functions (e.g. new measurement technologies that the new production standards will build upon). This subcomponent also includes the bureau of standards, statistical offices, science museums, research centers, etc.;
2) innovative and technological infrastructure, which includes the basic and advanced components, soft and hard elements;
3) unit of the policy development.

The most significant subcomponent includes the innovative infrastructure that can be represented in the form of hard organizations such as technological centers and institutions (sectoral or functional), as well as soft organizations such as innovation centers and similar bridging organizations (Edquist, 2013). Hard elements include physical infrastructure (industrial areas, technoparks, science advancement parks and innovation centers) and technological infrastructure, which are presented at a state-of-the-art level (e.g. research institutes and testing centers, academies of science, development centers and laboratories) (Matatkova and Stejskal, 2013). They also include incubators, research parks and fiber-optic backbone. Soft infrastructure (or knowledge infrastructure) includes educational institutions, universities and other communication organizations that allow for horizontal and vertical transfer of knowledge between various organizations and companies (Al-Hakim and Chen, 2014), as well as know-how, patents, useful models, etc. (Matatkova and Stejskal, 2013).

In particular, the difference between the hard and soft forms of innovative infrastructure is useful when comparing inventory of assets that are available for innovation in different places and the innovation ongoing there (Vitartas *et al.*, 2013). For example, a regional innovation system consists of the following three key layers: a layer of companies, a layer of additional and supporting companies, a layer of the environment and infrastructure. The first layer includes companies that introduce innovation to the market, register patents and bring financial resources for

research, development and creation of innovation. The second layer is companies producing additional and secondary services for the first layer of companies: suppliers of knowledge, sub-suppliers, institutions for cooperation, etc. The third layer can be divided into three separate parts: institutions creating the environment, sets of initiatives, as well as hard and soft infrastructure (physical and technological infrastructure, infrastructure of knowledge) (Matatkova and Stejskal, 2011; Akopova and Przhedetskaya, 2016; Akopova *et al.*, 2017; Dzhukha *et al.*, 2017).

However, until now, no clear and unambiguous terminological, functional and structural content of the concept of "innovative infrastructure" has been developed. A systematic approach belongs to its key methodological approaches to its study, where it is a holistic formation defining the relationship between its elements (subsystems) and primary production. There are several approaches to the definition of innovative infrastructure and therefore to understanding of its importance in the national innovation system. In the framework of the first approach, the innovative infrastructure is interpreted as a set of organizations engaged in servicing the innovation processes (Semke, 2012; Shekhovtsov *et al.*, 2017; Sibirskaya *et al.*, 2016; Stroeva *et al.*, 2016; Vovchenko *et al.*, 2017). At the same time, one group of scientists understands the innovative infrastructure as a set of objects facilitating the implementation of the innovation chain at the regional and national levels, while the other understands it as a set of the structures promoting the development of innovative activity. This approach needs better exploitation, which will allow revealing the nature of the processes occurring in it (Raykhlina, 2010). According to the second approach, the innovative infrastructure is treated as a set of conditions, which makes it similar to the concept of "innovative environment", especially when the sets of conditions are similar. The third approach examines the innovative infrastructure as a set of institutions (Semke, 2012), which makes it similar to the concept of "infrastructure of innovative activity".

Most of the researchers define the innovative infrastructure as a set of organizations supporting the process of innovation. Such a definition, expressed as citation of its constituent elements, requires periodic adjustments due to the constant expansion of the complex of organizations of innovative infrastructure and the emergence of new forms of support. Along with this, many authors, in particular in the legal documents, narrow the list of these organizations by technology incubators, technology centers and technoparks, reducing the innovative infrastructure to its technological subsystem, one of the few existing (Semke, 2012). At the same time, the innovative infrastructure is broken down into the production and technology, information, human resources, consulting, financial and marketing components, identifying the cognominal infrastructures. The purpose of the production and technological infrastructure (technology and innovation zones, innovation and industrial complexes, innovation and technology centers, technological clusters, technoparks and centers of the collective use of high-tech equipment) is to provide

access to productive resources to primarily small businesses. The information infrastructure provides access to information through the Internet, the state system of scientific and technical information, regional information networks, and resources of the structures supporting small businesses. The personnel training infrastructure is aimed at a balanced training of specialists in the field of academic and technological management and advanced training of personnel in the field of innovation. The consulting infrastructure includes the technology transfer centers and organizations providing technological and marketing consulting, as well as consulting in the field of economy and finance and in the field of the foreign economic activity. The financial infrastructure provides access of innovative enterprises to financial resources (seed and startup funds, budgetary and non-budgetary funds of technological development, guarantee structures and funds, venture capital funds). The sales infrastructure is represented by foreign trade associations, specialized intermediary firms, Internet and exhibitions (Shepelev, 2015).

As such, the term "innovative infrastructure" is understood as a combination of interrelated systems and their respective organizational elements of various forms of ownership, various organizational and legal forms and a multi-level structure, which provide a variety of services to support the entire cycle of innovative activity with corresponding resources (intellectual, raw materials, labor, financial, etc.).

2.2. Kazakhstan innovative infrastructure

Measures aimed at shaping and developments of the national innovation system have been taken in Kazakhstan since the early 2000s. JSC "National Innovation Fund" was established in 2003, the purpose of which was to improve the overall innovative activity in the country and to promote the development of high-tech and knowledge-based industries. In the next two years, the first domestic venture capital fund was established, and the first contest of innovative business plans was launched. A special economic zone "Information Technology Park "Alatau IT City" began operating in 2006, and the first innovation congress was held. Regional technoparks were created in Astana, Ust-Kamenogorsk and Shymkent in 2007 and 2008. The period from 2009 to 2011 is described by the creation of sectoral design engineering bureaus and Kazakh-French and Kazakh-Korean technology transfer centers. The foundation of the Kazakhstan innovation system was laid in these years. JSC "National Agency for Technological Development" (NATD) was established in 2012 in order to assist in ensuring the coordination between innovative development processes and the provision of the government support measures (NATD, 2017). At the moment, the republic has an active policy of development and promotion of innovation, and the individual elements of the national innovation system are being created.

One of the six key fields of JSC "NATD" is development of the efficient innovative infrastructure. Multi-level innovative infrastructure is one of the important elements of the Kazakhstan innovation system, along with the scientific potential, innovative entrepreneurship and financial infrastructure. It includes national and regional technology parks, technology business incubators, technology cities, etc. (Resolution of the Government of the Republic of Kazakhstan No. 387, 2005) without clearly dividing them into production and technological, financial, human resources, information, consulting, and sales components (The Republic of Kazakhstan President's Decree No. 579, 2013).

The elements of the industrial and innovative infrastructure of the Republic of Kazakhstan include special economic zones (including an independent cluster fund), industrial zones, technoparks, joint-stock investment funds of risky investment, technology commercialization centers, design engineering bureaus, international centers of technology transfer, and innovation clusters (Entrepreneurial Code, 2015). The innovative infrastructure includes all elements, except for industrial zones, while venture capital funds can be attributed to joint-stock investment funds of risky investments. As such, as of March 2016, 10 special economic zones operated in Kazakhstan, including 1 independent cluster fund (Independent Cluster Fund "Park of Innovative Technology" under the umbrella brand "Almaty TechGarden"), 19 technoparks, 29 technology commercialization centers, 4 design engineering bureaus, 6 international centers of technology transfer and 2 innovation clusters (OECD, 2016) (Table 1).

Table 1. *Main infrastructure elements of innovation system of Kazakhstan*

Element of innovative infrastructure	Kazakhstan		
	Number	Name	Location
Special economic zone	10	"Seaport Aktau" (Oil and Gas Mechanical Engineering)	Aktau
		"NIPT" (Petrochemistry)	Atyrau
		"Burabay" (Tourism)	Burabay
		"Astana - New City" (Mixed)	Astana
		"Saryraka" (Metallurgy)	Karaganda
		"Chemical Park Taraz" (Chemistry)	Taraz
		"Ontustik" (Textile)	Shymkent
		"Park of Innovative Technologies" (IT Innovations)	Almaty
		"Khorgos – Eastern Gates" (IT Innovations)	Taldykorgan
		"Pavlodar" (Petrochemistry)	Pavlodar
Technopark	19 (main)	"Saryraka"	Karaganda
		"Algorithm"	Uralsk
		East Kazakhstan Regional Park "Altai"	Ust-

			Kamenogorsk
		Regional Technology Park in South Kazakhstan	Shymkent
		"National Industrial Petrochemical Technopark"	Atyrau
		"Tokamak" Technopark of Nuclear Technology	Kurchatov
		Kyzylorda Technological Park	Kyzylorda
		Technopark of Space Monitoring (3)	Priozersk, Almaty, Astana
		KazNTU Technopark (Satpaev Kazakh NTU)	Almaty
		Almaty Regional Technopark	
		"Park of Innovative Technologies" (PIT)	
		Science and Technology Park "Alatau"	
		Almaty Technopark	
		"Alatau IT City" National Technopark	
		Regional Astana Technopark	Astana
		Nazarbayev University (NU) Technopark	
		Science Park "Astana Business Campus" (NU)	
Engineering design bureau	4	"Transport Design Engineering Bureau"	Astana
		"Agricultural Engineering Design Bureau"	
		"Mining and Metallurgical Equipment Design Bureau"	Ust-Kamenogorsk
		"Oil and Gas Equipment Design Bureau"	Petropavlovsk
International center for technology transfer	6	Kazakh-French Center for Technology transfer (partner – CEIS)	Astana
		Kazakh-Korean Technological Cooperation Center (partner – Innopolis Daedeok)	
		Kazakh-Norwegian Center for Technological Cooperation (partner – International Development Norway)	
		Kazakh-American Center for Technological Cooperation (partner – Innovaro inc.)	
		Kazakh-Russian Technological Cooperation Center (partners – First President of Russia B.N. Yeltsin Ural	

		Federal University, non-profit partnership "The ecologists district guild")	
		Kazakh-Chinese Center for Technological Cooperation (partner – Guangdong Union for the Scientific and Technological Cooperation with the CIS countries)	
Innovative Cluster	2	Nazarbayev University "Innovative Cluster"	Astana
		Park of Innovation Technologies "Innovative Cluster"	Almaty
Commercialization offices	29 (main)	Satpaev Kazakh National Technical University	Almaty
		Kazakh-British Technical University	
		Al-Farabi Kazakh National University	
		Kazakh National Agrarian University	
		Almaty Technical University	
		KazNTU Technopark	
		Sokolsky Institute of Organic Catalysis and Electrochemistry	
		South-West Research Institute of Livestock Farming and Plant Growing	
		Eurasian National University	Astana
		Kazakh Agro Technical University	
		Nazarbayev University	
		Regional Astana Technopark	
		National Center for Biotechnology	
		Technology Commercialization Office (World Bank)	
		Zhangir Khan West Kazakhstan Agrarian and Technical University	Uralsk
		"Algorithm" Technopark	
		Korkyt-ata Kyzylorda State University	Kyzylorda
		M.O. Auezov South Kazakhstan State University	Shymkent
		National Center on Complex Processing of Mineral Raw Materials of the RoK	
		Technopark "Saryarka"	Karaganda
		Karaganda State University	
		Karaganda State Technical University	
		Karaganda Economical University of Kazpotrebsoyuz	
		D. Serikbayev East Kazakhstan State	Ust-

		Technical University	Kamenogorsk
		S. Amanzholov East Kazakhstan State University	
		East Kazakhstan Regional Park "Altai"	
		Shakarim Semipalatinsk State University	Semey
		Innovative Eurasian University	Pavlodar
		Institute of Plant Biology and Biotechnology	Stepnogorsk
Private equity and venture capital funds	12 (main)	Macquarie Russia & CIS Infrastructure Fund	Astana
		Russian-Kazakhstan Nanotechnology Venture Fund	
		"Verny" Capital	
		JSC "Baiterek" Venture Fund	
		ADM Kazakhstan Capital Restructuring Fund	Almaty
		"Citic Kazyna" Investment Fund I	
		"Amun" Capital	
		"Centras" Private Equity Fund	
		Kazakhstan Growth Fund L.P.	
		Falah Growth Fund I	
		JSC "AIFRI "Venture Fund Centras"	
		Rakishev Kenes, Independent Investment Entrepreneur	

A small number of infrastructure links of the innovation system were created in Kazakhstan. The elements of the innovative infrastructure largely support a medium-tech technology sector. The Kazakhstan innovative infrastructure is represented by hard elements; there are no well-defined soft elements. It can be divided into production and technological (special economic zones, technoparks, design engineering bureaus, innovation clusters), consulting (international centers of technology transfers, commercialization offices) and financial (private equity and venture capital funds) components. Lack of its information, human resources and sales components in the country program documents leads to the fact that they are not taken into account during the development of innovative infrastructure, due to which the innovative infrastructure is flawed and cannot function efficiently.

Lack of the system that coordinates the national, regional and sectoral levels of the national innovation system led to chaotic development of innovative infrastructure, without taking into account the needs of the real sector of economy and development of the specific strategy to be implemented (EXIMAR, 2014). Although the innovative infrastructure elements have been created, they are distributed unevenly. As we can see, the spatial distribution of infrastructure links of the Kazakhstan

innovation system is unbalanced in the regional context. 60% of the infrastructure links of the Kazakhstan innovation system is concentrated in two regions (cities of republican importance) out of sixteen. The development of only central links can lead to imbalance in the entire chain of the innovation path, so attention must also be paid to stimulating the innovative activity in other regions. The existing Kazakhstan innovative infrastructure is in imperfect state and requires further development.

3. Data and Methodology

According to the concept of the national innovation system, the innovative activity is greatly influenced by country-specific factors, including formal and informal institutions, level of scientific, technological and industrial potential, structure and type of economy, etc. A detailed study is needed to assess the Kazakhstan innovative infrastructure and determine the factors that influence its efficient functioning. SWOT analysis is a reliable method to identify and structure the strengths and weaknesses of the innovative infrastructure of the republic and assess the external factors that influence it. It also allows providing strategic solutions on improving the innovative infrastructure and policy for its formation.

The situational SWOT analysis of Kazakhstan innovative infrastructure was conducted in the framework of the study, where the selection and assessment of the strategy of its development were carried out in three stages. At the first stage, the internal and external environments of the innovative infrastructure were analyzed using the internal factors evaluation (IFE) matrix and the external factors evaluation (EFE) matrix.

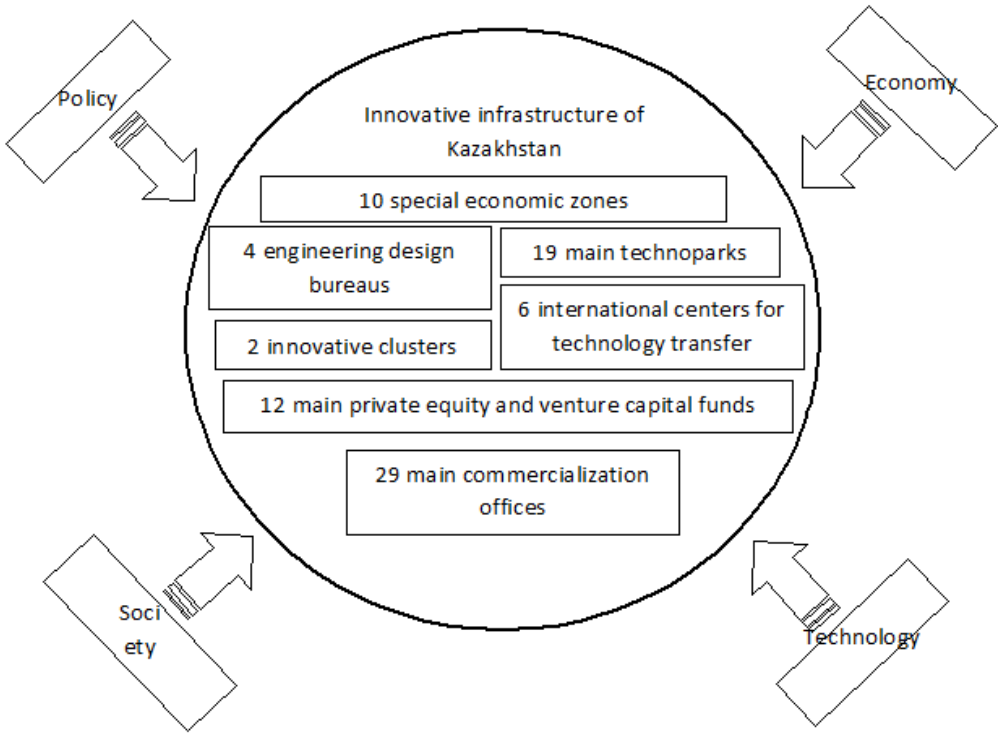
The obtained information has identified its strengths and weaknesses (internal factors), opportunities and threats (external factors). After that, the SWOT matrix was used to evaluate its strengths and weaknesses, opportunities and threats. Finally, the strategic position and action evaluation (SPACE) matrix and the quantitative strategic planning matrix (QSPM) were built as a tool for the formulation of strategies based on internal and external evaluations and SWOT analysis (Hashemi *et al.*, 2011).

The innovative infrastructure of the Republic of Kazakhstan served as the object of this study. The data collected through the study of scientific literature and policy documents, analysis of statistical data served as the basis for the analysis. Ratings were weighed during the questionnaire survey of the experts exploring the issues of the innovative development of the republic, including the innovative infrastructure.

4. Results

The first essential step in this analysis is consideration of external factors of the innovative infrastructure, which cannot be controlled but can be taken into account for increasing or decreasing their influence on the object of the study. The methodology of PEST analysis was used to assess the external factors influencing the innovative infrastructure, which takes into account the political, economical, social and technological factors (Figure 1).

Figure 1: *Internal and external environment of innovative infrastructure of Kazakhstan*



The external factors evaluation matrix is a strategic management tool used to visualize and prioritize the opportunities and threats that may be encountered during the formation and development of the innovative infrastructure of the country (Ommani, 2011). The EFE matrix was built in order to assess the external environment of the Kazakhstan innovative infrastructure (Table 2).

Table 2. *External factors evaluation matrix of innovative infrastructure of Kazakhstan*

External factors		Weight	Rating	Weighted score
Opportunities	*Political factors*			
	1. Availability of political will for innovative transformations	0.09	4	0.36
	Economical factors			
	2. Economic integration (creation of the Eurasian Economic Union (EAEU), accession to the World Trade Organization (WTO), creation of the Silk Road Economic Belt)	0.08	4	0.32
	3. Development of new industries (creative industries, "green" technology, etc.)	0.09	4	0.36
	4. Expansion of sources of innovation funding	0.08	4	0.32
	Social factors			
	5. Development of STEM education	0.09	4	0.36
	Technological factors			
	6. Transfer of the advanced foreign technology	0.08	4	0.32
	Total	0.51	-	2.04
Threats	*Political factors*			
	1. High level of corruption	0.1	1	0.1
	Economical factors			
	2. Raw-material orientation of the economy	0.1	1	0.1
	3. High level of the interest rate	0.07	1	0.07
	4. New wave of the global economic crisis	0.06	1	0.06
	Social factors			
	5. Poor culture of entrepreneurship and lack of innovative culture	0.08	1	0.08
	Technological factors			
	6. Technological backwardness of the economy	0.08	1	0.08
	Total	0.49	-	0.49
Total weighted score		1	-	2.53

Notes

1. Weight ranges from 0 to 1 for each factor. The weight assigned to a given factor points at its relative importance. Zero means that it is of no importance, while one indicates that the factor is very influential. The total sum of the weights shall amount to one;
2. Rating is defined on a scale from 1 to 4 for each factor. The rating reflects whether the factor is a serious threat (1), negligible threat (2), negligible opportunity (3) or great opportunity (4);
3. Weighted score is the product of weight and rating of the corresponding factor.

Table 2 shows a list of opportunities and threats of the Kazakhstan innovative infrastructure. As we can see, economic factors have the prevailing importance for it, while the factors providing opportunities for its efficient operation can be noted as prevailing in its external environment.

The internal factors evaluation matrix is a strategic management tool used to evaluate strengths and weaknesses. It is also a tool for formulation of a strategy that can be used to assess the efficiency of the object of analysis in relation to the identified internal strengths and weaknesses (Ommani, 2011). IFE matrix was built to assess the internal environment of the Kazakhstan innovative infrastructure (Table 3).

Table 3. *Internal factors evaluation matrix of innovative infrastructure of Kazakhstan*

Internal factors		Weight	Rating	Weighted score
Strengths	1. Availability of the key infrastructure links	0.07	4	0.28
	2. Availability of the key elements of production and technological, consulting and financial components of the innovative infrastructure	0.07	4	0.28
	3. Availability of a single coordinating body responsible for the development of the innovative infrastructure	0.07	3	0.21
	4. Maturity of infrastructure links that support a medium-tech sector	0.06	4	0.24
	5. Availability of public instruments to support innovation	0.09	4	0.36
	Total	0.36	-	1.37
Weaknesses	1. Low level of integration of science, education and production	0.09	1	0.09
	2. Lack of the denoted soft innovative infrastructure	0.07	1	0.07
	3. Small number of infrastructure links and weak connections between them	0.08	1	0.08
	4. Regionally and functionally unbalanced allocation of infrastructure links	0.07	2	0.14
	5. Lack of the elements of information, human resources and sales components of the innovative infrastructure	0.08	1	0.08
	6. Immaturity of infrastructure links supporting a high-tech sector	0.08	1	0.08
	7. Lack of the methodological procedures for quality monitoring, analysis, assessment and	0.07	1	0.07

	forecasting of the innovative infrastructure development			
	8. Poor personnel pool	0.1	1	0.1
	Total	0.64	-	0.71
Total weighted score		1	-	2.08

Notes

1. Weight ranges from 0 to 1 for each factor. The weight assigned to a given factor points at its relative importance. Zero means that it is of no importance, while one indicates that the factor is very influential;
2. Rating is defined on a scale from 1 to 4 for each factor. The rating reflects whether the factor is a main weakness (1), negligible weakness (2), negligible strength (3) or main strength (4);
3. Weighted score is the product of weight and rating of the corresponding factor.

Table 3 shows strengths and weaknesses of the Kazakhstan innovative infrastructure. It shows that its weaknesses have prevailing influence among its internal factors.

The SWOT analysis method is not only a tool to diagnose strengths and weaknesses, opportunities and threats of the object of the study, but also one of the key instruments for the development of strategic plans. Strengths, weaknesses, opportunities and threats (SWOT) matrix facilitates the selection of the appropriate strategic area, paying attention to the dynamics of the internal and external environment.

Successive consideration of various combinations of the factors of the external environment and the intrinsic properties of the Kazakhstan innovative infrastructure allows justifying the choice of strategic measures for its development. SWOT matrix of the Kazakhstan innovative infrastructure was built on the basis of the matrices of internal and external factors evaluation and the strategic position and action evaluation matrix (Table 4).

Table 4. *Strengths, weaknesses, opportunities and threats matrix of innovative infrastructure of Kazakhstan*

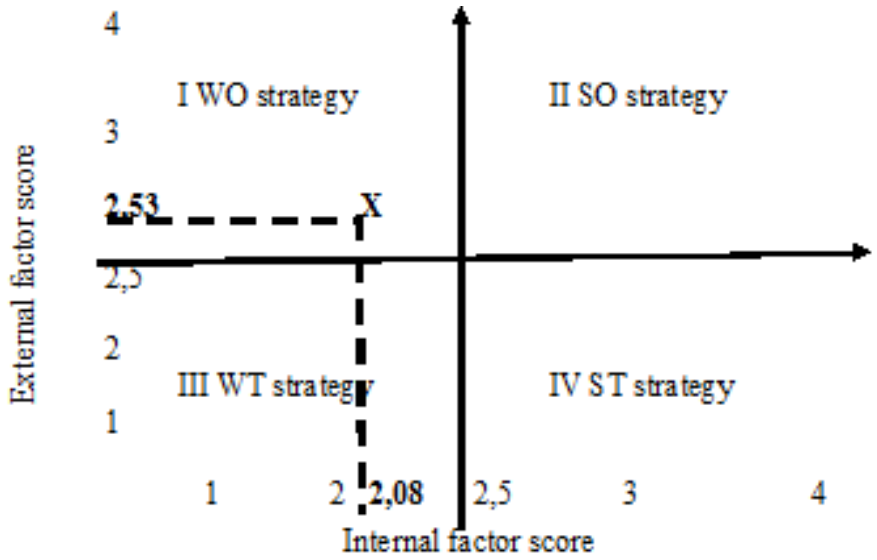
Internal factors / External factors	Strengths	Weaknesses
	S1. Availability of the key infrastructure links S2. Availability of the key elements of production and technological, consulting and financial components of the innovative infrastructure S3. Availability of a single coordinating body responsible for the development of the innovative infrastructure S4. Maturity of infrastructure links that support a medium-tech sector S5. Availability of public instruments to support innovation	W1. Low level of integration of science, education and production W2. Lack of the denoted soft innovative infrastructure W3. Small number of infrastructure links and weak connections between them W4. Regionally and functionally unbalanced allocation of infrastructure links W5. Lack of the elements of information, human resources and sales components of the innovative infrastructure W6. Immaturity of infrastructure links supporting a high-tech sector W7. Lack of the methodological procedures for quality monitoring, analysis, assessment and forecasting of the innovative infrastructure development W8. Poor personnel pool
Opportunities	SO strategies	WO strategies
O1. Availability of political will for innovative transformations O2. Economic integration (creation of the Eurasian Economic Union (EAEU), accession to the World Trade Organization (WTO), creation of the Silk Road Economic Belt) O3. Development of new industries (creative industries,	SO1. (S1, S5, O1, O3) SO2. (S2, S3, S5, O1, O2) SO3. (S2, S3, S5, O3) SO4. (S3, S5, O2, O4) SO5. (S2, S3, S4, S5, O5) SO6. (S2, S3, S4, O6)	WO1. (W1, W3, O1, O4) WO2. (W1, W2, W3, W5, O1, O2) WO3. (W3, O1, O3, O4, O6) WO4. (W4, O1, O2, O3) WO5. (W2, W3, W5, W8, O1, O5, O6) WO6. (W6, O1, O2, O3, O6) WO7. (W3, W4, W7, O1, O4, O6)

"green" technology, etc.) O4. Expansion of sources of innovation funding O5. Development of STEM education O6. Transfer of the advanced foreign technology		
Threats	ST strategies	WT strategies
T1. High level of corruption T2. Raw-material orientation of the economy T3. High level of the interest rate T4. New wave of the global economic crisis T5. Poor culture of entrepreneurship and lack of innovative culture T6. Technological backwardness of the economy	ST1. (S3, S5, T1) ST2. (S2, S4, S5, T2) ST3. (S2, S3, S5, T3) ST4. (S4, S5, T4) ST5. (S3, S5, T1, T5) ST6. (S2, S3, S5, T6)	WT1. (W1, W3, T1, T2, T6) WT2. (W2, W8, T2, T4, T5) WT3. (W3, W8, T5, T6) WT4. (W4, T2, T6) WT5. (W3, W5, W8, T1, T3, T6) WT6. (W6, W8, T6) WT7. (W7, T1, T2, T3, T6)

The performed SWOT analysis allowed to build a strategic position and action evaluation matrix, which is a management tool used to choose the type of a strategy that is required at this stage, taking into account all the internal and external factors (Figure 2). This matrix is broken down into four quadrants, each of which implies a certain type or nature of the strategy (Ommani, 2011). Possible options of strategies are listed below (Vaněk *et al.,* 2012; Izosimov and Shevchenko, 2013):

1) SO strategy: Maxi-Maxi. Potentially, it is the most successful strategy, which shows which strengths must be used to get a return on opportunities in the external environment;
2) ST strategy: Maxi-Mini. This is a strategy aimed at using internal strengths to overcome and prevent threats;
3) WO strategy: Mini-Maxi. This is a strategy that shows at the expense of which opportunities of the environment the existing weaknesses can be overcome;
4) WT strategy: Mini-Mini. This is a strategy that shows which weaknesses one must get rid of to try and prevent a looming threat.

Figure 2: *Strategic position and action evaluation matrix of innovative infrastructure of Kazakhstan*



Strategies of group I were proposed for the development of the current Kazakhstan innovative infrastructure, based on the strategic position and action evaluation matrix, which was built on the data from the matrices of evaluation of internal and external factors.

The quantitative strategic planning matrix was built for an objective selection of the best possible strategy for the development of the Kazakhstan innovative infrastructure among the strategies reviewed in Table 4 (Table 5). Its basic principle lies in the fact that it is necessary to systematically evaluate the internal and external environments, conduct studies, thoroughly assess benefits and drawbacks of various alternatives, perform analysis, and then make a decision on a particular course of action (Ommani, 2011).

Table 5. *Quantitative strategic planning matrix of innovative infrastructure of Kazakhstan*

Key factor	Weight	WO1		WO2		WO3		WO4		WO5		WO6		WO7	
		AS	TAS	AS	TAS	AS	TAS	AS	TAS	AS	TAS	AS	TAS	AS	TAS
O1	0.09	4	0.36	4	0.36	4	0.36	4	0.36	4	0.36	4	0.36	4	0.36
O2	0.08	2	0.16	4	0.32	3	0.24	4	0.32	1	0.08	4	0.32	1	0.08
O3	0.09	1	0.0	3	0.2	4	0.3	4	0.3	2	0.1	4	0.3	1	0.0

			9		7		6		6		8		6		9
O4	0.08	4	0.32	3	0.24	4	0.32	3	0.24	3	0.24	3	0.24	4	0.32
O5	0.09	3	0.27	3	0.27	3	0.27	3	0.27	4	0.36	3	0.27	3	0.27
O6	0.08	3	0.24	2	0.16	4	0.32	1	0.08	4	0.32	4	0.32	4	0.32
T1	0.1	3	0.3	3	0.3	3	0.3	3	0.3	1	0.1	2	0.2	1	0.1
T2	0.1	3	0.3	2	0.2	2	0.2	1	0.1	3	0.3	3	0.3	1	0.1
T3	0.07	2	0.14	2	0.14	2	0.14	1	0.07	1	0.07	2	0.14	1	0.07
T4	0.06	1	0.06	1	0.06	1	0.06	1	0.06	1	0.06	1	0.06	1	0.06
T5	0.08	2	0.16	3	0.24	2	0.16	2	0.16	4	0.32	2	0.16	1	0.08
T6	0.08	2	0.16	2	0.16	4	0.32	2	0.16	4	0.32	4	0.32	3	0.24
S1	0.07	3	0.21	1	0.07	2	0.14	3	0.21	4	0.28	3	0.21	3	0.21
S2	0.07	2	0.14	1	0.07	4	0.28	3	0.21	4	0.28	4	0.28	3	0.21
S3	0.07	4	0.28	4	0.28	4	0.28	4	0.28	4	0.28	4	0.28	4	0.28
S4	0.06	1	0.06	2	0.12	3	0.18	3	0.18	1	0.06	4	0.24	1	0.06
S5	0.09	4	0.36	3	0.27	4	0.36	4	0.36	4	0.36	4	0.36	4	0.36
W1	0.09	4	0.36	4	0.36	3	0.27	3	0.27	3	0.27	3	0.27	3	0.27
W2	0.07	3	0.21	4	0.28	2	0.14	1	0.07	4	0.28	2	0.14	2	0.14
W3	0.08	4	0.32	4	0.32	4	0.32	3	0.24	4	0.32	3	0.24	4	0.32
W4	0.07	2	0.14	3	0.21	3	0.21	4	0.28	1	0.07	3	0.21	4	0.28
W5	0.08	3	0.24	4	0.32	3	0.24	2	0.16	4	0.32	2	0.16	2	0.16
W6	0.08	2	0.16	2	0.16	3	0.24	2	0.16	3	0.24	4	0.32	3	0.24
W7	0.07	3	0.21	2	0.14	1	0.07	4	0.28	3	0.21	1	0.07	4	0.28
W8	0.1	2	0.2	3	0.3	1	0.1	1	0.1	4	0.4	3	0.3	1	0.1
Sum of TA			5.45		5.62		5.88		5.28		6.08		6.13		5

S															
Priority			5		4		3		6		2		1		7

Notes

1. AS – Attractiveness score – indicates to which extent each factor is important or attractive to each alternative strategy: not attractive (1), somewhat attractive (2), reasonably attractive (3), highly attractive (4);
2. TAS – Total attractiveness score – indicates relative attractiveness of each key factor and the associated individual strategy
3. Sum of total attractiveness score indicates which strategy is the most attractive. Higher scores indicate the greatest attractiveness of this strategy given all relevant internal and external key factors that can influence the strategic decision.

Based on the results of Table 5, the priority of the proposed strategies for the development of the Kazakhstan innovative infrastructure is as follows:

a) WO6. b) WO5. c) WO3. d) WO2. e) WO1. f) WO4. g) WO7.

5. Discussion

Economic factors have the prevailing importance for the Kazakhstan innovative infrastructure. The factors providing opportunities for its efficient operation and further development can be noted as prevailing in its external environment. The important opportunities for the innovative infrastructure of the republic include the availability of political will for innovative transformations, development of STEM education and new industries, economic integration, transfer of the advanced foreign technology, and expansion of the sources of innovation funding. The most important threats include high level of corruption, raw-material orientation of the economy, poor culture of entrepreneurship and lack of innovative culture, technological backwardness of the economy, as well as high level of the interest rate and new wave of the global economic crisis.

The Kazakhstan innovative infrastructure is described by high influence of its weaknesses. The low level of integration of science, education and production; poor personnel pool; small number of infrastructure links and weak connections between them; regionally and functionally unbalanced allocation of infrastructure links and immaturity of infrastructure links supporting a high-tech sector are considered the main weaknesses of the Kazakhstan innovative infrastructure. At the same time, the availability of the key infrastructure links and a single coordinating body responsible for the development of the innovative infrastructure, as well as the availability of public instruments to support innovation are its most important strengths.

In accordance with the results of the built SWOT matrix, the following areas of building an efficient Kazakhstan innovative infrastructure can be performed:

1. It is suggested to use the strengths of the innovative infrastructure to the greatest possible extent in order to implement the existing opportunities:

SO1. Further development of the existing innovative infrastructure in order to create new science-driven productions;
SO2. Integration of the existing innovative infrastructure in the framework of the transnational and global innovation system;
SO3. Formation of new infrastructure links of the Kazakhstan innovation system to support creative industries and science-driven productions, as well as to develop the "green" economy;
SO4. Establishment of the joint funds of innovative infrastructure development with partner countries (Russia, China, etc.);
SO5. Inclusion of universities, especially technological ones, in the soft infrastructure of the Kazakhstan innovation system and expansion of the educational grants for STEM specializations (science, technology, engineering and mathematics) for its support;
SO6. Development of the efficient mechanism for the transfer of the advanced technology for its subsequent modernization and creation of the proprietary advanced or unique technology.

2. It is suggested to use the opportunities of the external environment to overcome existing weaknesses of the innovative infrastructure:

WO1. Formation and functioning of the infrastructure links of the innovation system on the principles of the "triple helix" using the mechanism of a state-private partnership;
WO2. Inclusion of the existing elements and creation of new elements of the knowledge infrastructure in the Kazakhstan innovative infrastructure based on the experience of China and the EAEU member states in order to form a supra-national innovation system;
WO3. Modernization of the existing infrastructure links and formation of new ones to support new industries and the transfer of advanced technology;
WO4. Systemization of the activities of the elements of innovative infrastructure and submission of their development strategies to a single plan of the innovative scientific and technical development, as well as the development of the national and regional programs for the development of the Kazakhstan innovative infrastructure given the real production, potential new productions and integration processes (cooperation within the framework of the Silk Road Economic Belt, EAEU);
WO5. Inclusion of the existing research centers, universities and centers of scientific and technical information in the human resources and information infrastructure of

the Kazakhstan innovation system, transfer of the advanced information technology in order to create the sales infrastructure (electronic innovation exchange, etc.);
WO6. Development of infrastructure links supporting high-tech and science-driven industries at the expense of the transfer of advanced technology and the development of the creative industries;
WO7. Development of methodological and statistical basis for quality monitoring, analysis, assessment and forecasting of development of the innovative infrastructure.

3. It is suggested to use the strengths of the innovative infrastructure in order to minimize the consequences and prevent the looming threats:

ST1. Functioning of state institutions of innovation development on the basis of "single-window" system;
ST2. Improvement of existing infrastructure links for the purpose of the priority development of manufacturing industries;
ST3. Expansion of the government grants and instruments of non-financial support for innovative enterprises, as well as establishment and development of venture capital funds in the regions;
ST4. Increasing the public instruments to support innovation for small and medium-sized businesses engaged in medium- and high-tech sectors of the Kazakhstan economy;
ST5. Creation of the elements of information infrastructure and ensuring transparency of the elements of financial infrastructure of the Kazakhstan innovation system;
ST6. Creation of infrastructure links of the Kazakhstan innovation system to support productions of the fifth and sixth technological modes.

4. It is suggested to get rid of the weaknesses of the innovative infrastructure and to minimize their impact in order to prevent the looming threats:

WT1. Functioning of elements of the production and technological infrastructure of the innovation system on the principles of the "triple helix" and using a mechanism of the public-private partnership;
WT2. Formation of the knowledge infrastructure to develop the creative industries and science-driven industries;
WT3. Creation of new and improvement of existing infrastructure links of the innovation system of Kazakhstan to support the production of the fifth and sixth technological modes;
WT4. Development of the financial and feasibility study for each element of the innovative infrastructure in accordance with national and regional programs for the development of the Kazakhstan innovative infrastructure;

WT5. Expansion of access of innovative enterprises to the information and sales infrastructure of the Kazakhstan innovation system;
WT6. Improvement of the production and technological infrastructure of Kazakhstan to support science-driven industries;
WT7. Development of a single feasibility study and a reporting form for each element of the innovative infrastructure.

The reviewed strategies can play an important role in the development of the Kazakhstan innovative infrastructure. However, at the moment, taking into account all the internal and external factors that influence the Kazakhstan innovative infrastructure, the implementation of strategies aimed at overcoming the existing weaknesses of the innovative infrastructure by using the opportunities of the external environment is a priority area of its development.

6. Conclusion

The Kazakhstan innovative infrastructure is represented by 10 special economic zones (including 1 independent cluster fund), 19 technoparks, 29 centers of technology commercialization, 4 design engineering bureaus, and 6 international centers of technology transfer and 2 innovation clusters. According to the results of the performed SWOT analysis, the innovative infrastructure existing in the republic is in the imperfect state. It is described by a small number of infrastructure links, their regionally and functionally unbalanced allocation, as well as weak links between them. Other internal factors hindering its development include poor personnel pool, lack of the methodological procedures for quality monitoring, analysis, assessment and forecasting of the innovative infrastructure development, as well as immature infrastructure links supporting high-tech sector and the low level of integration of science, education and production.

The following strategic areas of the development of the Kazakhstan innovative infrastructure are suggested at the expense of the use of opportunities of the external environment in order to minimize the impact of its weaknesses:

- Development of infrastructure links supporting high-tech and science-driven industries at the expense of the transfer of advanced technology and the development of creative industries;
- Inclusion of the existing research centers, universities and centers of scientific and technical information in the human resources and information infrastructure of the Kazakhstan innovation system, transfer of advanced information technology for the purpose of creation of the sales infrastructure (e.g. creation of electronic innovation exchange, etc.);
- Modernization of the existing infrastructure links and development of new ones to support new industries and transfer the advanced technology (e.g.

use the opportunities of holding the international exhibition "EXPO-2017: Energy of the Future" to develop the "green" economy in the country);

- Inclusion of the existing elements and creation of new elements of the knowledge infrastructure in the Kazakhstan innovative infrastructure based on the experience of China and the EAEU member states in order to form a supra-national innovation system;
- Formation and functioning of the infrastructure links of the innovation system on the principles of the "triple helix" using the mechanism of a state-private partnership;
- Systemization of the activities of the elements of innovative infrastructure and submission of their development strategies to a single plan of the innovative scientific and technical development, as well as the development of the national and regional programs for the development of the Kazakhstan innovative infrastructure given the real production, potential new productions and integration processes (cooperation within the framework of the Silk Road Economic Belt, EAEU);
- Development of methodological and statistical basis for quality monitoring, analysis, assessment and forecasting of development of the innovative infrastructure.

The suggested set of strategic measures is listed in descending order of priority and requires urgent attention, but at the same time does not negate the need to move forward in other areas as well, using the strengths of the Kazakhstan innovative infrastructure and mitigating the impact of external threats.

The obtained results can be of a subjective nature. However, due to the lack of methodological and statistical basis for quality monitoring and analysis of the innovative infrastructure development, the results of this study can be considered in order to determine the status and priority areas of development of the Kazakhstan innovative infrastructure, in particular when developing the state policy in the field of science, innovation and technology.

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