

IMPLEMENTATION OF NINTH SUSTAINABLE DEVELOPMENT GOAL IN KAZAKHSTAN: CHALLENGES AND OPPORTUNITIES

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Abstract. Kazakhstan's sustainable development is based on the integration of national economic strategies in line with international initiatives such as the UN Sustainable Development Goals (SDGs). One of the key objectives of SDG 9, "Building resilient infrastructure, promoting inclusive and sustainable industrialization and innovation," is to enhance scientific research and technological potential, which is closely linked to increased investment in research and development (R&D) and the development of human resources.

In this study, the authors address the problem of insufficient R&D funding, low business participation, and scarcity of researchers in Kazakhstan. These aspects, despite their crucial role in sustainable development, remain unresolved. Based on the regression analysis data and international experience, solutions to improve the situation in the country have been proposed.

Key words: research and development, innovation, sustainable development goals, economic growth.

Аңдатпа. Қазақстанның орнықты дамуы БҰҰ-ның Орнықты даму мақсаттары (ОДМ) сияқты халықаралық бастамаларға сәйкес ұлттық экономикалық стратегиялардың интеграциясымен байланысты. "Берік инфрақұрылым құру, ауқымды және тұрақты индустрияландыру мен инновацияларға жәрдемдесу" атты орнықты дамудың тоғызыншы мақсатының негізгі міндеттерінің бірі ғылыми-зерттеу және тәжірибелік-конструкторлық жұмыстарға (ҒЗТҚЖ) инвестициялардың өсуі және кадрлық елеуетті дамытумен тығыз байланысты ғылыми зерттеулер мен технологиялық елеуетті жандандыру болып табылады.

Бұл зерттеуде ҒЗТҚЖ-ны қаржыландырудың жеткіліксіздігі, бизнестің қатысу үлесінің төмендігі және Қазақстандағы зерттеушілер санының аздығы сияқты мәселелер қарастырылады. Бұл аспектілер, тұрақты дамудағы маңызды рөліне қарамастан, толық шешілмеген күйінде қалып отыр. Сондықтан, берілген мақалада регрессиялық талдау және халықаралық тәжірибе деректеріне салыстырмалы талдау негізінде елдегі жағдайды айтарлықтай жақсартуға бағытталған ұсыныстар келтірілген.

Түйін сөздер: ғылыми-зерттеу және тәжірибелік-конструкторлық жұмыстар, инновациялар, тұрақты даму мақсаттары, экономикалық даму.

Аннотация. Устойчивое развитие Казахстана связано с интеграцией национальных экономических стратегий в соответствии с международными инициативами, такими как цели устойчивого развития (ЦУР) ООН. Одной из ключевых задач 9 ЦУР «Создание стойкой инфраструктуры, содействие всеохватной и устойчивой индустриализации и инновациям» является активизация научных исследований и технологического потенциала, что тесно связано с ростом инвестиций в научно-исследовательские и опытно-конструкторские разработки (НИОКР) и развитием кадрового потенциала.

В данной статье рассматривается проблема недостаточного финансирования НИОКР, низкая доля участия бизнеса и нехватка количества исследователей в Казахстане. Данные аспекты, несмотря на их ключевую роль в устойчивом развитии, остаются не до конца решенными. На основе данных регрессионного анализа и международного опыта представлены рекомендации по улучшению ситуации в стране.

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Ключевые слова: научно-исследовательские и опытно-конструкторские разработки, инновации, цели устойчивого развития, экономический рост

Introduction

Integration of the research and development (R&D) with sustainable development goals (SDGs) provides a strategic framework for tackling global challenges such as biodiversity loss, resource scarcity, and social inequalities. Investment in clean technologies, such as carbon capture and storage, energy-efficient systems, and sustainable agriculture practices are important for fostering environmental sustainability while supporting economic growth [1-3]. Additionally, R&D in social sciences plays a crucial role in addressing the societal dimensions of sustainability, including poverty alleviation, health equity, and education, by providing evidence-based strategies for policy implementation.

Therefore, sustainable development is becoming a major topic in science, technology, and innovation policies and has taken center stage in academic discussions on socioeconomic renewal. The existing literature focuses on innovation and intense research and development efforts in integrating the sustainability principles into the current socio-technical systems. Nonetheless, persistent worries about the slow and insufficient results of R&D investments over time have resulted in a persistent decline in spending [4].

President Kassym-Jomart Tokayev in his State of the Nation Address emphasized the

importance of fully developing the industrial potential of the country. Over the years of independence, there have been some achievements in this area, but it has not been possible to realize the full potential of the domestic market. Two thirds of the processed goods are imported from other countries [5].

In this regard, in order to ensure the strategic self-sufficiency of the economy, the President of the country set the task of developing new industries in ferrous and non-ferrous metallurgy, petrochemistry, automotive and mechanical engineering, the production of building materials, food and other sectors.

To achieve these indicators, it was noted that the legislative framework had been updated, important industries had been defined, key export priorities had been identified, and government support measures had been expanded.

Research and development plays a key role in the sustainable development of Kazakhstan, as it contributes to innovation, technological progress and the solution of socio-economic and environmental problems. Table 1 represents the impact of R&D on various aspects of sustainable development in Kazakhstan.

Table 1 – Impact of R&D on sustainable development in Kazakhstan

№	Category	Impact
1	Economic growth and economic diversification	R&D contributes to the development of new technologies and industry, helping to diversify Kazakhstan's economy, which traditionally depends on the extraction of natural resources. Through research and innovation, it is possible to create new industries such as high-tech manufacturing, renewable energy, agriculture using new technologies, as well as the creation of start-ups and small innovative enterprises. This is an important step for a country seeking to reduce its dependence on oil and gas.
2	Environmental sustainability	Kazakhstan is facing a number of environmental problems, such as aridity, pollution of water and soil, and deterioration of ecosystems. R&D can contribute to the development of environmentally friendly technologies such as renewable energy sources (solar, wind), water and air purification technologies, sustainable agriculture and natural resource management. The application of innovative solutions in the field of ecology will help reduce the burden on the environment and reduce the country's carbon footprint.
3	Social development	R&D can contribute to improving the quality of life of citizens of Kazakhstan through the development of new medical technologies, improving infrastructure, solving problems with transport and communications. For example, the

		development of innovative educational programs and online solutions will enhance education, and the introduction of telemedicine will improve access to medical services in remote regions.
4	Energy efficiency and sustainability	The development of R&D in the field of energy helps to increase the efficiency of the use of traditional energy sources and the introduction of technologies for the use of renewable energy sources. In the context of global climate change, Kazakhstan needs to switch to green energy, as well as develop new approaches to improving energy efficiency at the level of industrial enterprises and in household consumption.
5	Development of human resources and intellectual potential	Investments in R&D require a high level of qualification of employees. This creates opportunities for improving the level of education, developing scientific potential and training highly qualified specialists. Sustainable development in Kazakhstan will depend on the ability to train and attract personnel who can work in innovative sectors of the economy.
<i>Note – compiled by authors</i>		

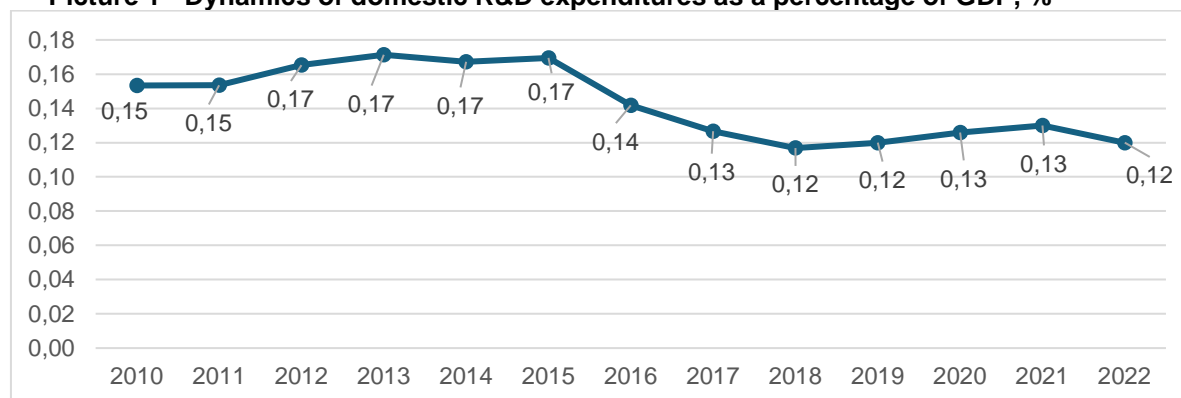
Based on the information in the table above, it can be stated that R&D is an important tool for the implementation of sustainable development in Kazakhstan. It contributes to economic diversification, improvement of the environmental situation, quality of life and development of human capital. Therefore, it is crucial for Kazakhstan to continue investing in scientific research and innovation to ensure the long-term sustainability and competitiveness of its economy in a global context.

For the purpose of this research the authors compared and contrasted the amount of domestic R&D expenditures as a percentage of GDP in Kazakhstan and foreign countries. Moreover, the regression analysis was used to determine the impact of internal R&D costs on the number of research specialists.

Findings and discussion

Research activities are directly related to the development of the intellectual potential of the country. The introduction of innovative technologies requires the availability of qualified personnel, which stimulates the development of the educational system and the training of specialists in high-tech industries. The quality of education and scientific potential is a key factor in ensuring sustainable economic growth and competitiveness. An important aspect is also the attraction of foreign specialists and partnerships with international scientific centers, which contributes to the integration of Kazakhstan into the global scientific and technological network. According to the data provided on Picture 1, domestic R&D expenditures as a percentage of GDP in 2022 decreased by 0.03 percentage points (from 0.15 to 0.12) compared to 2010. At the same time, in 2012 (0.17) increased by 0.02 percentage points and retained its position until 2015.

Picture 1 - Dynamics of domestic R&D expenditures as a percentage of GDP, %



Source: [6]

In 2022, domestic R&D expenditures as a percentage of GDP exceed the national average in Mangystau (0.33) and North Kazakhstan (0.42) regions, as well as in Astana (0.22) and Almaty (0.25) cities. Low rates in Akmola (0.05), Aktobe (0.04),

Almaty (0.03), Atyrau (0.00), West Kazakhstan (0.02), Karaganda (0.07), Kostanay (0.02), Kyzylorda (0.02), South Kazakhstan (0.00) Pavlodar (0.02) Turkestan (0.02) regions, Zhetisu (0.01) and Ulytau (0.00) regions.

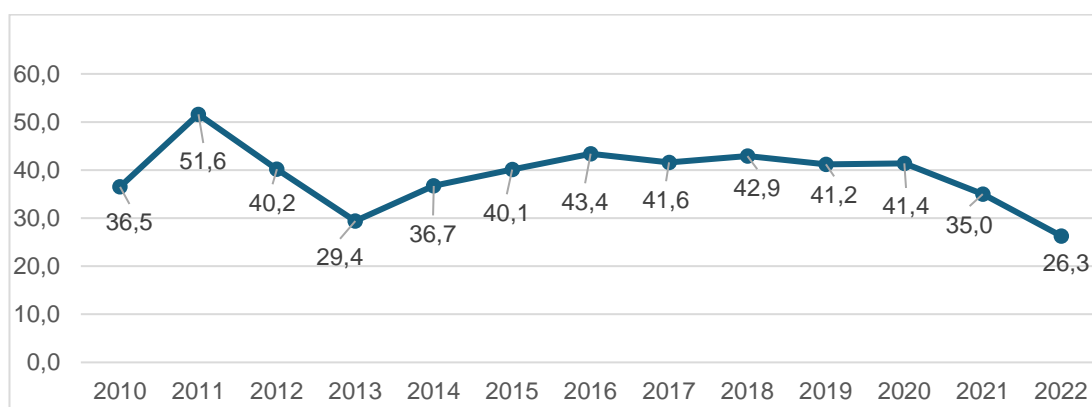
That is the reason why Kassym-Jomart Tokayev emphasized that "along with the state budget, funds from subsurface users and national companies, the key source of financing for science should be the large private sector – industrial corporations and other organizations" [7]. Experience from around the world demonstrates that, in addition to the government and the large private sector, small and medium-sized enterprises play a significant role in the implementation of R&D. Greater mobility, readiness to take chances and make changes, and flexibility in responding to market demands are characteristics of small and medium-sized businesses. Through the efforts of investment funds, small and medium-sized enterprises engage in R&D utilizing a venture method in numerous countries, where they receive government backing and tax incentives.

Investments in research and development (R&D) are important to the strategy of long-term business development and competitiveness. In a dynamic market and an accelerating pace of technological change, continuous investments in R&D enable organizations to create new and improve existing products and services. These processes ensure the generation of innovations, which is a source of competitive advantages in an environment where the demand for high-quality and technologically advanced products is constantly growing. In addition, the development of new technologies can significantly reduce production costs, improve product performance, and open up new market segments.

Furthermore, investing in R&D enhances a company's ability to adapt to changes in the market environment, such as changing consumer preferences, legislative requirements, or economic fluctuations. Forecasting and implementing technological changes in R&D processes allows an organization not only to respond to current trends, but also to proactively prepare for possible transformations in the industry. Thus, R&D becomes the main tool for ensuring sustainable long-term growth of the company, reducing the risks associated with technological lag and changes in the external environment.

R&D includes not only the development of new products, but also the improvement of production technologies, which directly affects business efficiency. The development and implementation of new production or management methods can significantly reduce operating costs, increase productivity, and improve quality control. In this context, R&D expenses can be considered as investments in improving operational efficiency and reducing costs, which has a positive impact on the overall financial stability of the company. The share of business expenses in total R&D costs in 2022 compared to 2010 (from 36.5 to 26.3) are shown in the picture 2. According to statistics data, in 2011 there was an increase in the share of business expenses in total (51.6%), but the positions were not maintained and in 2013 it dropped to 29.4%. A positive trend has been observed from 2013 to 2020 (41.4%).

Picture 2 - Dynamics of the share of business expenses in total R&D costs, %



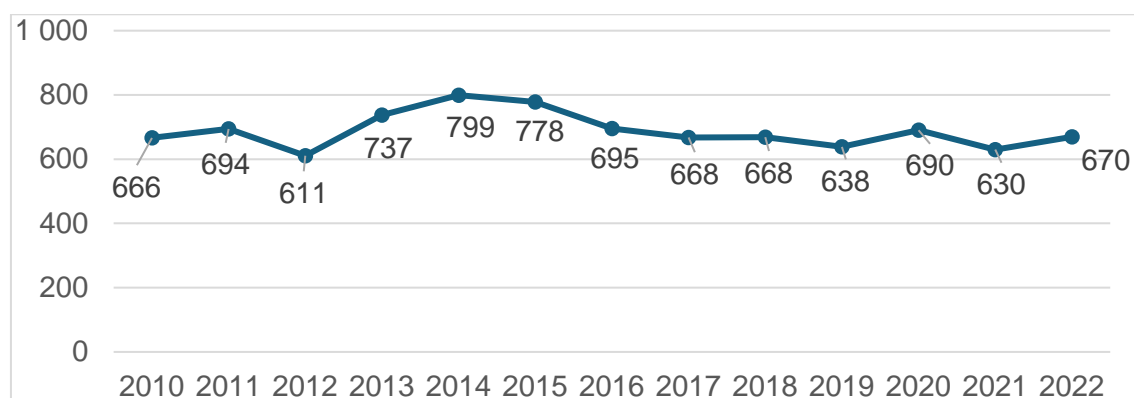
Source: [8]

The company's active innovation activities contribute to the creation of favorable conditions for attracting highly qualified specialists and scientists. Having a strong scientific and research base makes the organization more attractive to talented personnel who seek to work in a dynamic and developing company. As a result, the organization gets access to new ideas, advanced working methods and high competencies, which accelerates the processes of innovative development. Thus, R&D expenses are of strategic importance for an organization, as they ensure not only technological development,

but also increase the business' resilience to external risks, optimize internal processes, and strengthen its competitive position in the market. In modern conditions, where innovation is becoming the main success factor, these costs inevitably occupy a significant share in the structure of total business costs.

According to the UN Sustainable Development Goals, the number of research specialists (equivalent to full-time employment) performing R&D in the country in 2022 amounted to 670 people per 1,000,000 people (Picture 3).

Picture 3 - Dynamics of the number of research specialists (in full-time equivalent) who performed R&D, people per 1,000,000 inhabitants



Source: [9]

The largest number of research specialists are concentrated in the Abai region (7%), Mangystau region (7.8%), Astana (18.9%) and Almaty (29.3%). Low rates are noted in Almaty (1%), Atyrau (0.7%), South Kazakhstan (0.0%), Turkestan (0.9%) regions and Ulytau region (0.1%). This trend has been maintained since 2010 and there are no significant changes.

The regression analysis revealed a positive relationship between the internal costs of research and development (R&D) and the number of research specialists employed in this field. The increase in internal R&D costs increases the number of specialists involved in scientific research. The trend indicates that investments in the scientific field, including financial and technical support, create favorable conditions for attracting qualified personnel.

The growth of investments in R&D, including through government programs, contributes not only to an increase in the number of specialists, but also to the development of their professional skills, the creation of new jobs and the strengthening of human resources. This, in turn, has a positive effect on the level of innovation in the economy, improves the country's competitiveness in the international arena and contributes to the sustainable development of the scientific and technical sphere.

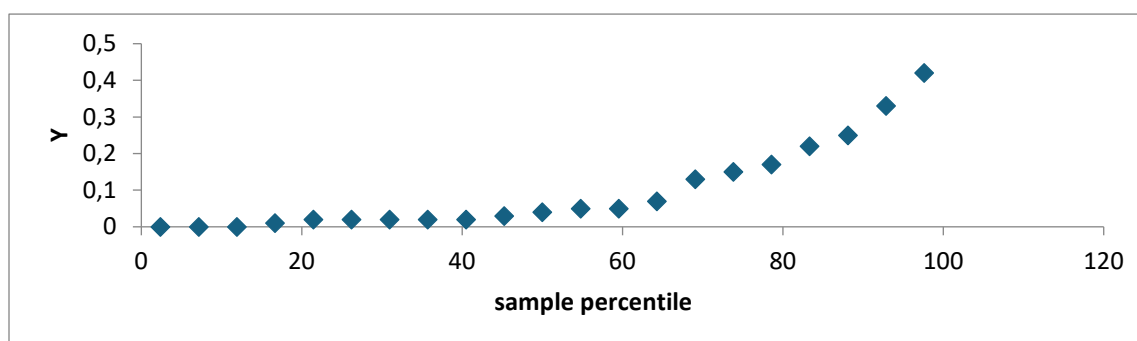
It should be noted that increased R&D funding encourages the creation of new research centers, infrastructure improvements, and the introduction of modern technologies. These measures will interest young professionals, which helps to increase their number, but also strengthen the educational base that supports the constant replenishment of staff.

Table 2 – Regression analysis

N=13	Regression results for the dependent variable: The number of research specialists (in full-time equivalent) who performed R&D, $R = ,61413962$ $R^2 = ,37716747$ Adjusted $R^2 = ,16955663$ $F(3,9) = 1,8167$ $p < ,21422$ Std. Error of estimate: 50,129					
	Beta	Std.Err. of beta	b	Std.Err. of b	t(9)	p-value.
Intercept			213,953345	346,392212	0,61766211	0,552104
The share of business expenses in total R&D costs	0,06316588	0,29756557	0,54139685	2,55044424	0,21227551	0,83662182
Domestic R&D expenditures as a percentage of GDP	1,01084079	0,57110247	2666,60831	1506,57414	1,76998147	0,11050974
Investments in fixed assets	0,51517562	0,58358872	1,5046E-05	1,7044E-05	0,88277172	0,40032378

Note: Compiled by authors

Picture 4 - Graph of the normal distribution



Note: Compiled by authors

Based on the data above, it can be concluded that internal R&D costs have a significant impact on the number of research specialists. Therefore, it can be stated that the higher internal R&D costs, the higher the number of research specialists. Increased funding may make it possible to attract qualified talents, create new jobs, or offer more competitive conditions for researchers.

The analysis shows that internal R&D costs have a significant impact on the number of research specialists. This indicates the importance of investment support for scientific research, which in the long term will contribute to the development of scientific and technical potential and economic growth. Therefore, the Head of State also noted the need to ensure stable and decent salaries for leading scientists, including it in the basic financing of science. In addition, at a meeting of the National Council of Public Trust, he instructed them to introduce direct financing of research institutes engaged in fundamental science [10].

The main problem, he noted, is that a serious barrier to the development of fundamental science is the limitation of grants for three years. It is difficult to achieve any significant results in such a short time. In this regard, it is necessary to consider extending the terms of grant funding for science to five years. The Government is actively promoting the internationalization of higher education by attracting 23 well-known foreign universities to the country. It was noted that it is necessary to create conditions for their effective work, including a gradual increase in the state order for training specialists.

In addition, similar support measures will be directed at domestic universities, where educational programs meet modern standards. At the same time, funding is concentrated on universities capable of providing a high level of educational process, rather than being distributed across all educational institutions without taking into account their effectiveness.

It is necessary to strengthen the interaction of leading universities with the economic sectors, as well as to build an innovation policy in accordance with national scientific and technological priorities. This will provide new opportunities for applied research and accelerate the implementation of industry innovations.

The President of the Republic of Kazakhstan supports sending the scientists abroad for internships to exchange experience. The training of qualified specialists will be carried out not only at universities, but also in institutions of vocational and technical education. The government was also instructed to consider the possibility of hiring the best college graduates to work in sectoral government agencies, focusing on their achievements.

A comparative analysis of R&D costs as a percentage of GDP for Kazakhstan and several countries with similar economic structures (for example, Kyrgyzstan, Belarus, Uzbekistan, Turkey, Azerbaijan) shows the following trends from 2010 to 2022 (Picture 4):

1. Kazakhstan: R&D costs are decreasing from 0.17% in 2010 to 0.12% in 2022. The reasons include a low level of

innovation activity and limited R&D funding from businesses.

2. Kyrgyzstan: Similarly to Kazakhstan, the share of R&D costs is small, starting from 0.15% in 2010 and decreasing to 0.11% in 2022. Limited resources and low priority of research are the main factors.

3. Belarus: Higher cost level compared to Kazakhstan: 0.59% in 2010 and 0.64% in 2022. This is due to the strong emphasis on applied research, especially in technical and engineering fields.

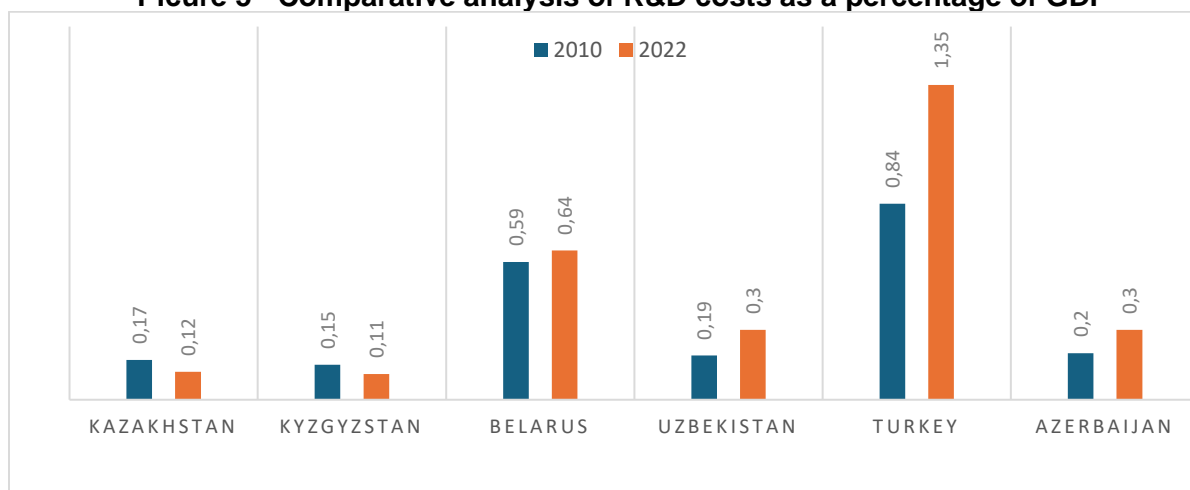
4. Uzbekistan: The level of R&D has been gradually increasing: from 0.19% in 2010 to 0.3% in 2022. This is due to the active government support for educational and scientific programs.

5. Turkey: More significant investment in R&D: from 0.84% in 2010 to 1.35% in 2022. The main drivers are the development of technology, especially in the defense industry and the IT sector.

6. Azerbaijan: The share of costs fluctuated around 0.2–0.3%, which is due to limited research in the industrial sector, but there is growth in the field of digitalization and technology.

According to this analysis, it is noticeable that Kazakhstan lags behind its partners in the EAEU and comparable countries such as Turkey and Belarus in terms of investment in research and development. This reduces the country's competitiveness in the field of innovation.

Picture 5 - Comparative analysis of R&D costs as a percentage of GDP



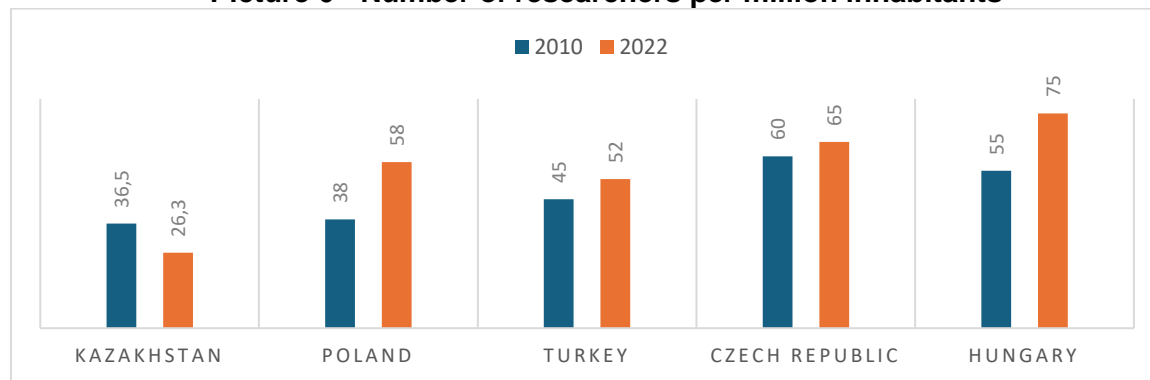
Source: [11]

To improve the situation, Kazakhstan should focus on more efficient allocation of budget funds and attracting private investment in research activities, as Turkey and Belarus are doing.

If we conduct a comparative analysis of the share of business expenses

in total R&D costs and the number of researchers (per million inhabitants) for Kazakhstan and comparable countries based on data from 2010-2022, it shows the following picture (Picture 6)

Picture 6 - Number of researchers per million inhabitants



Source: [12]

Based on the comparative analysis it can be stated that share of business in R&D costs in Kazakhstan remains relatively low, 36.5% in 2010 and 26.3% in 2022. The main financing is provided from the state budget, which indicates insufficient involvement of the private sector, lack of strong investment incentives (tax incentives or subsidies), insufficient development of venture capital, and the predominance of the raw materials economy, which does not require high R&D costs.

In Poland in 2022, the share of business in R&D investment reached 58%, which is higher than in Kazakhstan. This is due to the active encouragement of the private sector to participate in research, including grants, subsidies, and partnerships with universities. Poland actively uses EU funds to support R&D, which also contributes to the growth of the business share.

Meanwhile in Turkey the business share increased from 45% in 2010, to more than 50% in 2022. The growth is associated with an emphasis on technological development, the creation of technology parks and the stimulation of small and medium-sized businesses (SMEs) through support programs. Turkey focuses on the

commercialization of scientific developments, which attracts business.

In Czech Republic the private sector financed 60% of R&D costs in 2010, and this figure has increased to 65% by 2022. A significant share is accounted by high-tech industries (for example, automotive, pharmaceuticals).

In Hungary the share of business rocketed from 55% to 75% by 2022. The main investments come from multinational corporations, which is driven by the attraction of foreign direct investment in research and development.

Number of researchers per 1 million inhabitants:

1. Kazakhstan: In 2020, this figure was approximately 715 people per million inhabitants, which is significantly lower than the European average.

2. Poland: About 1,500 researchers per million inhabitants, which is twice as many as in Kazakhstan.

3. Turkey: The figure is about 1,200 people per million, due to the expansion of university and corporate research.

4. Czech Republic and Hungary: In both countries, the number of researchers exceeds 2,000 per million inhabitants due to systematic measures to support R&D and attract personnel from abroad.

Conclusion and recommendations

The role of research and development in promoting sustainable development is multifaceted and indispensable. R&D serves as the cornerstone for driving technological and methodological innovations that address the complex interdependencies between

environmental preservation, economic growth, and social equity. Through scientific inquiry and technological advancement, R&D fosters the development of novel solutions to mitigate the adverse effects of climate change, optimize resource utilization, and reduce environmental degradation. Moreover, R&D facilitates the transition to a circular

economy by enabling the design of sustainable production processes, renewable energy technologies materials with reduced environmental footprints. To increase the level of R&D costs in Kazakhstan and improve the overall innovation environment, it is necessary to develop a detailed step-by-step algorithm, including:

1. Analyze the current situation in the country and identify the reasons for the low level of investment in R&D:
 - assess the current amounts and sources of R&D financing (public, private, international);
 - learn from the best practices (Turkey, Belarus);
 - identify weaknesses: lack of personnel, inefficient use of funds, weak connection between science and business.

2. Develop incentive strategies and create incentives for the growth of R&D investments:

- develop tax incentives for companies investing in R&D;
- increase the amount of grants to support innovative projects;
- simplify procedures for attracting foreign investments in scientific projects.

We believe that the implementation of these mechanisms will allow Kazakhstan not only to increase the level of investment in R&D, but also to create a more sustainable innovation ecosystem focused on long-term development, including:

1. To increase the share of R&D in GDP to 0.5-1% in the next 5 years;
2. Increase the number of innovative enterprises;
3. Increase Kazakhstan's position in the Global Innovation Index [13].

The successful realization of sustainable development hinges upon the synergistic collaboration between governmental agencies, private sector entities, academic institutions, and non-governmental organizations. Multidisciplinary and cross-sectoral partnerships are essential for

3. It is necessary to strengthen the scientific infrastructure and create modern conditions for research.

- upgrade equipment at key research institutes;
- direct investments into digitalization of research processes.

4. One of the important factors is the development of human resources, professional development and an increase in the number of specialists in science:

- increase funding for personnel training programs;
- develop internship programs for scientists abroad;
- create conditions for the return of Kazakhstani scientists from abroad and attract foreign scientists.

5. It is necessary to increase the links between business and science, to integrate science into the production process:

- to organize platforms for interaction between scientists and business (forums, hubs);
- to introduce mechanisms for joint financing of R&D by private and public entities;
- implement innovatively effective pilot projects.

translating R&D outcomes into scalable solutions and ensuring their widespread adoption across diverse socio-economic contexts. As global sustainability challenges continue to evolve, sustained investment in R&D will be pivotal in developing adaptive, resilient, and inclusive systems that align with the long-term objectives of sustainability.

These measures will reduce the gap between Kazakhstan and more developed countries in terms of key indicators of innovation activity. To solve the problem of the low share of business in R&D financing and the insufficient number of researchers in Kazakhstan, it is necessary to take consistent steps, each of which is aimed at eliminating specific barriers.

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ҚАЗАҚСТАНДА ТОҒЫЗЫНШЫ ОРНЫҚТЫ ДАМУ МАҚСАТЫНЫҢ ІСКЕ АСЫРЫЛУЫ: СЫН-ҚАТЕРЛЕР МЕН МҮМКІНДІКТЕР

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ВНЕДРЕНИЕ ДЕВЯТОЙ ЦЕЛИ УСТОЙЧИВОГО РАЗВИТИЯ В КАЗАХСТАНЕ: ВЫЗОВЫ И ВОЗМОЖНОСТИ

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