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## THE IMPACT OF HUMAN CAPITAL AND TECHNOLOGY IN BUSINESS ON THE INNOVATION ECONOMY

**Abstract.** *Against the backdrop of economic transformations, Azerbaijan is trying to improve its competitiveness in the world. Innovations are becoming a key element of this process, and investments in education and training strengthen the basis for further changes. From this point of view, the item "The situation of the influence of business system development on national innovation activity in Azerbaijan requires strengthening the coordinated actions of both the state and the private sector in attracting investment, human capital and technological resources" in the research work. To confirm this position, we set ourselves the task of analyzing both theoretical approaches and the real situation in this area in Azerbaijan. Taking them into account, they were taken as quantitative and qualitative factors and analyzed on the basis of a fuzzy model using the MATLAB software package, and the methods of statistical comparative analysis and grouping were also used. The theoretical significance of the study lies in expanding the scientific approach to the issue of the influence of human capital, and technology on the formation of an innovative economy in the business system. The practical significance lies in the fact that the proposed results of innovative activity can be important in building an innovative economy in Azerbaijan and in studying the problems of increasing competitiveness.*

**Keywords:** *innovation, human capital, technology, national economy, education, sustainable development.*

### INTRODUCTION

Highly skilled employees play a key role in generating new ideas, quickly adapting to changes in technology and effectively implementing innovative solutions. The quality and composition of human capital, which is considered the main element in implementing the innovation process, primarily depends on the education system. An effective education system that instills critical thinking, creativity and problem-solving skills is essential for developing innovative capabilities. The results of international assessments show that countries with highly effective education systems often rank high in innovation indices. The second indicator is the quality of the workforce's skills. Research shows that the availability of a skilled workforce, especially in the fields of STEM (science, technology, engineering and mathematics), directly affects the development of technological innovation, and that countries with a large number of STEM graduates in their workforce usually demonstrate greater potential for innovation. The third indicator is lifelong learning and retraining, which means the ability of workers to constantly adapt and master new skills in the face of rapid technological change. Countries with strong lifelong learning and professional development systems tend to maintain their innovation advantages [20]. Azerbaijan has adopted the Law on Science, which regulates intellectual property issues. The National Academy of Sciences of Azerbaijan founded the Technology Transfer Center to fortify the bonds between sci-

ence and business. Companies utilize internship programs to increase the practical focus of the student education.

### LITERATURE REVIEW

The country's transition to an innovative economy requires the formation of a new development paradigm. The structure and size of knowledge-intensive sectors, which hasten the evolving scientific and the technical revolutions of business, serve as the foundation for this paradigm. Contradictions in society can become the engine of innovation — when the growing needs of people conflict with the limited resources to meet them, this can lead to the search for new solutions and technologies. Innovation is a complex, multifaceted phenomenon, the full understanding of which requires analysis from various economic points of view [3]

Scientific institutions form the basis of the knowledge production environment. Educational companies provide a mechanism for transferring knowledge to the business environment, contribute to the development of innovatively active companies. H. Etzkowitz and L. Leydesdorff present a "triple helix" model in innovation systems, showing the university-industry-government relationship as the main factor in innovative development and stating that they are the key to innovation and the production of new knowledge in a knowledge society. Hybrid organizations at the intersection of these three sectors — universities, industry and

government — allow for new organizational forms (e. g. corporate universities, technology parks). This approach is significant for business systems because it highlights how crucial information exchange and collaboration are to fostering innovation inside the business system [8; 11]. According to C. Freeman and B.-Å. Lundvall's "National Innovation Systems and the Concept of Interactive Learning", the innovation process is the outcome of intricate interactions between various organizations (businesses, government agencies, and universities) within a national economy. They note that national innovation systems, shaped by institutions, policies and historical context, play an important role in determining a country's innovation performance, while interactive learning and user-producer relationships play a central role in the innovation process in national systems. Their concept of national innovation systems allows us to understand how various elements within a country interact to stimulate innovation. Emphasizing the importance of business as a key element of a national innovation system, they consider the interaction of various elements of the business system and their collective influence on innovation results, noting that the institutional environment of innovation development plays an important role, and innovation plays an important role. The result is the interaction between various entities (companies, universities, states). The need to create an effect of interaction between various participants in the innovation process, policy and regulation of governments, financial systems. The activities of companies, universities and research institutes, training centers must be carried out in an interconnected manner in order to serve a specific purpose [4]. A number of resources are necessary for successful innovative development of the economy. According to the resource-based approach proposed by E. Penrose and J. Barney, unique (valuable, rare, inimitable and irreplaceable) resources and capabilities of a company, core competencies and capabilities contribute to competitive advantage and innovation [2]. A sufficient supply of scientific and technical personnel, financial and natural resources, as well as a developed infrastructure, which are considered the basis of knowledge resources, constitute the general level of innovative development of the economy, acting simultaneously as resources and factors serving innovative development. It should be noted that all these resources interact within the framework of certain economic relations, to one degree or another participate in the innovation process, ensuring the acquisition of an innovative product or service. At the same time, the results of one innovative activity can be used as an initial resource for the next in-

novative cycle, creating a continuous development process. Thus, human and intellectual resources include such indicators as the quantity, qualification and cost of labor, the level of education, which affects the quality of production and provision of services, scientific and technical information, as well as the quality of management, the quantitative and qualitative composition of employment. It should be noted that P. Romer emphasizes the role of knowledge and human capital as the main factors of economic growth, in contrast to traditional factors of production, in the "model of endogenous technological change in economic growth". He notes that most technological changes arise as a result of deliberate human actions in response to market incentives [13]. For this reason, users of products and services are increasingly able to implement innovations on their own, which leads to the democratization of the innovation process [6]. As a result, the growth of innovation and the ability to learn from others has a direct impact on productivity [15].

Technical and technological resources — machinery and equipment, devices, information and communication software, etc. include such indicators as The role of technological change in economic growth is undeniable. Long-term economic growth is primarily due to technological progress, not capital accumulation [17]. Therefore, the competitiveness of a country depends on the ability of its industry to implement innovations and modernize [14].

According to M. K. Atakishiyev and G. S. Suleimanov, the concept of innovation involves the use of the results of scientific and technological progress in market economy. This concept reflects activities that involve the introduction of new products and services to meet customer needs. At the same time, innovation includes the qualitative side of investments; it shows what purpose investments are used [1]. At present, the processes occurring in the world in accordance with the requirements of the third millennium require companies to establish activities in the area of innovative development. This determines the need to use new technologies and knowledge when building business systems. As a result, the technology should be adjusted taking into account the internal and external factors involved in the implementation of the goals and objectives set by the company. This is possible with the participation of personnel with certain knowledge and skills, as well as advanced management. According to expert estimates, the share of the intellectual component in the cost of products has been steadily increasing from about 3 % 30 years ago to 65–70 % now. In economically developed countries, the share of new technologies, products

and equipment is up to 70–85 % of GDP growth, according to optimistic experts, up to 95 % [19].

#### **Analysis of the situation with human capital and innovation technology in Azerbaijan**

Analysis of the development of human capital and science in Azerbaijan showed that the Human Development Index of Azerbaijan in 2022 was 0,760, which allowed the country to enter the category of countries with high HDI and take 89th place among 193 countries in the world. Recently, the average life expectancy is 73,5 years, and the average length of education is 12,7 years. Every year, increasing in the number of educational institutions of all levels and the number of students studying in them (**Table 1**).

Expenditures allocated to science from the state budget increased from 9,3 million manat in 2000 to 143,6 million manat in 2020 and to 204,9 million manat in 2022. Expenditures on local research and development increased from 15,9 million manat in 2000 to 162,5 million manat in 2020. There was a significant increase in domestic current expenditures on research and development in all areas of science, especially in medicine (23 times) and the humanities (21,7 times). In 2022, science expenditures accounted for 4,7 % of all budget expenditures. However, the ratio of science expenditures to GDP remains stable at 0,2 % (**Table 2**).

Conducting research in the business sector is important for the formation and development of an

innovative economy. Unfortunately, compared to foreign countries, in Azerbaijan, there is a decrease in the number of companies whose research and activities are carried out by the business sector. It should be noted that the share of these companies decreased by 7 % in 2022 compared to 2005 (**Table 3**).

Analysis of the costs of scientific research of microenterprises for all types of economic activity in 2022 compared to 2021, including 1,2 times for microenterprises and 1,5 times for small enterprises, shows that the average number of business entities has increased by 1,2 times (**Figure 1**). The number of research organizations in the country decreased from 137 in 2000 to 131 in 2022, but the number of personnel engaged in scientific work increased from 15,809 in 2000 to 19,875 in 2022 (25,7 %). The number of researchers has increased by 1,5 times over 20 years (2000–2020), with the largest growth recorded in medicine (3,1 times) and social sciences (2,8 times). The share of women in science has increased from 50,5 % in 2000 to 57,6 % in 2020. There has also been an increase in the number of doctors and candidates of science among researchers (**Figure 2**).

Thus, it can be concluded that Azerbaijan demonstrates positive dynamics in the development of human capital and science. Investments in education and science, especially at the level of higher education, as well as the number of students and researchers in the field of scientific re-

Table 1

#### **Dynamics of human capital development indicators in Azerbaijan**

	<b>Average life expectancy</b>	<b>Average years of education</b>	<b>Years of schooling</b>	<b>GDP per capita, \$</b>	<b>Human Development Index</b>
1995	65,3	10,0	10,2	397,2	0,612
2000	66,8	10,4	10,6	662,9	0,640
2005	68,8	10,7	10,7	1579,8	0,679
2010	71,0	11,7	10,7	5922,0	0,740
2015	71,9	12,7	10,7	5561,5	0,758
2020	73,0	12,9	10,6	4272,2	0,756
2022	73,5	12,7	8,3	7806,4	0,760

**Source:** United Nations Development Programme.

Table 2

#### **Comparative analysis of research and development expenditures for 2021**

	<b>Israel</b>	<b>USA</b>	<b>Turkey</b>	<b>Azerbaijan</b>	<b>Georgia</b>
Expenditures relative to GDP	5,56	3,46	1,4	0,21	0,25

**Source:** Compiled by the author based on materials from [https://www.theglobaleconomy.com/rankings/research\\_and\\_development/%202022/](https://www.theglobaleconomy.com/rankings/research_and_development/%202022/).

Table 3

Distribution of research organizations by sector

	2005	2010	2020	2022
<b>Total</b>	<b>146</b>	<b>145</b>	<b>127</b>	<b>131</b>
state sector, in %	63,7	64,1	67,7	65,6
business sector, in %	11,6	9,0	3,1	4,6
sector of higher education, in %	24,7	26,9	29,1	29,8

Source: Compiled by the author based on materials from <https://stat.gov.az/source/industry/> (dated 06.08.2024).

search, are increasing. However, certain problems remain, such as the need to increase the share of expenditure on science in relation to GDP and further development of innovation infrastructure.

Significant growth was observed in the financing of education, which creates the basis for the training of qualified personnel for innovative sectors of the economy. Funds allocated for education from the state budget have increased significantly. If in 2021, 3277,7 million manats were allocated for this area, which is 49,5 % more than in 2019, then in 2022, 3886,6 million manats were allocated. The analysis shows that, despite a 2.1-fold increase in expenses on improving the level of professional training of employees, acquiring new qualifications, and improving their qualifications, the number of managers and specialists who improved their qualifications decreased by 2.1 times. If the first case is positive, then the second case should be considered as a negative indicator.

Over the 12 years analyzed, there was an increase in professional training of personnel by

1.1 times, and expenses allocated for education from the state budget increased by 3 times. The analysis shows that the number of students in higher education institutions is increasing, for example, from 140,241 people in 2010 to 212,173 people in 2022, and this increase was 1.5 times. The number of students admitted to the Master's program has also increased: if in the 2015/2016 academic year it was 4953 people, then in the 2021/2022 academic year it reached 10877 people, which is 2.1 times more. The increase in the number of students in higher education institutions indicates an increase in the potential human capital of innovative enterprises. From 2015 to 2022, there was an increase in the number of students admitted to the Master's program in the group of technical and technological specialties by 198,4 %. This indicates an increase in the training of technical and technologically qualified specialists capable of working in innovative industries.

The analysis shows that in 2022, compared to 2012, the specialties of health care, social security,

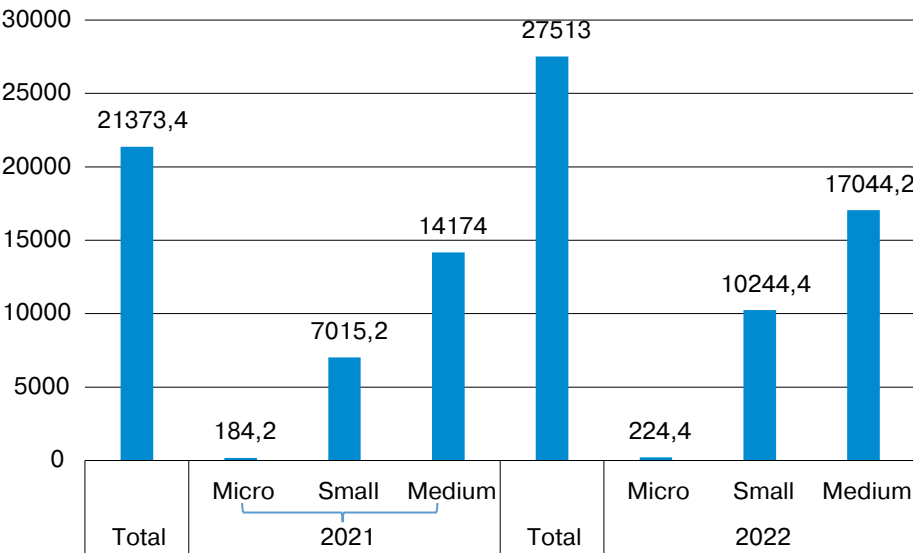


Figure 1. Diagram. Expenses on scientific and research work for all types of economic activity in entrepreneurial enterprises, thousand mantas

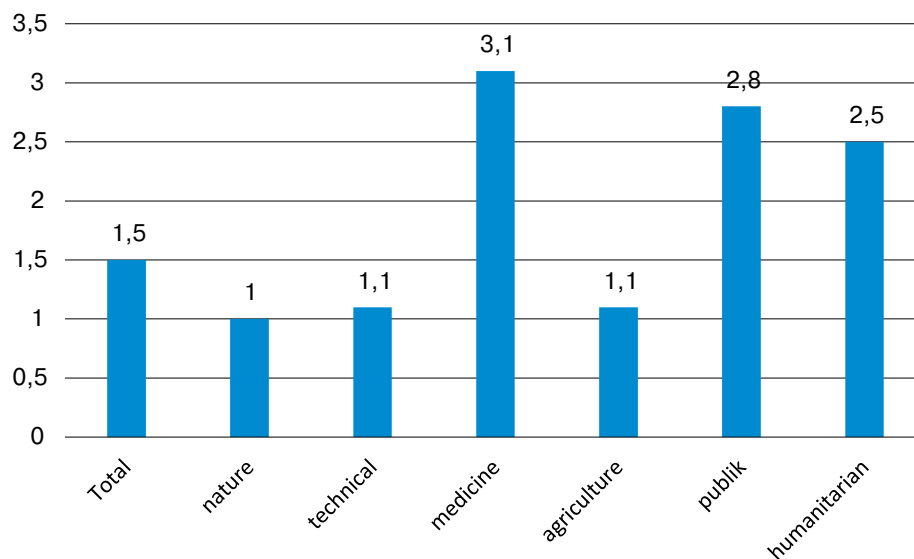
Source: Compiled by the author based on materials from: <https://stat.gov.az/source/industry/>.

and services occupy the first place, technical and technological specialties second, economics and management third, and agriculture fourth.

Another element serving the innovative development of the country is the production of innovative machines and equipment. In general, the analysis of the development of this sphere in the country shows that, although there was no radical change in the number of state enterprises in this sphere for 2015–2022, the number of non-state enterprises increased by 1.8 times, and the number of private entrepreneurs registered for

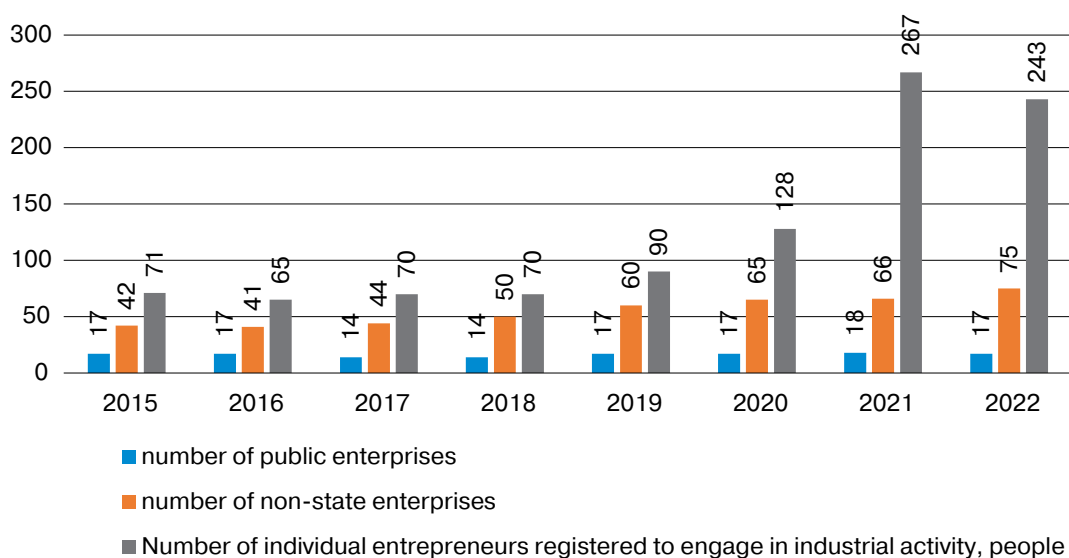
production activities increased by 3 times; there was an increase by 4 times (**Figure 3**). This indicates a growing interest of business structures in the production of technologies that can play the role of potential and a platform for innovative development.

The analysis also shows an increase in the production of machinery and equipment during 2015–2022. Thus, the index of industrial production increased by 1.9 times, the index of physical volume of industrial production — by 2.2 times. The greatest growth will occur in 2022, and it is positive



**Figure 2.** Diagram. Growth in the number of researchers in 2000–2020, times

**Source:** Compiled by the author based on materials from: <https://stat.gov.az/source/industry/>.



**Figure 3.** Diagram. The number of enterprises producing machinery and equipment, units

**Source:** Compiled by the author based on materials from: <https://stat.gov.az/source/industry/>.

that this growth indicates an increase in the volume of output in the industrial sector (**Figure 4**).

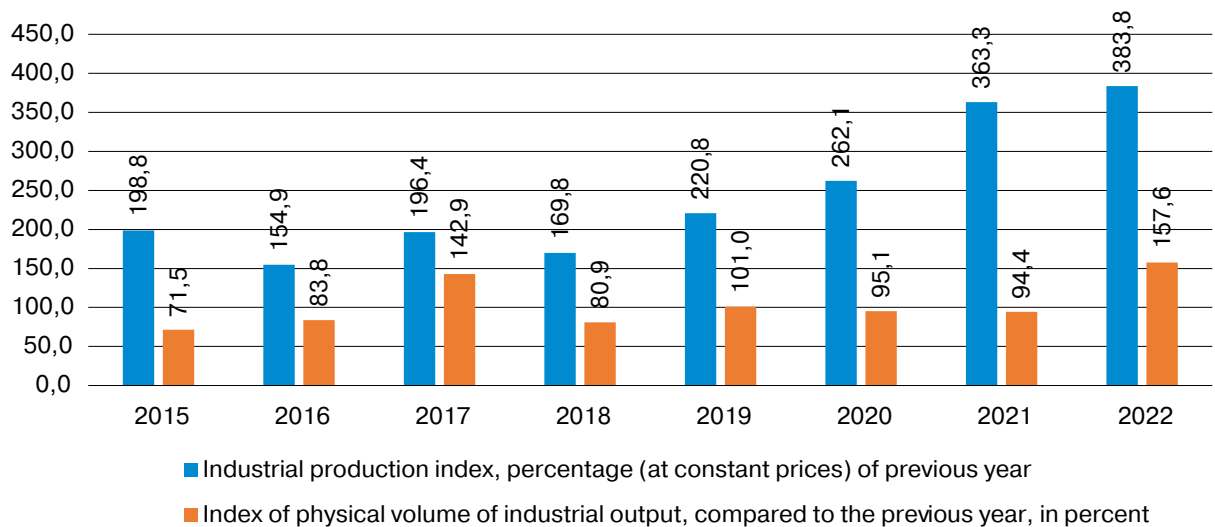
The analysis shows that the share of the sector in the total volume of industrial output in the country in 2022 compared to 2015 decreased from 0,8 % to 0,4 %, while the share of the non-state sector in this sector remained unchanged at 0,1 %.

To achieve this, it is necessary to increase the activity of business structures in this area.

It should be noted that small and medium entrepreneurs engaged in innovative activities receive additional benefits. According to new initiatives, they are exempt from profit and income taxes for up to three years from the date of receiving the Startup Certificate. In 2021, 27 small businesses received such a certificate, and in 2022, their number reached 78. According to the results of 2023, 164 startups were registered in the country, which demonstrates positive dynamics in the field of entrepreneurship support. One of the important trends in modern business is the active involvement of micro, small, and medium enterprises in the world of e-commerce platforms. In this regard, special attention is paid to the *www.kobmarket.az* resource, which serves as an effective tool for expanding sales opportunities and improving interactions between entrepreneurs and their customers. The main objective of this portal is to satisfy the needs of both businessmen and buyers as much as possible, which makes it an important part of the market. Such platforms actively contribute to the development of e-commerce, which has a positive effect on the digitalization process for both small and medium-sized enterprises and their customers, being an important tool for increasing sales and

entering new markets. The portal *www.kobmarket.az*, created with the support of KOBIA, is aimed at expanding online sales opportunities for small and medium entrepreneurs. Currently, entrepreneurs registered on the portal have created more than 90 online stores offering a wide range of products, including food, household appliances, clothing, and many other categories of goods. This provides access to the market for more than 1,500 products, which creates additional opportunities for entrepreneurs. An important aspect of the portal is the convenient registration procedure, which allows new businessmen to open their online stores and start selling without additional costs. Also, a convenient reporting system allows them to monitor the effectiveness of their sales. Currently, active work is underway to stimulate businesses to use the portal's capabilities more widely. One of the main tasks is to update and improve modern electronic methods, which will certainly have a positive effect on the pace of sales. In addition, it is planned not only to expand the range of products but also to actively add services, which will make the platform even more convenient and multifunctional for users.

The Information Technology Development Fund has been established in Azerbaijan, which provides grants and soft loans to IT startups. Startup.az is a platform that provides detailed information about the startup ecosystem in Azerbaijan — startups on the market, investors, financial funds, incubation, and acceleration centers created to support startups through a single portal and on this platform. As of August 10, 2024, 157 startup projects have been implemented in 17 areas (<https://www.startup.az/>)



**Figure 4.** Diagram. Production of machinery and equipment in Azerbaijan

**Source:** Compiled by the author based on materials from: <https://stat.gov.az/source/industry/>.

startup.html). The High Technologies Park of ANAS operates and supports infrastructure and technology startups. The Innovation and Digital Development Agency was created to promote innovation in business. The Digital Azerbaijan program is being implemented, aimed at digitalizing the economy.

Global experience in implementing innovations demonstrates the availability of appropriate legislative and regulatory support. These include:

- Clear definition of ownership of state-funded research;
- Definition of responsibility for financing innovative projects;
- Creation of favorable conditions for the formation of companies specializing in the commercialization of scientific work;
- Development of mechanisms for the participation of universities, scientific institutions, and individual researchers in the creation of start-ups, including the possibility of acquiring a share in the capital of such companies.

It should also be noted that a certain procedure has been established for companies presenting their ideas to obtain start-up certificates issued by the Agency for the Development of Small and Medium-Sized Businesses. This certificate is a quality mark and additionally confirms the innovative potential and commercial attractiveness of the projects. Projects that received this certificate were also supported by grant funds, which allowed them to develop their ideas and bring them to life.

It is also important to understand the criteria by which a start-up has the right to certification. Firstly, the founders of a startup must not have a controlling stake in a legal entity operating in the medium or large business sector; their share must not exceed 49 %. This provision is aimed at supporting aspiring entrepreneurs and preventing larger business structures from influencing the development of startups. In addition, the main thing is that the products or services provided by start-ups must be truly competitive and stand out from similar offers on the market. Projects must also be profitable and demonstrate real potential for increasing demand for their products or services over the next three years. Of course, a focus on innovation has become one of the decisive criteria: each idea must involve the creation of added value either through new solutions in production processes or through the introduction of new technologies that can optimize and improve current business operations.

The vector of the strategy for supporting and developing small and medium-sized businesses through electronic trading platforms, as the experience of *www.kobmarket.az* shows, is aimed at integrating innovative solutions and creating

new opportunities for trade and services. Including strengthening direct interaction between aspiring entrepreneurs and potential investors. This creates a healthy competitive environment and contributes to the comprehensive development of the business environment in the country. It should also be noted that the work carried out around the *www.kobmarket.az* platform and supporting organizations can significantly change the face of business in the country. This will not only be a dynamic development of the market but also an opportunity for ordinary citizens to engage in entrepreneurial activity and take advantage of modern technologies and services. Effective interaction between science and business, as well as international exchange of knowledge and technology, play an important role in the formation of an innovative economy. By combining all these elements, it is possible to achieve sustainable economic growth and technological progress, which is especially important for countries in the process of transforming their economies. In fact, many developing economies have a clear advantage in this regard. They have high human capital, which does not always correspond to their income and economic development. In many developing countries, research projects are carried out by foreign companies through their subsidiaries, indicating a significant interdependence between the countries. This also means that many patents registered in these countries are actually owned or co-owned by foreign companies. Imports and exports of high-tech products often become important sources of new knowledge and technology for companies. International competition stimulates companies to develop innovative solutions and apply best practices. At the same time, the movement of people plays an important role in the process of knowledge transfer. International migration and exchanges contribute to a better implementation and application of advanced technologies. However, brain drain remains a serious problem for many developing countries, whose talents migrate to more developed countries. Successful technological progress requires constant generation of new ideas and their effective commercialization. Start-up founders and researchers who decide to found their own companies become key players in the process of commercializing their inventions. At this time, the development of a competitive environment, entrepreneurship, and new business initiatives play an important role. Competition and the threat of new players entering the market force existing companies to invest in research, development, and innovation. At the same time, new companies are often not shy about using modern technologies; even if they have mistakes, they make efforts to correct

them and introduce innovations faster and more effectively. Thus, the formation of an innovative economy in Azerbaijan requires a comprehensive approach to the development of human capital and technology. This involves not only investing in education and infrastructure but also creating a culture that encourages innovation, entrepreneurship, and lifelong learning. It is also important to find a balance between achieving technical skills and soft skills, which are becoming increasingly important in the era of automation and artificial intelligence.

Taking this into account, we will take them as quantitative and qualitative factors and analyze them based on a fuzzy model using the MATLAB software package.

We took the following indicators as factors influencing the volume of Azerbaijan's GDP:

- The volume of innovative products in the industry as a whole, thousand dollars;
- Costs of technological innovations in the entire industry at the expense of enterprises' own funds, thousand dollars;
- The quality of innovation management in the entire industry;
- The quality of innovative research in the entire industry;

- The quality of labor force skills stimulates innovation in the entire industry.

As can be seen, many of these factors have fuzzy properties. Therefore, to determine the influence of the above factors influencing the volume of GDP in Azerbaijan, the fuzzy rules of logical inference method was used (**Table 4**) [7; 9; 12; 16; 18; 21].

In order to build the model, we must first determine the input and output linguistic variables. Thus, the output linguistic variable is the volume of Azerbaijan's GDP. The input linguistic variables are the volume of innovation output in the entire industry, the costs of enterprises on technological innovation in the entire industry, the quality of management of innovation implementation in the entire industry, the quality of innovative research in general and the quality of the skills of the workforce implementing innovations in the entire industry. Let us designate these input and output linguistic variables as follows:

- Volume of Azerbaijan's GDP —  $y$ ;
- Volume of innovative products in the entire industry —  $x_1$ ;
- Costs of technological innovation in the entire industry at the expense of enterprises' own funds —  $x_2$ ;

Table 4

Statistical indicators of Azerbaijan for 2007–2022

Years	GDP, million \$	The volume of innovative products in the entire industry, thousand \$	Expenses of enterprises in all industries on technological innovations at their own expense, thousand \$
2007	33050,30	1428,4	29817
2008	48852,50	10415	7168,9
2009	44297,00	995	4465,6
2010	52909.30	7990,3	4465,5
2011	65951.60	34906,9	29119,9
2012	69683.90	30673,4	11677,7
2013	74164.40	15955,5	15776,8
2014	75234.70	17129,1	26942,2
2015	52996.80	1480,8	33894,6
2016	37862.80	22738,1	8952
2017	40867.90	8750,5	9340,5
2018	47112.90	17533,8	20163,5
2019	48174.20	15061,2	27835,1
2020	42693.00	16816,5	10371,7
2021	54825.40	40754,7	2827,7
2022	78807.50	65582,1	108,7

**Source:** Compiled by the author based on the materials of the State Statistics Committee of the Republic of Azerbaijan.



- The quality of management of innovation implementation in the entire industry —  $x_3$ ;
- The quality of innovative research in the entire industry —  $x_4$ ;
- The quality of the skills of the workforce that contribute to innovation in the industry —  $x_5$ .

The term sets for these variables are listed in

**Table 5.**

The interval values corresponding to the sets of terms of these variables are given in **Table 6**. The quality of innovation management in all industries, the quality of innovation research in all industries, the quality of the qualifications of the workforce implementing innovations in all industries—since the variables have qualitative characteristics, the interval values of these variables are based on expert assessment [0–10].

Then, fuzzification fuzzy set is performed. The Gaussian function is taken as the membership function of these fuzzy sets. The next step is to construct logical rules based on expert judgments. After establishing these rules based on expert assessment, the fuzzy logic rules will be as follows:

- If ( $x_1$  is high) and ( $x_2$  is high) and ( $x_3$  is high) and ( $x_4$  is high) and ( $x_5$  is high), then ( $y$  is high);
- If ( $x_1$  is high) and ( $x_2$  is middle) and ( $x_3$  is high) and ( $x_4$  is high) and ( $x_5$  is high), then ( $y$  is high);
- If ( $x_1$  is high) and ( $x_2$  is middle) and ( $x_3$  is middle) and ( $x_4$  is high) and ( $x_5$  is high), then ( $y$  is high);
- If ( $x_1$  is middle) and ( $x_2$  is middle) and ( $x_3$  is middle) and ( $x_4$  is middle) and ( $x_5$  is middle), then ( $y$  is middle);

Table 5

**Term sets of input and output linguistic variables**

Linguistic variables	Variables	Term sets		
Output variable				
Volume of GDP in Azerbaijan, million \$	$y$	low	middle	high
Introduction variables				
Volume of innovative product in the entire industry	$x_1$	low	middle	high
Costs of technological innovation in the entire industry at the expense of enterprises' own funds	$x_2$	low	middle	high
The quality of management of innovation implementation in the entire industry	$x_3$	low	middle	high
The quality of innovative research in the entire industry	$x_4$	low	middle	high
The quality of the skills of the workforce that contribute to innovation in the industry	$x_5$	low	middle	high

**Source:** Compiled by the author for the model.

Table 6

**Interval values corresponding to the sets of terms of input and output variables**

Variables	Term sets		
	low	middle	high
Output variable			
$y$	[33050.3–48302.7]	[48302.7–63555.1]	[63555.1–78807.5]
Input variables			
$x_1$	[995–22524.03]	[22524.03–44053.07]	[44053.07–65582.1]
$x_2$	[108.7–11370.67]	[11370.67–22632.63]	[22632.63–33894.6]
$x_3$	[0–3]	[3–6]	[6–10]
$x_4$	[0–3]	[3–6]	[6–10]
$x_5$	[0–3]	[3–6]	[6–10]

- If ( $x_1$  is middle) and ( $x_2$  is middle) and ( $x_3$  is middle) and ( $x_4$  is middle) and ( $x_5$  is middle), then ( $y$  is middle);
- If ( $x_1$  is middle) and ( $x_2$  is high) and ( $x_3$  high) and ( $x_4$  is middle) and ( $x_5$  is middle), then ( $y$  is middle);
- If ( $x_1$  is low) and ( $x_2$  is low) and ( $x_3$  is low) and ( $x_4$  is low) and ( $x_5$  is low), then ( $y$  is low);
- If ( $x_1$  is low) and ( $x_2$  is high) and ( $x_3$  is low) and ( $x_4$  is low) and ( $x_5$  is low), then ( $y$  is middle);
- If ( $x_1$  is low) and ( $x_2$  is high) and ( $x_3$  is high) and ( $x_4$  is low) and ( $x_5$  is low), then ( $y$  is middle);
- If ( $x_1$  is low) and ( $x_2$  is high) and ( $x_3$  is high) and ( $x_4$  is high) and ( $x_5$  is low), then ( $y$  is middle) and so on.

Thus, the rules of GDP volume are established by means of linguistic variables. Based on each rule, we obtain fuzzy sets for the output variable  $y$ . The composition method yields a fuzzy set with ranges of values of fuzzy output variables. Using the centroid method, we obtain an exact numerical solution from this fuzzy set.

The fuzzy logical inference method was implemented in the MATLAB software package [10].

As a solution to this problem, we obtain the following exact values for each linguistic variable:

**If  $x_1 = 45\,030$  thousand US dollars and  $x_2 = 22\,950$  thousand US dollars and  $x_3 = 2,818$  and  $x_4 = 2.636$  and  $x_5 = 6,944$ , then  $y = 55\,900$  million US dollars**

The graph of the dependence of  $y$  (the volume of Azerbaijan's GDP) on  $x_2$  (the costs of enterprises on technological innovations in all sectors

at their own expense) and  $x_5$  (the quality of the qualifications of the workforce implementing innovations in all sectors) is shown in **Figure 5**.

**Figure 6** shows fuzzy sets of each variable in accordance with the general rule base and obtaining an exact solution.

Thus, Azerbaijan's success in building an innovative economy will depend on the country's ability to adapt to rapidly changing global trends, effectively use its human resources and technological potential, and create favorable conditions for the development of innovation in all areas of the economy.

World experience shows that in order to stimulate innovative development and accelerate its financing, it is necessary to pay attention to several key areas:

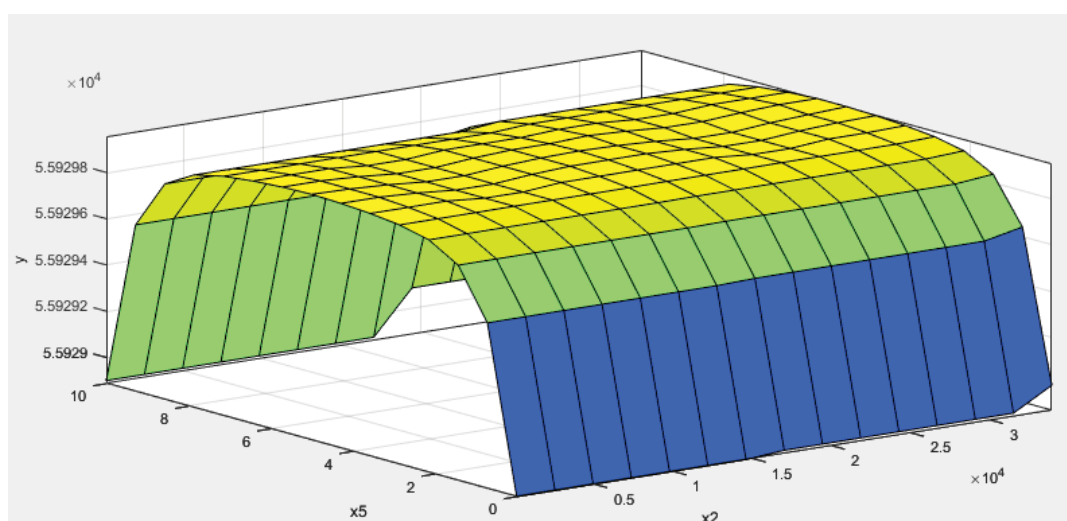
Support for the creation and development of start-ups and small innovative enterprises.

Expanding access of small and medium-sized businesses to innovative technologies and opportunities for their implementation.

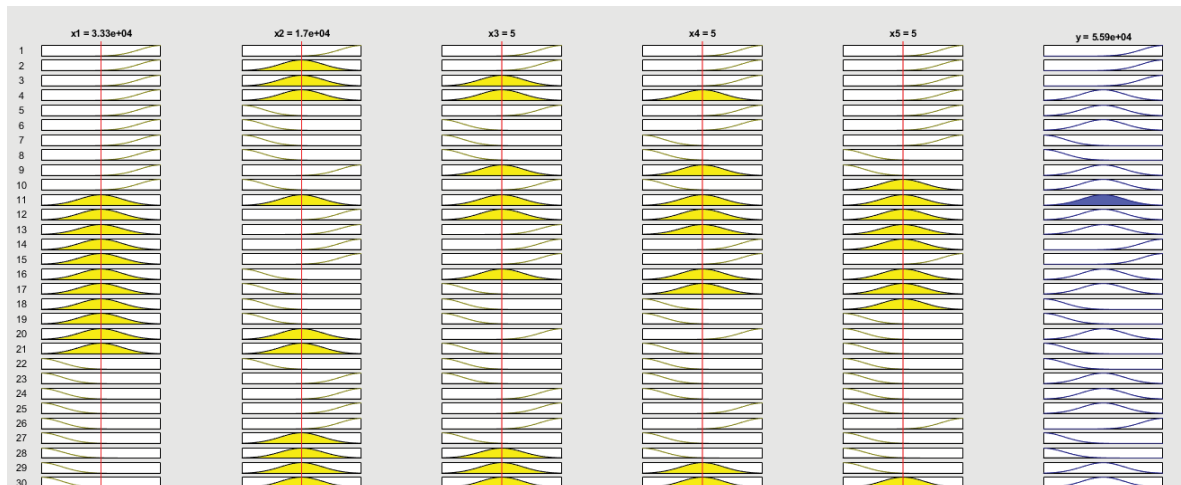
Strengthening ties between the academic sector (universities and public research organizations) and industry, as well as encouraging companies to implement new technologies.

## RESULT

Creating favorable conditions for innovation involves not only the creation of innovative ideas, but also the ability to quickly turn them into business. Stimulating the entrepreneurship of new ideas means motivating people to promote ideas economically and administratively, creating a culture of innovation, etc. unites. Our analysis showed



**Figure 5.** Graph of the dependence of  $y$  (GDP volume in Azerbaijan) on  $x_2$  (enterprise expenditures on technological innovations in all sectors) and  $x_5$  (quality of the qualifications of the workforce implementing innovations in all sectors)



**Figure 6.** Fuzzy sets of each variable on a common rule base and obtaining an exact solution

that if the volume of innovative output in the entire industry is 45,030 thousand US dollars, and the cost of technological innovation in the entire industry is 22,950 thousand US dollars, the quality of management is low (2,818) and the quality of research is poor (2,636) and the quality of labor force qualification is good (6,944), then the volume of GDP in Azerbaijan is 55,900 million US dollars. These will be US dollars.

For the innovative development of Azerbaijan, the following measures are recommended to be implemented:

- Strengthening state support measures to stabilize and increase spending on technological innovation;
- Stimulating technological innovation in various sectors of the economy, especially supporting product innovation;
- Increasing innovation activity in less innovative areas such as water supply, waste treatment and recycling;
- Increased attention to technological innovation in areas such as the production, distribution and supply of electricity, gas and steam;
- In addition to the purchase of new technologies, equipment and software, investments in research and development, as well as personnel training are increased.

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## ВПЛИВ ЛЮДСЬКОГО КАПІТАЛУ ТА ТЕХНОЛОГІЙ У БІЗНЕСІ НА ІННОВАЦІЙНУ ЕКОНОМІКУ

**Резюме.** На тлі економічних перетворень Азербайджан намагається підвищити свою конкурентоспроможність у світі. Інновації стають ключовим елементом цього процесу, а інвестиції в освіту та навчання створюють основу для подальших змін. У цьому контексті розвиток національної інноваційної активності в Азербайджані потребує посилення скоординованих дій як держави, так і приватного сектора, зокрема стосовно залучення інвестицій, людського капіталу та технологічних ресурсів. Для підтвердження впливу людського капіталу та технологій у бізнесі на інноваційну економіку у статті автор поставив завдання проаналізувати як теоретичні підходи, так і реальну ситуацію в цій сфері в Азербайджані. Аналіз було здійснено на основі нечіткої моделі з використанням пакета програм MATLAB, а також було застосовано методи статистичного порівняльного аналізу та групування. Теоретична значущість дослідження полягає в розширенні наукового підходу до питання про вплив людського капіталу та технологій на формування інноваційної економіки в бізнес-системі. Практична значущість полягає в тому, що висунуті результати інноваційної діяльності можуть мати значення в процесі побудови інноваційної економіки в Азербайджані та під час розв'язання проблем підвищення конкурентоспроможності.

**Ключові слова:** інновації, людський капітал, технології, національна економіка, освіта, сталий розвиток.

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## РЕГІОНАЛЬНА ЕКОНОМІКА ТА РІЗНІ МОДЕЛІ ЇЇ РОЗВИТКУ: РОЛЬ ОСОБИСТОСТІ У НАУЦІ

*Пам'яті мого вчителя*

**Резюме.** У статті розглянуто внесок доктора економічних наук, професора, заслуженого діяча науки і техніки України Пили Василя Івановича в розвиток вітчизняної регіоналістики. На матеріалах наукових досліджень, виконаних у 2000-х рр., показано отримані під його керівництвом теоретичні розробки та практичні результати у сфері розбудови спеціальних (вільних) економічних зон і територій пріоритетного розвитку,