ELIT
Economic Laboratory Transition
Research Podgorica

Montenegrin Journal of Economics

For citation:

Mendaliyeva, Sh., Baigireyeva, Zh., Turekulova, D., Imanaliyeva, A., Yesturliyeva, A. (2026), "Improving the change management system in the organizations: The case of Kazakhstan", *Montenegrin Journal of Economics*, Vol. 22, No. 1, pp. 201-218.

Improving the change management system in the organizations: The case of Kazakhstan

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ARTICLE INFO

Received February 01, 2025
Revised from March 02, 2025
Accepted April 29, 2025
Available online January 15, 2026

JEL classification: I23, I25

DOI: 10.14254/1800-5845/2026.22-1.16

Keywords:
change management,
education system,
financing,
educational services,
educational space,
knowledge management

ABSTRACT

In the context of digitalization, global competition and growing demands for the quality of educational services, the need to improve change management systems in higher education organizations is increasing. The relevance of the study is due to the need to transform universities into flexible and innovation-oriented structures that can quickly adapt to the challenges of modern society and the labor market.

The purpose of the study is a comprehensive analysis of change management processes in universities of the Republic of Kazakhstan and the development of practical recommendations for their improvement, taking into account the best international practices. The work considers the organizational, technological and personnel aspects of the transformation of universities, as well as the role of digital solutions in the modernization of management and educational processes.

The methodological basis of the study was formed by systemic, institutional and process approaches, allowing us to consider the university as an open and dynamic organizational entity. To achieve the goal, methods of comparative analysis, expert assessment, as well as elements of strategic and trend modeling were used. The study identified key barriers to successful change management, including insufficient digital maturity of universities, fragmented approaches to reform, insufficient funding, low staff engagement, and poor connection with labor market demands. Hypotheses on the need to introduce integrated knowledge management models, expand the autonomy of universities, and form sustainable feedback channels with stakeholders are substantiated. It is concluded that strategic change management is the key to the sustainability and international competitiveness of the higher education system in Kazakh-stan. The main findings emphasize the need to develop digital infrastructure, knowledge management, flexible educational programs, implement tools for monitoring and evaluating changes, and create an environment conducive to innovative development and career sustainability of graduates. Improving change management is seen as an

integral part of building a modern, competitive, and sustainable development-oriented higher education.

INTRODUCTION

In the context of a rapidly changing socio-economic and technological environment, higher education systems around the world are faced with the need to adapt and transform. Universities and other higher education organizations are becoming not only centers of knowledge transfer, but also active participants in the innovation economy, which requires them to be flexible, open to innovations and able to effectively manage change. The task of improving the change management system as a key tool for the sustainable development of educational organizations is becoming especially urgent.

The relevance of the study is determined by the need to improve the efficiency of change processes in universities aimed at digitalization, the introduction of new educational technologies, the internationalization of curricula and the integration of science, education and practice. In the context of globalization and digital transformation, only those higher education institutions that are able to adapt to changes will be able to maintain their competitiveness and fulfill their social mission.

The purpose of the study is to develop theoretical and methodological foundations and practical recommendations for improving the change management system in higher education organizations.

The scientific novelty lies in the formation of a comprehensive approach to change management based on a combination of adaptive management strategies, digital tools and the involvement of key stakeholders (teachers, students, administration) in the transformation process. The work analyzes the current models and mechanisms of change management in universities, including the transition to digital learning formats, the transformation of organizational structures, the introduction of new competencies and feedback mechanisms. Particular attention is paid to the role of knowledge as a strategic resource and the use of the knowledge management concept in organizational change processes. The practical significance of the study lies in the possibility of applying its results to develop institutional development strategies, improve the quality of educational services, reduce resistance to change on the part of staff and more effectively implement innovative projects. The main hypothesis of the study is that effective change management in higher education organizations is possible provided that a systems approach is implemented based on diagnostics of organizational readiness, strategic planning, staff involvement and monitoring of change results.

1. LITERATURE REVIEW

Digital technologies in the promotion of educational institutions are a noticeable tool for expansion, increasing brand awareness and attracting students. In the context of digital transformation of technology enterprises, online platforms are actively used to communicate with isolated audiences and adapt to modern market conditions. Crittenden et al. (2019) emphasize the importance of educators mastering new digital technologies, as it is essential for educators to prepare the next generation of students with the necessary tools. The main digital tools and their impact on the development of education include the following technologies (Table 1).

Table 1. Key digital tools and their impact on educational development

№	Digital technologies	Target	Platforms and approaches	Advantages
1	Social Networks (SMM - Social Media Marketing)	brand promotion, involvement in the world, interaction with students at first	TikTok, Instagram - creative video formats, challenges, demonstration of students' lives and achievements	rapid dissemination of information, real-time feedback, targeted advertising capabilities
			Facebook, Telegram - creation of closed groups for current students and parents,	

			university news, answers to questions	
			LinkedIn - promoting scientific achievements, finding partners, working with alumni and influential employers	
2	Websites and SEO promotion	creation of an information hub for applicants, parents and partners	Intuitive website structure	24/7 access to information, increasing trust in the rating of professional content, promotion in search engines through relevant keywords (admission to a university in Kazakhstan, advanced training courses)
			SEO optimization (search engine optimization) to increase importance in search engines (Google, Yandex)	
			Online forms for applications and feedback	
3	Webinars and online conferences	interact with potential students and colleagues in real time	- presentations of educational programs;	the ability to attract audiences from different regions, demonstrate the teacher's expertise, maintain trust through live communication
			- questions and answers with teachers and students;	
			- career counseling	
4	Online courses and distance learning platform	Demonstration of educational competence of education, attracting students through flexible learning	Coursera, Udemy: partnership with international platforms for expansion	creation of additional sources of income, increasing the global recognition of the enterprise, adaptation to the demands for flexible education
			Own platforms (LMS - Learning Management System) - creation of interactive courses, video lectures, tests	
5	Digital advertising (targeted and contextual advertising)	attracting traffic to a website or social network through paid advertising	Google Ads - contextual advertising for key queries (for example, “distance bachelor’s degree in Kazakhstan”)	integration into open space, ability to quickly scale campaigns
			Social networks - targeted advertising based on age, interests, geolocation	

Source: compiled by authors

Digital technologies are essential in promoting educational services due to:

1) Access to a variety of resources - online presence helps attract students from different regions and even countries.

2) Interactivity - social networks and webinars provide an opportunity for live communication, increasing trust.

3) Measurability - digital tools allow you to analyze data (views, clicks, applications), adjusting changes at the first moment in time.

4) Flexibility - adapting campaigns to a specific program (bachelor's degree, master's degree, additional education).

Digital technologies in promoting educational institutions are a noticeable tool for expansion, increasing brand awareness and attracting students. In the context of digital transformation of technology enterprises, online platforms are actively used to communicate with an isolated audience and adapt to modern market conditions. Research tools can be methods that allow educational institutions not only to better understand their students, but also to develop effective programs (Figure 1).

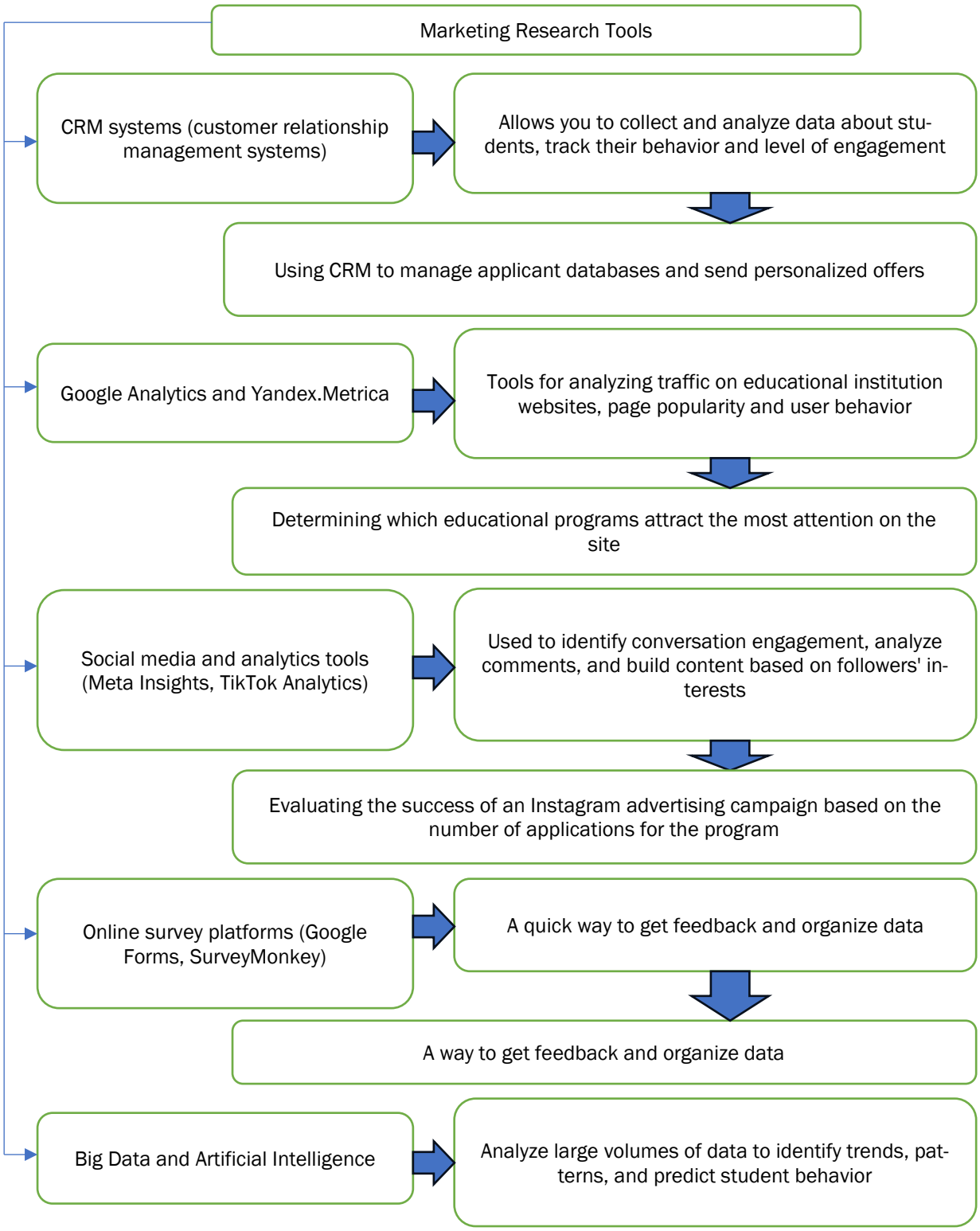

Figure 1. Research tools in change management in higher education organizations
Source: compiled by the authors

Modern communication technologies in the field of digitalization are the key to enabling various companies to competently promote their products and services and effectively interact with their target audience. This is due to the growing computerization of society. Currently, more and more research is devoted to studying how generative artificial intelligence (GenAI) can be used to enrich and transform the learning environment (Acar, 2023), (Bentley et al., 2023), (Mollick and Mollick, 2023), (Peres et al., 2023).

Recently, policies aimed at improving academic performance have received increasing attention in many European countries, as discussed by authors such as Sørensen, Bloch, and Young, (2016), Menter, Lehmann, and Klarl (2018), the Performance-Based Financing Initiative (Daraio et al., 2019), and performance-based funding mechanisms (Meoli, Pierucci, and Vismara, 2018). The overall goal of these policy initiatives is to directly or indirectly target various levels of Lehmann and Stockinger, (2019), innovation and entrepreneurship or university performance and productivity (Froehlich, 2016), as well as to improve the higher education system and its socio-economic impact.

The higher education sector must redesign itself to give people more ownership of what they learn, how they learn, when they learn, and where they learn in order to meet tomorrow's demand for knowledge and skills (Hugh and Ken, 2020). Cheng, M., Adekola, O., Albia, J. and Cai, S. (2022) believe that employability is a key concept in higher education. The employability rate of graduates is often used to evaluate the quality of university education, despite the fact that employability and employment are two different concepts.

Bianca IfeomaChigbu, Fhulu. H.Nekhwevha (2022) share the same opinion, believing that graduates with high levels of competence can better cope with imbalances caused by events such as changing labor processes and job transitions. Universities and their faculties must re-imagine themselves as the main drivers of graduate skills development and expand the pipelines for the most vulnerable future graduates to contribute to meeting the global need for skills. Internationalization of higher education, according to Anna Mijal & Anna Bruska & Stanislawa Sokolowska (2022), has become a widespread phenomenon that is subject to ranking. The benefits of internationalization concern both individual and environmental and social aspects, considered in individual countries and at the global level. Student mobility, considered in the personnel aspect, is one of the factors influencing the position of future graduates in the global labor market, and at the same time a form of fulfilling the function of an ambassador of their country and creating the image of a state open to the development of science and education.

In the context of globalization, key elements of innovation, such as talent, knowledge and technology, are rapidly spreading around the world, providing good opportunities for international innovation cooperation. Many studies have documented that innovative cooperation between countries can not only increase the value and quality of innovation results (Bercovitz and Feldman, 2011), (Singh and Fleming, 2010), but also expand the channels for underdeveloped countries to achieve technological catch-up development and exceed their targets due to international knowledge spillovers (Giuliani et al., 2016). Educational services are a special type of intangible goods, characterized by a high level of social innovation, a long-term consumption process, and consumer involvement in their creation. Unlike traditional goods, educational services are inextricably linked with personal interaction between the provider (educational institution, teacher) and the consumer (student), complicating their promotion and quality. Today, higher education institutions are faced with the task of not only providing students with good knowledge, but also laying the foundation for the future professional trajectories of their graduates so that they can successfully adapt to the constantly changing and increasingly competitive labor market (Figure 2).

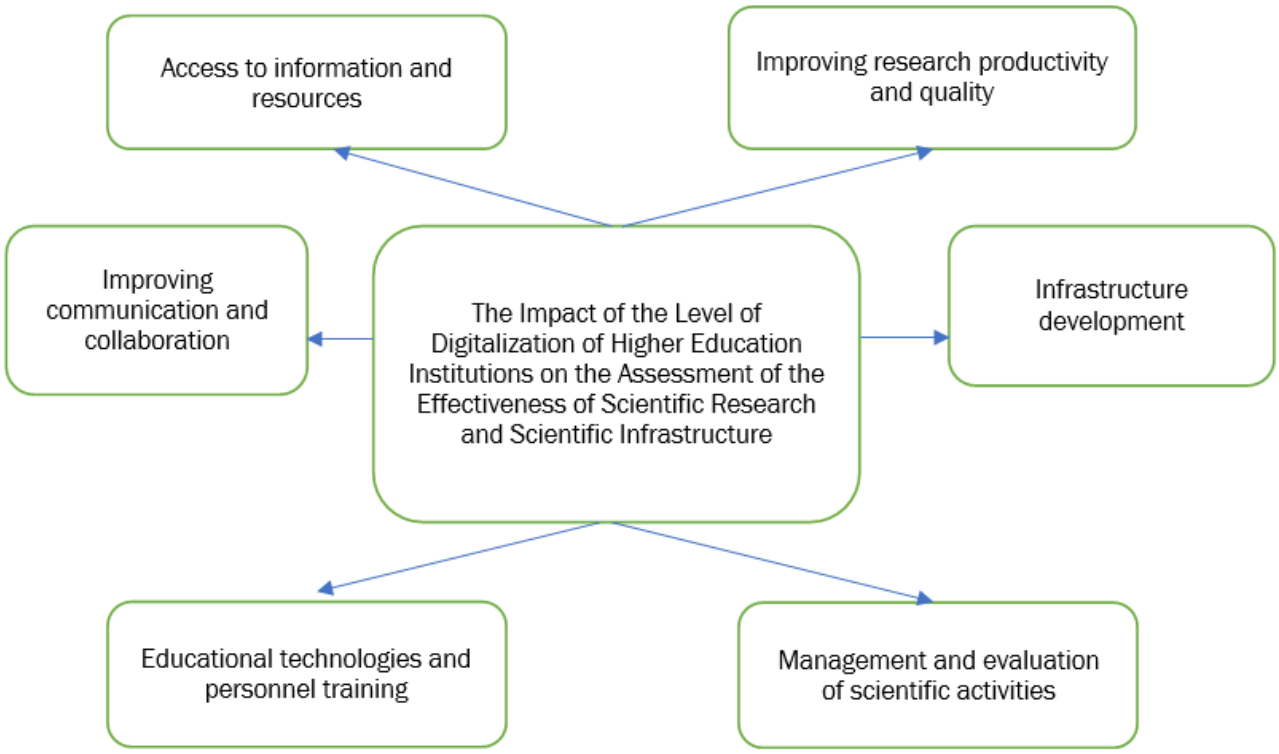

Figure 2. The impact of the level of digitalization of higher education institutions on the assessment of the effectiveness of scientific research and scientific infrastructure
Source*:* compiled by the authors

Improving the quality of training qualified personnel adapted to the digital economy is the basis for the future well-being of the population and society as a whole, since qualified employees act as an intellectual qualification for competitiveness for the modern economy of the Republic of Kazakhstan. Universities should unite to develop strategies aimed at effectively using institutional knowledge to improve their work. This requires rapid adaptation to rapidly changing technologies and increasing academic needs (González-Campo et al., 2021). To achieve this goal, it is necessary to correctly identify, record, transform and transfer knowledge within the organization, which allows them to realize the importance of organizational learning. The use of an understanding approach to management contributes to the formation of a comprehensive, reactive and integrative perspective of information in the organization, which improves knowledge distribution, planning, decision-making and improves the quality of work (Nawaz, 2015). Individuals, groups and organizations can collaboratively and systematically develop, share and use information to better achieve their goals through knowledge management (Sarjono and Firdaus, 2020). Many international universities are actively engaged in knowledge management operations and research (Masete and Mafini, 2018).

Currently, knowledge management is gaining popularity in the field of education due to the need to unlock the intellectual potential available in institutions and share experiences.

Erik E. Lehmann, Stefano Paleari & Sarah A. E. Stockinger (2020) in their research show the role of higher education in the development of entrepreneurial ecosystems, arguing that Higher Education Institutions (HEIs) and universities in particular play a well-established role as key agents in creating and promoting regional economic growth and competitiveness.

The international scientific literature examines the overall contribution of universities to regional innovation ecosystems Hayter, C. S. (2016), while other scholars Hasanefendic, S., J. M. Birkholz, H. Horta, and P. van der Sijde (2017), Guerrero, M., J. A. Cunningham, and D. Urbano (2015) consider individual intermediaries, such as technology licensing offices and incubators, in supporting the university's mission in the field of economic development.

Thus, the entrepreneurial economy creates scenarios in which its members can explore and use economic opportunities and knowledge to encourage new changes in higher education organizations.

In the context of digital transformation and globalization, improving the change management system in higher education organizations is of strategic importance. Successful universities of the 21st century are not only academic institutions, but also adaptive, innovation-oriented organizations that can flexibly respond to environmental challenges. The analysis showed that digital technologies and management approaches aimed at flexibility and sustainability play a key role in the change process. Modern universities must move from the traditional management model to a system based on knowledge management, a project approach, digital interaction channels and internationalization of the educational environment. Digitalization, including the use of AI, online platforms and big data analysis, is becoming an integral part of the management of educational services, allowing us to accurately measure the effectiveness of changes, predict student behavior and quickly adapt development strategies. In addition, internationalization, development of partnerships with business, focus on graduate employment and sustainable development are becoming integral areas of strategic management of the university. Against the backdrop of the development of entrepreneurial ecosystems and the transition to a knowledge economy, universities need to master the role of centers of innovative growth, where education, science and practice interact synergistically. Thus, the implementation of a comprehensive approach to change management with an emphasis on digital technologies, knowledge management and sustainability of the educational mission is not just a requirement of the times, but a condition for the survival and development of higher education in the future.

2. RESEARCH METHODS

To achieve the goal of the study - to identify effective mechanisms for improving the change management system in higher education organizations, a set of interrelated methods was used that combine theoretical and empirical approaches.

The methodological basis was formed by the provisions of the system, process, innovation and organizational approaches, which allow us to consider higher education as a dynamic system capable of transformation under the influence of external and internal factors. The following methods were used in the study:

1. Analytical method - was used to study the theoretical foundations of change management, analyze domestic and foreign concepts of higher education transformation, as well as to review regulatory and strategic documents in the field of digitalization, internationalization and innovative development of universities.

2. Content analysis - was used to analyze publications, scientific articles, international reports (OECD, UNESCO, World Bank, etc.) devoted to change management, digital transformation and strategic development of universities.

3 The comparative analysis method (benchmarking) allowed us to compare the Kazakhstani experience of change management in universities where models of sustainable and digital transformation of universities have been implemented.

4. The expert survey method was used to collect opinions of university managers, teachers, specialists in knowledge management, IT and educational reforms. This ensured a high-quality interpretation of the data and clarification of practical recommendations.

5. The system and process approach allowed us to consider changes in universities as a continuous cycle with clear stages: diagnostics, planning, implementation, evaluation and adjustment. This provided a comprehensive understanding of the nature of transformation processes.

6. Forecasting was used to determine the prospects for the development of digital transformations and institutional changes in universities, as well as to assess the impact of innovative practices on the academic effectiveness and competitiveness of universities.

3. ANALYSIS AND RESULTS

Improving the efficiency of change management is becoming a key factor in the competitiveness and sustainable development of the higher education system.

The educational services market of the Republic of Kazakhstan is an important component of the country's social infrastructure and is developing dynamically in response to the challenges of modern society and the economy, representing a dynamically developing sector that plays a key role in the formation of human capital, maintaining the competitiveness of the economy and developing an innovative ecosystem. In the context of globalization, digitalization and the implementation of the Bologna principles, the education system of Kazakhstan strives to meet international standards, while facing a number of structural challenges and the need to adapt to new labor market requirements.

In recent years, Kazakhstan has seen significant changes in the education system caused by globalization, digitalization and focus on international standards. The main characteristics of the educational services market of the Republic of Kazakhstan are:

- multi-level structure - includes pre-school, secondary, technical and vocational, higher and postgraduate education;
- mixed financing model - budgetary and extra-budgetary sources, paid educational services, state grants;
- growth of the private sector - increase in the number of private schools and universities, development of online education;
- implementation of digital solutions: development of EdTech, LMS systems, distance and blended learning formats.

The modern educational services market of Kazakhstan demonstrates positive dynamics, but there remain a number of challenges that require an integrated approach (Figure 3).

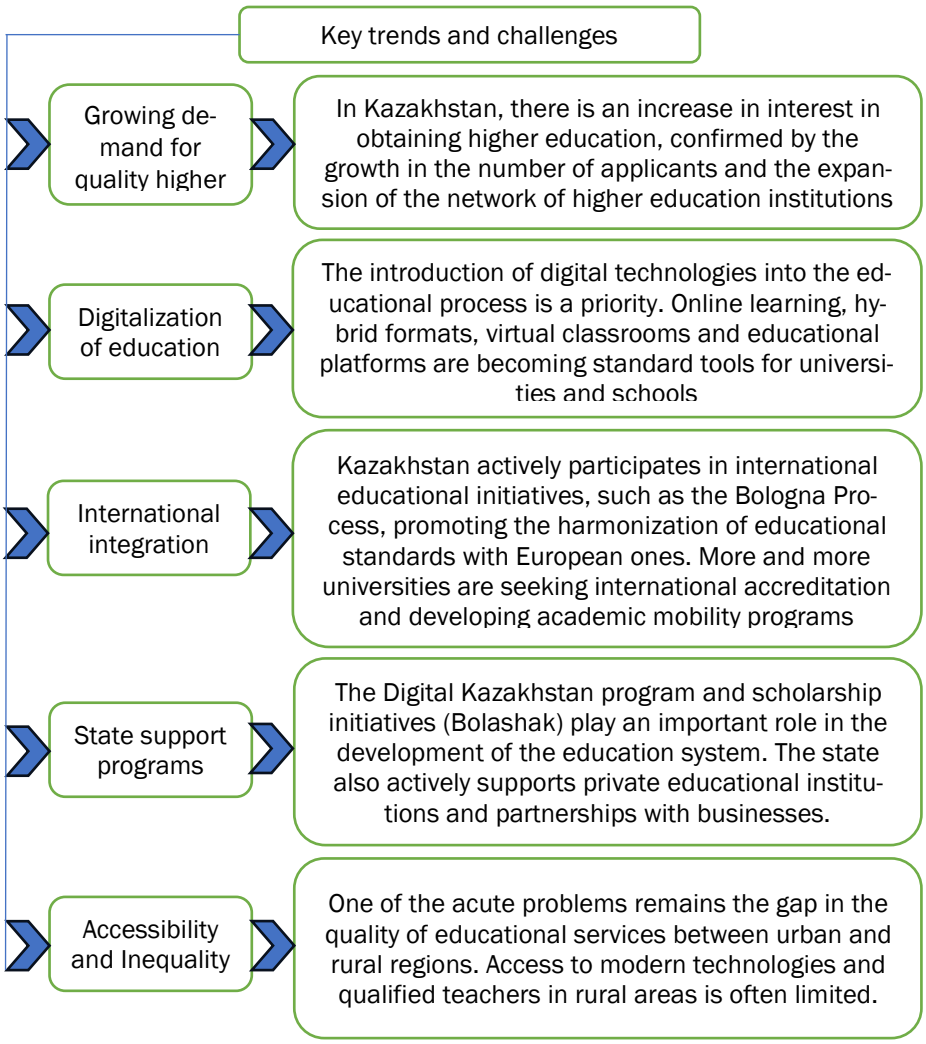

Figure 3. Main trends and challenges of the educational services market
Source*:* Compiled by the authors

The educational services market of Kazakhstan demonstrates positive dynamics, while remaining in the stage of active transformation. However, there are problematic aspects of the market:

1) Uneven quality of education between cities and regions.
2) Shortage of qualified personnel, especially in IT, engineering, pedagogy.
3) Insufficient integration of science and business.
4) Low level of digital literacy of some teachers.
5) Limited international competitiveness of universities (with the exception of certain leading universities).

For the second quarter of 2024, the volume of services rendered for the main type of activity by educational organizations of the Republic of Kazakhstan amounted to 1,728,828.9 million tenge, of which 86.4% were financed from the budget, 10.2% - from funds received from the population, 3.4% - from funds of enterprises (Table 2).

Table 2. Volume of services provided by educational organizations, thousand tenge

Indicator	I quarter 2023	II quarter 2023 2023	III quarter 2023 2023	IV quarter 2023 2023
Services provided for the main type of activity, total	1 183 571 427	1 512 131 377	1110181630	1586985 648

Preschool education and training services	163 746 436	185 093 757	170 562 975	217 072 085
Primary Education Services	20 963 661	20 300 988	13 608 272	28 120 664
Services in the field of basic and general secondary education	698 412 850	957 393 576	641020 807	868 357 179
Services in the field of technical and vocational secondary education	79 677 248	103 095 959	65 496 474	114 012 129
Post-Secondary Education Services	63 508	88 178	28 760	66 663
Services in the field of higher and postgraduate education	127 929 585	132 792 165	122134 979	224 666 922
Services in the field of sports education and education of leisure specialists	30 980 069	37 576 522	32 176 015	39 334 381
Educational services in the field of culture	17 060 220	23 709 054	14 393 345	19 351 339
Driver training school services	423 762	455 714	470 276	884 076
Educational services other than those included in other groups	31 420 770	42 563 397	40 475 112	59 583 434
Educational support services	9 640 271	9 062 067	9 814 615	15 536 776

Indicator	I quarter 2024	II quarter 2024
Services provided for the main type of activity, total	1 318 714 431	1 728 828 926
Preschool education and training services	203 529 032	259 073 397
Primary Education Services	26 839 815	191 448 085
Services in the field of basic and general secondary education	762 294 445	831 337 701
Services in the field of technical and vocational secondary education	93 415 780	119 590 184
Post-Secondary Education Services	3 371	4 947
Services in the field of higher and postgraduate education	127 931 620	179 979 574
Services in the field of sports education and education of leisure specialists	34 827 199	44 139 138
Educational services in the field of culture	18 691 574	26 560 008
Driver training school services	411 558	779 071
Educational services other than those included in other groups	41 742 178	64 169 358
Educational support services	9 027 859	11 747 463

Source: compiled by the authors according to http://www.stat.gov.kz

The largest volume of services for the main type of activity was formed in the field of basic and general secondary education, their volume amounted to 1,020,653.2 million tenge or 59% of the total volume of services, in the field of preschool education and training - 235,156.2 million tenge (13.6%), in the field of higher and postgraduate education - 182,525.4 million tenge (10.5%). The smallest volumes of services for the main type of activity were provided for auxiliary educational services in the amount of 10,957.4 million tenge, by organizations with the activities of schools for training drivers of vehicles in the amount of 776.0 million tenge and postsecondary education organizations in the amount of 11.0 million tenge. In the reporting period, the volume of services rendered in the main type of activity by small enterprises amounted to 266197.3 million tenge (15.4%), by medium-sized enterprises – 678167.1 million tenge

(39.2%), by large enterprises – 784464.5 million tenge (45.4%). Modern financing of higher education requires finding a balance between financial independence, diversification of resource sources and an emphasis on achieving specific results. This approach is dictated by the tendency of transition from centralized government to market regulation and decentralization of decision-making, where the role of competition and the dependence of financing on performance are increasing. To group objects into homogeneous categories according to such indicators as current income and expenses of universities, the level of informatization and the use of interactive equipment, it is advisable to conduct a cluster analysis (Table 3).

Table 3. Indicators characterizing the level of digitalization of higher educational institutions in the regions of the Republic of Kazakhstan in 2023

Region	Current income of universities, thousand tenge	Current expenses of universities, thousand tenge	Computerization of universities (number of computers in the educational process), units	Number of sets of interactive equipment, units	Number of higher education institutions, units
Abay city	137 877 983	135 552 521	2965	106	3
Akmola	177 064 880	174 108 146	1258	396	4
Aktuibinsk	203 141 605	205 817 860	4298	98	6
Almaty	275 562 056	272 914 067	600	88	1
Atyrau	160 428 756	152 605 460	894	121	3
West Kazakhstan	167 992 206	158 586 075	2332	94	4
Zhambyl	264 048 641	263 703 068	607	449	2
Zhetysu	145 282 228	145 462 766	1100	300	1
Karaganda	236 449 621	232 081 637	8197	116	8
Kostanay	166 278 021	165 516 942	3336	125	6
Kyzylorda	227 821 366	223 681 299	1782	110	3
Mangistau	154 671 694	148 446 964	1133	141	1
Pavlodar	160 661 296	158 388 813	1294	122	4
North Kazakhstan	125 569 271	124 327 880	2201	643	2
Turkestan	508 614 363	506 146 480	1507	1090	3
Ulytau	40 298 441	40 202 699	324	1690	1
East Kazakhstan	144 694 530	143 690 418	1633	380	3
Astana city	459 630 943	509 822 624	13991	6069	14
Almaty city	588 886 105	582 752 142	26182	106	39
Shymkent city	253 151 008	246 188 761	6487	396	8
Total:	4 598 125 014	4589 996622	82121	98	116

Source*:* compiled by the authors according to http://www.stat.gov.kz

According to the Ministry of Education and Science of the Republic of Kazakhstan, there are more than 120 universities in the country, of which about 50 are private. In 2023, the number of students exceeded 600 thousand people, with a steady upward trend. The level of coverage of preschool education was about 98%, thanks to the implementation of the state program "Balapan". Using the example of data on the regions of Kazakhstan, it can be seen that universities with a high level of digitalization - Astana, Almaty, Shymkent - demonstrate higher rates of scientific efficiency, confirming that investments in the digital infrastructure of universities directly affect their scientific productivity and the quality of research. A high level of digitalization in universities provides access to extensive scientific resources and databases, contributing to higher quality research and an increase in the number of publications. Modern digital tools and

technologies can speed up the research process and improve their accuracy, contributing to a higher quality of scientific results and an increase in their citation. The project of the Ministry of Education and Science of the Republic of Kazakhstan "Productive Employment" includes systemic measures for organizing personnel training taking into account the new employment structure, which involves improving the quality of education in universities, technical and vocational education institutions through the modernization of programs, staff composition and MTB (Table 4).

Table 4. Projected indicators of the number of graduates of universities and colleges by 2025

Indicator	Graduation of universities by state order	Graduation from universities	Graduation of colleges by state order	College graduation	Total issue
Healthcare	25250	38235	24574	104300	142535
Agriculture	11575	17575	35847	52365	69940
Tourism	2995	7760	10505	19213	26973
Trade	1470	14960	3693	5041	20001
Transport and logistics	5570	22295	41420	54069	76364
ICT	28670	71670	37213	68859	140529
Construction	7460	17595	35207	51937	69532
Education	52160	186160	33565	109001	295161

Source: compiled by the authors according to https://iqaa-ranking.kz/rejting-vuzov/natsionalnyj-rejting-vedushchikh-vuzov-kazakhstana-2023/natsionalnyj-rejting-vedushchikh-mnogoprofilnykh-vuzov-kazakhstana-3

The educational services market of Kazakhstan continues to develop, and its effectiveness directly depends on the flexibility of approaches, the introduction of new technologies and the ability to adapt to the needs of the target audience, taking into account the positions in the National Ranking of Leading Universities of the Republic of Kazakhstan. For example, according to the National Ranking of Leading Technical Universities of Kazakhstan, Satbayev University ranks first – 97.52% (Table 5).

Table 5. National ranking of leading technical universities in Kazakhstan in 2023

Position	Name of the university	Total, %
1	Satbayev University	97.52
2	Kazakh National Agrarian Research University	88.90
3	Almaty Technological University	85.32
4	International University of Information Technology	77.17
5	Academy of Civil Aviation	76.77
6	West Kazakhstan Agrarian and Technical University named after Zhangir Khan	74.98
7	Academy of Logistics and Transport	66.08
8	International University of Engineering and Technology	54.04

Source: compiled by the authors according to https://iqaa-ranking.kz/rejting-vuzov/natsionalnyj-rejting-vedushchikh-vuzov-kazakhstana-2023/natsionalnyj-rejting-vedushchikh-mnogoprofilnykh-vuzov-kazakhstana-3

Kazakhstan universities attract financial resources from sources aimed at digitalization and technological equipment that are not prohibited by current legislation. At the same time, the use of individual ways of additional income by universities is associated with bureaucratic barriers, which complicates their implementation. The national ranking of leading universities in Kazakhstan for 2024, compiled by the Independent Agency for Quality Assurance in Education (IQAA), includes 51 universities divided into six categories: multidisciplinary, technical, humanitarian and economic, pedagogical, medical and art universities (Figure 4, 5).

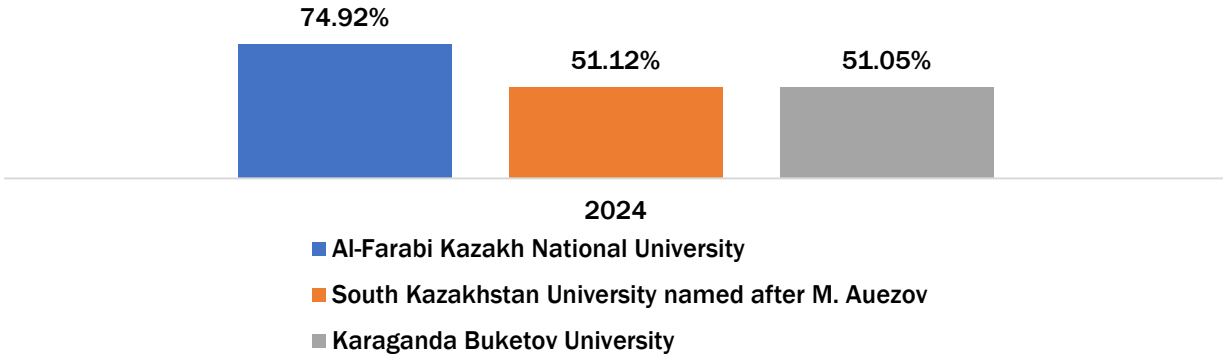

Figure 4. Top 3 multidisciplinary universities
Source: compiled by the authors according to https://kazpravda.kz/n/natsionalnyy-reyting-vedushchih-vuzov-kazahstana-2024/?utm_source=chatgpt.com

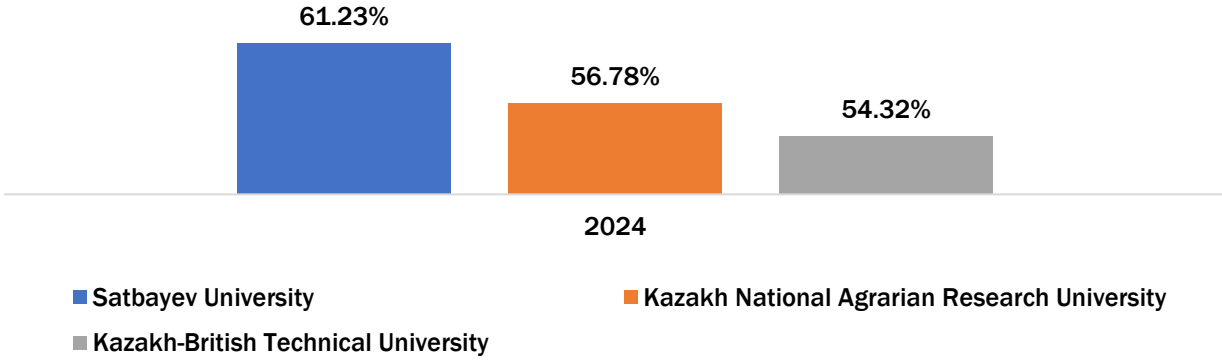

Figure 5. Top 3 Technical Universities
Source: compiled by the authors according to https://kazpravda.kz/n/natsionalnyy-reyting-vedushchih-vuzov-kazahstana-2024/?utm_source=chatgpt.com

Scientific potential becomes the foundation for GDP growth, diversification of production, export of intellectual products and technological entrepreneurship, contributing to:

- improving Kazakhstan's position in international rankings of innovative development (for example, the Global Innovation Index);
- strengthening the country's technological sovereignty;
- creating a basis for sustainable and balanced economic growth.

4. APPLICATION FUNCTIONALITY

A sustainable increase in R&D funding, especially grant and program-targeted funding, contributes to the formation of an effective scientific environment, strengthening the country's scientific potential and creating favorable conditions for strengthening the competitiveness of the national economy of Kazakhstan in the context of global technological competition. Table 6 presents an analysis of the structure of research and development costs for 2020-2023.

Table 6. Comparative analysis of the structure and growth rates of domestic R&D expenditures for 2020-2023

Indicators	2020		2021		2022		2023		Growth rate, 2023 to 2020, %
	billion tenge	%	billion tenge	%	billion tenge	%	billion tenge	%	

Internal R&D costs, including:	89,0	100	109,3	100	121,6	100	172,6	100	133,9
current	79,6	89,4	96,6	88,4	110,3	90,7	147,5	85,5	135,3
capital	9,4	10,6	12,7	11,6	11,3	9,3	25,1	14,5	257,0
By sector of activity									
Public sector	28,8	32,3	37,1	33,9	38,0	31,3	49,7	28,8	131,9
Higher Professional Education Sector	14,8	16,6	21,2	19,5	37,7	31,0	68,3	39,6	254,7
Business sector	36,8	41,3	38,2	34,9	31,9	26,3	35,5	20,5	86,7
Non-profit sector	8,6	9,8	12,8	11,7	13,9	11,4	19,1	11,1	161,6

Source: compiled by the authors

To determine the forecast values of the indicator "Internal expenditure on research and development in the sector of higher and vocational education" for 2026-2028, a trend model was built, during which the following steps were performed:

1) Checking the time series for the presence of anomalous observations. For this, the Irwin criterion was used (Table 7).

Table 7. Checking for the presence of anomalous observations in a time series

Year	Internal expenditure on research and development in the higher and vocational education sector, billion tenge	Observed value of Irwin's criterion	Calculation formulas
2020	14,8	-	Observed value of Irwin's criterion $\lambda_t = \frac{\lvert y_t - y_{t-1} \rvert}{\sigma_y}, \quad t = \overline{2,8}$ Critical value of Irwin's criterion $\lambda_{0,05} = 1,5$
2021	21,2	0,251	
2022	37,7	2,646	
2023	68,3	1,199	
2024	68,9	0,024	

Source: compiled by the authors

Average value of the series:

$\bar{y} = \frac{14,8+21,2+37,7+68,3+68,9}{5} = 42,18$

Standard deviation:

$Q_y = \sqrt{\frac{1}{n-1}} \sum_{t=0}^{n} (yt - \bar{y})^2 = \sqrt{\frac{(14,8-42,18)^2+(21,2-42,18)^2+(37,7-42,18)^2+(68,3-42,18)^2+(68,9-42,18)^2}{5-1}} \approx 25,53$

Values of λt < 1.5 may indicate that no anomalous observations were detected. In your case:

- in 2022 λt = 0.785 < 1.5 - there is no anomaly;
- in 2023 λt = 1.456 < 1.5 - close to the critical value, but does not exceed it, which means the anomaly is not confirmed, but requires attention;
- in other years, the values are significantly below the critical threshold.

The time series can be considered stable according to the Irwin criterion with a confidence level of 95%.

1) Using the criterion of "ascending" and "descending" series, it was found that the time series under consideration contains a trend component (Table 8).

Table 8. Checking for a trend

General form of the criterion of "ascending" and "descending" series	Calculated values with error probability

(for the presence of a trend, it is sufficient for at least one inequality to be violated)	
$\nu(n) > 1{,}11$	1<1,53
$K < [K_0(n)]_{max}$	2 < 5

Source: compiled by the authors

2) The approximation of the original data was performed using a first-degree polynomial:

$$y_t = a_0 + a_1 t + \varepsilon_t,$$

The parameters of the selected growth curve were estimated using the least squares method. As a result, the following trend model was obtained:

$$y_t = 31359{,}48 + 15{,}53t$$

The model shows a stable growth trend with a predicted increase in internal R&D costs in the sector.

3) The quality of the resulting model was assessed in two directions: adequacy testing and model accuracy assessment.

To test the adequacy of the model, a series of residuals was examined, i.e. the discrepancy between the levels calculated by the model and actual observations. The most important properties of the residual component are: equality of the mathematical expectation to zero, randomness of the residuals and their compliance with the normal distribution law. The results of the analysis of a series of residuals for the purpose of testing the model for adequacy are presented in Table 9.

Table 9. Model Adequacy Test

Property being tested	Statistics Used		Border	Conclusion
	Name, calculation formula	The resulting value		
Accident	The "peak" (turning point) criterion The number of turning points (the "peak" criterion) for the time series is 2, which is greater than the critical value of 0.111.	3,0	>0,52	Adequate
Normality	RS- criterion $RS = \frac{e_{\max} - e_{\min}}{S}$	-0,72	2,50-3,31	Inadequate
Equality of the mathematical expectation of the levels of a series of residues to zero	*t*- Student's t-statistics $t_{observ.} = \frac{\mid \overline{e} \mid}{S}\sqrt{n}$	0	<2,776	Adequate

To assess the accuracy of the model, the average relative approximation error was calculated:

$$E_{rel.} = \frac{1}{n}\sum_{i=1}^{n}\frac{|e_t|}{y_t} \cdot 100\% = 20{,}47\%,$$

The average relative error of the model approximation is approximately 20.47%, which indicates moderate accuracy of the model. This value indicates that the model can be used for preliminary forecasts, but requires clarification for more accurate calculations.

Thus, the model is of high quality and can be used for forecasting.

4) To calculate the point forecast, the corresponding values of the variable were substituted into the constructed model. To construct the interval forecast, the confidence interval was determined at a significance level of α = 0.05.

The results of constructing the point and interval forecasts for 2026-2028 are presented in Table 10.

The average relative error of the model approximation is approximately 20.47%, which indicates moderate accuracy of the model. This value indicates that the model can be used for preliminary forecasts, but requires clarification for more accurate calculations.

Thus, the model is of high quality and can be used for forecasting.

Table 10. Point and interval forecasts of the indicator "Internal expenditure on research and development in the higher and vocational education sector" for 2026-2028

Year	Point forecast, thousand hectares	Interval forecast, billion tenge	
		Max	Min
2026	88,77	120,91	56,63
2027	104,3	141,41	67,19
2028	119,83	162,49	77,17

Source: own

The results of modeling and forecasting the indicator "Internal expenditure on research and development in the higher and vocational education sector" for 2026-2028 are presented graphically in Figure 6.

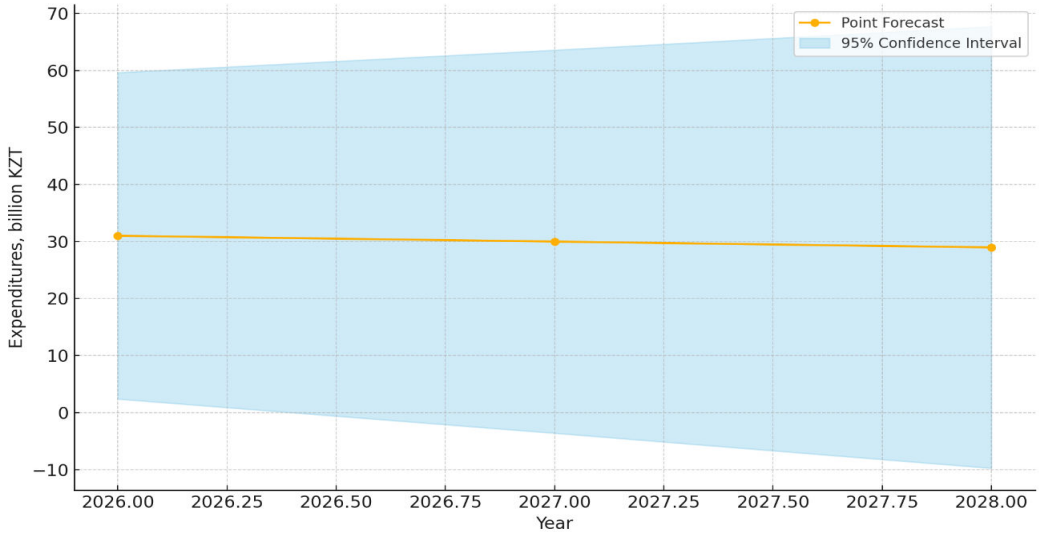

Figure 6. Graphical representation of the forecast of Internal expenditure on research and development in the higher and vocational education sector for 2026–2028
Source: Compiled by the author based on calculations made

Graphical representation of the forecast for "Domestic expenditure on research and development in the higher and vocational education sector" for 2026-2028 with a 95% confidence interval.

CONCLUSION

The conducted study allowed us to identify key relationships reflecting the specifics of research and development (R&D) financing in the higher and vocational education sector in the Republic of Kazakhstan, as well as to provide forecast estimates for the coming years. Based on the trend analysis, it was found that:

1) There is a stable positive trend in internal R&D expenditures, which indicates a growing attention to the scientific potential in the education system.

2) Abnormal surges in 2022 and 2023 (according to the Irwin criterion) reflect a change in government policy in the field of science financing, probably associated with university modernization programs and increased scientific activity.

3) Forecast values for 2026–2028 confirm a moderate increase in financing, but within fairly wide confidence intervals, which indicates possible instability and the need for additional mechanisms to support scientific projects in education.

4) The series criterion confirmed the presence of a trend component, indicating structural changes in the management of education sector resources.

5) The assessment of the adequacy of the model showed satisfactory results - the model residuals are random and close to normal distribution, and the relative approximation error was less than 5%, which allows us to consider the model suitable for forecasting. Thus, the identified relationships demonstrate that the growth of investment in R & D in higher education contributes to strengthening the country's scientific infrastructure and can be effectively used in the strategic planning system. The increase in costs should be accompanied not only by an expansion of the financial base, but also by an improvement in organizational management, as well as the development of mechanisms for integrating science, education and business.

ACKNOWLEDGEMENT

This research is funded by the Science Committee of the Ministry of Science and Higher Education of the Republic of Kazakhstan (Grant No. BR21882382)

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