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COMPARATIVE ANALYSIS OF INTERNATIONAL MODELS OF R&D COMMERCIALISATION AND THEIR ADAPTATION FOR KAZAKHSTAN

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Abstract. This article examines international models of research and development (R&D) commercialisation and their adaptation within the framework of the state policy of the Republic of Kazakhstan in the field of science and innovation. A comparative analysis of institutional and financial mechanisms that ensure the effectiveness of technology transfer in leading countries namely the United States, Canada, Australia, South Korea, and the European Union is conducted. The results of the study indicate that successful commercialization systems are built upon strong university–industry collaboration, well-developed technology transfer infrastructure, hybrid financing mechanisms, and a clear regulatory framework. Particular attention is given to the analysis of the Kazakhstani model, including the identification of key barriers and potential directions for its improvement.

The findings of this research may be applied in the development of state policy in the fields of science, innovation, and technological advancement.

Keywords. *science commercialisation, technology transfer, innovation policy, R&D, international experience, Kazakhstan, state regulation.*

ҒЗТКЖ КОММЕРЦИЯЛАНДЫРУДЫҢ ХАЛЫҚАРАЛЫҚ ҮЛГІЛЕРІ ЖӘНЕ ОЛАРДЫ ҚАЗАҚСТАН РЕСПУБЛИКАСЫНЫҢ МЕМЛЕКЕТТІК САЯСАТЫНА БЕЙІМДЕУ

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Аңдатпа. Бұл мақалада ғылыми зерттеулер мен әзірлемелерді (ҒЗТКЖ) коммерцияландырудың халықаралық үлгілері және оларды Қазақстан Республикасының ғылым мен инновациялар саласындағы мемлекеттік саясатына бейімдеу мәселелері қарастырылады. Зерттеу барысында АҚШ, Канада, Аустралия, Оңтүстік Корея және Еуропалық Одақ елдеріндегі технологиялар трансфері жүйесінің институционалдық және қаржылық тетіктеріне салыстырмалы талдау жүргізілді. Халықаралық тәжірибе университеттер мен өнеркәсіп арасындағы тұрақты әріптестік, технологиялар трансфері инфрақұрылымының дамуы, аралас қаржыландыру тетіктері және тиімді құқықтық реттеу жүйесі коммерцияландырудың негізгі факторлары екенін көрсетеді. Сонымен қатар Қазақстандағы ғылыми нәтижелерді коммерцияландыру жүйесінің институционалдық шектеулері мен даму әлеуеті талданды. Зерттеу нәтижелері халықаралық тәжірибені ескере отырып Қазақстанның ғылыми-инновациялық саясатын жетілдіру бағыттарын анықтауға мүмкіндік береді.

Түйін сөздер: *ғылымды коммерцияландыру, технологиялар трансфері, инновациялық саясат, ҒЗӘ, халықаралық тәжірибе, Қазақстан, мемлекеттік реттеу.*

МЕЖДУНАРОДНЫЕ МОДЕЛИ КОММЕРЦИАЛИЗАЦИИ НИОКР И ИХ АДАПТАЦИЯ ДЛЯ ГОСУДАРСТВЕННОЙ ПОЛИТИКИ РЕСПУБЛИКИ КАЗАХСТАН

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Аннотация. В данной статье рассматриваются международные модели коммерциализации научных исследований и разработок (НИОКР) и вопросы их адаптации к государственной политике Республики Казахстан в

области науки и инноваций. В ходе исследования проведён сравнительный анализ институциональных и финансовых механизмов системы трансфера технологий в США, Канаде, Австралии, Южной Корее и странах Европейского союза. Международный опыт показывает, что ключевыми факторами коммерциализации являются устойчивое партнёрство между университетами и промышленностью, развитие инфраструктуры трансфера технологий, смешанные механизмы финансирования и эффективная система правового регулирования. Также проанализированы институциональные ограничения и потенциал развития системы коммерциализации научных результатов в Казахстане. Результаты исследования позволяют определить направления совершенствования научно-инновационной политики Казахстана с учётом международного опыта.

Ключевые слова: *коммерциализация науки, трансфер технологий, инновационная политика, НИОКР, международный опыт, Казахстан, государственное регулирование.*

Introduction

The development of scientific research and its commercialisation are key factors in ensuring sustainable economic growth, innovative competitiveness, and technological sovereignty. In many countries, the transition from a «science for science's sake» model to a «science for the economy» model is driven by a combination of institutional reforms, legal incentives, and a well-developed technology transfer infrastructure [1].

In the context of globalisation, science is becoming not only an element of domestic policy but also an instrument of international competitiveness and a tool of state «soft power». Therefore, the study of international models of R&D commercialisation and their adaptation to national contexts is of strategic importance for Kazakhstan.

In the Republic of Kazakhstan, strategic priorities are defined by the Concept for the Development of Higher Education and Science for 2023-2029, which provides for the strengthening of cooperation between higher and postgraduate education institutions, research organisations, and businesses; the development of technology transfer mechanisms; and the improvement of research productivity. One of the key targets is to increase R&D expenditure to 1% of GDP by the end of the implementation period [2].

According to the National Academy of Sciences, internal R&D expenditures in 2023 amounted to 172.6 billion tenge (approximately USD 383 million), which is 42% higher than in 2022. However, the funding structure remains imbalanced: 74.3% comes from the national budget, 16% from organisations' own resources, and only 5% from the private sector. At the same time, the GERD-to-GDP ratio (0.145%) is significantly lower than in OECD countries, where it exceeds 2.5–3% [1].

Despite these positive trends, the institutional structure of commercialisation in Kazakhstan remains insufficiently integrated: interactions between science, business, and government are sporadic, and private sector participation in research financing remains limited.

This study aims to conduct a comparative analysis of international R&D

commercialisation models and to identify mechanisms applicable to improving Kazakhstan's science and innovation policy.

The research objectives include:

1. To characterise institutional commercialisation models in leading countries (the United States, Canada, Australia, the Republic of Korea, and EU countries).
2. To analyse international methodologies for assessing the effectiveness of technology transfer centres (ATTP, AUTM).
3. To compare identified practices with Kazakhstan's national context.

To develop proposals for adapting best practices, taking into account the country's resource and institutional specificities.

The main research question is: Which international models of R&D commercialisation are the most effective, and which elements of these models can be adapted to enhance the effectiveness of Kazakhstan's state policy in science and innovation?

The study hypothesises that the adaptation of key elements of international R&D commercialisation models, including the legal autonomy of universities in intellectual property management, hybrid financing mechanisms (grants and private investment), a well-developed technology transfer infrastructure, and partnerships with business, will increase the effectiveness of the state policy of the Republic of Kazakhstan in the field of science and innovation and accelerate the integration of scientific developments into the economy.

Scientific novelty of the research: The scientific novelty of the study lies in its comprehensive comparative institutional analysis of international R&D commercialisation models, with a focus on identifying mechanisms for their adaptation to the conditions of the national innovation system of the Republic of Kazakhstan. Unlike most existing studies, which focus primarily on individual countries or specific technology transfer tools, this paper proposes a systematic approach to comparing the institutional, financial, and organisational parameters of the commercialisation of scientific developments. This approach made it possible to identify key institutional gaps between international models and Kazakhstani practice and to formulate directions for the institutional transformation of the system of scientific results commercialisation.

Literature Review

The commercialisation of scientific research and development (R&D) occupies a central place in contemporary academic literature, as it is widely recognised as a key mechanism for transforming scientific knowledge into economic and social value.

A significant contribution to the theoretical understanding of technology transfer processes has been made by the Triple Helix concept developed by H. Etzkowitz and L. Leydesdorff. This model emphasises the importance of close interaction between universities, industry, and government in driving innovation [3].

A number of studies focus on institutional factors that determine the effectiveness of the commercialisation of scientific results. In their study of university–industry cooperation, J. Bruneel and co-authors note that the key barriers to interaction between the academic and industrial sectors are differences in organisational goals, institutional logics, and project time horizons [4]. According to the authors, universities are oriented towards long-term scientific outcomes and academic freedom, whereas businesses prioritise rapid commercial impact and market returns. Overcoming these

barriers requires the development of specialised intermediary institutions such as technology transfer offices, innovation centres, and technology parks.

International research also highlights the growing role of universities as key actors in the innovation economy. In their work, Sh. Breznitz and H. Etzkowitz analyse global models of university technology transfer and note that, in developed countries, universities are becoming centres for the commercialisation of scientific knowledge, forming innovation clusters, start-up ecosystems, and mechanisms of interaction with industry [5]. The authors emphasise that successful commercialisation models are based on a well-developed institutional infrastructure, including technology transfer offices, venture funds, business incubators, and intellectual property protection mechanisms.

Within the framework of the economic approach to the analysis of innovation systems, the theory of national innovation systems proposed by B. Lundvall has had a significant impact. According to this concept, innovative development is determined not only by the level of scientific research but also by the quality of interaction between universities, industry, and government institutions. The commercialisation of scientific results is regarded as an important element in strengthening a country's innovation potential and technological competitiveness [11].

A separate strand of research is concerned with the factors affecting the effectiveness of the commercialisation of scientific results. Contemporary empirical studies show that the effectiveness of technology transfer depends on factors such as the level of R&D funding, the availability of a well-developed commercialisation infrastructure, the human capital of research organisations, and the degree of private sector involvement. For example, G. Alibekova, B. Yedgenov, and E. Mynbayeva conduct a comparative analysis of the factors affecting the commercialisation of scientific developments in different countries, showing the significant influence of the institutional environment and funding structure on innovation outcomes [12].

At the same time, a number of studies indicate the existence of structural barriers to the development of university–industry cooperation. In particular, the study by K. Moldashev and B. Sakhimbek shows that, in Kazakhstan, interaction between universities and industry remains limited due to institutional barriers, low levels of trust among participants in the innovation system, and the insufficient development of technology transfer infrastructure [13].

Thus, the analysis of the academic literature makes it possible to identify several key approaches to the study of R&D commercialisation: institutional, economic, and organisational. Despite the considerable volume of research, most studies focus on the experience of developed countries, while the adaptation of international commercialisation models to developing innovation systems, including Kazakhstan, remains insufficiently explored. This underscores the relevance of the present study and the need for a comparative analysis of international R&D commercialisation models in order to identify mechanisms applicable to improving the state policy of the Republic of Kazakhstan in the field of science and innovation.

Institutional Models of Commercialisation in Developed Countries

One of the most successful and sustainable models of research commercialisation is considered to be the American model, based on the Bayh-Dole Act (1980), which granted universities ownership rights over the results of federally funded research. This law created the legal foundation for an innovation ecosystem in which

universities became active participants in the commercial circulation of knowledge.

The implementation of the Act led to the establishment of a network of Technology Licensing Offices (TLOs), venture funds, business incubators, and industrial parks affiliated with universities. By the late 1990s, the United States had become a global leader in the number of university patents and start-ups created on the basis of academic research. These processes are supported by professional associations such as AUTM (Association of University Technology Managers) and ATTP (Alliance of Technology Transfer Professionals) [6].

Canada applies a similar model but with a more prominent role of federal agencies such as NSERC, NRC, and CECR. Commercialisation there is integrated into national science programmes and supported by hybrid funding mechanisms: base grants for universities are combined with investments from industrial partners. This approach has led to the creation of dozens of commercialisation centres embedded within universities, ensuring sustainable links between academia and industry [7].

In Australia, the institutional model of commercialisation is based on strong connections between research centres and industry. The Cooperative Research Centres (CRC) system unites universities, research organisations, and private companies around shared applied objectives. Within each CRC, joint laboratories are established where research results are immediately translated into industrial implementation [8].

South Korea demonstrates a unique example of state–industry partnership. The KAIST system, supported by the Ministry of Science and ICT, provides a complete vertical structure from fundamental research to market-ready products [9]. The government plays a strategic role by investing in infrastructure, training professionals, and integrating universities with major industrial conglomerates such as Hyundai, Kia, and Samsung.

According to comparative international studies (OECD, ATTP), the efficiency of commercialisation in developed countries is evaluated at multiple levels from universities and research institutes to national agencies. Evaluation indicators include financial metrics (ROI, profitability), innovation metrics (patents, licences, start-ups), and socioeconomic effects (job creation, technology exports) [10].

Thus, in developed countries, science commercialisation is built on four fundamental institutional principles:

1. Legal autonomy of universities in managing intellectual property rights.
2. Infrastructure support – presence of TTOs (Technology Transfer Offices), incubators, venture funds, and innovation clusters.
3. Hybrid financing mechanisms combining public grants, private investment, and venture capital.
4. Systemic coordination among government, academia, and industry.

Theoretical Foundations and Methodological Approaches to Commercialisation

In contemporary academic discourse, the commercialisation of scientific results is interpreted as a multi-level process encompassing the creation, protection, dissemination, and implementation of knowledge in economic practice. Theoretically, it aligns with the concept of National Innovation Systems (NIS) developed by B. Lundvall, in which science and technology are regarded as key drivers of long-term economic growth [11].

A central position in the methodology of commercialisation analysis is occupied by the «Triple Helix» model formulated by H. Etzkowitz and L. Leydesdorff. It posits that successful innovation development is achievable only through the mutual integration of three sectors: university, industry, and government. Within this framework, universities are viewed not merely as centres of education and research but as entrepreneurial organisations capable of producing marketable knowledge-based products [3].

The «Quadruple Helix» concept further extends this model by incorporating civil society and end-users, reflecting a shift towards open innovation. This highlights that the effectiveness of commercialisation is determined not only by technological but also by social outcomes, such as employment, sustainable development, and digital inclusivity.

From a methodological standpoint, the commercialisation process is analysed through economic, institutional, and behavioural models. Economic models assess the profitability and return on investment of R&D (ROI, IRR, NPV); institutional models examine the structure of interactions among key stakeholders; and behavioural models investigate the motivations of researchers and entrepreneurs. The combination of these approaches provides a more holistic understanding of both the financial and organisational aspects of knowledge transfer to the economy.

Kazakhstan: Institutional Barriers and National Specificities

The system of R&D commercialisation in Kazakhstan remains at a formative stage and is characterised by several structural features. According to studies by G. Alibekova, E. Mynbayeva, and B. Yedgenov, the dominance of public funding, accounting for more than 70% of total R&D expenditures, combined with a low share of private investment, constrains the sustainability of the national innovation system [10]. At the same time, the technology transfer infrastructure, including university-based Technology Transfer Offices (TTOs), business incubators, and venture funds, remains underdeveloped and is largely concentrated in major urban centres.

According to prior studies, including econometric assessments, increases in R&D expenditures and firms' innovation activity have a positive impact on the export of innovative products. However, this effect tends to be short-term due to the lack of stable linkages between research institutions and industry.

The commercialisation of science in Kazakhstan is further hindered by weak demand from the business sector, bureaucratic constraints, limited competencies in intellectual property management, and an underdeveloped entrepreneurial culture. Nevertheless, rising patent activity, the expansion of grant funding, and the growing number of commercialisation projects indicate the gradual development of certain elements of the national innovation system.

Despite these improvements, the process remains fragmented and predominantly administrative in nature: there is no unified institutional coordination, the functions of various government bodies overlap, and support for R&D is largely confined to project-based funding. According to K. Moldashev and B. Sakhimbek, one of the key barriers is the persistent gap between universities and industry, exacerbated by low levels of trust and the lack of stable channels of interaction [13].

To overcome these barriers, it is necessary to strengthen institutional linkages within the «science–business–government» nexus, develop a robust legal framework for intellectual property management, create venture financing instruments, and establish a national system for evaluating the effectiveness of commercialisation.

International Methodologies and Experience in Evaluating Commercialisation Effectiveness

Global practice has developed a variety of methodologies for assessing the effectiveness of commercialisation that reflect both economic and institutional dimensions. The most widely applied include:

1. Data Envelopment Analysis (DEA) – used to determine the relative efficiency of projects by comparing inputs (resources) and outputs (results) [14].
2. Structural Equation Modelling (SEM) – employed to identify interconnections among success factors (financial, personnel, technological) and overall commercialisation outcomes [15].
3. Commercialisation Capability System – a comprehensive framework for assessing an organisation's technological, marketing, and managerial capacity [16].
4. Two-stage index models – used by the OECD and ATTP to construct comparative rankings based on composite indicators [17].

The Kazakhstani case, implemented by Science Fund JSC, represents one of the first examples of the local adaptation of international approaches. According to previously published studies, an analysis of 152 commercialisation projects over the period 2016-2018 employed a three-stage evaluation procedure:

Stage I – data collection and systematisation (financial indicators, patents, exports, taxes, sectors, and regions);

Stage II – application of regression analysis and DEA modelling methods, as reported in prior studies, to calculate sub-indices (sales, patents, employment, co-financing, fixed assets, exports, and licences);

Stage III – calculation of an integrated efficiency index.

These methods are discussed in the present study in the context of a review of previously published research and international practices for evaluating the effectiveness of commercialisation.

Materials and Methods

The purpose of this study is to identify the patterns and determinants of R&D commercialisation effectiveness in leading economies and to develop recommendations for adapting international models to enhance Kazakhstan's science and innovation policy.

To achieve this goal, the research followed a multi-stage design that included data collection and systematisation, comparative and institutional analysis, and the interpretation of results in the context of Kazakhstan's National Innovation System (NIS).

Empirical Base:

- Statistical data from international organisations (OECD, WIPO, World Bank, AUTM, ATTP);
- Official reports from national agencies and universities in the United States, Canada, Australia, South Korea, and EU member states;
- Regulatory acts of the Republic of Kazakhstan, such as the Law on Science and Technology Policy and the Concept for the Development of Higher Education and Science for 2023–2029;
- Analytical reports of the National Academy of Sciences and JSC «Science Fund»;
- Scientific publications on the commercialisation of scientific developments.

The following methods were used in the study:

1. Comparative institutional analysis – to identify the specifics of legal regulation, organizational structure and financing mechanisms of R&D commercialisation systems in various countries.

2. Content analysis of regulatory documents, strategic programs and analytical reports of international organizations (OECD, WIPO, AUTM, ATTP).

3. Comparative analysis of statistical indicators of innovation development (GERD), R&D financing structure, indicators of patent activity, development of technology transfer infrastructure.

The use of these methods made it possible to identify the institutional features of international R&D commercialisation models and the mechanisms that can be adapted to the national innovation system of Kazakhstan.

Stages of the Study:

- collection and organisation of international and national data on commercialisation mechanisms and institutional frameworks;
- classification of models according to key parameters, including legal foundations, financing structures, intellectual property management, and technology transfer infrastructure;
- comparative analysis of leading countries (the United States, Canada, Australia, South Korea, and the EU) and Kazakhstan;
- comparison of Kazakhstan's commercialisation tools with international approaches to assessing the effectiveness of technology transfer presented in OECD, AUTM, and ATTP materials;

development of recommendations for institutional adaptation and policy reform.

The main question of the study was which international models of R&D commercialisation are the most effective and which elements of these models are applicable to improving Kazakhstan's science and innovation policy.

Results and Discussion

Comparative Analysis of International and Kazakhstani Models

The comparative analysis showed that the effectiveness of the commercialisation of scientific developments is largely determined by the level of institutional maturity of national innovation systems. The key factors are the structure of R&D financing, the degree of autonomy of universities in managing the results of intellectual activity, the development of technology transfer infrastructure, and the nature of interaction between the academic sector and industry.

An analysis of international experience demonstrates that the United States, Canada, Australia, South Korea, and the European Union have established institutionally stable commercialisation systems based on a combination of legal autonomy of universities, a well-developed technology transfer infrastructure, and active private sector participation in research financing.

In contrast, in the Republic of Kazakhstan, the system of commercialisation of scientific results is at the stage of institutional formation and is characterized by high dependence on government funding and limited business involvement.

Table 1. Comparative features of R&D commercialisation models

Parameter	USA / Canada / EU / Korea	Kazakhstan
Legal Framework	Bayh–Dole Act (1980) and national laws granting universities ownership of IP	«Law on Science and Technology Policy» lacks dedicated IP ownership provisions
Financing	60–80% of R&D funded by the private sector	70–75% funded by the state budget
Infrastructure	Network of TTOs (Technology Transfer Offices), incubators, clusters, venture funds	Fragmented university-based offices, weak coordination
IP Management	Universities own and manage IP rights	Rights often retained by state or grantor
Evaluation	Multi-level systems: AUTM, ATTP, CECR, Business Finland	No central evaluating body; isolated methodologies
Partnerships	Strategic university–industry alliances	Episodic cooperation, low trust

Thus, developed countries display mature institutional frameworks and well-defined performance indicators, whereas Kazakhstan's model still reflects administrative characteristics and a fragmented structure.

Key Findings of the Study

1. Institutional Differentiation

Global experience confirms that autonomous universities are more successful in commercialising their research outputs. In Kazakhstan, ministerial dependency constrains universities' innovation activity. Granting autonomy and IP rights would significantly enhance technology transfer and attract investment.

2. Financial Structure

In OECD countries, private sector participation in R&D funding ranges from 60-80% (and exceeds 75% in South Korea). In Kazakhstan, it remains below 7%, reflecting minimal corporate involvement. This imbalance reduces market orientation and limits long-term innovation capacity.

3. Organisational and Infrastructural Maturity

In developed countries, technology transfer infrastructure is networked, encompassing Technology Transfer Offices (TTOs), technoparks, accelerators, venture funds, and industry-specific platforms. In Kazakhstan, these elements exist but operate in isolation. The absence of a unified digital platform for interaction among researchers, investors, and businesses results in a low conversion of scientific ideas into economic products.

4. Intellectual Property Management

Leading universities such as Stanford, MIT, and Cambridge operate structured systems for patenting, licensing, and revenue-sharing. Kazakhstan lacks a central IP database and a unified support framework for patents from registration to licensing, reducing investment attractiveness.

5. Evaluation and Monitoring Systems

Advanced countries employ multi-level evaluation structures – internal audits, national rankings, and annual reports. AUTM (USA) and ATTP provide standardised metrics; OECD uses innovation indices. Kazakhstan's assessments remain fragmented, with few consistent national indicators.

Despite positive trends including growth in patenting, grants, and commercialisation projects Kazakhstan's system remains unbalanced. Most innovation efforts rely on state grants without sustainable market incentives.

Currently, commercialisation processes in Kazakhstan are mainly implemented within the framework of government grant programs and are not accompanied by sustainable market mechanisms for the introduction of scientific developments.

Identified Challenges

- absence of a fully developed technology transfer ecosystem;
- duplication of functions across ministries and subordinate agencies;
- shortage of professionals in IP management, venture investment, and innovation leadership;
- weak motivation among scientists to patent and implement research results.

According to surveys by the National Centre for Science and Technology Evaluation (NCSTE), only 8-10% of research projects reach the prototype stage, and fewer than 3% achieve commercial application. This underscores the need to reform R&D governance and introduce measurable performance criteria.

Internationally, a shift is evident from the traditional «lab-to-market» approach to an integrated innovation ecosystem, where commercialisation forms part of a continuous cycle:

Scientific research →Technological development→Patenting→Technology tran sfer→Entrepreneurship→Reinvestment in science.

This integrated model is already institutionalised in countries such as the USA, Finland, and South Korea, through joint laboratories, corporate R&D centres, and acceleration programmes.

For example, Business Finland and KISED (Korea Institute of Startup & Entrepreneurship Development) coordinate collaboration between universities and private enterprises by providing both financial and advisory support.

For Kazakhstan, implementing similar mechanisms is possible through institutional adaptation – specifically, by establishing a National Commercialisation Operator responsible for analytics, support, and monitoring of innovation projects.

The comparative analysis shows that differences in the institutional architecture of national innovation systems significantly affect the effectiveness of the processes of commercialisation of scientific research.

The final conclusion

The results of the comparative analysis indicate that the countries with the most developed system of commercialisation of scientific research have a number of common institutional characteristics. These include a high share of private R&D financing, a well-developed technology transfer infrastructure, university autonomy in managing intellectual property results, as well as sustainable mechanisms for interaction between science and industry.

Comparing these parameters with the Kazakh model makes it possible to identify key institutional gaps and formulate directions for reforming the R&D commercialisation system.

A comparative analysis confirms that successful commercialisation of R&D is impossible without a comprehensive institutional architecture that unites science, government and business into a single innovation space.

International experience shows that the higher the autonomy of universities, the tighter the ties with industry and the more transparent the evaluation mechanisms, the higher the level of return on investment in science.

Institutionalization of commercialisation is becoming a key task for Kazakhstan. This is the creation of a sustainable national mechanism for monitoring, supporting and evaluating performance, which will turn scientific knowledge into real economic capital and increase the country's competitiveness in the global innovation space.

A model of institutional adaptation of R&D commercialisation for Kazakhstan

The comparative analysis of international research commercialisation models allows us to form a conceptual model of institutional adaptation for the Republic of Kazakhstan.

The proposed model is based on the integration of five key elements of the innovation ecosystem:

1. The legal autonomy of universities in the management of intellectual property and technology licensing.

2. A hybrid financing system combining government grants, corporate investments and venture capital.

3. Well-developed technology transfer infrastructure, including technology transfer offices (TTOs), technology parks, incubators and acceleration programs.

4. A system for monitoring and evaluating the effectiveness of commercialisation based on international indicators (OECD, AUTM, ATTP).

5. Institutional coordination between government, universities and business, ensuring the formation of a sustainable innovation ecosystem.

Within the framework of this model, commercialisation is considered as a continuous cycle of transformation of scientific knowledge into economic value.

The implementation of this model will increase the effectiveness of the national R&D system, strengthen the interaction of science and business and ensure the sustainable integration of scientific developments into the economy of the Republic of Kazakhstan.

Recommendations

1. Establish a National Centre for Commercialisation and Technology Transfer (NCCTT) under the Ministry of Science and Higher Education. The centre should perform analytical, certification, and monitoring functions, support projects, and publish annual reports modelled after AUTM, ensuring transparency and international comparability.

2. Reform R&D Financing. Shift from predominantly budget-funded research to hybrid models involving businesses, international partners, and venture capital. Introduce tax incentives and super deductions for investment in applied research.

3. Grant Institutional Autonomy to Universities. Legally allow universities and research institutes to retain ownership of publicly funded R&D outcomes, establishing revenue-sharing mechanisms between the state, institutions, and inventors.

4. Develop Human Capital. Create a national system for training and certifying technology transfer professionals following RTTP international standards. This will foster a professional market for innovation managers and strengthen institutional capacity.

5. Digitalise Commercialisation Processes. Integrate data on research projects, patents, technology transfer offices, grants, and start-ups into the unified information system «Kazakhstan Science» platform, ensuring open access and data-driven management across academia, business, and government.

6. Implement Comprehensive Evaluation Systems. Develop and institutionalise a national methodology for assessing commercialisation efficiency, based on DEA models, OECD innovation indicators, and ATTP standards, measuring both economic and social outcomes.

Conclusion

This study demonstrates that the effectiveness of commercialising scientific and technological research results depends on a combination of institutional, financial, and managerial factors, all integrated into a single innovation ecosystem.

Global experience shows that commercialisation is not merely a means of generating profit but a strategic mechanism for economic modernisation, market diversification, and ensuring technological sovereignty.

The comparative analysis of models in the USA, Canada, South Korea, Australia, and EU member states confirms that the main drivers of successful systems are university autonomy, a developed technology transfer infrastructure, hybrid funding schemes, and stable partnerships between academia, business, and the state. Institutional structures such as AUTM, ATTP, CECR, and KAIST play a coordinating role, establishing professional standards, providing certification, and supporting the formation of international innovation networks.

For Kazakhstan, the study identifies several structural imbalances: a predominant reliance on public funding, low participation of the private sector, and the absence of a national coordinating body or unified monitoring system.

Despite positive trends – including the increase in patents, rising R&D expenditure, and the establishment of university technology transfer offices – the process remains largely administrative, lacking continuity and market mechanisms.

Transitioning from fragmented initiatives to a comprehensive innovation ecosystem requires the institutionalisation of commercialisation as a core strategic direction of national science and technology policy. This involves creating effective inter-ministerial coordination, professional certification systems, and transparent digital monitoring of innovation outcomes.

By integrating these reforms, Kazakhstan can accelerate the transfer of research results into economic value, enhance global competitiveness, and ensure sustainable development through innovation.

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