Transforming the Research Commercialisation Ecosystem from Science Push to Open Innovation Model

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Abstract

This paper provides a critical analysis of the commercialization of research in a developing country that is undertaking science and technology policy reforms with an emphasis on the shift from a science-push to an open innovation model. Research commercialization is pivotal for technological advancement, but many innovations fail to reach the market, falling into the so-called "Valley of Death." In Kazakhstan, recent reforms are aimed at overcoming this gap, but the persistence of traditional linear models presents considerable obstacles. Through document analysis and semi-structured interviews, this study explores the nature of these reforms and the barriers encountered by academia and industry in the commercialization process. Theoretically, the study makes a contribution by examining the challenges of shifting from linear innovation models to more complex systems approaches. The findings underscore the difficulty of this transformation in Kazakhstan, highlighting the legacy of the Soviet-era focus on science-push models and the insufficient capacity of local industry to absorb new knowledge. The paper argues that building an effective commercialization pathway requires substantial investment in research infrastructure, capacity building, and regulatory adjustments to facilitate stakeholder collaboration.

Keywords: innovation policy, science and technology, triple helix, open innovation, science-push

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Abstract

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1. INTRODUCTION

Research commercialization is a critical component of the innovation ecosystem, facilitating the transfer of technology from academic laboratories to industry. However, this journey is fraught with challenges. The term “Valley of Death” is often used to describe the numerous barriers that prevent promising ideas from reaching the market.[1], [2] While basic and partially applied research are heavily funded by governments, often leading to significant scientific discoveries, the subsequent transition to marketable products and services is less straightforward. For-profit organisations typically find it risky to invest in untested and emerging technologies, contributing to the "Valley of Death." To bridge this gap, governments and universities often allocate additional funding and resources, supporting business incubators, acceleration programs, and proof-of-concept projects.[3], [4] Venture capital also plays a crucial role in supporting deep-tech and R&D-based innovations.[5], [6]

While such elements of the innovation ecosystem are well-established in developed countries, developing countries frequently rely on technology imports while attempting to build their own innovation potential. This paper critically evaluates the innovation policy in Kazakhstan, a developing country undertaking significant reforms and dedicating resources to boost research commercialization, and explores the challenges faced in this process. The study contributes to the literature on innovation policy and research commercialization by exploring the transformation from a science-push to an open innovation model.

The debate between the science-push and demand-pull innovation models that started in the second half of the twentieth century has evolved into a systems approach in innovation policy that focused on interaction among stakeholders rather than linear process from basic research to the market [7], [8]. The initial triple helix model of cooperation among stakeholders (government, universities, and businesses) that can be viewed as part of systems approach has expanded into a quintuple helix model, incorporating civil society and environmental actors [9]. Another complementary model that focuses on the role of firms was proposed by Chesbrough [10, p. 43] and stipulates that “valuable ideas can come from inside or outside the company and can go to market from inside or outside the company as well”.

In presenting new Law on science and technology policy adopted in 2024, the Ministry of Science and Higher Education of Kazakhstan stressed the need for open model of science and innovation [11], [12]. However, policy-making practice often favours the implementation of linear models, such as science-push. The preference for the science-push model is particularly evident among university and research institutes’ administrators. The country had a robust scientific base under the Soviet Union, which followed a linear and planned approach to technology transfer from laboratories to industry. In this context, the shift towards open science and innovation model provides an avenue to explore the transformation process and the challenges and opportunities faced by developing countries in enhancing their innovation ecosystems.

While there is abundant literature on innovation systems and polices in developed countries, the policy, the lack of support from main actors is one of the barriers to conduct studies in

developing countries context though such studies are very important of cross country analysis [13]. Previous studies on research commercialisation in the context of Kazakhstan were based on university and faculty perspective [14], [15] or provided overview of policies and recommendations [16]. This paper provides the analysis of science and technology policy shift in the country and perspectives of government, universities distinguishing between academia and technology transfer offices (TTOs) and businesses.

2. SURVEY OF LITERATURE AND THEORETICAL FRAMEWORK

Despite criticism from different fronts, the science-push linear model is striving due to its backing by standardized statistics and manuals used at OECD and national levels [7]. In this model, universities and research institutes play central role and innovation starts with basic research, progresses into applied research and development, and results in production and diffusion [17], [18]. The studies have failed to identify sequential pattern that support science-push model's proposition that publication activities related to curiosity-driven basic research should form an initial bell-shaped curve, followed by a second curve representing patent activities linked to applied research and development, with market diffusion occurring after the patent cycle concludes [19].

The alternative explanation of innovation – demand pull model brought forward a fact that innovation is driven by need or demand with defence sector being primary driver [20]. In this model production problems or needs are understood by researchers to offer possible solutions thus coupling research with production (Martin and Willens as cited by Godin & Lane 2013). However, the model was criticised due to too broad definition of "demand" to be measured and failure to explain disruptive innovations [21]. Given such shortcoming, the demand-pull model was later incorporated into more holistic systems and interaction models [20].

The concept of National Innovation Systems (NIS) provides a framework to understand how nations organize and facilitate innovation through the interplay of various actors and institutions. Emerging in the late 1980s, the NIS framework was shaped by scholars such as Freeman [22], Lundvall [23] and Nelson [24], who highlighted the importance of interconnected networks that promote, nurture, and apply innovation for societal benefit. At its core, the NIS emphasizes the dynamic relationships among institutions like universities, research organizations, government bodies, and industries. These entities collaboratively influence a nation's ability to foster technological advancements and address socio-economic challenges. The concept underlines the need for a conducive environment where resources, knowledge, and ideas flow freely, facilitating innovative outcomes that contribute to national competitiveness and development .

Early models, such as Sabato's (1975) "Triangle Model," emphasized the government's central role in coordinating interactions among academia, industry, and public policy. However, as innovation systems evolved, there was growing recognition of the multi-dimensional relationships and the necessity of balanced collaboration among actors. These perspectives led to a broader understanding of how different nations configure their innovation systems, taking into account unique socio-economic and cultural factors, as well as cross-national comparisons.

One of the most popular holistic systems approaches the Triple Helix model, introduced in the mid-1990s, highlights the synergy between the state, business, and universities and serves as a framework for analyzing innovation systems in their socio-economic and political contexts.[25], [26] The model identifies three primary actors: economic entities, knowledge producers, and government institutions [26].

Over time, a Quadruple Helix was introduced to include civil society, mass media, creative industries, and public values, recognizing the growing role of societal actors in the innovation process [27]. This adaptation is a response to the growing awareness that innovation is not solely a matter of interaction between the state, academia, and industry but is also heavily shaped by social needs, cultural values, and public discourse.

With the increasing importance of environmental issues due to climate change and ecological risks, the Quintuple Helix was suggested in 2010, adding the environmental groups as a fifth actor [28]. The Quintuple Helix introduces an ecological perspective to the innovation framework, reflecting the recognition that environmental sustainability is no longer a peripheral concern but a central pillar of socio-economic development. The inclusion of natural environments emphasizes that innovation should not only drive economic growth and social welfare but must also contribute to sustainable practices [9]

Complementing the Triple Helix module that emphasizes the interaction among actors within their contexts, the Open Innovation model adopts firm-centric view and focuses on how this interaction can benefit innovation. Open Innovation is defined as “the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively” [29]. Organizations can systematically seek, retain and utilize internal and external knowledge for continuous innovation [30]. The knowledge is more available these days due to open access policies, high mobility of academic staff between universities and industry and company campuses and labs on university premises.

Gassmann and Enkel (2006) identify three types of cooperation processes in innovation: 'Outside-In,' where external knowledge sources like customers, suppliers, and universities contribute to an enterprise's knowledge inflows; 'Inside-Out,' which involves external commercialization of internal knowledge such as new products or brands; and the 'Coupled-Process,' which integrates both strategies through strategic alliances to meet market demands [31]. Open innovation model diverges from viewing industry as sole actor and regards knowledge generation as a holistic process, engaging a wide array of key actors and diverse sources of knowledge [32].

Despite the development in theory and practices of innovation, the science-push model, along with other linear approaches, continues to be highly regarded due to its premise of a clear and direct relationship between targeted policy measures, including funding research initiatives, and measurable results, such as the development of new products [18]. For example, the research on Russia shows persistence of Soviet legacy and mentality of state push for deployment of R&D to production [33]. In understanding science and technology related

policies in post-Soviet states, it is important to understand this mentality that serves as a barrier for switching from science-push to more holistic models of innovation.

3. METHODOLOGY

This qualitative explorative study employs a combination of document analysis and semi-structured interviews to address the following research questions: (1) What are the reforms being undertaken regarding research commercialization in Kazakhstan and the responses to these reforms? (2) What are the challenges in research commercialization as perceived by various stakeholders? The research design is informed by the need to explore complex institutional processes and stakeholder perspectives within the context of Kazakhstan's evolving science policy landscape.

3.1. Document Analysis

Document analysis was employed to provide a foundational understanding of the policy environment and contextual factors influencing research commercialization. The documents analyzed include national laws related to science policy, Ministry of Science and Higher Education orders, calls for grant applications, as well as published interviews and opinion pieces authored by policymakers, research administrators, and scholars. Additionally, global innovation index reports were included to provide insights into the broader context of Kazakhstan's innovation system. This approach allowed for triangulation of multiple data sources, enhancing the reliability and validity of the findings.

3.2. Qualitative Interviews

Semi-structured interviews were conducted to gain in-depth insights into the experiences and perspectives of key stakeholders involved in research commercialization. The interviews involved representatives from academia, industry, and university administrative staff responsible for technology commercialization. Participants were selected using purposive sampling, aimed at ensuring a diverse range of views and experiences related to commercialization efforts.

The interviews took place between January 2 and March 5, 2024, via the Zoom platform. Before each interview, participants were briefed on the study's objectives, their rights as participants, and the measures taken to ensure the confidentiality of their data. Informed consent was obtained from all participants, either verbally during the initial meeting or via email. All interviews were recorded with participants' permission to ensure accuracy, and recordings were subsequently transcribed for analysis.

3.3. Participants

The study participants were selected among three key groups: technology transfer office staff (TTO), business representatives (BUS), and scientists (SCI). This sample comprised:

- Technology Transfer Office Staff (TTO): These individuals are responsible for coordinating and managing commercialization processes within their respective universities.
- Business Representatives (BUS): This group includes entrepreneurs and managers involved in innovation development and implementation within private companies.
- Scientists (SCI): This group consists of academic researchers and scientists who are actively engaged in research projects and their commercialization.

The information about participants is provided in table 1.

Table 1. Information about participants

№	Role	Position	Organization
1	TTO	Deputy Director of Technology Transfer Office	Public University
2	BUS	Entrepreneur and Innovation Development Manager	Private Company
3	TTO	Head of Technology Transfer Office	Public University
4	TTO	Deputy Director of Technology Transfer Office	Public University
5	TTO	Vice-Rector for Commercialization	Private University
6	BUS	Company Management	Private Manufacturing Company
7	SCI	Scientist-Entrepreneur	Startup
8	TTO	Director of Technology Transfer Office	Public University
9	SCI	Project Manager, Professor	Research Institute
10	SCI	Scientist	Public University
11	SCI	Lead Research Scientist	Research Institute
12	SCI	Scientific Project Leader	Public University
17	SCI	Scientific Project Leader	Public University
13	BUS	Scientific Project Leader	Private Company
14	BUS	Deputy for Science, Project Manager	Private Company
15	BUS	Company Director	Private Company
16	BUS	Technical Director	Private Company
17	BUS	Head of R&D Departments	Private company
18	SCI	Director of Research Institute	Research Institute

3.4. Data Analysis

Data analysis was conducted using Dedoose software, which facilitated the coding and categorization of qualitative data. A thematic analysis approach was employed, whereby interview transcripts and documents were systematically coded to identify key themes, patterns, and variations in stakeholder perspectives. This process involved multiple rounds of coding, beginning with open coding to capture emerging themes, followed by axial coding to group related concepts.

4. RESULTS

In the last three years, Kazakh government has been increasing funding for research and commercialisation and pushing forward reforms to increase impact from research. Alongside increase in funding of basic and applied research via three year grants from approximately two hundred thousand USD to four million USD per project, the government re-launched its grants for commercialisation of research.

The new Law on Science and Technology Policy resulted in merging previously separate Law on Science and Law on Commercialisation and introducing new measures to boost research commercialization. The reforms and the new legislation were presented by the Minister of Science and Higher Education as a milestone in switching from *"the mobilization approach: … a Soviet closed model of science, where the focus is on closed research institutes and strong, well-prepared, cohesive teams with narrow specializations towards open model of science*" [11].

Head of Science Committee of Kazakhstan, main body responsible for research policy and funding noted that *"the main flaw of the existing model remains the predominance of fundamental and applied research (82%), while experimental design work accounts for only 18%".* Government remains the main source of research funding (70%) which is at odds with the rations in developed countries where more than two-thirds of funding comes from private sector [34].

In the last two years, the government policy has shifted towards prioritizing the economic impact from research and based on President Tokayev's call that "*scientific projects need to address not only academic demands but also take into account the country's strategic development goals and the needs of the economy*" [35]. In addressing this call, the government went step further to prioritize the needs of business enterprises. In answering the question of a Prime-Minister on what is being done to introducing new mechanisms for commercialization of research, the Minister of Science and Education stated:

> *"Now we no longer ask scientists for relevant topics and directions for scientific research. Instead, we go to the production sector, study and gather specific technological problems that require scientific input to solve. In other words, it will be the production sector that sets the tasks for the scientific community*."

This shift was complemented by introducing new requirements into the call for grant application for financing basic and applied research. All the application should state the current technology readiness level (TRL) and the TRL to be achieved as a result of project implementation. In addition the call issued in September 2024 required listing the Science Committee as one of the patent owners in application for patents received as a results of research financed through the government grants. The Committee mentioned the need for making the patents work and a notice from the Supreme Audit Chamber of the Republic of Kazakhstan as a rationale for such initiative (communication from the Committee

representative during Zoom meeting with scholars).[1] Additionally, the winners of grants in applied projects were required to publish one article based on input from industry in multidisciplinary journals.

Although the scholarly community welcomed the introduction of the new law and recent reforms, there was backlash against radical changes, such as the government's collection of business needs and the requirement for publications to align with these needs. In an article published in major state newspaper, Director of the National Center for Complex Processing of Mineral Raw Materials noted that science should not turn into a factory laboratory and government should avoid using research funding to solve problems of private business [36]. The Young Researchers Alliance and Council of Young Researchers of the National Academy of Science have also raised their concerns about issues in the call for grants regarding patents and publications.

In extreme cases, as outlined above, the government and the scholarly community are working to find compromises. However, the overall research policy environment is shifting towards higher expectations for applied research, commercialization, and enhanced university-industry collaboration. A new tax incentive scheme is currently being developed to encourage businesses to invest in research and development.

Given the historical dominance of a state-sponsored science-push model, building a national innovation system based on the principles of open innovation and collaboration among government, academia, and industry remains challenging. One of the key challenges is the bureaucracy's inclination to pursue transformation through push policies rather than investing in long-term solutions, such as rebuilding R&D capacity that has been eroded over more than two decades of underfunding, and strengthening institutions that support start-ups and entrepreneurship—efforts that require coordination across multiple ministries. There are also persistent expectations among some established scholars and research administrators that the government should formulate technical specifications and finance programs aimed at establishing new factories [37].

In the following section, we present findings from our interviews on the barriers that hinder the transformation towards an open innovation model for the commercialization of research.

4.1. Barriers for open innovation

Open innovation model is based on a premise that companies innovation comes both from internal and external sources and companies should seek for ideas outside of their boundaries. One of the main sources of knowledge are universities and research institutions that may share it through licensing, spin-offs and other channels. Close collaboration with companies provides universities with understanding of market needs and practical challenges that will improve real-world application of academic research. This model requires close collaboration, networking

[1] Supreme Audit Chamber of the Republic of Kazakhstan and some members of Parliament raised concern of government financing research projects and having now ownership over the results of such project in the form of patents

approach and building strategic alliances among universities and businesses. Its application in Kazakhstan faces some challenges outlined below.

4.1.1. Low interest of businesses in research commercialization

Many companies exhibit a reluctance to collaborate with academic institutions and researchers for innovation. This hesitancy often stems from a perception of high risk and uncertainty associated with investing in unproven technologies. There are also individual factors such as top management's interest in innovation. As put by one of the participants in company top management:

> *"If, let's say, in a board of directors consisting of five people, at least one person clearly understands the goals, tasks, and processes [related to innovation], they will be able to convince the other five to act within a certain risk appetite, allocate funds or efforts to this thing [collaboration with scholars]."(Participant 16)*

Businesses may prioritize immediate profitability over long-term innovation. Given the low levels of property right protections[2], high interest rates (base rate as of September 2024 is 14.25%) and high inflation (20.7% in 2023) long term investments in high risk innovation projects without government support is less likely. Scholar and TTO officers have difficulty in finding co-financing partners to apply for commercialization grants:

> *"[when approached to co-finance the project] many people in the business sector would disagree with that because, at first glance, it's not profitable for them. In three years, the money they invested will not bring profits due to inflation; that money will essentially disappear. It's more profitable for them to invest that money into an already existing product right now." (Participant 4)*

4.1.2. Low of absorptive capacity of companies

Another critical barrier is the limited absorptive capacity of local enterprises. Many Kazakhstani companies lack the necessary expertise and skills to adopt and implement new technologies developed through scientific research. Particularly there is a shortage of qualified engineers and technical personnel capable of bridging the gap between academic research and industrial application. As indicated by participant from business sector *"in the field of industrial automation and industry overall, there is generally a weak competence among Kazakhstani specialists" (Participant 2).* The government acknowledges this issue and addresses it by allocating higher proportion of government scholarships for tertiary education for engineering and technology related majors.

The participants from companies with R&D departments indicated that their priority in cooperation with universities is procurement of qualified graduates, particularly engineers. There is a tendency to bring ready to use technology and use catch-up strategies rather than

[2] Kazakhstan ranks 74th according to International Property Right Index 2023 https://www.internationalpropertyrightsindex.org/

investing into in-house technology development. Some companies participating in commercialization grants scheme aimed to build internal R&D capacity through establishing labs and training personnel as part of the project.

According to Knowledge absorption indicators of Global Innovation Index (GII) data for Kazakhstan, the country is 83rd place on intellectual property payments as percentage of total trade and data for research talent in businesses is not available. However, the rankings are higher for the imports of high-tech as percentage of total trade (52nd place).

4.1.3. Bureaucracy in universities and mistrust

Open innovation is associated with less hierarchical structures and decentralisation in organisations.[3] However, public universities in Kazakhstan with large science faculties are highly centralised organisations with hierarchical structures. Rectors are powerful figures with limited degree of decision making delegated to deans and middle manager in administrative departments. TTOs are part of hierarchical structure and usually are in form of departments under a vice-rector for research or in some case under the director of a research office.

Interview participants from academia, TTOs and business all expresses their frustration with bureaucratic hurdles within universities. One of the problems of vertical control based cultures is the number of people involved in the process of decision making. Such processes as signing of the contract between university and the company or simply sending the scholar for the business trip or conference as part of the project may involve many departments before it is signed off by the Rector. The number of people and department involved can be measured by signatures required. AS put by one participant with extensive administrative experience:

> *"Recently, I met [representative of regional public university], and they say that we are reducing...[bureaucratic barriers]. They have 12 signatures. [names another public university] the lecturer also says that we only have 11 signatures left"(Participant 18)*

Low speed of decision making and necessity to negotiate with various department within university often with conflicting interests demotivates scholars and interested business partners in dealing with technology transfer and research commercialisations.

> *"We know that when collaborating with businesses, quick decisions are necessary: a quick signature, a quick stamp, make a decision, issue an invoice, stamp it, and move on. But when we have to wait for the rector's signature, sometimes we have to wait until they return from a trip. Such situations also complicate and slow down the process of interaction with our business partners."(Participant 3)*

Some companies eager to apply for commercialisation grants but frustrated by previous experience partnering with universities decided to switch to working with accredited scholars

[3] Büschgens, T., Bausch, A., & Balkin, D. B. (2013). Organizational culture and innovation: A meta-analytic review. *Journal of product innovation management*, *30*(4), 763-781.
Rangus, K., & Slavec, A. (2017). The interplay of decentralization, employee involvement and absorptive capacity on firms' innovation and business performance. *Technological Forecasting and Social Change*, *120*, 195-203.

in their applications. *"We have worked with individual [accredited] scholars as well as universities, and it's quicker with individual scholars" (Participant 6)*

According to the commercialisation grant requirements companies have to partner with research organisation, including universities, or individual that have research accreditation.

4.1.4. Absence of platforms for connecting

There is a lack of platforms that bring stakeholders together. Businesses and scholars often meet at forums organized by government agencies or universities. However, these meetings mostly feature a few guest speakers and presentations by a small number of scholars, and they fail to focus on networking. One of the participants suggested that "these meetings should be precisely targeted, I think, perhaps even without any kind of initial welcoming speeches from the leaders" (Participant 1).

Such forums rarely include any pre-forum matching activities, and organizers often select a handful of promising projects that are presented on multiple platforms. One of the participants noted that he saw the same people at many forums he attended in different cities, which was also noticed by other attendees.

Managers of a company that wanted to cooperate with scholars for commercialization projects spent more than a month searching through publications, thesis databases, and contacting university research offices in order to find scholars who might be interested in their idea. Several participants from business and academia indicated the need for an online platform that hosts both the needs of companies and solutions by scholars.

> *"There is not enough information points [Online platforms] where ideas or problems are presented. That is, for scientists and businesspeople to come together, it was necessary for scientists to be informed about the business people's problems, and for businesspeople to learn about the scientists' achievements." (Participant 10)*

4.1.5. Insufficient IP portfolio and TTO competencies

Participants from companies and Technology Transfer Offices (TTOs) frequently cited the poor quality of research organizations' intellectual property (IP) portfolios as a significant challenge. Kazakhstani research organizations have accumulated a relatively large number of patents for inventions (43rd in the Global Innovation Index) and utility models (10th in the Global Innovation Index). Many patents are obtained as part of government research grants, which often require patents as an obligatory output. Consequently, scholars tend to apply for utility patents due to the faster procedures and lower threshold for novelty, primarily to fulfill grant requirements promptly. Interview participants frequently used the phrase "we all know how patents are received in Kazakhstan," reflecting a general lack of trust in the novelty and quality of these patents.

The commercialization potential of the IP portfolio is further hampered by insufficient academia-industry collaboration during the early stages of technology development. There is

a prevalent tendency to develop technologies without substantial involvement from business partners, relying instead on government commercialization funding to advance these technologies to the market. One academic participant reported initiating a production line as part of a commercialization project with limited market research, no business partners, minimal business expertise, and no support from the technology transfer office. Another participant noted that it is common practice not to involve business partners due to their lack of interest or trust, and that business partners are often brought in only to formally fulfill grant requirements, which have recently been updated to include co-financing from companies.

Challenges associated with the IP portfolio are exacerbated by a lack of competencies among TTO staff in assessing the market potential of technologies. Interviews with TTO personnel indicated that most had prior experience in university administration rather than business development or commercialization. Since most TTOs were established less than a decade ago and are largely staffed by administrative personnel, interviewees emphasized the need for training focused on business skills to enhance their capacity to effectively support technology transfer and commercialization initiatives.

5. DISCUSSION AND CONCLUSION

Across the globe, policymakers have increasingly favored the "technology push" model, attracted by its straightforward rationale and the economic justification of addressing market failures through public investment in research and development (R&D). However, prioritizing research funding without concurrently supporting other innovation-related activities often leads to unmet expectations. Consequently, researchers frequently face criticism for not delivering the anticipated outcomes. [17].

Since the 1990s, scholars in Kazakhstan have experienced over two decades of chronic underfunding for research. As research grant funding has increased in recent years, expectations for scholars have also risen. Policymakers have noted that the majority of these funds are being allocated to basic research. This challenge is not unique to Kazakhstan; in Russia, investments in research and development (R&D) and technology transfer within agricultural research organizations (RTOs) have similarly been redirected toward basic research, diminishing the applied research component of these RTOs. [38].

In 2023, the Ministry of Science and Higher Education of Kazakhstan shifted government policy from broadly supporting research to prioritizing commercialization. Although this shift has been highly praised by members of parliament and the media, in the context of limited research capacity, it may restrict the anticipated positive effects of funding. The results indicate that the government is leaning towards supporting demand-pull and open innovation approaches. This is evident in initiatives such as collecting problems from businesses for scholars to address, increasing R&D funding, and providing additional incentives for applied research within grant schemes.

Universities and research institutes are important sources of knowledge and competence, contributing to enterprises' knowledge inflows within the open innovation model [31].. However, given the challenges related to the quality of intellectual property (IP) in Kazakhstani

universities, further investment is needed in research infrastructure and basic research to build the capacity of research organizations to generate and transfer knowledge to companies.

There are also structural issues related to the private sector. Previous research shows that firms with more open innovation strategies and strong absorptive capacity are more inclined to engage specialist knowledge providers, including universities and research institutions [39], [40], [41]. Interview participants from technology transfer offices (TTOs), the academic community, and industry highlighted the limited interest and absorptive capacity of local companies. For representatives of large manufacturing firms, collaboration with universities primarily focused on training engineers rather than pursuing innovation opportunities, driven by an acute shortage of technical personnel.

This paper contributes to the scholarly literature on science and innovation policy by exploring the ongoing reforms in Kazakhstan in this domain. Transformation towards an open innovation model requires investment in research infrastructure, human capital, regulatory frameworks, and attention to institutions such as contract enforcement and property protection. Governments in developing countries should avoid attempting to force transformation simply by collecting demands from industry and imposing them on academia to push commercialization efforts. The issues identified through interviews indicate the need to build an ecosystem and introduce structural and organizational-level changes that support the translation of research. Some key recommendations for policymakers in countries with similar contexts are as follows:

- Further invest into research infrastructure for basic and applied research to increase the portfolio of intellectual property available for commercialisation;
- Introduce tax incentives and work with business associations to motivate businesses to work with local researchers;
- Provide capacity building funding alongside research and commercialisation grants to support business development and entrepreneurship training for TTOs, scholars and innovation brokers;
- Engage in Public-Private partnerships to create online and offline platforms for improving collaboration among stakeholders in research commercialisation;
- Improve regulatory environment and increase confidence of private investors to involve venture capital in commercialisation initiatives;
- Introduce organisational changes to public universities that will lead to decentralisation and greater autonomy for technology transfer offices.

It is important to assess current capacity of research organisations in order to increase the effectiveness of commercialisation funding and other government polices in this area. Open innovation model is firm-centric and emphasizes knowledge exchange. In developing countries with limited business-ready IP portfolio and weak innovative and entrepreneurial culture within universities and research institutions, the focus should be on capacity building.

6. LIST OF REFERENCES

[1] P. E. Auerswald and L. M. Branscomb, "Valleys of Death and Darwinian Seas: Financing the Invention to Innovation Transition in the United States," *The Journal of Technology Transfer*, vol. 28, no. 3, pp. 227–239, Aug. 2003, doi: 10.1023/A:1024980525678.

[2] H. Son, Y. Chung, and S. Yoon, "How can university technology holding companies bridge the Valley of Death? Evidence from Korea," *Technovation*, vol. 109, p. 102158, Jan. 2022, doi: 10.1016/j.technovation.2020.102158.

[3] J. Hudson and H. F. Khazragui, "Into the valley of death: research to innovation," *Drug Discovery Today*, vol. 18, no. 13, pp. 610–613, Jul. 2013, doi: 10.1016/j.drudis.2013.01.012.

[4] M. Jung, Y. Lee, and H. Lee, "Classifying and prioritizing the success and failure factors of technology commercialization of public R&D in South Korea: using classification tree analysis," *J Technol Transf*, vol. 40, no. 5, pp. 877–898, Oct. 2015, doi: 10.1007/s10961-014-9376-5.

[5] N. Magomedova, N. Villaescusa, and A. Manresa, "Exploring the landscape of University-affiliated venture funds: an archetype approach," *Venture Capital*, vol. 25, no. 3, pp. 317–349, Jul. 2023, doi: 10.1080/13691066.2022.2163001.

[6] M. J. Rodríguez-Gulías, D. Rodeiro-Pazos, S. Fernández-López, C. Corsi, and A. Prencipe, "The role of venture capitalist to enhance the growth of Spanish and Italian university spin-offs," *Int Entrep Manag J*, vol. 14, no. 4, pp. 1111–1130, Dec. 2018, doi: 10.1007/s11365-017-0489-9.

[7] B. Godin, *Models of Innovation: The History of an Idea*. Cambridge: MIT Press, 2017.

[8] L. Leydesdorff and I. Ivanova, "'Open innovation' and 'triple helix' models of innovation: can synergy in innovation systems be measured?," *J. open innov.*, vol. 2, no. 1, p. 11, Aug. 2016, doi: 10.1186/s40852-016-0039-7.

[9] L. Donati, G. Stefani, and M. Bellandi, "The Evolutionary Emergence of Quintuple Helix Coalitions: A Case Study of Place-Based Sustainability Transition," Sep. 2023, doi: 10.1163/21971927-12340010.

[10] H. W. Chesbrough, *Open Innovation: The New Imperative for Creating and Profiting from Technology*. Harvard Business Press, 2006.

[11] Т. Панченко, "Нурбек показал Байтасову первое казахстанское лекарство от рака," Forbes.kz. Accessed: Oct. 18, 2024. [Online]. Available: https://forbes.kz/articles/budet_li_u_kazahstana_svoe_lekarstvo_ot_raka

[12] "Саясат Нурбек и директора НИИ обсудили вопросы развития науки," gov.egov.kz. Accessed: Nov. 18, 2024. [Online]. Available: https://betaegov.kz/memleket/entities/sci/press/news/details/705242

[13] R. N. Weerasinghe, A. K. W. Jayawardane, and Q. Huang, "Critical inquiry on National Innovation System: Does NIS fit with developing countries?," *Sustainable Technology and Entrepreneurship*, vol. 3, no. 1, p. 100052, Jan. 2024, doi: 10.1016/j.stae.2023.100052.

[14] D. Jonbekova, J. Sparks, M. Hartley, and G. Kuchumova, "Development of university–industry partnerships in Kazakhstan: Innovation under constraint," *International Journal of Educational Development*, vol. 79, p. 102291, Nov. 2020, doi: 10.1016/j.ijedudev.2020.102291.

[15] G. Kuchumova, D. Bilyalov, and D. Jonbekova, "Faculty engagement in university-industry research partnerships: findings from a developing country," *Studies in Higher Education*, vol. 48, no. 9, pp. 1455–1467, Sep. 2023, doi: 10.1080/03075079.2023.2203135.

[16] O. B. Kenzhaliyev *et al.*, "Conditions to facilitate commercialization of R & D in case of Kazakhstan," *Technology in Society*, vol. 67, p. 101792, Nov. 2021, doi: 10.1016/j.techsoc.2021.101792.
[17] D. Marinova and J. Phillimore, "Models of innovation," in *The international handbook on innovation*, vol. 1, Elsevier Amsterdam, 2003, p. 2164.
[18] U. Schmoch, "Double-boom cycles and the comeback of science-push and market-pull," *Research Policy*, vol. 36, no. 7, pp. 1000–1015, Sep. 2007, doi: 10.1016/j.respol.2006.11.008.
[19] U. Schmoch, "Double-boom cycles and the comeback of science-push and market-pull," *Research Policy*, vol. 36, no. 7, pp. 1000–1015, Sep. 2007, doi: 10.1016/j.respol.2006.11.008.
[20] B. Godin and J. P. Lane, "Pushes and Pulls: Hi(S)tory of the Demand Pull Model of Innovation," *Science, Technology, & Human Values*, vol. 38, no. 5, pp. 621–654, Sep. 2013, doi: 10.1177/0162243912473163.
[21] D. Mowery and N. Rosenberg, "The Influence Of Market Demand Upon Innovation: A Critical Review Of Some Recent Empirical Studies," *Research Policy*, vol. 8, pp. 102–153, Apr. 1993, doi: 10.1016/0048-7333(79)90019-2.
[22] C. Freeman, "The 'National System of Innovation' in historical perspective," *Cambridge Journal of Economics*, vol. 19, no. 1, pp. 5–24, Feb. 1995, doi: 10.1093/oxfordjournals.cje.a035309.
[23] B.-A. Lundvall, *National systems of innovation: Towards a theory of innovation and interactive learning*. London: Pinter Publishers, 1992.
[24] R. R. Nelson, *National Innovation Systems: A Comparative Analysis*. Oxford: Oxford University Press, 1993.
[25] Y. Cai and H. Etzkowitz, "Theorizing the Triple Helix model: Past, present, and future," *Triple Helix*, vol. 7, no. 2–3, pp. 189–226, 2020.
[26] L. Leydesdorff and H. Etzkowitz, "Triple Helix of innovation: introduction," *Science and public policy*, vol. 25, no. 6, pp. 358–364, 1998.
[27] O. Afonso, S. Monteiro, and M. Thompson, "A growth model for the quadruple helix," *Journal of Business Economics and Management*, vol. 13, no. 5, pp. 849–865, Nov. 2012, doi: 10.3846/16111699.2011.626438.
[28] E. G. Carayannis and D. F. J. Campbell, "Triple Helix, Quadruple Helix and Quintuple Helix and How Do Knowledge, Innovation and the Environment Relate To Each Other? : A Proposed Framework for a Trans-disciplinary Analysis of Sustainable Development and Social Ecology," *IJSESD*, vol. 1, no. 1, pp. 41–69, Jan. 2010, doi: 10.4018/jsesd.2010010105.
[29] H. Chesbrough, Vanhaverbeke Wim, and J. West, Eds., *Open Innovation: Researching a New Paradigm*. Oxford University Press, 2006. doi: 10.1093/oso/9780199290727.001.0001.
[30] U. Lichtenthaler, "Open Innovation: Past Research, Current Debates, and Future Directions," *AMP*, vol. 25, no. 1, pp. 75–93, Feb. 2011, doi: 10.5465/amp.25.1.75.
[31] O. Gassmann and E. Enkel, "Towards a Theory of Open Innovation: Three Core Process Archetypes," Jul. 2004, Accessed: Nov. 15, 2024. [Online]. Available: https://www.alexandria.unisg.ch/handle/20.500.14171/67618
[32] B. A. Becker and C. Eube, "Open innovation concept: integrating universities and business in digital age," *Journal of Open Innovation: Technology, Market, and Complexity*, vol. 4, no. 1, pp. 1–16, Mar. 2018, doi: 10.1186/s40852-018-0091-6.
[33] I. Dezhina and H. Etzkowitz, "Path dependence and novelties in Russian innovation," *Triple Helix*, vol. 3, no. 1, p. 11, Nov. 2016, doi: 10.1186/s40604-016-0042-9.

[34] "Perezagruzka kazakhstanskoy nauki i drugie funktsii: dlya chego sozdan Natsional'nyy sovet po nauke i tekhnologiyam" [Rebooting Kazakhstani Science and Other Functions: Why the National Council for Science and Technology Was Created], informburo.kz. Accessed: Nov. 18, 2024. [Online]. Available: https://informburo.kz/interview/perezagruzka-kazaxstanskoi-nauki-i-drugie-funkcii-dlya-cego-sozdan-nacionalnyi-sovet-po-nauke-i-texnologiyam

[35] "Vystuplenie Kasym-Zhomarta Tokaeva na zasedanii Natsional'nogo soveta po nauke i tekhnologiyam pri Prezidente Respubliki Kazakhstan — Ofitsial'nyy sayt Prezidenta Respubliki Kazakhstan" [Speech by Kassym-Jomart Tokayev at the Meeting of the National Council for Science and Technology under the President of the Republic of Kazakhstan - Official Website of the President of the Republic of Kazakhstan], Akorda.kz. Accessed: Nov. 18, 2024. [Online]. Available: https://www.akorda.kz/ru/vystuplenie-kasym-zhomarta-tokaeva-na-zasedanii-nacionalnogo-soveta-po-nauke-i-tehnologiyam-pri-prezidente-respubliki-kazahstan-123423

[36] kazpravda.kz, "Otraslevaya nauka ne dolzhna prevrashchat'sya v zavodskuyu laboratoriyu" [Sectoral Science Should Not Turn Into a Factory Laboratory]. Accessed: Nov. 18, 2024. [Online]. Available: https://kazpravda.kz/n/otraslevaya-nauka-ne-dolzhna-prevrashchatsya-v-zavodskuyu-laboratoriyu/

[37] kazpravda.kz, "Nauka dolzhna prinosit' real'nuyu pol'zu obshchestvu" [Science Should Bring Real Benefits to Society]. Accessed: Nov. 18, 2024. [Online]. Available: https://kazpravda.kz/n/nauka-dolzhna-prinosit-realnuyu-polzu-obshchestvu/

[38] T. W. Thurner and S. Zaichenko, "Technology transfer into Russia's agricultural sector—Can public funding replace ailing business engagement?," *Science and Public Policy*, vol. 45, no. 5, pp. 683–691, Oct. 2018, doi: 10.1093/scipol/scy001.

[39] J. E. Rohenkohl, A. C. da Rosa, J. Ruffoni, and O. Martinelli, "Necessary and sufficient conditions for the absorptive capacity of firms that interact with universities," *International Review of Applied Economics*, vol. 38, no. 1–2, pp. 175–193, 2024, doi: 10.1080/02692171.2021.1957783.

[40] B. S. Tether and A. Tajar, "Beyond industry–university links: Sourcing knowledge for innovation from consultants, private research organisations and the public science-base," *Research Policy*, vol. 37, no. 6, pp. 1079–1095, Jul. 2008, doi: 10.1016/j.respol.2008.04.003.

[41] J. West and M. Bogers, "Leveraging External Sources of Innovation: A Review of Research on Open Innovation," *Journal of Product Innovation Management*, vol. 31, no. 4, pp. 814–831, 2014, doi: 10.1111/jpim.12125.