“Commercialization of R&D and opportunities for the development of academic entrepreneurship in Kazakhstan”

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COMMERCIALIZATION OF R&D AND OPPORTUNITIES FOR THE DEVELOPMENT OF ACADEMIC ENTREPRENEURSHIP IN KAZAKHSTAN

Abstract

The transition to an innovative economy requires greater attention to creating favorable conditions for the commercialization of scientists' developments and the possibility of realizing the accumulated scientific potential. This study aimed to examine the commercialization process in the Republic of Kazakhstan and identify factors influencing the development of academic entrepreneurship in universities. It examines a gradual change in legislation on technology transfer and the dynamics of implemented commercialization projects during 2016–2022. Structured interviews were conducted with academics of the biggest 14 universities in Kazakhstan with a sample of 209 respondents to identify factors influencing the desire of scientists to engage in academic entrepreneurship. The findings revealed that the most attractive factors for academics are flexible working hours (4.67 of 5), the opportunity to implement their own innovative ideas (4.12), and an increase in income (3.63). In turn, negative factors include the lack of qualified personnel (4.56), difficulties in legislation (4.27), and bureaucratic barriers (3.78). The study revealed that gender and age moderately affected scholars' desire to engage in academic entrepreneurship (Cramer's V = 0.3025). The greatest desire to start their own business was demonstrated by men aged 26-35 years and by women aged 36-45 years. The findings also show that the scientific fields positively affect the number of ready-made ideas, patents, and technologies that academics offer to businesses.

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INTRODUCTION

Commercialization of R&D is an important and integral part of the innovation process when the results of scientific and (or) technical activities receive tangible form and can be brought to market. At the same time, all participants in the commercialization process can not only translate their ideas and creativity into a specific product that satisfies consumer needs but also receive income (Prodan & Drnovsek, 2010). Commercialization allows scientific developments to be brought to practical application, contributes to the development of technological progress, and improves the well-being of society.

Kazakhstan, possessing large reserves of natural resources, has proclaimed a course toward innovative development since the beginning of the 2000s to move away from resource dependence and realize its own scientific and technical potential. Basic laws in industrial and innovative development were adopted, and changes were made to legislative acts regulating the scientific field, scientific personnel training, and research activities financing (Sitenko, 2011). It was planned that

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universities, as sources of advanced knowledge and scientific developments (Etzkowitz & Leydesdorff, 2000), would be actively involved in commercialization (Marczewska et al., 2023).

Using the experience of developed countries, Kazakhstani universities were able to improve their innovation infrastructure. Technology parks and research commercialization offices were opened in several universities (Alibekova et al., 2019). Universities received autonomy in terms of training scientific personnel (Master's and Ph.D. programs). Scientific research in universities is conducted at the expense of the state budget as part of the distribution of grants for R&D. University scientists are also involved in research commissioned by the business sector. At the same time, the declared opportunities for creating small innovative enterprises (spin-offs) at universities remained unrealized. Despite the potential for scientists to exercise their intellectual property rights, academic entrepreneurship has not received widespread development. Of the many completed scientific projects, only a few were implemented.

Thus, it is relevant to study commercialization features in the Republic of Kazakhstan and identify factors influencing the decision of university employees to engage in academic entrepreneurship.

1. LITERATURE REVIEW AND HYPOTHESES

Interest in the process and mechanisms of commercialization arose in the literature with the growth in the scope and importance of research conducted in collaboration with industry, as well as the adoption of the Stevenson-Wydler Technology Innovation Act in the United States in 1980. As a result, the funding available for public-private R&D projects has increased, and universities have become more active in creating structures focused on commercializing scientific discoveries (Drejer & Jorgensen, 2005).

Open models, first described by Chesbrough (2003), treated R&D as an open system in which many partners could be involved. The standard scheme of the innovation process, when all stages of innovation from the idea to the introduction to the market occur only on the organization's own base without the involvement of external sources, has become less viable due to the accelerated scientific and technological progress (Enkel et al., 2009). In turn, the open innovation model allows an organization to attract external resources (financing, human capital, etc.) and partners to carry out innovative activities, including the commercialization of their own developments (Abdul Razak et al., 2014).

Defining the concept of commercialization, most scientists emphasize the embodiment of an innovative idea in a new product (Gans & Stern, 2003; Dehghani, 2015). In addition, researchers may highlight the mandatory profit from bringing the product to market, as well as the mechanism for distributing intellectual property rights. Thus, Mitchell and Singh (1996) view commercialization as obtaining ideas further improved by additional knowledge, embodied in finished goods and sold on the market. Ambos et al. (2008) noted that technology commercialization is realized through the sequential processes of design, production, and promotion of products with the developed technology through licensing or other joint actions. Kirchberger and Pohl (2016) define technology commercialization as transferring technological innovation from the technology developer to an organization that applies the technology to produce commercial products.

With the advent and development of the triple helix concept (Etzkowitz & Leydesdorff, 2000), universities have become increasingly important in the innovation process as sources of innovative knowledge and ideas. Etzkowitz (2004), Shane (2004), Fini and Lacetera (2010) substantiate the new role of the university in society, the so-called "third mission," when, along with teaching and scientific research, universities are tasked with entrepreneurial activity (Compagnucci & Spigarelli, 2020). This requires universities to change the structure of management of scientific research and technology transfer processes (Drivas et al., 2018). Universities should not only create new knowledge but also the possibility of its application in various technological solutions and products. At the same time, universities can also train specialists with entrepreneurial skills (Bejinaru, 2018). The task of the university is to organize effective interaction in a single space and on an ongoing basis between education, scientific research, and the implementation of their results (Rajalo & Vadi, 2017).

Academic entrepreneurship involves the activities of university staff (sometimes also master's and doctoral students) to establish partnerships with the business sector to develop and implement their own research results (Sieg et al., 2023). Many researchers (Brantnell & Baraldi, 2022; Colombelli et al., 2019) emphasize the complexity of this process since academic entrepreneurship operates within an existing organization with established rules, unlike, for example, individual entrepreneurship (Min et al., 2020). Academic entrepreneurship is creating and managing an innovative enterprise based on knowledge or technology derived from research activity and protected by copyright (Siegel & Wright, 2015).

Academic entrepreneurship is a narrower concept than commercialization (Malwina & Hubert (2021), as it considers the implementation only of those developments that are obtained because of research activities within the university (Aydemir et al., 2022).

Academic entrepreneurship has grown most in developed countries, where universities have gained new opportunities in research funding and intellectual property rights (Lacetera, 2009; Davey et al., 2016). In developing countries, academic entrepreneurship has only occurred in selected, largest universities with government support (Tunio, 2020). The main challenge remains the lack of funding from the business sector for university R&D (Davey et al., 2016), insufficient involvement of faculty staff (D'Este & Perkmann, 2011), insufficient knowledge of legislation in the field of innovation entrepreneurship, and bureaucratic complexities (Haeussler & Colyvas, 2011; D'Este & Patel, 2007).

Since academic researchers initiate innovative projects, it is important to know what personal factors they possess (Boardman & Ponomariov, 2009). An academic entrepreneur's experience and scientific connections can be crucial to the success of a project (Stuart & Ding, 2006). Thus, the initiation of the commercialization process largely depends on their motivation to engage in entrepreneurial activities in parallel with teaching and research activity (Huyghe & Knockaert, 2015; Kraetzig & Sick, 2021).

Many studies have examined the impact of external incentives on academics, such as increased income upon starting a business, expanding networks, and obtaining new types of resources (West & Bogers, 2014; Lam, 2011; Tartari et al., 2014; Gössling et al., 2021). However, fewer publications are devoted to the characteristics of researchers' internal motivations for academic entrepreneurship (Filippetti & Savona, 2017). Research has mainly focused on understanding the factors that an individual must possess to take an active part in academic entrepreneurship (the so-called portrait of an academic entrepreneur) (Teixeira & Nogueira, 2016; Aydemir et al., 2022). At the same time, the activity of academic entrepreneurship itself and its integration into the teaching and research activities of scientists have been less studied (Sieg et al., 2023).

Among the critical issues associated with the development of academic entrepreneurship, researchers highlight the motivation of university staff to perform entrepreneurial functions, as well as the factors influencing the intention to engage in entrepreneurial activity (Stuart & Ding, 2006; Audretsch et al., 2015). Stuart and Ding (2006) confirmed the hypothesis that scientists more often switch to entrepreneurship when working in institutes with other scientists already engaged in project commercialization. Teixeira and Nogueira (2016) identified a key of academic entrepreneurship as the number of contacts established with the industry. A study on the influence of organizational support on the decision of university teaching staff to engage in entrepreneurial activity (Urban & Gamata, 2020) revealed that the main factors of motivation were university reward systems with a focus on R&D comercialisation and informal factors (attitudes, role models). At the same time, the study notes that management support do not play a key role.

In Kazakhstan, the study of the academic entrepreneurship phenomenon has just begun in the last decade (Yessengeldin et al., 2016). With the adoption of laws in the field of innovation in the

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early 2000s, researchers paid more attention to the development of optimal mechanisms for interaction between individual elements of the innovation process. Universities were considered key players in the innovation system. However, they were assigned the role of a source of innovative ideas and developments while industrial enterprises were to implement the created technologies. Most of the works of that period are devoted to organizational and legal issues of commercialization of innovations created by Kazakh scientists (Guimon, 2017; Alibekova et al., 2019), as well as the ability of universities to create favorable conditions for cooperation with business sectors in the implementation of developments (Issabekov et al., 2022; Jonbekova et al., 2020).

With the improvement of legislation on intellectual property protection and commercialization, as well as the emergence of research (entrepreneurial) universities, issues of entrepreneurship in higher education institutions began to be considered more broadly (Alibekova et al., 2019; Shakenova, 2022). The entrepreneurial activity of scholars began to be viewed not as an alien or "undignified" component of academic life but as a necessary and final stage of research activity (Asmaganbetova et al., 2021). The requirements for scientific research have also changed. Now, in some cases, they had to include obtaining a prototype of the product or technology being developed, as well as co-financing from the partner enterprise. Some authors began to pay attention to external factors that influence the successful implementation of developments (Kenzhaliyev et al., 2021; Ilmaliyev et al., 2022) and the personal qualities of scientists – leadership, extensive connections, and expert experience (Seitzhanov et al., 2020). At the same time, issues related to the motivation of academics to engage in entrepreneurial activities in combination with teaching at a university, as well as the desire of scientists to bring their scientific developments to practical application in a finished product, remain poorly studied (Nurgaliyeva et al., 2022).

The lack of a systematic approach to the organization of academic entrepreneurship and an understanding of the motivation of scientific staff and university administration in the commercialization of scientific developments can reduce the number of implementations of potentially interesting developments for business (Hayter et al., 2018). Thus, the need to create favorable conditions for all participants in the innovation process and the development of an effective mechanism for the implementation of university developments determined the relevance of research in this area.

This study aims to examine the commercialization features in the Republic of Kazakhstan and identify factors influencing the development of academic entrepreneurship in the country's universities.

The hypotheses proposed are as follows:

H1: *Gender and age of university scientists affect their desire to organize own business.*

H2: *Branch of science of university scientists affects the presence of innovative ideas/developments available for implementation.*

2. METHOD

The population in this study was full-time employees with academic degrees and research experience from the 14 Kazakhstani universities (Fernandez-Perez et al., 2015). The method used to collect primary data was a structured questionnaire. To gather an information, 783 questionnaires were distributed through e-mail. The data collection took place from August 2023 to November 2023.

The questionnaire contained questions about demographic characteristics, research disciplines, availability of ready-made inventions/patents/ideas for implementation in production, establishing connections with other regional entities, and factors influencing scientists in their decision to engage in academic entrepreneurship (Erikson et al., 2015). The questions were scored using a 5-point Likert scale, with 1 standing for "strongly disagree" and 5 for "strongly agree." A total of 214 questionnaires were received (of 784 sent), with an overall response rate of 27.3%. Questionnaires covered five fields of research according to the Frascati Manual methodology (OECD, 2015): natural sciences, engineering and technology, medical and health sciences, social sciences, and humanities. Since only five questionnaires were received for the humanities, it was decided to exclude them from consideration. Consequently, the research considered a total of 209 responses.

To assess the relationships between qualitative characteristics, the Pearson chi-square method and Pearson contingency tables were used. When assessing the significance of differences using the Pearson chi-square method, the differences between the actual existing frequencies in groups (observed (O_i)) and the expected (E_i) frequencies calculated using the formula, which corresponds to the chi-square distribution, were analyzed. If the difference between the expected and observed frequencies is small (the chi-square has not reached its critical value), the null hypothesis of no differences is accepted. If the differences are significant (the critical chi-square value is reached for a given number of degrees of freedom), the null hypothesis is rejected. In this case, the differences are considered statistically significant.

The more the chi-square differs from 0, the more likely it is to reject the null hypothesis and decide about the statistical significance of the existing differences in the populations being compared.

To calculate the chi-square coefficient, the formula was used:

$$\chi_n^2 = \sum_{i=1}^{n} \frac{\left(O_i - E_i\right)^2}{E_i}, \tag{1}$$

where O_i – observed frequencies, E_i – expected frequencies.

Degree of freedom was calculated by the formula:

$$df = (c-1)(r-1), \tag{2}$$

where c – number of columns with frequencies, r – number of rows with frequencies.

3. RESULTS AND DISCUSSION

3.1. Review of legislation in the field of commercialization and opportunities for universities

Today, in Kazakhstan, the issues of commercializing scientific and technical activities are particularly relevant given society's expectations of the application of domestic developments in the real sector of the economy.

The policy of transition to innovative activity and the implementation of accumulated scientific potential began to be implemented in the republic at the beginning of the 2000s. The Law on Innovation activity was adopted on July 3, 2002. It defined the basic principles, forms, and directions for the implementation of state innovation policy. Subsequently, government programs and strategies in the field of innovative development and technology transfer for local technologies were adopted (Saiymova et al., 2018).

Four stages in the formation of legislation in the field of innovation and technology policy may be distinguished (Table 1). At the first stage, at the state level, a course for innovative development was determined, and legislative acts defined the basic concepts and institutions in the field of innovation. At the second stage, issues related to the protection of intellectual property rights, financing of scientific research, and training of scientific personnel (Doctor of Philosophy – Ph.D.) were more clearly defined. At the same time, mechanisms for the commercialization of R&D were developed only at stage 3 with the adoption of the Law on Commercialization of the results of scientific and (or) scientific and technical activity.

The Law on Commercialization (2015) made it possible to implement government initiatives in the field of commercialization at the republican level. Since 2016, according to the order of the Minister of Education and Science of the Republic of Kazakhstan dated May 17, 2016 No. 319, Science Fund JSC was determined as the Operator for grant financing of commercialization of R&D. The state through the Science Fund announced a competition for grant funding for the commercialization of domestic developments, subject to co-financing of part of the project from the private sector. From 2016 to 2018, grant competitions were held for the commercialization of scientific results. As a result, about 150 projects received government support (Table 2).

A competition was also held in 2022, in which 72 projects (out of 152 applications) were approved for funding, and finally, 68 agreements were ultimately concluded with grant recipients.

In general, competition for the commercialization of R&D in 2016–2018 made it possible to implement 151 projects to introduce domestic develop-

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Table 1. Legislative acts and government programs in the field of innovative and technological development

Stages	Acts	Basic provisions
Stage 1. Determining the long-term course of development towards an innovative economy and creating the basic institutional framework for the development of innovation	On innovation activity (dated July 3, 2002). On state support of innovation activity (dated March 23, 2006). Strategy for industrial and innovative development for 2003–2015. Program for the formation and development of the national innovation system for 2005–2015.	The state supports innovation by providing innovative grants; financing through development institutions with a set of measures for innovative development. The concepts of "innovation infrastructure," "technology park (technopark)," "innovation project," and "innovation grant" are legally established. As part of the Strategy, a shift away from the raw material orientation of the economy was announced, and development institutions were created to support innovation activity.
Stage 2. Recognizing commercialization as an important and independent stage in the innovation process. Increased attention to intellectual property issues and inventors' rights	On science (dated February 18, 2011). On state support for industrial and innovative activity (dated January 9, 2012).	Introduction of various forms of funding for scientific research (basic, grant, program-targeted), securing the intellectual property rights obtained as a result of funding from the state budget to scientific organizations (researchers) – an analog of the Bayh-Dole and Stevenson-Wydler laws adopted in the 80s in the USA.
Stage 3. Creating and consolidating mechanisms for the commercialization of innovations, linking them with the mechanisms of entrepreneurial activity	On the innovation cluster Park of Innovative Technologies (dated June 10, 2014). On commercialization (dated October 31, 2015). Entrepreneurial Code, dated October 29, 2015).	The R&D commercialization mechanisms are developed: licensing agreements for scientific developments, creating a start-up company; implementation (use) of the results of scientific and technical activities in own production. The need to create start-up companies with the participation of organizations of higher education, scientific organizations whose activities are aimed at commercializing the results of scientific activity is emphasized.
Stage 4. Improving commercialization mechanisms and increasing their transparency	On science and technology policy (Draft of the Law, dated April, 2024).	Financing of R&D by local executive bodies. Introduction of grants for the development of scientific infrastructure. Improving the mechanism of grants for the commercialization of R&D, considering target groups (start-ups, scientific organizations, corporations), and differentiating the conditions for providing grants, including co-financing.

Table 2. Number of commercialization projects implemented at the republican level as a result of government grants for R&D commercialization

Year	2016	2017	2018	2022[2]
Total number of projects	25	71	61	68
Including co-financing	18	61	59	n/a
Including the number of projects from universities	4	3	6	n/a
Grant amount, million tenge / million US dollars[1]	4759/13.91	15954.6/48.94	14509.8/42.09	17000/36.92
On average per 1 project, million US dollars	0.56	0.69	0.69	0.54
Amount of co-financing of the business sector, million tenge	610	2 160	2 470	3 400
	(12.8%)	(13.5%)	(17.0%)	(20%)

Note: [1]Calculations were made based on official exchange rates on average for the period (year) of the National Bank of the Republic of Kazakhstan. [2]No commercialization competitions were held during 2019–2021.

ments into production. 140 high-tech industries were created, of which 15 projects were exported, and five projects achieved sales of more than 1 billion tenge (2.9 million US dollars).

Meanwhile, an analysis of the project portfolio indicates that government grants for commercialization have not become a mechanism that would facilitate the mass introduction of developments into production. In 2022, the number of government-supported projects did not exceed the level of 2017, also demonstrating a decrease in funding per project. For that period, only five projects reached high-income levels, while most projects did not bring significant profits and did not have a noticeable impact on economic growth, which indicates their low innovative potential.

A negative trend was also the fact that most projects were implemented in the largest cities, such as Almaty (51%) and Astana (13.9%), while the regions were represented by one or two projects. Thus, it was not possible to meaningfully involve regional scientists and innovators in the commercialization processes.

Among 151 implemented projects, the grant recipients were mostly business representatives (26.5%), with low involvement of universities (8.6%). The sales indicator of finished innovative products and services showed a similar proportion: the highest results belonged to business representatives, 79%, research and production centers showed 11%, research institutes – 5%, and universities – only 4.5%.

Thus, the republic's universities are not sufficiently involved in the practical implementation of accumulated knowledge, although the 2015 Law on Commercialization states that "Commercialization of the results of scientific activity, along with educational and scientific activities, is a priority area of activity for higher educational institutions and scientific organizations."

For the involvement of universities in technology commercialization, the government, with the support of the Ministry of Industry and New Technologies, initiated the creation of nine research commercialization offices (RCO) at research institutes and universities in 2012. RCOs were placed in the regions of Almaty, Karaganda, Ust-Kamenogorsk, Uralsk, and Shymkent. In addition, technology parks have been created in the republic since 2004. Therefore, in 2022, 56 commercialization offices and 20 technology parks were established in the country (Table 3).

Table 3. Objects of innovation infrastructure in the Republic of Kazakhstan

Infrastructure facilities	Total	Including at universities
Research commercialization offices	56	43
Technology parks	20	10

Technology parks were tasked with supporting the development of knowledge-intensive entrepreneurship and increasing the innovative activity of firms. However, technology parks mainly play the role of business centers that rent office space, laboratories, provide administrative support and consulting services (Yessengeldina et al., 2014). Another problem is the low profitability of technology parks, as some of them have negative profits.

Universities are home to most research commercialization offices and half of all technology parks. They also have the largest share of R&D staff: in 2021, the higher education sector had 8,157 employees (or 37.7%) out of a total of 21,617 employees.

Thus, universities have all the necessary conditions for the development of commercialization: the results of research activity, innovative infrastructure for technology transfer, and research staff. They have the potential to participate more actively in commercialization processes both at the national level (through grants for commercialization) and through attracting private financing.

In terms of the number of researchers per 1 million population, Kazakhstan is significantly inferior to the leading countries, which entails a correspondingly small total number of publications. This is largely due to the lack of mandatory requirements for scientists to publish research results in international journals in English language. Only since 2011, publications in foreign peer-reviewed journals had become necessary for obtaining the degree of Doctor of Philosophy (Ph.D.), as well as obtaining the academic titles of associate professor and professor.

According to the statistical data, at the beginning of the 2021–2022 academic year in the Republic of Kazakhstan, the number of operating higher educational institutions amounted to 122 organizations, including:

- 83 universities, including research ones;
- 16 academies;
- 12 institutes and equivalent conservatories, higher schools, and colleges;
- 9 national higher educational institutions;
- 2 national research universities.

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The status of "research university" began to be assigned to higher education organizations in 2011. The legislation of the Republic of Kazakhstan defines a research university as an organization of higher and (or) postgraduate education that implements the university development program approved by the Government of the Republic of Kazakhstan and participates in the organization and conducting of fundamental and applied scientific research and other scientific, technical, development works. This status guarantees appropriate staff work schedules, adequate wages, social benefits, increased scholarships for students, etc. Currently, five universities have research status, and it is planned that in the future, this status will be assigned to several more universities.

Since 1991, Kazakhstani scientists have published a total of 48,858 articles in journals indexed by Scopus. Table 5 presents the top 10 universities that have high international rankings according to QS-2024. These universities have master's and Ph.D. programs, a developed research sector, and a high level of publication activity.

The largest share of publications belongs to Al-Farabi Kazakh National University and Nazarbayev University. Nazarbayev University does not participate in the QS ranking, but it may also be included in the top 10 with 6,548 published articles (share – 0.13).

According to WIPO, there were 3,137 patents in force in 2021 in Kazakhstan. In the period from 2019–2021, 3,203 patent applications were filed by Kazakhstani scientists. The share of universities in patents was 8.9%.

Publications in referred journals, as well as patents, confirm the active research activity of academics, although the share of commercialization projects from universities remains low (Table 2). Academic entrepreneurship has not become a mass phenomenon in the country, but it has a single character. The next study stage was conducted to identify factors influencing the development of academic entrepreneurship in the country and the desire of academics to engage in entrepreneurial activities.

3.2. Respondents' demographics

Table 4 shows the detailed results of participants' demographics. Demographically, most participants were men, accounting for 59.5%, while women reached 40.7%. The demographic results show that in the age category, 129 respondents under 45 years constituted the majority (61.72%).

In field of science category, most participants represented natural sciences (48.33%), while scientists from engineering and technology accounted for 25.84%, social sciences – 17.70%, and medical and health sciences – 8.13%.

3.3. Factors assessment

The purpose of the first part of the survey was to identify scholars' experiences in interacting with other participants in the region's innovation system. The degree of interaction between university scientists and external organizations during the research was assessed from no interaction (score 1) to very intensive (score 5). For the evaluation, the choice of options intensive (4) or very intensive (5) was considered. As a result, almost 90% of respondents indicated stable interaction in the

Table 4. Sample demographic information

Variables	Frequency	Percentage	Cumulative Percentage
Gender			
Male	124	59.3%	59.3%
Female	85	40.7%	100%
Total observations	209		
Age			
26-35	56	26.79%	26.79%
36-45	73	34.93%	61.72%
46-55	43	20.57%	82.30%
56-65	25	11.96%	94.26%
65 and over	12	5.74%	100.00%
Total observations	209		

scientific field with other universities and 44.98% – with government institutions. At the same time, the smallest percentage of relationships was indicated with business structures (25.84%).

Assessing the nature of relationships with business, 63.7% of respondents indicated that this cooperation developed while creating new knowledge or technology. However, activities to share research results that could potentially be of interest to the business sector involved only 44.23% of researchers. This fact suggests that collaboration with businesses is more often in the early stages of idea or technology creation than in the later stages of commercialization, such as prototype creation and production.

The purpose of the second part of the survey was to identify the desire and motivation of university researchers to engage in entrepreneurial activities, as well as the availability of developments they could offer to the business sector. The statement "You have ideas/technology/patent to offer or implement into business" was assessed on a 5-point Likert scale. Based on survey results, more than 55% of respondents answered that they had ideas/technology/patents to offer or implement into business (percent of respondents who indicated agree or strongly agree). To measure the willingness to be entrepreneurs, the survey used the statement "You want to start your own business" with a 5-point Likert scale. The results showed that 153 researchers (respondents who indicated 4 or 5 points) would like to start their own business, which would facilitate further implementation of the results obtained. It indicates a high interest of university scientists to participate in entrepreneurial activities related to their field of research.

The third part of the survey was available only for respondents who indicated willingness to start their own business. Among the factors that have the greatest influence on their desire, respondents were asked to evaluate the following six factors (Table 5). The factors were rated by respondents on a 5-point scale, where 1 was assigned to the factor with the weakest influence, and 5 to the strongest.

The most significant factor for starting their own business (4.67 points out of 5) was flexible work arrangements. A strong motivation for launching a business is also the opportunity to implement own innovative ideas and technologies (4.12 points). The factor of increasing income from starting a business was in 3rd place in terms of importance, with a value of 3.63 points. Most respondents positively assessed the possibility of receiving support from the university where they are employed. The least influencing factor was the governmental support of entrepreneurial initiatives (2.19 points).

In addition, respondents assessed the negative factors that may hinder the development of academic entrepreneurship (Table 6).

The most important factors negatively affecting the development of academic entrepreneurship, according to respondents, are the lack of qualified personnel in their area of research (4.56), the com-

Table 5. Positive factors that influence employees to start a business

Factors	Mean	N
Flexible work arrangements	4.67	153
Implementation of your own innovative idea or/and new product	4.12	153
Opportunity to increase income	3.63	153
Support from home university	3.47	153
Availability of niche markets for the proposed product	2.33	153
Attractiveness of government, development institutions, and/or agents of innovative infrastructure support measures	2.19	153

Table 6. Negative factors that influence academic entrepreneurship

Factors	Mean	N
Lack of qualified personnel	4.56	153
Complex and unclear legislation in the field of commercialization and academic entrepreneurship	4.27	153
Bureaucracy and administrative burden	3.78	153
Lack of financing (initial capital) to organize a business	3.32	153
Lack of business knowledge	3.26	153
Difficulties in obtaining support from third parties (government programs, development institutions)	2.41	153

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plex and unclear legislative framework in relations between business and the academic environment (4.27), and bureaucracy and administrative burden (3.78). Interesting fact that the underfunding is not the main factor for the lack of business initiatives from university staff. Support from third parties and government and regional programs did not demonstrate a significant impact.

The study tested the first hypothesis about the relationship between the gender and age of academics and the desire to organize their own business. To identify dependencies between qualitative variables, Pearson contingency tables were constructed in the RStudio software (Table 7). Values without parentheses represent observed frequencies, values in parentheses represent expected frequencies, and values in square brackets represent residuals.

The results found sufficient evidence to reject the null hypothesis of no relationship between the variables. Cramer's V of 0.3025 indicates a moderate association between considered variables.

The Chi-square statistic for each cell was calculated to identify which cells contribute the most to the overall Chi-square. The Pearson residuals were visualized using the corrplot package in RStudio software (Figure 1).

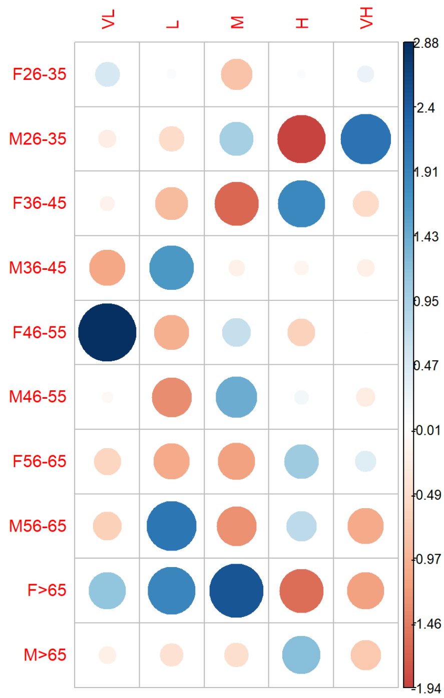
Positive values (in blue) in cells indicate attraction (a positive relationship) between the corresponding row and column variables. Figure 1 shows that the greatest desire to start their own business was shown by men aged 26-35 years, and moderate desire was demonstrated by women aged 36-45 years. Negative residues are highlighted in red. This implies repulsion (negative relationship) between the corresponding row and column variables.

The second hypothesis about a relationship between scientific areas and the availability of innovative ideas/developments that have the potential for implementation was tested. A Pearson contingency table was compiled to identify dependencies between qualitative variables (Table 8). The results found sufficient evidence to reject the null hypothesis of no relationship between the variables. The strength of the dependence value is $V = 0.2694$, which indicates a moderate dependence.

Table 7. Relationship between the gender and age of scientists and the desire to start a business

Gender and age	Desire to start a business					Total
	Very low	Low	Moderate	High	Very high	
F26-35	1 (0.60)	2 (1.89)	1 (2.24)	8 (7.84)	6 (5.43)	18
	[0.51]	[0.08]	[–0.83]	[0.06]	[0.25]	
M26-35	1 (1.31)	3 (4.11)	7 (4.85)	9 (16.98)	19 (11.76)	39
	[–0.27]	[–0.55]	[0.98]	[–1.94]	[2.11]	
F36-45	1 (1.21)	2 (3.79)	1 (4.48)	23 (15.67)	9 (10.85)	36
	[–0.19]	[–0.92]	[–1.64]	[1.85]	[–0.56]	
M36-45	0 (1.21)	7 (3.79)	4 (4.48)	15 (15.67)	10 (10.85)	36
	[–1.10]	[1.65]	[–0.23]	[–0.17]	[–0.26]	
F46-55	2 (0.33)	0 (1.05)	2 (1.24)	3 (4.35)	3 (3.01)	10
	[2.88]	[–1.03]	[0.68]	[–0.65]	[–0.01]	
M46-55	1 (1.11)	1 (3.47)	7 (4.11)	15 (14.37)	9 (9.95)	33
	[–0.10]	[–1.33]	[1.43]	[0.17]	[–0.30]	
F56-65	0 (0.37)	0 (1.16)	0 (1.37)	7 (4.79)	4 (3.32)	11
	[–0.61]	[–1.08]	[–1.17]	[1.01]	[0.38]	
M56-65	0 (0.47)	4 (1.47)	0 (1.74)	8 (6.10)	2 (4.22)	14
	[–0.68]	[2.08]	[–1.32]	[0.77]	[–1.08]	
F>65	1 (0.33)	3 (1.05)	4 (1.24)	1 (4.35)	1 (3.01)	10
	[1.15]	[1.90]	[2.47]	[–1.61]	[–1.16]	
M>65	0 (0.07)	0 (0.21)	0 (0.25)	2 (0.87)	0 (0.60)	2
	[–0.26]	[–0.46]	[–0.50]	[1.21]	[–0.78]	
Respondents	7	22	26	91	63	209

Note: F – Female; M – Male. $\chi2 = 66.001$, df = 36, p-value = 0.001672, Cramer's $V = 0.3025$.



Note: VL – Very low, L – Low, M – Moderate, H – High, VH – Very high.

Figure 1. Strength of relationship between variables based on Pearson residuals

Table 8. Relationship between scientific fields and the availability of innovative developments for possible implementation

Scientific fields	Availability of ideas/developments/patents for potential implementation					Total
	Very low	Low	Moderate	High	Very high	
Medical sciences	0 (0.65)	3 (3.74)	5 (2.93)	6 (4.88)	3 (4.80)	17
	[–0.81]	[–0.38]	[1.21]	[0.51]	[–0.82]	
Social sciences	3 (1.42)	13 (8.14)	14 (6.37)	5 (10.62)	2 (10.44)	37
	[1.33]	[1.70]	[3.02]	[–1.72]	[–2.61]	
Natural sciences	2 (3.87)	24 (22.23)	16 (17.40)	26 (29.00)	33 (28.51)	101
	[–0.95]	[0.38]	[–0.33]	[–0.56]	[0.84]	
Engineering sciences	3 (2.07)	6 (11.88)	1 (9.30)	23 (15.50)	21 (15.24)	54
	[0.65]	[–1.71]	[–2.72]	[1.90]	[1.47]	
Respondents	8	46	36	60	59	209

Note: $\chi 2$ = 45.506, df = 12, *p*-value = 8.438e-06, Cramer's *V* = 0.2694.

Figure 2 shows that the largest number of developments was noted by respondents in engineering sciences (both positions high and very high), life sciences took second place, and the smallest share belongs to social sciences.

Thus, the study of academic entrepreneurship issues made it possible to identify several features of the commercialization of university developments in Kazakhstan. First, there is insufficient interaction between university scientists and the business sector. Basically, scientists interact with other universities and scientific institutes. Second, the study showed the presence of developments among university researchers that could be implemented in industrial enterprises, as well as the willingness of the academics themselves to engage in academic entrepreneurship.

The study also identified barriers to the development of academic entrepreneurship. The respondents indicated the lack of qualified personnel as a crucial negative factor. The problem of reducing scien-

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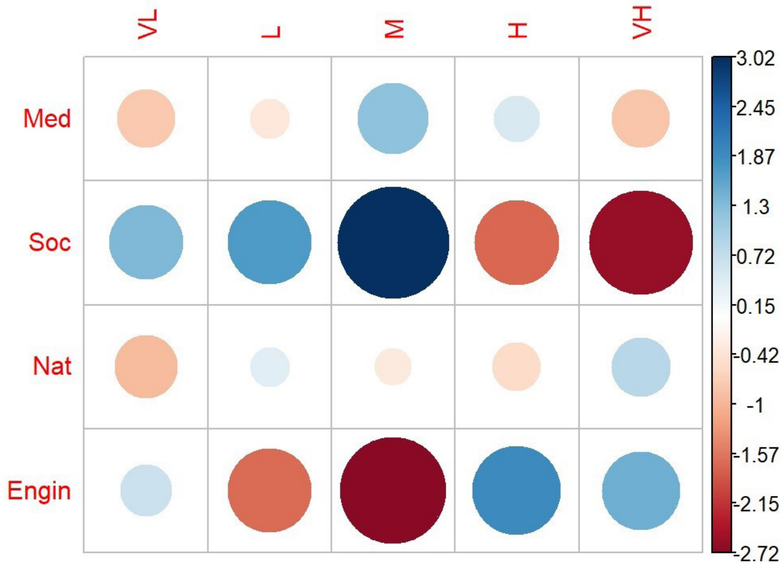

Figure 2. Strength of relationship between studied variables

tific and technical personnel has been discussed in publications in recent years (Alibekova et al., 2019; Issabekov et al., 2022), which is due to the general low funding of the research sector. The Concept for the Development of Higher Education and Science of the Republic of Kazakhstan till 2029, the draft of which is currently being considered by the Government of the Republic of Kazakhstan, provides several measures to increase human resources potential and form a critical mass of scientists for R&D sector, including:

- flexible financing system. Every year, competitions for various types of grant funding are planned. The annual internship program will be provided for 500 Kazakh scientists at the world's leading scientific centers. The internship will cover academic writing, English, digital skills, developing scientific applications, and other necessary competencies and skills.
- support for young scientists.

To strengthen the emphasis on engineering knowledge and attract young scientists with academic degrees to universities and scientific organizations, the "Zhas Galym" (Young Scientist) project will operate for a number of years. As part of this project, young scientists under 40 years old will receive a grant to continue their research in post-doctoral studies. It is planned to increase the number of grants for technical areas of personnel training. As well, the preparation of masters and doctors of philosophy (Ph.D.) will continue through the integration of universities and scientific organizations.

An important issue is the development of mechanisms for financing R&D by private capital. Within the framework of the concept, it is planned that the financing of R&D from extra-budgetary funds will be based on the distribution of funds allocated by subsurface users in the amount of 1% of the cost of mineral extraction. Thus, the adoption of the Strategy would make it possible to implement mechanisms for the inclusion of university teaching staff in entrepreneurial activities, as well as to increase the share of financing scientific projects from the business side.

CONCLUSION, LIMITATIONS, AND FUTURE RESEARCH

The paper aims to examine the features of the commercialization process in Kazakhstan and identify factors influencing the development of academic entrepreneurship in the country's universities. Since 2015, several legislative acts have been adopted in Kazakhstan to develop commercialization and academic entrepreneurship, and programs to support the commercialization of developments have been introduced. In 2016–2022, more than 200 projects were financed from the state budget, but the share of projects from universities was insignificant.

The empirical study showed that university researchers are highly interested in entrepreneurial activity. The relationship between the age and gender of researchers and their intention to engage in entrepreneurial activity was confirmed. The greatest desire to engage in academic entrepreneurship was demonstrated by young scientists under 45: men aged 26-35 years and women aged 36-45 years. The study also confirmed the hypothesis about links between scientific fields and the availability of innovative developments for possible implementation.

The limiting factors for the development of academic entrepreneurship in the republic include imperfections in the legislative framework in university-industry cooperation, lack of preferences for business, and lack of highly qualified personnel. Academics can get new opportunities to commercialize their developments with the adoption of the Concept for the Development of Higher Education and Science of the Republic of Kazakhstan until 2029.

Future research should analyze the financial results of completed commercialization projects and established start-ups to determine the effectiveness and profitability of projects. An updated mechanism for the commercialization of university developments may also be explored based on the results of expected changes in science and technology policy legislation.

AUTHOR CONTRIBUTIONS

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Writing – review & editing: Diana Sitenko.

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