Davit HAKHVERDYAN

Director of "AMBERD" Research Center, ASUE,

Doctor of Sciences (Economics), Professor

Lusine KARAPETYAN

Acting Director of ASUE College of Finance and Economics,

Associate Professor of the Chair of Business Administration, PhD in Economics

THE ISSUES OF COMMERCIALIZATION OF SCIENTIFIC RESEARCH RESULTS AND SCIENTIFIC ENTREPRENEURSHIP IN ARMENIA

Keywords: knowledge, commercialization, innovation, research, entrepreneurship

In the modern economy, competitive advantage is primarily achieved based on the differentiation of intellectual products. Since the 1990s, state administration bodies have strongly encouraged the commercialization of scientific inventions and technologies because it affects economic growth in two main ways. [1]

1. transformative knowledge generated by scientific research is adopted by local businesses for their research and development (R&D), supporting innovative products and processes that have just entered the market;

2. universities have ever-increasing capacity and opportunity to independently create and transfer new technologies.

As a strategy, commercialization requires that a business develop a marketing plan, determine how the product will be supplied to the market, and anticipate barriers to success[2].

According to David Coombe (Director of Research and Innovation, London School of Economics), the reason for commercialization does not need to be about making a significant profit. Even the largest universities with international reputations for excellence will have only a small number of spin-outs that make significant profits.

[1] Science Commercialization, Course Curriculum and Instructor Manual, FAST, Yerevan 2022, p.6.

[2] University of Pittsburg, Innovation Institut, https://www.innovation.pitt.edu/contact-splash/why-commercialize/

Most ventures make a modest financial return. Instead, commercialization activities can be a powerful way to enhance and sustain research impact after funding ends[3].

Research commercialization initiatives can, in theory, generate interest and investment in emerging areas of research, with consequent gains or improvements in research funding, job creation, scope and quality of innovation, creation and growth of industries, and economic sustainability of universities[4].

Commercializing academic research is a key way universities and research organizations meet their KPIs and prove their impact and the value they are adding to industry and society as a whole[5].

The effective transfer of knowledge and technologies between academic institutions and the business world, as well as the need to include academic institutions in commercial and "entrepreneurial" research activities, have changed the nature of cooperation[6].

Nowadays it is crucial to bring research results from the research centers, and laboratories to the practical field that is to turn scientific knowledge into commercialized goods and services.

University leaders are becoming continuously more responsive to the needs of the innovation economy, incorporating innovation, entrepreneurship, and economic engagement into university strategy. One of the most effective tools to succeed in this mission is the commercialization of scientific inventions and technologies or the transfer of scientific technology.[7] However, it should be noted that the existing material and technical base and infrastructures in the field of scientific and scientific-technical activities in the Republic of Armenia limit the possibilities of conducting research under the requirements of modern science and do not ensure the effective use of scientific potential.[8]

During the last 20 years, the RA authorities began to adopt legal acts regarding science, scientific and technical activities, and innovation activities. In 2006, the RA Law "On State Support of Innovative Activities" was adopted, according to which[9] state support for innovative activities is carried out through the annual program of support for innovative activities. The program includes activities in the following directions:

[3] UK Research and Innovation, https://www.ukri.org/councils/esrc/impact-toolkit-for-economic-and-social-sciences/how-to-commercialise-your-research/why-commercialisation-is-important/
[4]T. Caulfield, U. Ogbogu, The commercialization of university-based research: Balancing risks and benefits, https://bmcmedethics.biomedcentral.com/articles/10.1186/s12910-015-0064-2
[5]Five benefits of research commercialisation, https://ximbio.com/news/importance-of-commercialisation-and-ip-a-wasted-exercise-or-a-value-generator
[6] K. Khachatryan1 , A. Hakobjanyan, K. Nikoghosyan, The Development of Entrepreneurial Education in the Framework of University-Industry Collaboration in the Republic of Armenia, https://www.dpublication.com/wp-content/uploads/2022/05/30-8109-1.pdf
[7] Science Commercialization, Course Curriculum and Instructor Manual, FAST, Yerevan 2022, p.5.
[8] RA strategic program of 2014-2025 on prospective development, https://www.gov.am/files/docs/1322.pdf, p. 150.
[9] "On State Support of Innovative Activities" RA Law, 2006, https://www.arlis.am/documentview.aspx?Docid=24697

creation and development of innovation infrastructures, implementation of innovation projects, technology transfer and commercialization, introduction of international standards, etc.

According to the decision of the RA Government No. 459 of April 30, 2009, the program on the consolidation of the potential of Armenian scientists was approved, where the commercialization of the outcomes of scientific activities, and the involvement of Armenian scientists from foreign countries in the training of science managers and the introduction of modern management in scientific organizations, etc. [10]

According to the RA strategic program of 2014-2025 on prospective development, the state has emphasized the implementation of the following activities for the development of the science sector.[11]

- to form a system ensuring the sustainable development of science and leading technologies,
- to promote the implementation of research aimed at obtaining knowledge used in the economy and the increase of innovations and patents in scientific organizations,
- to form a harmonious system ensuring the development of science, technology, and innovative knowledge by promoting the involvement of private business in science and the purposeful investment of this knowledge in various branches of education and economy, etc.

The Concept of Overhaul, Construction, and Modernization of RA Scientific Facilities presents the following issues in the field of science: the low level of commercialization of results of fundamental and applied significance made by the scientific organizations, the limited state of competitiveness opportunities, and the gap of science and production ties, etc. The main goal of the development of the concept is to define the strategy for the development of prospective and current interrelated programs for the overhaul of scientific facilities, the construction of new ones, and the modernization of existing ones, taking into account the organization of the pace of development of the country's economy on a scientific basis, the effective use of scientific potential in scientific organizations, and the adoption and implementation of approaches to the commercialization of scientific results and increasing competitiveness, as well as some other factors[12].

It is noteworthy that according to the decision of the RA Government of April 23, 2009, on creating "The National Center for Innovation and Entrepreneurship" a state non-commercial organization, and by the

[10] The decision of the RA Government No. 459 of April 30, 2009, https://www.arlis.am/DocumentView.aspx?DocID=51373
[11] RA strategic program of 2014-2025 on prospective development, https://www.gov.am/files/docs/1322.pdf
[12] The Concept of Overhaul, Construction, and Modernization of RA scientific facilities, RA Government, https://www.irtek.am/views/act.aspx?aid=76210

decision N454-N on approving its charter, the main activity goals of " The National Center for Innovation and Entrepreneurship" state non-commercial organization were defined, in particular,[13]

- the formation and implementation of effective mechanisms of technology transfer;
- provision of scientific and technical information and library services.

It is also important to create a favorable economic environment for scientific organizations and expand their entrepreneurial activities. To commercialize science, it is necessary to provide state support in the implementation of applied research, moreover, to form centers for the commercialization of scientific results. The above-mentioned centers should specialize in two issues: clarifying what is needed by entrepreneurs and presenting these standards to scientists, and at the end performing an intermediary service and ensuring the commercialization of the generated results.14 The perspective development program also emphasizes the promotion of innovative activities of small and medium-sized entrepreneurship.

The RA government, accentuating the problem of innovation and scientific entrepreneurship promotion and support, included it in the 2021-2026 activity program of the RA government, i.e., to introduce mechanisms for the promotion and maintenance of innovation and science-led entrepreneurship by creating a support structure for the formation of new business sectors from science and giving orders from business to science, which will study existing developments in science and have the potential for commercialization and accompany their commercialization process by providing advice and legal support. [15] In addition, the introduction of the most encouraging mechanisms for taxation of income from the commercialization of patented inventions was also presented in the program.

In this context, it will be interesting to consider the current situation of Armenia in the relevant fields, as well as to make comparisons in the context of other countries and international rankings. In particular, in RA in 2022, compared to 2021, the number of submitted applications for inventions has increased by about 9% (figure 1).

[13]See the decision N 454 of the RA Government of April 23, 2009, https://www.arlis.am/DocumentView.aspx?docid=67573
[14] RA strategic program of 2014-2025 on prospective development, https://www.gov.am/files/docs/1322.pdf, p. 156
[15] See the 2021-2026 activity program of the RA Government, https://www.gov.am/files/docs/4586.pdf, p. 25.

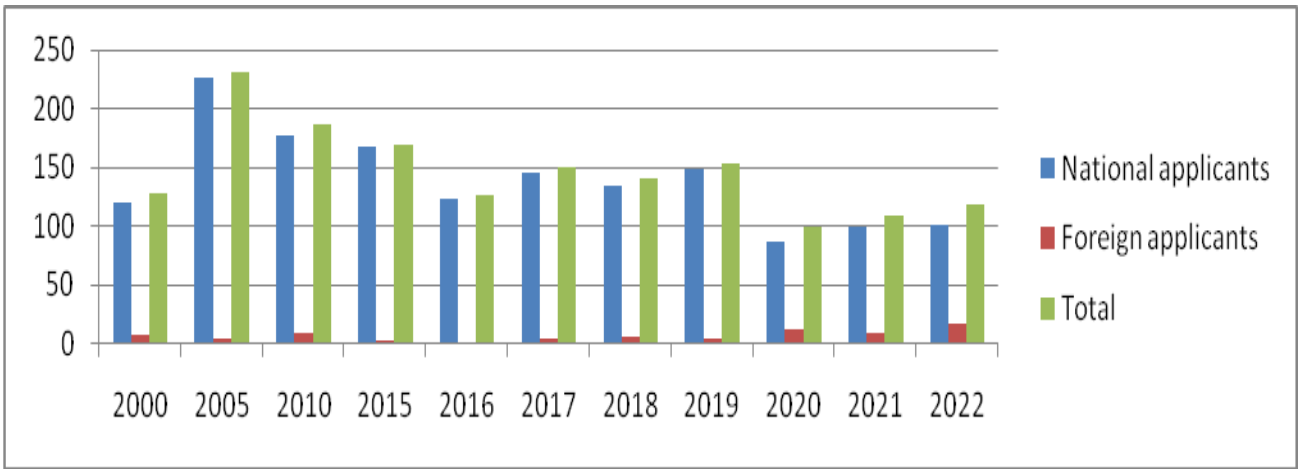

Figure 1: Dynamics of submission of applications, 2000-2022.[16]

Of the 118 applications submitted to the Intellectual Property Office in 2022, 101 were from national applicants, and 17 were from foreign ones. The highest indicator was recorded in 2005: 231 applicants, which is almost twice as much as at present. About 52% of applications received from natural and legal entities are from natural entities. It should be noted that the share of applications received from universities or scientific institutions was 30.5% (table 1).

Table 1: Number and ratio of applications received from natural and legal entities, 2022.[17]

Applicant	Number of applicants	% of the total number of applications
Natural person	61	51,7
A legal entity, including	57	48,3
commercial organization	21	17,8
A university or a scientific institution	36	30,5

Examining the dynamics of internal expenses on research and development, it becomes obvious that they had a growing trend. In 2021, compared to 2020, the above-mentioned expenses increased by about 11%. The highest indicator of the number of organizations performing research and development was recorded in 2005: 102 organizations, then a downward trend can be observed in the following years. In 2020, compared to 2005, the number of organizations was reduced by 37 to 65. In 2021, compared to 2020, the number of research

[16]Compiled by the authors based on the annual reports of the intellectual property office of the RA Ministry of Economy, https://aipo.am/hy/files/categories/12

[17] Ministry of Economy of the Republic of Armenia, Office of Intellectual Property,https://aipo.am/hy/files/categories/12

and development organizations increased by 29. From the data in Table 2, it becomes apparent that the number of people employed in this field has decreased. In 2021, compared to 2000, the number of employed people decreased by 33%, and compared to the previous year, it increased by 8.7%. The volume of scientific and technical works in 2021 increased by about 17% compared to 2020, and the actual volume of works completed and accepted by the client increased by 8% (Table 2).

Nevertheless, we can confirm that due to the lack of appropriate environment, conditions, and issues brought down by the state, an approximately sevenfold decrease in the number of scientists has been recorded, especially as a result of human capital flight. If in the past, Armenia was one of the leading countries in the world in the number of scientists per million inhabitants, today this indicator is 2 times less than the European average. The average basic salary of researchers is almost two times lower than the average salary in Armenia.

In 2020, 21,076 employees received professional training at the employer's expense, which is only 5.86% of the total number of employees, of which 12,624 (60% of those who received professional training and only 3.5% of employees) received training, increased their qualifications 3767 (60% of those who have received professional training and only 3.5% of workers)[18].

Table 2: The dynamics of indicators characterizing the scientific research sector, 2000-2021[19]

	2000	2005	2010	2015	2017	2018	2019	2020	2021
Domestic costs for research and development, million. drams	1519.1	4814.4	7987.9	11929.9	11.867.6	10.532.2	11.682.5	12932.7	14.373.0
Number of organizations engaged in research and development	88	102	81	70	69	63	63	65	94
Number of employees of organizations	7309	6892	6558	5044	4822	4452	4539	4499	4889

[18] Statistical Committee of the RA, https://www.armstat.am/am/?nid=82&year=2022.
[19] Compiled by the authors based on the data of the Statistical Committee of the Republic of Armenia, https://www.armstat.am/en/?nid=586

engaged in scientific research and developments including researchers and technicians	4971	5401	5460	4164	3807	3552	3512	3657	3949
Volume of scientific-and-technical works, million drams	2649.1	5657.5	8711.7	12634.2	12228.3	10871.3	11762.6	12336.6	14426.9
Actual volume of completed work and work accepted by the customer, At cost of work million drams	2262.2	4469	9393.1	10.069.3	11228.8	10026.7	10517.4	12667.2	13667.5

It is also interesting to study the Global Innovation Index (GII) of Armenia and its neighboring countries. According to the data of 2022, Armenia occupied the 80th place in the GII, compared to the previous year, the indicator went down by 11. Among the countries bordering Armenia, Turkey is the leader, occupying the 37th position, then Iran - 53rd, and Georgia - 74th. Georgia, like Armenia, lost its positions by 11 more, last year it occupied the 63rd rank (table 3).

Table 3. GII 2022 rankings overall and by the pillar in Armenia and neighboring countries[20]

	Overall GII rank	**Score**	**Human capital & research**	**Infrastructure**	**Market sophistication**	**Business sophistication**	**Knowledge & technology outputs**	**Creative outputs**
Armenia	**80**	**26.6**	**91**	**80**	**85**	**84**	**71**	**73**

[20] Compiled by the authors according to the following website: https://www.wipo.int/edocs/pubdocs/en/wipo-pub-2000-2022-section3-en-gii-2022-results-global-innovation-index-2022-15th-edition.pdf

Georgia	**74**	**27.9**	**70**	**83**	**72**	**64**	**75**	**86**
Azerbaijan	**93**	**21.5**	**87**	**90**	**80**	**77**	**117**	**105**
Turkey	**37**	**38.1**	**41**	**48**	**37**	**47**	**47**	**15**
Iran	**53**	**32.9**	**54**	**75**	**11**	**115**	**50**	**33**

Armenia always ranks higher with the created innovation result (Innovation Output Sub Index) than with the resources providing that result (Innovation Input Sub Index). In terms of innovative results created in 2022, Armenia ranks 73rd, and in terms of resources, it ranks 82nd. Therefore, the efficiency of converting available resources into output is high.

Table 4: Ranking of Armenia by GII, 2020-2022[21].

Years	GII	Innovation Input Sub Index	Innovation Output Sub Index
2020	61	83	47
2021	69	85	56
2022	80	82	73

In 2022, Armenia ranked 44th in terms of the business environment index, and it scored 53.3 points in the business policy index, ranking 54th out of 132 countries, and 24th in the business policy and culture index.

It ranks 91st in the group of "Human capital and research" indicators, and 100th in the research and development sub-indicator included in it. Thus, Armenia, with few resources for innovation, meager funding for education, negligible R&D allocations, and a low proportion of science and technology graduates, nevertheless provides results.

According to the UN Sustainable Development Goals National Report, Armenia is a regional leader in the IT and high-tech industry due to its competitive workforce, share of GDP, number of companies, and constant growth in revenues. Although Armenia's global scientific competitiveness is supported by research in selected fields, the commercialization of scientific knowledge is still weak in almost all fields. Armenia needs to invest more resources in building innovation and technological ecosystems, for comparison, it can be noted that the gross expenditure on R&D is equivalent to only 0.24% of GDP.

Thus, only 0.2% of the RA GDP was spent on research and development.

An important predictor of research and development (R&D) financing included in the calculation of the global innovation index is the average expenditure on research and development of the three leading global companies operating in the country, expressed in million US dollars. If a country has less than three listed

[21] Compiled by the authors according to the following website: https://www.wipo.int/edocs/pubdocs/en/wipo-pub-2000-2022-section3-en-gii-2022-results-global-innovation-index-2022-15th-edition.pdf, Global Innovation Index 2022.

global companies, the number is either the average of the sum of the two listed companies or the total of one listed company. For Armenia, the above-mentioned indicator is evaluated with 0 points, which means that there are no registered global companies in the country. The total absence or very low level of R&D corporate costs is one of the main weaknesses of Armenia, which is also specific to countries included in the same income group as Armenia.

As already mentioned, during the last 30 years, about 0.25 percent of the annual GDP is allocated for scientific research and experimental development. According to this indicator, Armenia is close to Uganda and Burundi. And, for example, Burkina Faso spends 0.7% of its GDP, Iran - 0.8%, Singapore - 1.9%, Turkey - 1%.

Several academic research findings document the significantly different goals of integrating for-profit enterprises and research organizations. Studies show that the emergence of new scientific research directions, the enrichment of the scientific potential of the staff, as well as raising additional funds, and interaction with business are attractive to science. Moreover, cooperation with businesses creates advantages for universities.

We have to record that the cooperation between enterprises and research institutes is almost non-existent and in this direction, it is needful to carry out massive work. On the other hand, it is very essential that RA business organizations gradually develop a culture of not harming the environment or at least minimizing the harm with their activities. Organizations must realize that environmental problems require a coordinated approach and integrated solutions. That is, the attention of enterprises should be targeted to the evaluation of environmental <burden> at all stages of the production process.

In recent years, the need for responsible business models has become evident, and companies that offer green products or services are incubators of creative, environmentally friendly growth and important economic performers that can change the future of society. The specific mission of green entrepreneurship is to promote the sustainable development of the local community and environment. Thus, a SWOT analysis has been carried out with general points and the strengths and weaknesses of the relevant sector, as well as the opportunities and threats have been highlighted and pointed out.

Table 5: SWOT analysis of green economy development through scientific entrepreneurship, business environment, and cooperation between research institutes

Strengths	Weaknesses
• The RA government provides state support for the development of SMEs, and rural communities, as well as for the implementation of internationally competitive fundamental studies, research arising from the requirements of the economy, and scientific research activities aimed at the acquisition of knowledge of dual significance. • There are a considerable amount of scientific research and	• Research and the efficiency of using the limited resources provided to the rural development and community are still low. • Low productivity and outdated technologies. • Lack of business management skills and experience. • Absence of appropriate tools.

technological resources in the country some scientific directions. The state invests certain efforts and resources in the direction of maintaining and developing the scientific potential of the country. • There are a few obstacles for start-up entrepreneurs, in addition, Corporate Social Responsibility (CSR) has started to be vital in business: enterprises have started to assume their share of responsibility in solving the problems of environmental, social, and development of rural communities. • Existence of a free market system. • There is potential for the creation of scientific innovation centers. • Rural enterprises have good potential for value increase. • High demand for food production with environmentally friendly and local raw materials, and increasing competition between enterprises. • Close cooperation with various international organizations. • The community will become attractive.	• Underdevelopment of infrastructure and institutional structures, particularly in remote rural communities. • Very low level of cooperation between entrepreneurs and scientific research institutes, furthermore, almost complete absence. • Local self-government bodies are not financially motivated to develop the existing business in their communities, because it does not contribute to increasing budget revenues. • Inefficient operations of the local business environment. • Low level of green infrastructure. • Limited natural resources. • Lack of cooperation with research institutes. • Lack of measures related to eco-innovation • Permanent migration of young professionals from rural communities.
Opportunities	Threats
• New jobs and businesses • Development of cooperation with scientific institutes. • Making the community attractive. • Increasing community income. • Optimal and economical use of resources. • Evaluation and use of ecologically clean food. • Probability of achieving great results with small opportunities. • Create a better ecological quality: improvement of regional and local governance. • Effective cooperation between local businessmen, authorities, and other stakeholders. • Increase of social protection of the rural population.	• The application of scientific research results often requires a relatively long time, it is difficult to predict their profitability and, therefore, the private sector of the economy is not always ready for such risky investments. • Future environmental degradation. • Natural disasters and the lack of their prevention and warning system. • The threat of war, and constant tension, particularly in the border communities. • Reducing future consumer demand for green products. • Environmental risks (abuse of resources, deforestation, land degradation, etc.) • Emigration from rural settlements. • Disproportionate development.in rural areas • Unfavorable demographic dynamics • Continuous abuse of natural resources and neglecting the principles of sustainable agriculture can lead to environmental problems in the medium

	and long term.

It is very important that the business organizations in RA gradually develop a culture of not harming the environment or at least minimizing the harm with their activities. Organizations must realize that environmental problems require a systematic approach and integrated solutions, i.e., cooperation with scientific research institutes becomes substantial. Therefore, the attention of enterprises should be targeted to the assessment of environmental <burden> at all stages of the production process. Enterprises actively dealing with environmental issues have been able to ensure environmental and economic efficiency, and have increased competitive advantages by saving resources, and improving the quality of management and production. The company assumably shows the maximum initiative to reduce the burden on the environment, which is expressed by the use of environmentally friendly technologies and the appropriate motivation of the staff, etc. In RA, most of the businesses are still not motivated for ecological reorientation, however, the creation of appropriate institutions, and rational motivations should encourage them to change their neutral behavior to an active and even proactive policy.

Thus, the transition to sustainable development in the Republic of Armenia will largely depend on the transformation of traditional production structures into environmentally oriented enterprises that adhere to the principles of a new development concept based on the harmonious interaction of economic, social, and environmental factors.

References

1. Five benefits of research commercialisation, https://ximbio.com/news/importance-of-commercialisation-and-ip-a-wasted-exercise-or-a-value-generator
2. Global Innovation Index 2022, https://www.wipo.int/edocs/pubdocs/en/wipo-pub-2000-2022-section3-en-gii-2022-results-global-innovation-index-2022-15th-edition.pdf
3. K. Khachatryan1 , A. Hakobjanyan, K. Nikoghosyan, The Development of Entrepreneurial Education in the Framework of University-Industry Collaboration in the Republic of Armenia, https://www.dpublication.com/wp-content/uploads/2022/05/30-8109-1.pdf
4. Ministry of Economy of the Republic of Armenia, Office of Intellectual Property,https://aipo.am/hy/files/categories/12

5. "On State Support of Innovative Activities" RA Law, 2006, https://www.arlis.am/documentview.aspx?Docid=24697
6. RA strategic program of 2014-2025 on prospective development, https://www.gov.am/files/docs/1322.pdf
7. The 2021-2026 activity program of the RA Government, https://www.gov.am/files/docs/4586.pdf,
8. Science Commercialization, Course Curriculum and Instructor Manual, FAST, Yerevan 2022
9. Science Commercialization, Course Curriculum and Instructor Manual, FAST, Yerevan 2022, p.6.
10. Statistical Committee of the RA, https://www.armstat.am/am/?nid=82&year=2022.
11. The Concept of Overhaul, Construction, and Modernization of RA scientific facilities, RA Government, https://www.irtek.am/views/act.aspx?aid=76210
12. T. Caulfield, U. Ogbogu, The commercialization of university-based research: Balancing risks and benefits, https://bmcmedethics.biomedcentral.com/articles/10.1186/s12910-015-0064-2
13. The decision N 454 of the RA Government of April 23, 2009, https://www.arlis.am/DocumentView.aspx?docid=67573
14. The decision of the RA Government No. 459 of April 30, 2009, https://www.arlis.am/DocumentView.aspx?DocID=51373
15. University of Pittsburg, Innovation Institut, https://www.innovation.pitt.edu/contact-splash/why-commercialize/
16. UK Research and Innovation, https://www.ukri.org/councils/esrc/impact-toolkit-for-economic-and-social-sciences/how-to-commercialise-your-research/why-commercialisation-is-important/