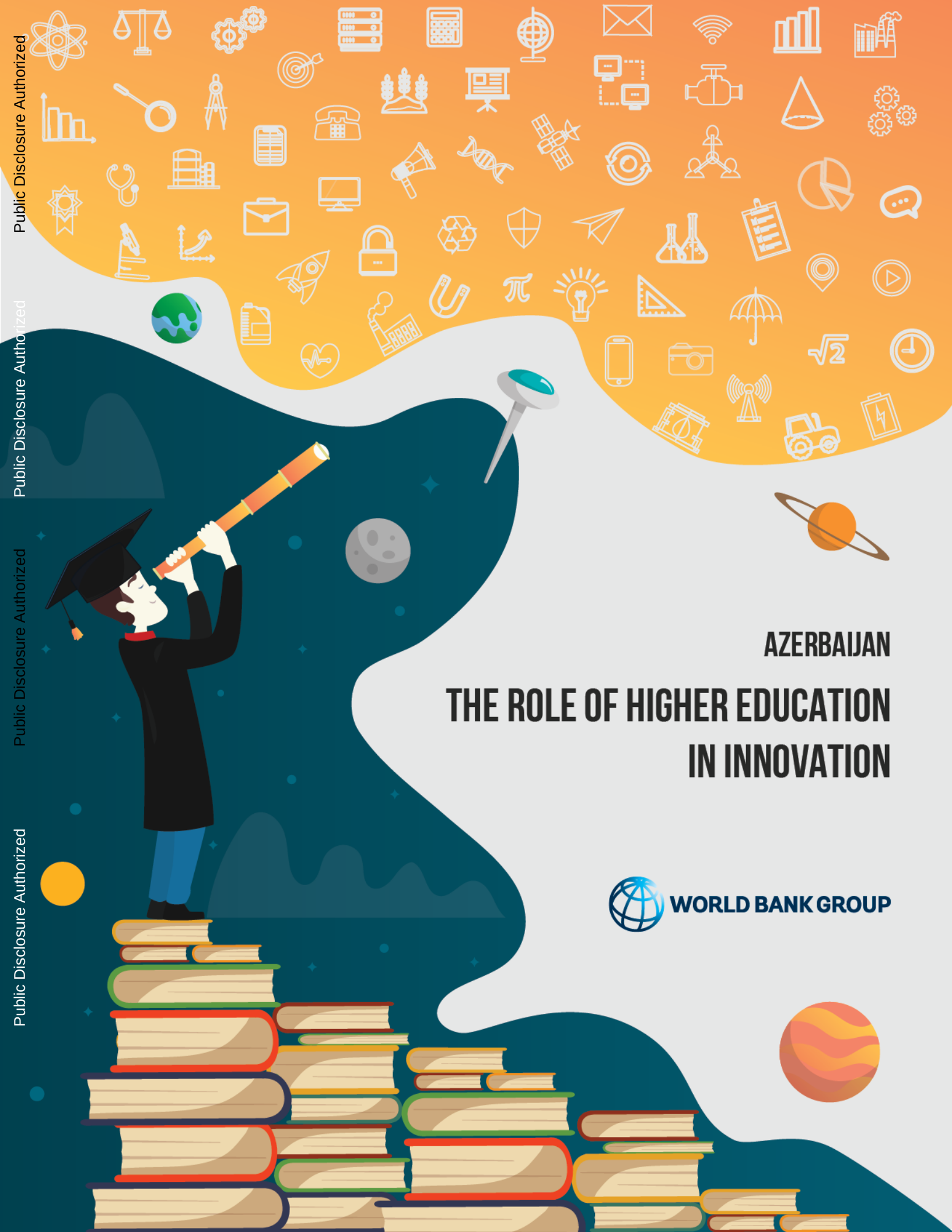

AZERBAIJAN

THE ROLE OF HIGHER EDUCATION IN INNOVATION

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ABBREVIATIONS

AIF	Academic Innovation Fund
ANAS	Azerbaijan National Academy of Sciences
ASOIU	Azerbaijan State Oil and Industrial University
BSU	Baku State University
CIS	Commonwealth of Independent States
CCSR	Coordination Council of Scientific Researches of the Republic of Azerbaijan
COE	Center of Excellence
EDS	Education Development Strategy
EHEA	European Higher Education Area
EU	European Union
GDP	Gross Domestic Product
HEI	Higher Education Institution
HERIC	Higher Education and Research for Innovation and Competitiveness
HTP	High Tech Park
ICT	Information and Communication Technologies
IP	Intellectual Property
IPR	Intellectual Property Rights
MHEP	Modernizing Higher Education Project
MOE	Ministry of Education
MTCHT	Ministry of Transport, Communications and High Technologies
NCP	National Contact Point
NGO	Non-Governmental Organization
NQF	National Qualifications Framework
OTTC	Office of Technology Transfer and Commercialization
PCT	Patent Cooperation Treaty
R&D	Research and Development
RI	Research Infrastructure
SDF	Science Development Foundation
SAC	Supreme Attestation Commission
SMEs	Small and Medium Enterprises
STP	Sumgait Technologies Park
TCP	Technology Commercialization Project
TTO	Technology Transfer Office
SSC	State Statistical Committee of the Republic of Azerbaijan
UIS	UNESCO Institute for Statistics
UNEC	Azerbaijan State University of Economics

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EXECUTIVE SUMMARY

As the push to engage in the global knowledge economy becomes increasingly vital to countries around the world, higher education institutions (HEIs) are being recognized as valuable centers for research and teaching in support of entrepreneurship, innovation, competitiveness, and economic growth. Many HEIs in Azerbaijan, however, lack the capacity to serve as effective dynamic hubs for such enterprising efforts, limiting Azerbaijan's ability to collaborate and compete with other nations in the global economy. Leveraging its expertise in this area, the World Bank carried out an analysis of the status of the research and innovation environment in Azerbaijan's higher education sector, identifying the main obstacles to the advancement of research work and its results and to effective coordination between higher education institutions and industry to achieve innovation-led growth.

Science in Azerbaijan is examined through policy and institutional lenses, encompassing its governance, funding and management issues. The analysis looks at innovation as a dynamic outcome from university-industry collaboration, examining issues of technology transfer and intellectual property rights, the start-up environment, and funding of research toward practical and applied outcomes. The results of the analysis presented in this note, based on national and international data sources along with numerous consultations with a variety of stakeholders, informs concrete policy measures that can be taken by Azerbaijani authorities to strengthen the capacity of HEIs to serve as key actors in the country's innovation ecosystem and facilitate economic diversification within the global knowledge economy.

Recently adopted national strategic documents are creating possibilities for reform by the MOE as well as by individual HEIs. The Education Development Strategy (EDS), approved by the President of the Republic of Azerbaijan in 2013, defines purposeful reforms in education with the main goal of building a competitive and leading education system in line with the world's best practices and based on cutting-edge technology infrastructure, quality and accessibility. The key findings and recommendations center on undertaking strategic efforts to maximize the quality and relevance of higher education as it relates to innovation and economic competitiveness.

HEIs are the hub of knowledge and creativity in all nations, and it is in Azerbaijan's strategic interest to focus renewed energy on enabling HEIs to contribute to and drive a dynamic economic rejuvenation.

The following key messages emerge from the analysis and inform the policy recommendations:

- Public investment in higher education and R&D is relatively low and focuses on basic, rather than applied, research.
- Targeted reforms are needed to increase the quality and relevance of R&D and improve the efficiency of public investments in science.
- The funding, evaluation, career management, and quality assurance mechanisms currently in place need to be updated to align with international best practice.
- Connectivity with international research networks, university-industry linkages, and technology commercialization mechanism can be strengthened.
- The availability and accessibility of modern research and prototyping equipment is uneven among the various stakeholders of the research and innovation sphere.

Using comparative examples from Eastern Europe, the South Caucasus, and Central Asia—as well as good practices from top performing systems—this policy note provides 12 key recommendations, which are summarized below and more fully contextualized in the sections that follow.

Summary of Policy Recommendations

	Short Term (1-2 years)	Medium Term (3-5 years)
Accelerate the R&D Effectiveness of Azerbaijan's HEIs	Recommendation 1: Expand the use of competitive funding to increase the quality and relevance of R&D.	Recommendation 2: Increase overall public investment in R&D, with more funding directed toward HEIs and promotion of applied research.
	Recommendation 3: Promote research internationalization.	Recommendation 4: Review the academic career system and adopt incentive and reward mechanisms in line with international best practices.
		Recommendation 5: Adopt sound evaluation practices and quality assurance mechanisms that promote high-quality research in higher education.
Strengthen HEIs' Third Mission and Connection with Industry	Recommendation 6: Review the capacity of existing TTOs and ensure that they assume a broader role in fulfilling the "third mission" of HEIs by developing links with the private sector.	Recommendation 7: Encourage universities to develop a "Commercialization Agenda".
	Recommendation 9: Encourage HEIs to offer faculty consultancies, contract research, and educational/training programs of relevance to the private sector.	Recommendation 8: Introduce incentives for commercialization of innovation for various stakeholders through revenue sharing and career performance systems.
Support Entrepreneurship Education and Innovation Infrastructure	Recommendation 10: Develop a research equipment registry and promote shared access by different stakeholders.	Recommendation 11: Consider developing a national Research Infrastructure Roadmap.
	Recommendation 12: Promote business incubators and Fab Labs within HEIs and strengthen the existing ones by application of international best practices.	

The World Bank remains ready to support interventions related to any of the findings and recommendations presented in this policy note with the aim of strengthening the quality and relevance of higher education and R&D in Azerbaijan to promote innovation for economic diversification and growth.

The Way Forward

Recommendations to Accelerate the R&D Effectiveness of Azerbaijan's HEIs

Recommendation 1:

In the short-term, expand the use of competitive funding to increase the quality and relevance of R&D. In particular, competitive funding can be effective in promoting research in targeted fields with high relevance for the development and diversification of the national economy. Lessons can be learned from the competitive funding mechanisms utilized in Kazakhstan, Montenegro, Uzbekistan, and other countries.

Recommendation 2:

In the medium-term, increase overall public investment in R&D, with more funding directed toward HEIs and promotion of applied research. By shifting the balance away from mainly financing fundamental to applied research, the public R&D budget can more effectively promote research that is of greater relevance to industry. Encouraging and incentivizing research partnerships that bring together HEIs, public research institutes, and private enterprises can be beneficial—while ensuring that a greater share of the R&D funding is directed at HEIs.

Recommendation 3:

Promote research internationalization. It is crucial pivotal for Azerbaijan to develop stronger links with international research and innovation networks to access new knowledge, technologies and know-how generated and developed outside national borders. The country should aim for:

- Greater participation in international exchanges of HEI students and faculty;
- More effective participation in Horizon 2020 calls for project proposals. This can be accomplished by provision of training on the preparation of good project proposals for international programs; promotion of English language in project applications; and enhancing capacity of the Horizon 2020 National Contact Points;
- Development of an internationalization strategy for higher education and R&D.

Recommendation 4:

Review the academic career system and adopt incentive and reward mechanisms in line with international best practices. Promote national policies for gender balance among academic staff. To generate good research competencies among academic staff, it is essential to endorse doctoral training and academic career management that is focused on high-quality research and innovation. One key step is to have a better-functioning tenure-track career system, which is characterized by three key elements:

- an entry position for which talented individuals can apply in order to access a career as a researcher and/or teacher;
- well-developed career pathways; and

- incentives and disincentives to enhance and ensure quality performance.

Recommendation 5:

Adopt sound evaluation practices and quality assurance mechanisms that promote high-quality research in higher education. This includes building a system of quality assurance that aligns with international standards of quality, transparency, and openness. It also requires seeking national and international accreditation norms that provide cross-border assurance to HEIs and employers alike that the outputs of higher education in Azerbaijan are up to the standards and quality of global neighbors. Moreover, a research evaluation system should be developed to facilitate and incentivize continuous improvements in high-quality research performance.

Recommendations to Strengthen HEIs' Third Mission and Connection with Industry

Recommendation 6:

Review the capacity of existing TTOs and ensure that they assume a broader role in fulfilling the "third mission" of HEIs by developing links with the private sector. Among technology transfer models for consideration could be establishment of a collective technology transfer office for several entities. The TTO would provide direct hands-on support to scientists who are willing to start the commercialization of their know-how, but also oversee building relationships with the business and financial communities; improving awareness of institutional research activity; educating Faculty and Students about intellectual property, market research and commercializing innovative technology, among others.

Recommendation 7:

Encourage universities to develop a "Commercialization Agenda". Such a document should specify how the university intends to support commercialization of scientific results thanks to a set of clear, transparent and understandable rules and procedures. Ideally such a policy should be linked to the Azerbaijani legal framework (such as the forthcoming Law on Innovation).

Recommendation 8:

Introduce incentives for commercialization of innovation for various stakeholders through revenue sharing and career performance systems by:

- Developing clear mechanisms defining distribution of revenues from commercialization in a manner that rewards all players in HEIs (researchers, departments and faculties);
- Revising the academic recruitment/career progression system to reflect a broader range of research outputs. For example, encourage recruiting, hiring and reward systems to include third mission activities. In such a policy, R&D staff are evaluated and rewarded according their ability to share knowledge (training), to generate knowledge (science), and to disseminate knowledge (transferring).

Recommendation 9:

Encourage HEIs to offer faculty consultancies, contract research, and educational/training programs of relevance to the private sector. This can be accomplished by identification of in-house expertise and possible services followed by preparation of an offer in demand by external clients. A contact unit could be appointed or a website created as a single-entry point for dialogue with the private sector within each HEI.

Recommendations to Support Entrepreneurship Education and Innovation Infrastructure

Recommendation 10:

Develop a research equipment registry and promote shared access by different stakeholders. To make HEIs and other innovation system stakeholders aware of all existing research and innovation equipment in the country, an electronic registry (or app à la *Uber* or *Airbnb* for scientific equipment) can be developed. Adopting regulations at HEIs to make accessing the existing infrastructure easier for all innovation system stakeholders (including firms and other external clients) would increase the efficiency of equipment utilization and can generate revenues for HEIs.

Recommendation 11:

Consider developing a national Research Infrastructure Roadmap. The Roadmap—similar to the EU members states' roadmaps—can set out proposals on establishing priorities for investment in new research infrastructure and using existing infrastructure more efficiently with a focus on priority areas of the Azerbaijani economy.

Recommendation 12:

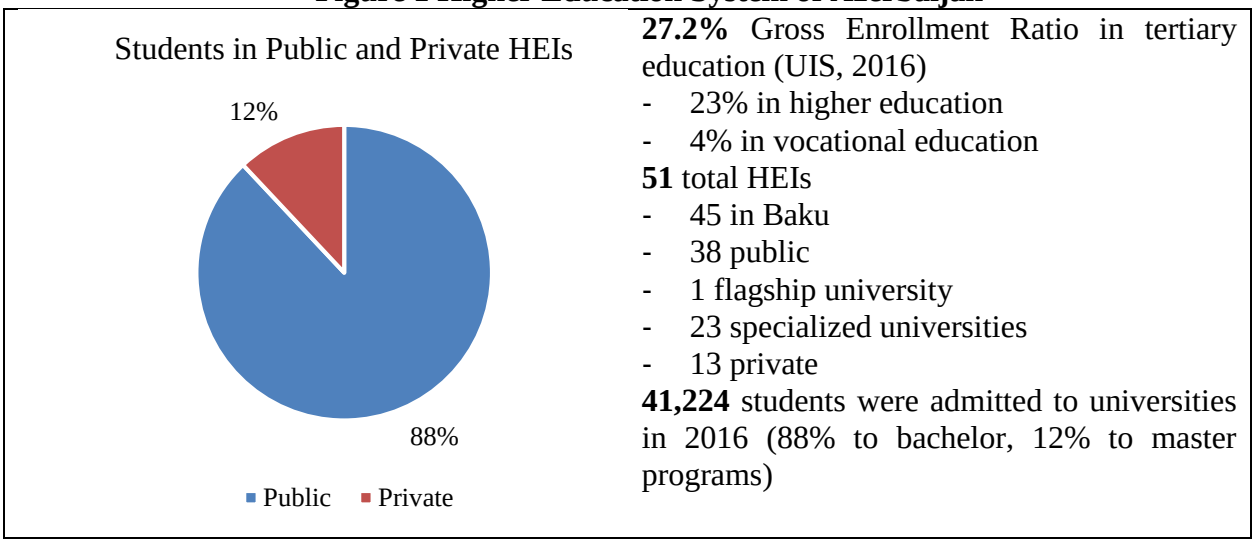
Promote business incubators and Fab Labs within HEIs and strengthen the existing ones by application of international best practices. Consider establishment of business incubators with pre-seed financing. Such incubators could become dynamic tools for fostering new ventures across a variety sectors by linking talent, technology, capital, and know-how in a single facility. Fab Labs are proof-of-concept labs that provide catalytic stimulus for knowledge sharing, entrepreneurship, and research. Creation of five Fab Labs has been already recognized by MOE in the concept of the Azerbaijani Innovation Ecosystem.

1. HIGHER EDUCATION AND RESEARCH SYSTEM OVERVIEW

1.1 Higher education sector in Azerbaijan

The higher education sector in Azerbaijan is composed of 51 HEIs (as of 2017). Twenty HEIs are public, reporting to the Ministry of Education (MOE); thirteen HEIs are private, overseen by MOE; and eighteen HEIs are public, but overseen by various other ministries. Among these, the majority are specialized universities (6 with military training focus, for example), and 15 are general HEIs providing a wide range of educational programs. Azerbaijani universities are heavily concentrated in the capital city of Baku, home to 82% of all HEIs in the country. In 2016, about 164,000 students studied at Azerbaijani HEIs, 88% of them enrolled in public universities. The five biggest public universities educate a majority of all students of the country: Baku State University (BSU), Azerbaijan State University of Economics (UNEC), Azerbaijan State Oil and Industrial University (ASOIU), Azerbaijan State Pedagogical University, and Azerbaijan Technical University. An overview of Azerbaijan's higher education system is presented in Figure 1.

Figure 1 Higher Education System of Azerbaijan

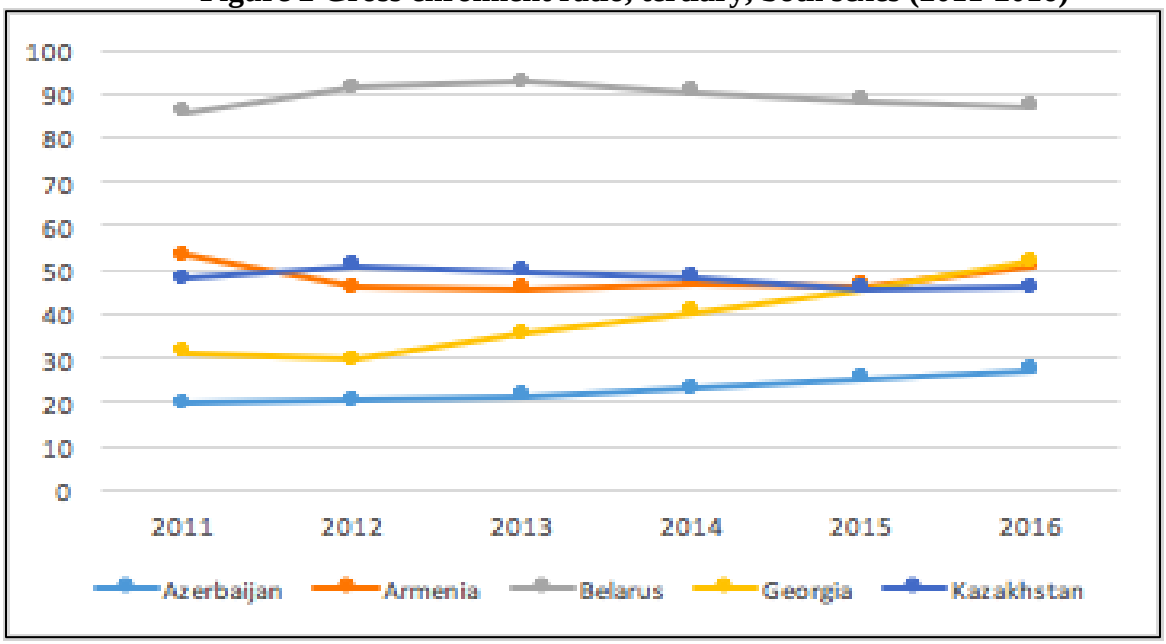


Source: SSC, 2016.

Azerbaijan saw a rapid increase in the number of HEIs after independence from the Soviet Union in 1991. From 17 in 1990, the number of HEIs increased to 46 by 1995. However, that number has changed little since then with the establishment of a small number of new public specialized universities under several public agencies to meet labor market demands. Recently, there has also been a trend of merging academies and polytechnic institutes into universities (for example, ADA University, Azerbaijan State Oil and Industrial University, and Mingechevir State University), thus expanding their educational program offerings.

The Azerbaijani higher education system continues to be characterized by low levels of tertiary education enrollment, compared both internationally and against its closest neighbors (Figure 2). In 2016, Azerbaijan's gross enrollment ratio in tertiary education was 27.2% (4% in vocational education and 23% in higher education) well below its neighbors Georgia (51.8%) and Armenia (51.2%) (UIS, 2016). Access to higher education is inequitable in relation to household income—ranging from 40 percent among the richest households, those in urban areas, and in Baku city to only 11 percent among the poorest households and those from rural areas.

Figure 2 Gross enrolment ratio, tertiary, both sexes (2011-2016)



Source: UIS, 2016.

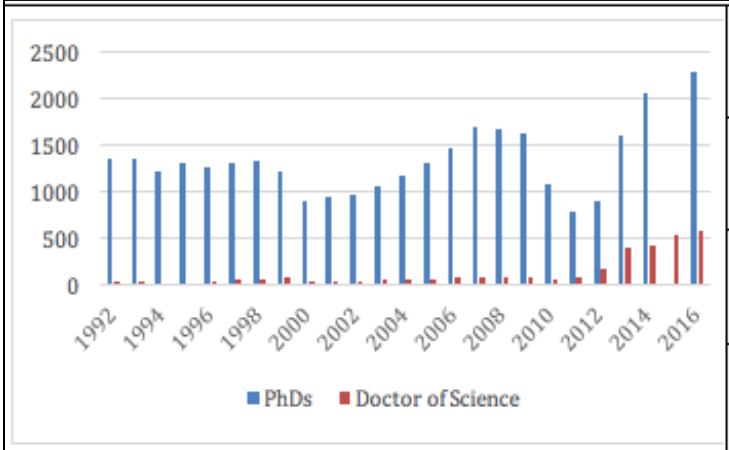
Recently adopted national strategic documents are creating possibilities for reform by the MOE as well as by individual HEIs. The Education Development Strategy (EDS), approved by the President of the Republic of Azerbaijan in 2013, defines purposeful reforms in education with the main goal of building a competitive and leading education system in line with the world's best practices and based on cutting-edge technology infrastructure, quality and accessibility. The strategy also sets goals for the higher education sector, including expanding and providing equitable access to universities, developing education quality through modern infrastructure and information communication technologies, improving the management capacity of HEIs, developing and strengthening quality assurance system and promoting transparency in higher education financing.

The twinning project of 2015-2017 (with the EU) contributed greatly to the development of a National Qualifications Framework (NQF) and the Standards and Guidelines for quality assurance in higher education in line with the European Qualification Framework. However, the NQF has not yet been endorsed in legislation. The draft NQF Decree proposes the NQF as a quality assurance tool for qualifications to the Cabinet of Ministers. Moreover, Azerbaijan joined the Bologna Process in 2005, integrating its credit system at the bachelor's and master's levels to harmonize with European Higher Education Area (EHEA). Although many HEIs have established

units for internal quality assurance, no international and intermediary quality assurance agencies function in the country, and the accreditation of HEIs is currently carried out by the Accreditation and Nostrification Office under the MOE.

Doctorate level studies remain largely unchanged since independence and joining the Bologna Process. Despite harmonizing its bachelor and master degree levels with the standards of the EHEA, Azerbaijan's doctorate studies continue to resemble the old Soviet education system of two levels of doctoral degrees—PhD and Doctor of Science. Both doctoral levels are granted, designed, and regulated by the Supreme Attestation Commission (SAC) under the President of Azerbaijan. SAC organizes dissertation defense committees, assigns specialization and topic indexes, and notarizes PhDs obtained from universities abroad. Existing regulations limit universities in deciding doctoral research areas and format of studies, as well as the efficiency of work of doctoral degree students. Strict regulations limit HEIs in doctoral degree provision, hinders autonomous decision-making regarding their research priority areas, and leads to potential inefficiencies in the deployment of research students. Both PhD and Doctor of Science degrees are provided at 110 institutions: 33 HEIs and 77 research institutes. In comparison with the 1990s, in 2016, there were 60% more PhDs and 500 more Doctors of Science in Azerbaijan (Figure 3). However, this does not translate into an increased research output for the country.

Figure 3 Doctoral degree student body change dynamics (1992-2016)



Students	PhD	Doctor of Science
Current students	2,182	541
Admitted students	420	101
Graduated students	543	79

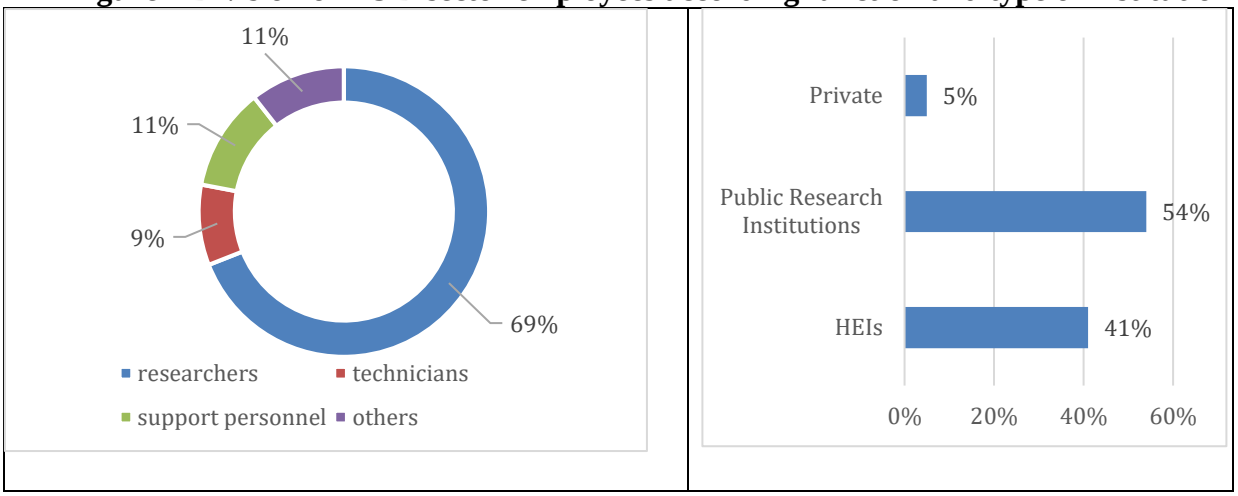
Source: SSC, 2018.

The recent Law on Science of 2016 still defines doctoral degrees as either doctor of philosophy or doctor of science, yet there have also been attempts at modernizing doctoral degree studies and bringing doctoral qualification in line with the requirements of the EHEA. For example, the NIZAMI capacity building project (supported through ERASMUS+) was aimed at restructuring and developing doctoral studies in Azerbaijan in line with EHEA requirements.

1.2 Science workforce

Research activity in Azerbaijan is fragmented across a variety of institutions. Research is performed by 135 institutions, among these are 38 institutions within HEIs, 88 research institutes (30 of those under the Azerbaijan National Academy of Sciences), 3 research construction organizations and 6 other types of institutions. Over 22,000 employees work in the research sector, 69% of them holding researcher positions (Figure 4). The largest body of researchers, the Azerbaijan National Academy of Sciences (ANAS), employs 4,582 people. Among researchers, only 35% hold an academic degree (7% doctors of science and 28% doctors of philosophy) (SDF, 2016).

Figure 4 Division of R&D sector employees according function and type of institution



Source: SSC, 2016.

Women are well-represented in the R&D sector; however, they remain underrepresented among academic staff, especially in the higher ranks. Eighty-seven percent—8,871 out of 10,168—of Azerbaijani researchers are women (SDF, 2016). Yet in terms of higher scientific titles and positions, such as honorary ANAS members and doctors of sciences, women lag behind: only 9 out of 74 academicians (*akademik*) and 12 out of 115 corresponding members are female. Other countries, such as Poland, also experience underrepresentation of women in the higher ranks within the R&D sector. In recent years, more than half of the EU countries have introduced general or specific legislation concerning equal opportunities in the higher education sector (see Box 1).

Box 1 Examples of National Policies for Gender Balance Among Academic Staff

Proposing concrete measures in the general legislation on equal opportunities

- In Finland, each organization with more than 30 people must have a gender equality plan which is updated annually in cooperation with staff representatives. The plan includes: 1) an assessment of the gender equality in the organization; 2) planned measures for promoting gender equality; and 3) an evaluation of the implementation and success of the measures developed earlier.

Ensuring that selection committees comprise both genders

- In France, at least 40% of the members of any selection committee must be women. In disciplines with greater gender disparity, the least-represented gender can be favored.
- Iceland has minimum requirements for gender representation on selection committees. An equality rights committee oversees all issues related to gender equality. Establishing minimum quotas for each gender
- In Austria, all staff categories and university boards should have an equal share of men and women. Women are recruited when they have the same qualifications as men.
- In Germany, the research organizations in the Pact for Research and Innovation have set target quotas for recruiting female researchers. The share for each staff category is based on the proportion of women at the career level immediately below. The long-term goal is an equal share of women and men at all career levels. Institutions report on progress to the German Research Foundation

Promoting gender balance in academia without prescriptive targets

- In Ireland, the Higher Education Authority (HEA) has carried out a systemwide review of gender profiles and gender equality policies in HEIs. Recommendations include: quotas for staff categories based on the share of genders at the career level immediately below; the use of the Athena SWAN institutional award; and a 40 % minimum representation of either gender in the bodies taking decisions on resource allocation, appointments and promotions. The HEA publishes annual data on the gender breakdown of academic staff.

Source: Eurydice (2017).

1.3 Higher education and science

A clear division between education and science remains entrenched in Azerbaijan. Reflecting the country's Soviet past, universities mainly provide instruction, while ANAS retains the primary responsibility for the organization and implementation of science (see Box 2). This is also reflected in the governance model in which Azerbaijani HEIs are governed by the Cabinet of Ministers and the Ministry of Education, while ANAS is under direct jurisdiction of the Office of the President.

Box 2 Overview of the Azerbaijan National Academy of Sciences (ANAS)

- Established in 1945, ANAS functions under the jurisdiction of the President and reports directly to the President of the Republic of Azerbaijan. It is the main R&D player in the country.
- ANAS encompasses 6 main departments with over 30 research and cultural institutions and 360 scientific laboratories.
- The staff of the ANAS consists of 10,140 individuals, including 4,582 researchers (2,527 of whom hold doctoral degrees). Since 2015, ANAS also offers master's degree studies, currently educating 67 students.
- ANAS allows university students to access its laboratories. Currently about 500 university students use ANAS scientific facilities.
- High Technologies Park under ANAS also offers technology transfer, business consultation,

office and laboratory services to its residents, ANAS researchers and other external researchers and companies.

- Among activities pursued by ANAS to promote development and internationalization of science are: (1) obligatory foreign language tests for all PhD students in order to graduate; (2) more emphasis on the development of ICT skills; and (3) organization of workshops and lectures for ANAS students by scientists and lecturers from leading universities.

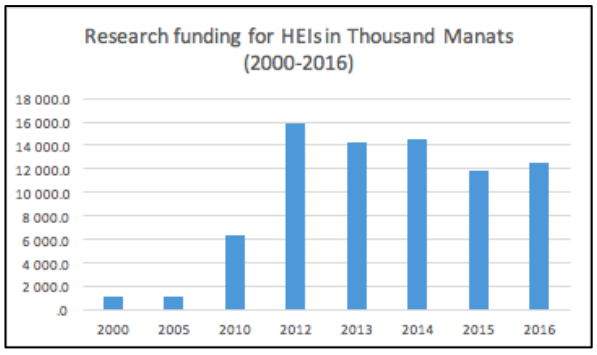
Since 2011, the SDF has initiated several grant competitions to support young scientists and researchers. In the fourth grant competition of 2017, for instance, 600,000 manats were allocated to 19 mostly multidisciplinary and applied research projects. Moreover, in 2016, together with ANAS, the Ministry of Education organized and carried out the "Education and Science Competition" with the objective of stimulating and supporting activities of research institutes and HEIs by providing funding for modern equipment and academic training. The competition aimed at allotting up to 100,000 manats of grants to winning fundamental and applied research projects by groups of researchers from various institutions. In total, more than 4 million manats were provided to 69 fundamental-applied research projects and to 2 special projects as a result of the competition.

In 2015, the first master's degree students started their studies at ANAS. The number of admitted master's students has been increasing since then; while the first cohort comprised only 19 students, this number increased to 67 in 2017. These first attempts by ANAS to bring education and research under the same roof are signs of a positive trend, though closer cooperation with HEIs remains desirable.

Research is also carried out at HEIs, yet very few of them have sufficient capacity to pursue high-quality research. Limited research funding is among the key challenges faced by HEIs. Despite close to a tenfold increase since 2000, HEIs obtain about 10% of the national annual budget for R&D, compared to 47% received by ANAS (Table 1).

Table 1 R&D by the type of institution (2016) and research funding allocation to HEIs (2000-2016)

Type of institution	Thousand manat	Percent of total
Scientific-research organizations	100 090.9	84.42%
Of which, ANAS:	*55 517.9*	*46.82%*
Construction organizations	187.1	0.16%
Higher education institutions	12 576.4	10.61%
Other	5 710.6	4.82%
Total	**118 565.0**	**100.00%**



Source: SSC, 2016.

1.4 Internationalization of research

University participation in international research programs is low in Azerbaijan. International knowledge and researcher flows are critical to access new research, technologies and

know-how generated and developed outside national borders; nonetheless, international funding for research has been utilized minimally by Azerbaijani researchers. The European Union (EU) remains Azerbaijan's main provider of grant funding. In 2014, Azerbaijan established the National Contact Point (NCP) Network to provide guidance and practical information on all aspects of participation in Horizon 2020: the EU Framework Program for Research and Innovation. However, both the number of applications and successful applications from Azerbaijan research and educational institutions remain low, with a success rate of 11%. From 2014-17, 43 project proposals were submitted by 28 Azerbaijani organizations, 5 of which were accepted including 3 proposals funded by the European Commission.

Participation in ERASMUS+ and Tempus projects also remains low. Between 2014-16 only 7 ERASMUS+ projects were awarded to Azerbaijani HEIs. In comparison with its neighbors, in 2007-2013, Azerbaijan implemented fewer Tempus IV projects (30) than both Armenia (40) and Georgia (48).

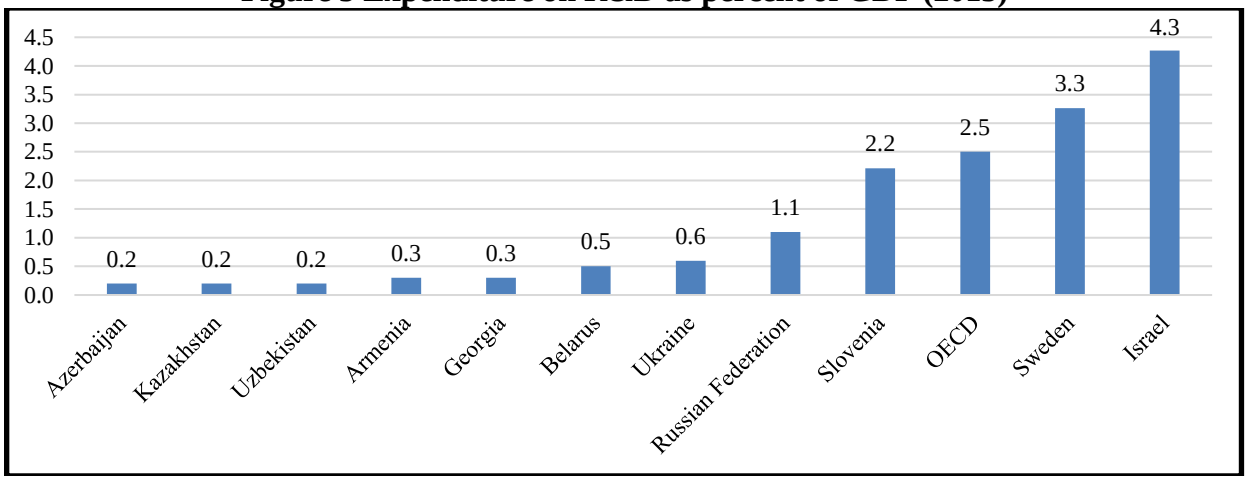
Successful participation in international programs is hampered by several obstacles. Among them are: (1) a lack of capacity and expertise due to limited experience in developing complex, multidisciplinary project proposals, shortage of resources for networking, developing global links and promotion of young researchers; (2) challenges of a legal nature associated with the use of grant funds; (3) insufficient support for NCPs (such as the lack of dissemination of information and insufficient funding); (4) limited private sector investment in R&D; and (5) the capacities of Azerbaijani R&D facilities.

2. RESEARCH & DEVELOPMENT FUNDING AND THE ROLE OF HEIs

2.1 Gross expenditures on R&D

Although expenditures on R&D have been increasing in absolute terms since 2000 in Azerbaijan, **total R&D spending remains low as a share of GDP.** The 118 million manat allocated to science in the 2018 national budget accounts for less than 0.2% of GDP. Such levels of investment are not sufficient for a country to make a meaningful impact in advancing its innovation capabilities**.** Innovative economies of similar size, such as Austria, Sweden, spend about 3% of GDP on R&D, while the OECD average is 2.5%. Middle income economies such as Serbia and Croatia spend around 1% of GDP, although they have been actively introducing reforms in recent years specifically aimed at increasing R&D investment. In comparison to other CIS countries, Azerbaijan's level of R&D investment lags behind Georgia, Armenia, Belarus, Ukraine and the Russian Federation, while it is at a low level that is comparable to that of Kazakhstan and Uzbekistan (Figure 5).

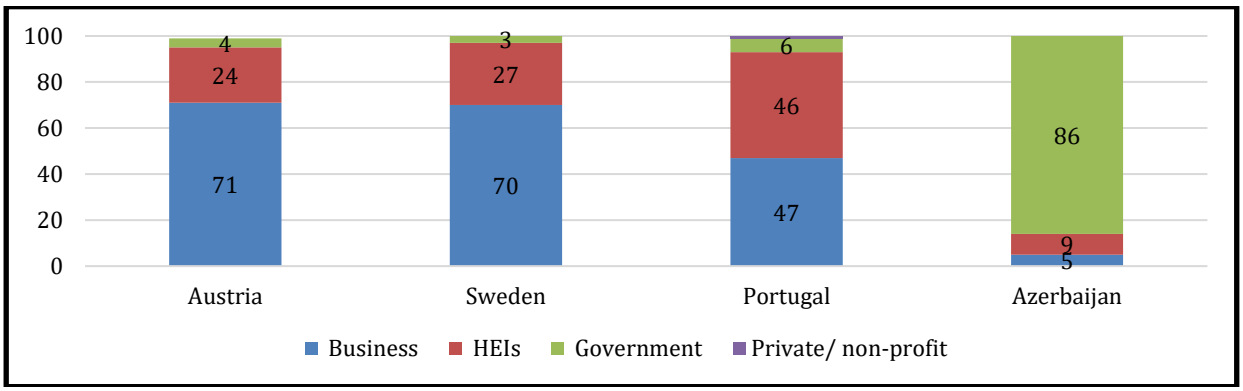
Figure 5 Expenditure on R&D as percent of GDP (2015)



Source: World Bank, 2018 (based on UIS data).

R&D in Azerbaijan in primarily carried by the public sector. Eighty-six percent of R&D is conducted by public research institutions, 9% by HEIs and 5% by the private sector. Such distribution is in contrast with practice in developed economies in which the private sector is the main driver of R&D expenditures, followed by HEIs (Figure 6). Such R&D structure with a leading role for the public sector is common among less developed economies across the world. Structural change in this area requires active public policies promoting the cooperation between public research institutions, universities, and the private sector.

Figure 6 Sectoral investment in R&D



Source: UIS.

Public funding of R&D in higher education is relatively low in Azerbaijan. Of the 2001.5 million manat (3% of GDP) in public funding allocated to education in 2018, approximately 200 million manat go to higher education (10% of the total education budget, less than 0.3% of GDP). Of this amount, 160 million is allocated to HEIs in the form of per capita student payments, while 42.7 million manat covers the costs of several budget-funded universities (and mainly finances infrastructure costs). This leaves the majority of universities heavily dependent on tuition fees, limiting their capacity for self-funding substantial research activities (Ministry of Economy, 2018).

2.2 Institutional and competitive funding of research: global trends and practice in Azerbaijan

Funding arrangements between the central government, universities and public research institutes are an important channel for delivering public research policy objectives and a major driver of change in the public research. Most countries combine, in varying proportions, institutional core funding with competitive R&D project grants.

- *Institutional (core) funding*: Institutional (core) funding, also defined as block grants, provides stable funding over the long term and a certain degree of research autonomy, which is essential for basic research. It is granted on the basis of various criteria—such as performance indicators, budget negotiations, and so forth—and typically covers staff salaries as well as the costs of operating and maintaining the research infrastructure. Block grants are used extensively for funding research and higher education, and they allow better institutional planning in the long terms.
- *Competitive (project) grants:* Competitive grants (or project funding) put more emphasis on research outcomes in the shorter run. The rationale for increasing the relative share of competitive funding in total higher education funding is that it is expected to yield relatively higher returns in terms of knowledge creation and research output. Increasing the share of project funding can be used further to make research organizations more responsive to the strategic and socioeconomic needs of the country, as these considerations can play an important role in funding allocation decisions. (Box 3 presents a list of common competitive funding instruments used in research funding.)

Box 3 List of Common Competitive Funding Instruments of Research Funding

Funding objective	Instrument	Potential target groups
Capacity building	Block grant, project, program (thematic or open), Center of Excellence (COE)	Research groups, organizations
Internationalization	Stipend, project, COE	Individuals, organizations
Commercialization	Award, expert support, venture capital	Research groups, organizations, individuals
Collaboration between PRIs - industry	Voucher, R&D tax credit, program, project, COE	SMEs, large firms
Strategic research (e.g. major challenges)	Project, program, COE	Research groups, individuals, consortia
Career advancement	Project, stipend	Young scholars (usually recently graduated PhDs)
Career renewal	Project, stipend	Senior research staff, R&D staff

Definitions

Project funding: the most well-known instrument, seen as a generic denotation for all types of competitive fixed-term resource allocation. Projects are usually short- to medium-term and allocate funding competitively. They have high flexibility in design depending on the project objective.

Grant: a term that may refer to a specific instrument or to funding instruments in general. In its specific form, a grant differs from a project in terms of the degree of freedom allowed to the recipient and the degree of administration required by the funder. Many charitable foundations employ this instrument, but ministries and research councils may also make limited use of grants. A typical example of a grant would be the Howard Hughes Foundations Medical Investigator program, which funds specific individuals rather than a research trajectory.

Stipend: a form of funding that usually does not have a detailed reporting component. Stipends are used mostly for the allocation of small sums and are often not renewed. Some funders use stipends to subsidize scientific trips, purchase small-scale equipment, or similar expenses.

Voucher: essentially an undertaking by the funder to reimburse a third party for expenses undertaken on behalf of the recipient. The European Union has a voucher scheme for small and medium-sized firms to source R&D services.

Source: Jacob (2014).

Among the objectives pursued by countries through competitive funding are the commercialization of public research and creation of links between research and industry via collaboration programs and public-private partnerships. Such programs have become increasingly popular in R&D and innovation policy because they are better adapted to innovation

goals or challenges. Collaboration programs can help make research and innovation policy more responsive to the changing nature of innovation and to social and global challenges. Public-private collaboration programs have a variety of forms. Organizationally, programs may be small-scale (shorter term) projects or large-scale, longer-term consortia with multiple (public and private) members and stakeholders (such as a Center of Excellence). In most countries these collaborative research or innovation efforts are carried out under a joint governance board with representatives from all partners and are co-financed by private partners in order to share risks and gain prior commitment.

Competitive funding programs can incorporate into their objectives various global trends and promote such elements as: multidisciplinarity, collaboration between a variety of research specializations, cooperation with the private sector, and international cooperation that facilitates the connection of a local economy to global knowledge networks.

Through good quality competitive funding programs vital reforms were initiated in the R&D sectors of Kazakhstan, Montenegro, and Uzbekistan. Though different in their overall objectives, these programs all rely on transparent evaluation processes, a combination of local and international evaluation panel members, and an identification of priority areas that are relevant for the respective national economies. The examples of the Kazakhstan Technology Commercialization Project (TCP), the Higher Education and Research for Innovation and Competitiveness (HERIC) program in Montenegro, and the Modernizing Higher Education Project (MHEP) in Uzbekistan are presented in Box 4. Each project's competitive funding element benefited from seed funding from the World Bank in the initial stages.

Box 4 Three Examples of Competitive Funding Projects in Eastern Europe and Central Asia

Example 1 – Kazakhstan: Technology Commercialization Project (TCP)[1], 2009 – 2015

Objectives:

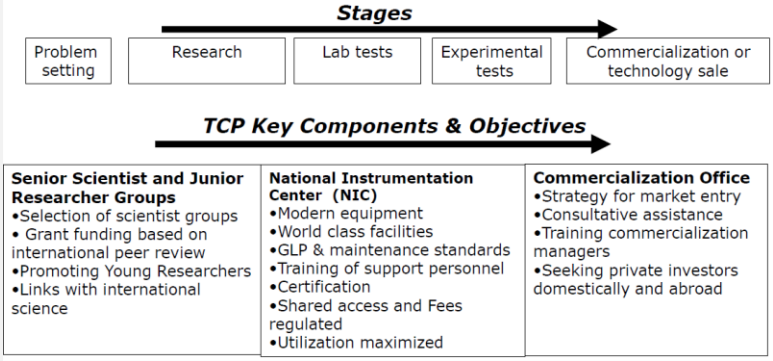
- Revitalize the potential of Kazakh science
- Restore the quality of Kazakh research infrastructure
- Link Kazakh science with domestic real sector and international technology markets
- Create capacity for technology management and commercialization

Budget:

- World Bank loan: USD 13 million
- Total budget: USD 75 million

Applied Modern Approach to Reforming Science:

- Organized "Senior Scientist and Junior Researcher Groups" based on scientific excellence
- Established National Instrumentation Center to break sectoral research "silos"
- Built capacity for Technology Commercialization Office
- Future public funding eligibility dependent on results
- Funded scientists directly on a competitive basis
- Integrated international peer review in public R&D funding



Example 2 – Montenegro: Higher Education and Research for Innovation and Competitiveness (HERIC) Project[2], 2012 – 2018

Objective: Improvement of the quality and commercial relevance of research

Budget: EUR 12 million, of which "Establishing a Competitive Research Environment" component has EUR 6 million

Projects funded through a competitive process:

- Pilot Center of Excellence in Bioinformatics (EUR 3.4 million for 2014-2018)

[1] For more details see: http://projects.worldbank.org/P090695/technology-commercialization-project?lang=en
[2] For more details see: http://www.heric.me/

- 8 collaborative research grants (between EUR 240-390 thousand, up to three years)

Promoted an Entirely New Approach to Fostering Research in Montenegro:

- Large and multiannual grants
- Rigorous project selection process (evaluation by distinguished international experts)
- National and international partnerships (promotion of multidisciplinarity and inter-institutional collaboration)
- Cooperation between researchers and business sector (applied research, market demand and sustainability promotion)
- Promotion of young talent into science
- Mentoring by international advisors in project commercialization
- First Center of Excellence as a pilot for future centers

Results:

- New products, patents, labs, start-ups, practices relevant for the economy
- Development of completely new disciplines in Montenegrin research community focused on market application and involvement of the private sector
- Influencing higher education programs - definition of new or expanding the existing curricula and programs in multidisciplinary areas (key!), e.g., smart energy networks, vectors of insects transmitting diseases, 3D product design
- International visibility through publications in leading thematic journals
- Much improved participation in EU Horizon 2020 due to better quality research proposals and international partnerships

Example 3 – Uzbekistan: Modernizing Higher Education Project (MHEP)[3] – Academic Innovation Fund (AIF), 2016 – 2023

Objective: To improve the relevance of higher education to the labor market by selecting and financing the innovative projects aimed at (i) strengthening university-industry linkages, and/or (ii) improving teaching and learning practices of HEIs.

Budget: Initial AIF allocation of USD 4 million financed by World Bank credit for the first two rounds of grants, expected future co-financing from the Government of Uzbekistan, if the AIF mechanism is shown to be successful in reaching its objectives.

Funding Windows:

- Window 1: Strengthening university-industry links
- Window 2: Improving teaching and learning practices at HEIs

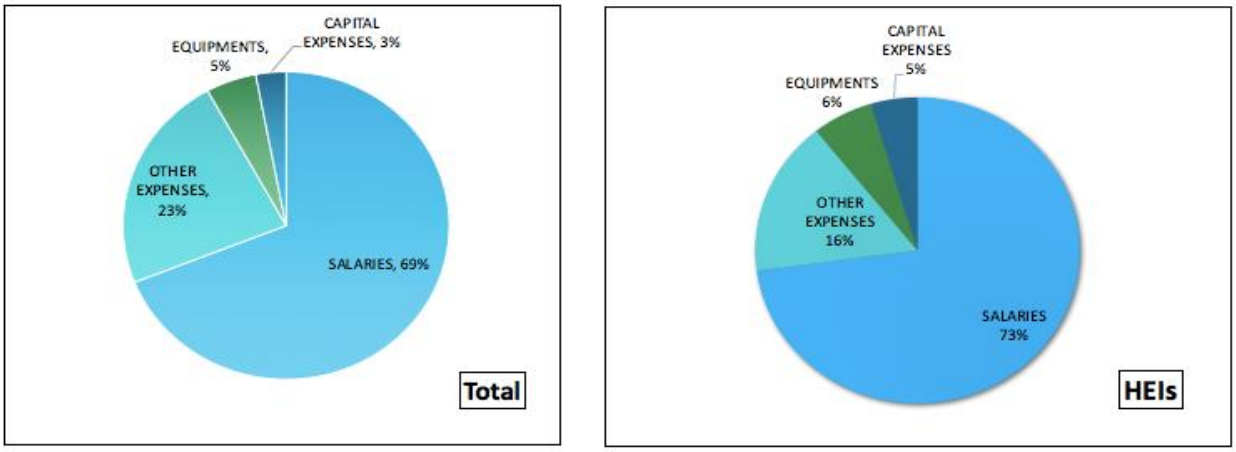
Funding Mechanisms: The first of two pilot rounds of grant funding will be launched in 2018 to award a total of USD 2 million across the two funding windows. Grant applications will be sought from Uzbek HEIs, as well as from consortia including Uzbek HEIs that may include foreign HEIs, foreign or domestic research institutes, representatives of industry and private enterprise, and others. Each grant award will be in the range of USD 100-200 thousand for a period of implementation of up to 2 years. A second pilot funding round will be announced in 2019. After the completion of two funding rounds, the effectiveness of the funding mechanism will be assessed.

[3] For more details see: http://projects.worldbank.org/P128516?lang=en

2.3 Institutional and competitive funding of R&D in Azerbaijan

R&D in Azerbaijan is primarily funded through institutional financing, out of which about 70% covers salaries. As a result, the share of funding allocated to research remains low (Figure 7). This trend is present in both the overall R&D sector as well as in HEIs.

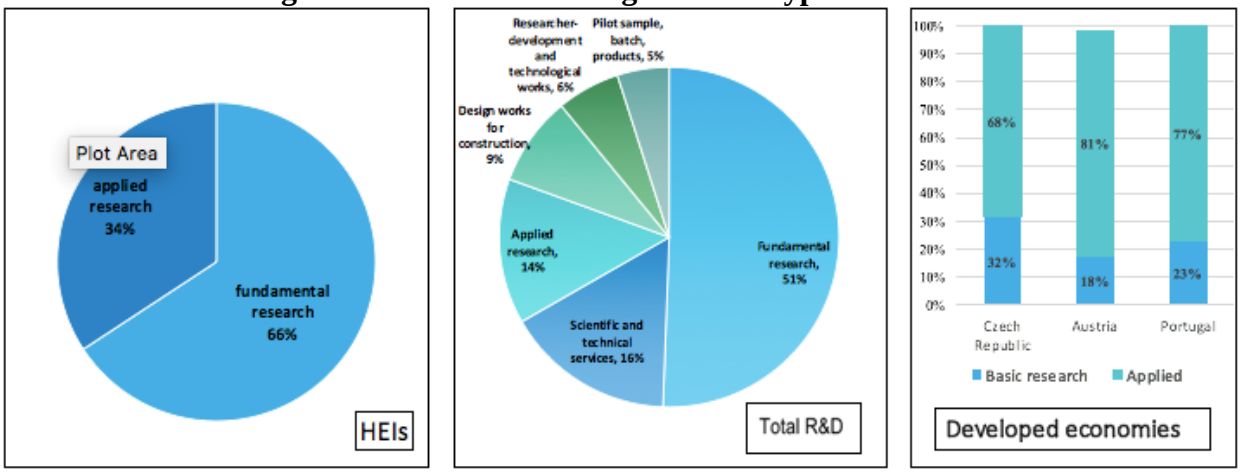
Figure 7 Division of research funds with HEIs and in the country



Source: SSC, 2016.

Within the institutional funding for R&D, most financing is channeled to fundamental (basic) research. At HEIs, 66% of R&D funds cover fundamental research compared to 34% of applied research (Figure 8). The percentage of applied research is even lower if all public R&D actors are considered—amounting to only 14%). In comparison, developed countries in Western Europe spend about 70% or more on applied R&D (for example, Czech Republic, Portugal, and Austria allocate 68%, 77%, and 81%, respectively, to applied research). Unlike basic research, applied research is more likely to be transformed into new products and processes relevant for the country's economy and is more likely to involve collaboration between researchers and the private sector.

Figure 8 Division of funding based on types of research



Sources: SSC, UIS.

Competitive funding in Azerbaijan represents a negligible share of total R&D financing. Competitive funding is administered by the Scientific Development Fund (SDF). During 2010-2015, less than 36 million manat was allocated to all research institutions in competitive funding (in comparison, the total annual R&D budget allocated for 2018 is 118 million manat). Of this total, 29% of competitive grants were awarded to HEIs, while 61% of grants went to the ANAS research institutes (Table 2). Of the total competitive funding allocation, only 19% went to HEIs. Nearly half (41%) of all competitive funding was allocated to 12 large projects (with a budget of above 500,000 manat per project).

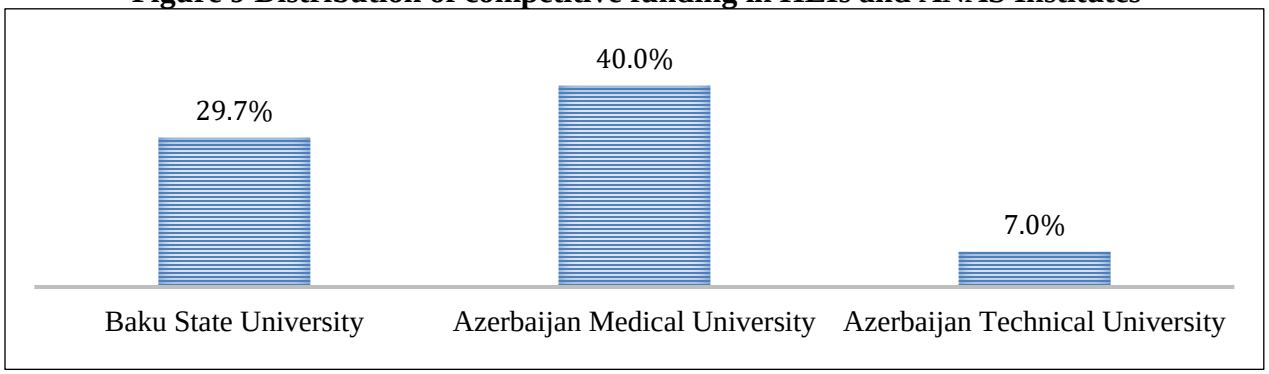
Table 2 General statistics of organizations participating in competitions (2010-2015)

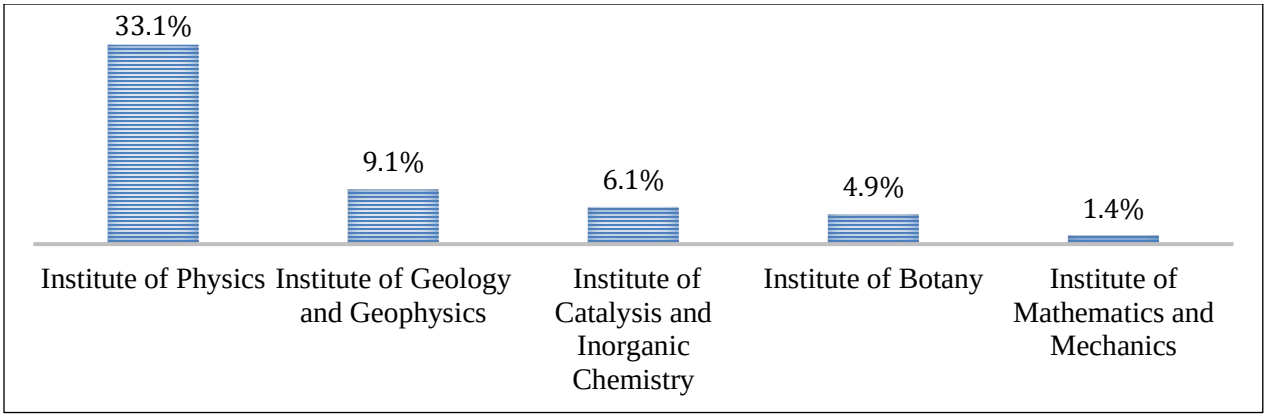
Institutions	**Number of projects**	**Allocation amount (manat)**	**Percent of projects**	**Percent of total allocation**
ANAS	272	26,620,822	61.26%	74.45%
Educational institutions	129	6,706,415	29.05%	18.75%
Field research institutions and others	31	2,054,100	6.98%	5.74%
NGO, other institutions and individuals	12	376,900	2.70%	1.05%
Total	**444**	**35,758,237**	100.00%	100.00%

Source: SDF, 2018.

Competitive funding is characterized by high concentration in several institutions. Figure 9 presents the distribution of competitive funding among HEIs and ANAS institutes. Out of 135 institutions performing research in Azerbaijan, a small number of institutions received large portions of competitive funding: 5 entities obtained 55% of this funding among the ANAS Institutes, while 3 universities (Baku State University, Azerbaijan Medical University, and Azerbaijan Technical University) received 77% of all competitive funding acquired by HEIs. It can be concluded that a vast majority of institutions pursuing R&D activities in Azerbaijan cannot count on much, if any, competitive research funding and thus must rely solely on institutional funding sources.

Figure 9 Distribution of competitive funding in HEIs and ANAS Institutes





Source: SDF, 2016.

2.4 R&D sector performance and global benchmarking

Relatively little research produced in Azerbaijan has a notable impact on global knowledge creation and diffusion. According to the H-index presented in Table 3, Azerbaijan ranks 113th in the world based on the quality (impact) of its research. This lags behind its regional peers of similar or much smaller size such as Belarus (73rd), Georgia (77th), or Moldova (101st).

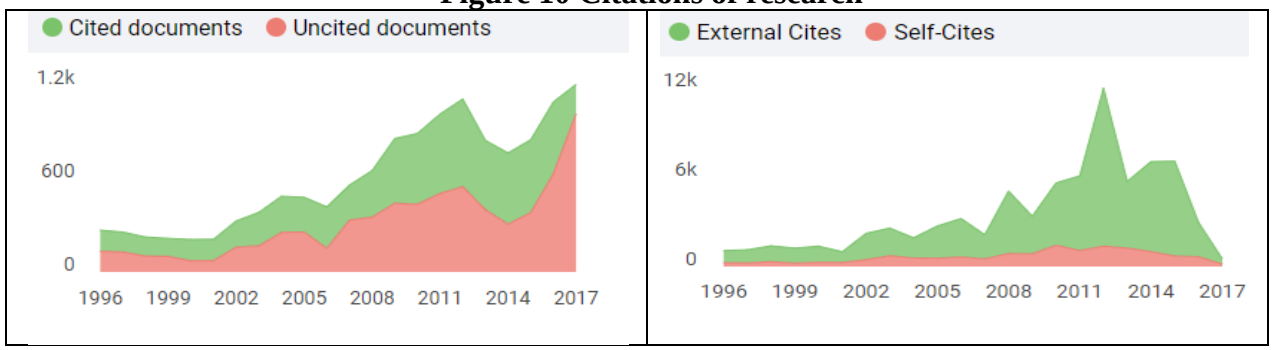
Table 3 H-index ranking (indicating the quality of research)

Rank	Country	Citable documents	Citations	Self-citations	Citations per document	H-index	Population (mln)
1	United States	546605	426316	224281	0.68	2077	323
2	United Kingdom	162965	144860	45752	0.76	1281	66
11	Sweden	36130	33053	7365	0.83	778	10
16	Israel	18372	15120	3069	0.74	624	9
63	Serbia	7047	3525	868	0.46	172	7
73	Belarus	1901	1192	397	0.6	158	10
77	Georgia	1493	1735	319	1.06	155	4
101	Moldova	463	370	61	0.76	97	4
113	**Azerbaijan**	**1053**	**478**	**148**	**0.44**	**87**	**10**
122	Uzbekistan	516	166	31	0.31	83	32
125	Kazakhstan	3194	906	330	0.28	81	18

Sources: Scimago Journal & Country Rank and World Bank.

Much of the knowledge produced in Azerbaijan does not get disseminated outside of the country. A large share of documents goes uncited: in 2017, out of 1093 citable documents, only 172 (15%) were cited (Figure 10). In terms of citable documents, Azerbaijan ranks 91st out of 239 countries, behind Belarus (76th), Georgia (82nd), and Kazakhstan (64th), though ahead of Moldova (108th).

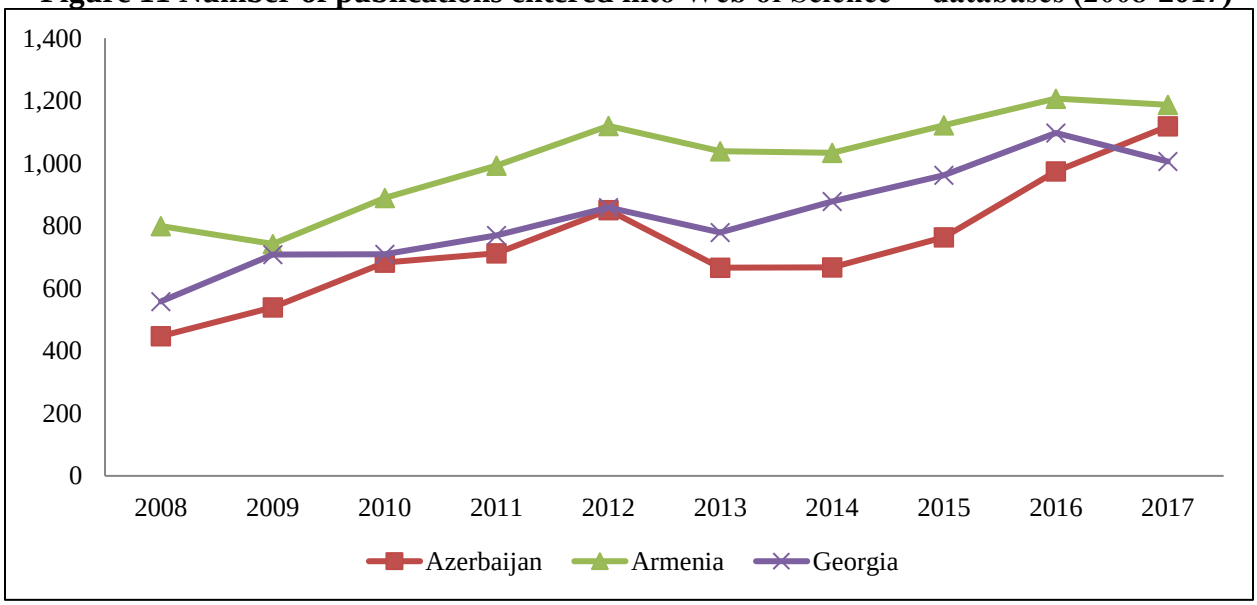
Figure 10 Citations of research



Source: Scimago Journal & Country Rank.

Recent improvements in the quantity of publication output must be acknowledged. According to data provided by Clarivate Analytics, in 2017 Azerbaijan managed to increase its rank among the countries of the South Caucasus, surpassing neighboring Georgia in terms of the number of publications entered into Web of Science databases (Figure 11). In the most recent year 1,118 research works from Azerbaijan were registered in Web of Science, indicating a record number of publication in the last twenty-five years. (A ranking of Azerbaijani HEIs based on publication activity is presented in Annex 1.) However, the low levels of citations and a low H-index indicate a relatively low quality of these publications.

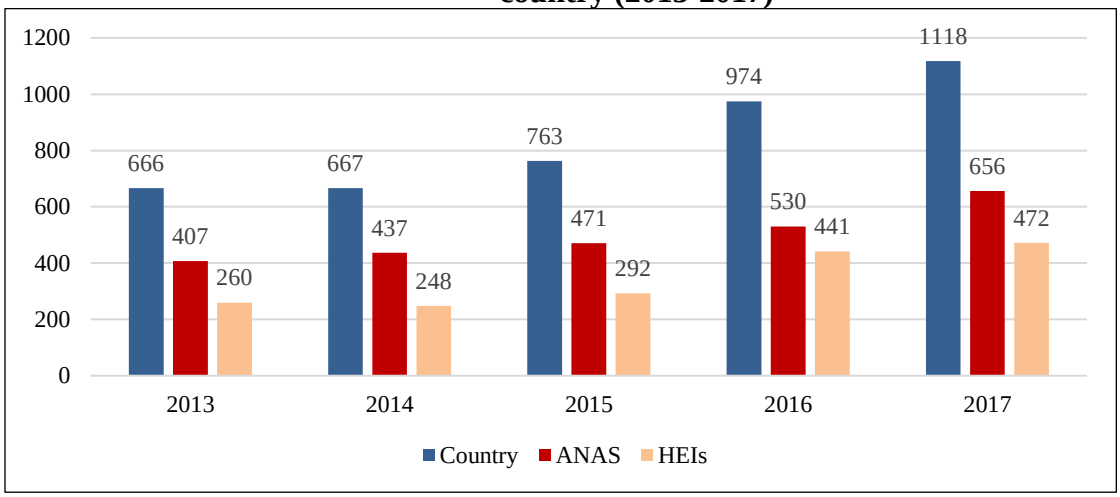
Figure 11 Number of publications entered into Web of Science™ databases (2008-2017)



Source: Clarivate Analytics, 2018.

The share of publications developed within HEIs is increasing in Azerbaijan. This is largely due to increased activities of universities in the research sphere, signaling a potential for growth in research outputs that can be supported and further developed. In 2017, 42% of the publication volume in Azerbaijan was produced by HEIs, up from 39% in 2013 (Figure 12).

Figure 12 Number of publications from HEIs and ANAS compared to Azerbaijan as a country (2013-2017)



Source: Clarivate Analytics, 2018.

2.5 The Way Forward—Recommendations to Accelerate the R&D Effectiveness of Azerbaijan's HEIs

This analysis presented above provides three key takeaways regarding the public expenditure on R&D and its effectiveness in Azerbaijan:

- Public investments in higher education and R&D need to be aligned with targeted reforms to increase the efficiency and quality of these investments and HEI performance.
- The National Qualifications Framework, quality assurance norms, doctoral-level studies and the research career system are not currently aligned with international best practice; and
- Connectivity with international research networks is underdeveloped.

Several policy recommendations have been identified to address the existing challenges and promote the development of scientific excellence in Azerbaijan. These include:

Recommendation 1:

In the short-term, expand the use of competitive funding to increase the quality and relevance of R&D. In particular, competitive funding can be effective in promoting research in targeted fields with high relevance for the development and diversification of the national economy. Lessons can be learned from the competitive funding mechanisms utilized in Kazakhstan, Montenegro, Uzbekistan, and other countries.

Recommendation 2:

In the medium-term, increase overall public investment in R&D, with more funding directed toward HEIs and promotion of applied research. By shifting the balance away from mainly financing fundamental to applied research, the public R&D budget can more effectively promote research that is of greater relevance to industry. Encouraging and incentivizing research partnerships that bring together HEIs, public research institutes, and private enterprises can be beneficial—while ensuring that a greater share of the R&D funding is directed at HEIs.

Recommendation 3:

Promote research internationalization. It is crucial pivotal for Azerbaijan to develop stronger links with international research and innovation networks to access new knowledge, technologies and know-how generated and developed outside national borders. The country should aim for:

- Greater participation in international exchanges of HEI students and faculty;
- More effective participation in Horizon 2020 calls for project proposals. This can be accomplished by provision of training on the preparation of good project proposals for international programs; promotion of English language in project applications; and enhancing capacity of the Horizon 2020 National Contact Points;
- Development of an internationalization strategy for higher education and R&D.

Recommendation 4:

Review the academic career system and adopt incentive and reward mechanisms in line with international best practices. Promote national policies for gender balance among academic staff. To generate good research competencies among academic staff, it is essential to endorse doctoral training and academic career management that is focused on high-quality research and innovation. One key step is to have a better-functioning tenure-track career system, which is characterized by three key elements:

- an entry position for which talented individuals can apply in order to access a career as a researcher and/or teacher;
- well-developed career pathways; and
- incentives and disincentives to enhance and ensure quality performance.

Recommendation 5:

Adopt sound evaluation practices and quality assurance mechanisms that promote high-quality research in higher education. This includes building a system of quality assurance that aligns with international standards of quality, transparency, and openness. It also requires seeking national and international accreditation norms that provide cross-border assurance to HEIs and employers alike that the outputs of higher education in Azerbaijan are up to the standards and quality of global neighbors. Moreover, a research evaluation system should be developed to facilitate and incentivize continuous improvements in high-quality research performance.

3. UNIVERSITIES' THIRD MISSION AND LINKAGES WITH INDUSTRY

3.1 Global trends in universities' "Third Mission"

HEIs are typically the backbone of a country's innovation ecosystem. They are the hubs of research, education and innovation, providing access to infrastructure and talent for innovators, as well as to local, national, and global networks of knowledge generators.

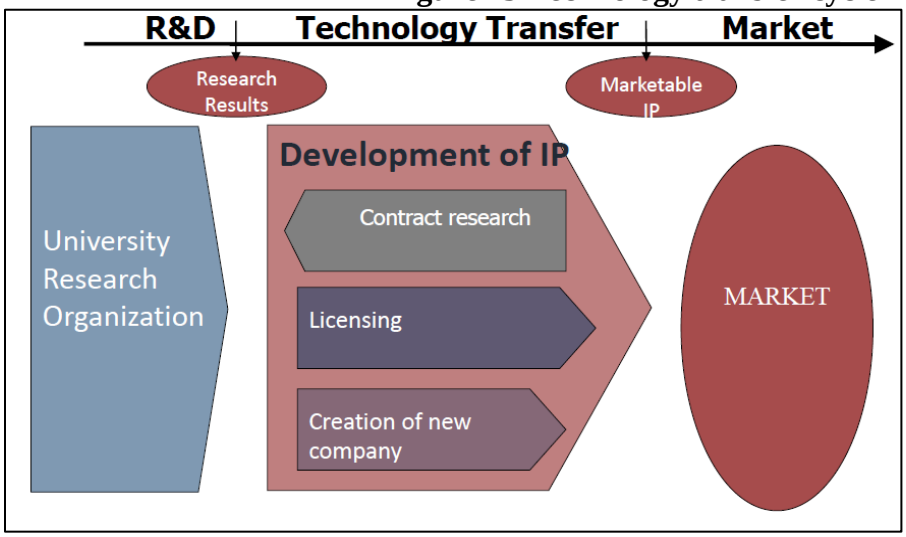
HEIs' "Third Mission"—in addition to teaching and research—is to build relationships with industry and civil society. Higher education and research are vital for the development of competitive innovation capabilities, yet investing only in the R&D sector is not sufficient to guarantee innovation or economic returns. A well-functioning knowledge-exchange model is based on interactive and long-term relationships between universities/research institutes and industry to determine which ideas and inventions have the opportunity to turn into innovations and generate economic returns. This industry-university learning environment supports the skills and human capital development required to adopt and apply process and product innovation and works with Small and Medium Enterprises (SMEs) as well as large corporations. It measures success in terms of the sustainability and transformation of industries and employment growth.

Innovative economies implement a variety of instruments to promote HEIs' "third mission." The aim is fostering knowledge exchanges by stimulating academic and student entrepreneurship and enhancing cooperation between universities and industry, as well as with the public sector and civil society.

3.2 Institution-based technology transfer and commercialization of research

The process of commercialization of a new product comprises a series of steps. These include idea generation, product definition, concept screening and Intellectual Property (IP) evaluation, preliminary marketing and market analysis, prototype development and testing, and actual commercialization through licensing, product development, or spin-off creation (Figure 13).

Figure 13 Technology transfer cycle



Source: World Bank own elaboration.

Transformation of national R&D capabilities into engines of innovation and growth requires an appropriate framework and research capacity as well as tools and institutions such as technology transfer offices (TTOs). A TTO (or technology transfer facility) is a critical body that connects the inventors, disseminators, and consumers of innovation, and effectively helps to commercialize the results of research. As such TTOs are accountable for:

(i) providing essential commercialization services to inventors (assisting researchers to navigate the complexities of patenting, licensing[4], and royalty negotiations);
(ii) serving as an information center on experiences with IP protection, management, and monetization, including the creation of spin-offs, through detailed record-keeping, trend monitoring, and analysis;
(iii) fostering the disclosure of new knowledge by maintaining a framework of uniform and consistent IP rights, disclosed protected technical information, and royalty sharing practices; and
(iv) educating faculty and students about intellectual property, market research, commercialization and promoting the culture of entrepreneurship through commercialization.

TTOs are not only responsible for the legal procedures related to patenting and licensing, but they also help to define the host institution's commercialization strategy. These strategies can include not only the choice of which fields of science and technology the institution should emphasize, but also the mode of commercialization that the research institution will focus on (such as licensing, start-ups, sponsored research, or consulting, for example). With this increased sophistication of commercialization activities, a major issue for many research institutions is attracting and maintaining TTO personnel with the appropriate skills (extending beyond legal experience in protecting IP) who can help to identify the right opportunities and to implement the institution's commercialization strategy.

TTOs are essential players in building relationships between researchers and the business community as they guide academic research to areas of greatest social and industrial need. TTOs bring global knowledge to academic researchers and local users who may be unaware of certain technologies due to limited information, helping them to identify promising research and commercialization opportunities. To be efficient, some countries set up collective TTOs (shared among several universities or research institutes). This type of approach has been promoted in the US, Chile, Germany, Poland, among others (see Box 5).

Box 5 Examples of Collective Technology Transfer Offices (TTOs)

a) The Center for Commercialization of Advanced Technology in the USA is a consortium of the University of California-San Diego, San Diego State University, the U.S. Navy, and the Office of Technology Transfer and Commercialization (OTTC) associated with California State University, San Bernardino, United States.

b) The Patent and Valorization Agency, Mecklenburg-Vorpommern AG in Germany is responsible for the screening, patenting, and commercialization of research results

[4] Licensing enables the IPR holder (such as a university or a research institute) to maintain ownership, and therefore control, of its IP while at the same time generating royalty income from the use of its IP by industry.

stemming from the regional universities and research institutes in Germany's federal region of Mecklenburg-Vorpommern. The agency works with 3,500 consulting researchers and the nine technology partners. Additionally, the agency is responsible for making the research staff of the technology partners more open to commercialization activities, as well as increasing the number of inventions with market potential and assisting them in matching research projects with demand and industrial trends. The commercialization strategy comprises a broad spectrum of alternative options, ranging from cooperation with the industry in terms of R&D to patenting and licensing, and the creation of start-ups and spin-offs.

c) OTRI CHILE S.A. is a consortium of five universities: Pontificia Universidad Católica de Chile, Universidad de Concepción, Pontificia Universidad Católica de Valparaíso, Universidad Católica del Norte and Universidad Técnica Federico Santa María, as well as Confederación de la Producción y el Comercio and the product exporters association ASEXMA CHILE A.G., which represent the business sector. OTRI CHILE protects and transfers results being obtained through applied scientific research that follows national and international business requirements. It accepts potentially protectable inventions from entities of any kind in order to evaluate and manage their patenting processes and, subsequently, to carry out the inventions' technology transfer to the national or international markets, normally through patent licensing.

d) Podkarpackie Center for Innovation is a sub-regional TTO in Poland. It has been implemented since 2017 with the support of the World Bank. The Center will help link businesses and university researchers, develop key skills of university researchers and administrative staff necessary for R&D collaboration, support R&D projects by providing resources (money, skills, knowledge), and stimulate students' entrepreneurship.

Sources: World Bank 2013, 2017.

Technology transfer offices are central, often (but not always) institutionally-based, drivers for research commercialization; however, in the majority of cases they do not generate positive net returns from patenting or licensing[5]. Commercialization brings notable levels of income to just a few universities in the world (see Box 6). Therefore, TTOs in developed economies expand activities into a wide range of IP management and supporting activities (such as patent scouting and consulting), marketing non-patent services, administering proof-of-concept and seed funds for entrepreneurship, and promoting an innovation culture.

Box 6 Few Universities Worldwide Successfully Commercialize Their IP

Only a few universities are successful at commercializing inventions that they have patented. In Europe, 10% of universities account for 85% of the total income generated by inventions. Most royalties from licensing agreements also accrue from a small number of blockbuster inventions. For example, Stanford's Office of Technology Licensing has received more than 8000 invention disclosures, but less than 1% of the Stanford disclosures have generated USD

[5] OECD (2013) Commercializing Public Research: New Trends and Strategies. OECD Publishing. Paris.

1 million or more in cumulative royalties.

The number of academic spin-offs has not significantly increased either, despite continued policy support. In the United States, MIT generates 22 spin-offs per year, while data from the US Association of University Technology Managers for FY2011 show that the average number of spin-offs per university per year among 157 colleges and research universities is 4 with a maximum of 58 at the University of California[6]. Europe outperforms the US, Canadian and Australian universities in this measure. European universities generate 2.4 spin-offs per USD 100 million of research expenditure, compared with 1.1 spin-offs for the US and Canada and 0.7 for Australia.

Source: OECD, 2013.

The effectiveness of technology transfer depends on an efficient Intellectual Property Rights (IPR) system[7]. An IPR policy which has clear rules on IP ownership and an effective dispute resolution system encourages inventors to patent their inventions. Streamlined IPR application processes facilitate its use by inventors, researchers, entrepreneurs, and SMEs. Effects are presented in a number of patents, trademarks, copyright, and designs.

Effective technology transfer requires an incentives system to motivate researchers to become interested in applied research and IP protection. Countries can develop mechanisms defining the distribution of revenues from commercialization in a manner that rewards all players (researchers, departments and faculties). For example, the Danish Law on Inventions at Public Research Institutions states that any net income from commercialization is divided between researcher(s) (1/3), the department (1/3) and the university (1/3). In the case of Poland, according to the Law on Science and Higher Education, if commercialization is pursued by the university, then the minimum participation of the researcher (or a research team) in profits from commercialization is to be at least 50% of the proceeds, reduced by no more than 25% of the costs directly attributable to such commercialization. In turn, when the commercialization is pursued by a researcher, then the level of university participation in the profits from commercialization received by the researcher is set at 25% of the proceeds received by the researcher (or research team), reduced by no more than 25% of the directly attributable costs incurred by the researcher.

Applied research and technology transfer can be incentivized through the inclusion of the third mission's activities in researcher performance evaluations and career development. The criteria for recruitment, promotion or performance evaluations of HEI staff should acknowledge industry and community engagement, commercialization of R&D results, and other knowledge exchanges.

HEIs can offer consultancy services, contract research, and professional development services that both create links with industry and become a source of income. Internationally, licensing income is a relatively small source of funding for HEIs compared to other "third-stream" activities, such as contract research and consultancy services. UK universities, which are leading the scene in Europe, make only 2–4% of their external income out of patenting and licensing,

[6] US Association of University Technology Managers (US AUTM), 2012. "Highlights of the AUTM U.S. licensing Activity Survey: FY2011"

[7] A detailed analysis of Azerbaijan's IP legal framework is outside the scope of this study.

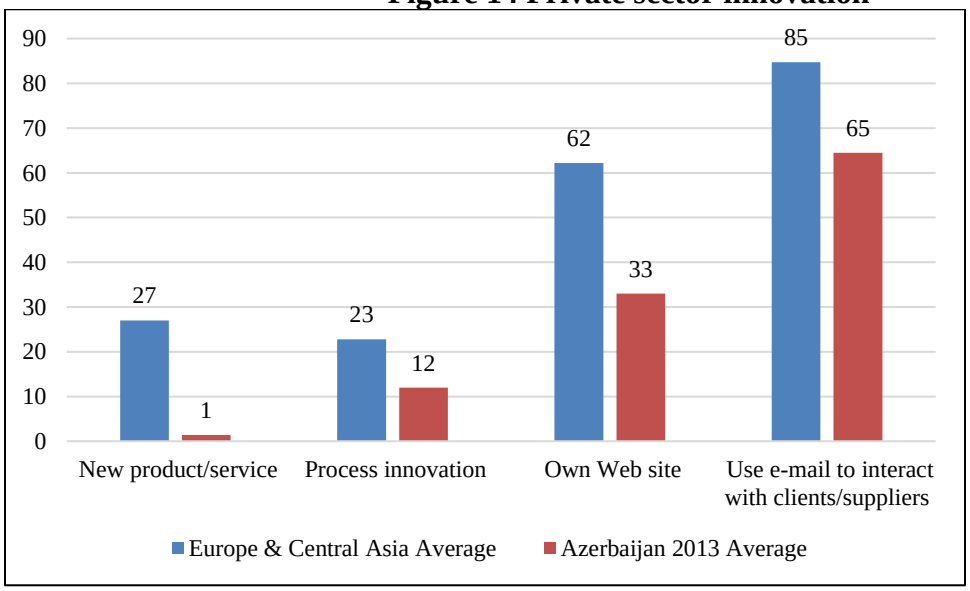
whereas much larger funds come from contract research, collaborative research and professional education (OECD 2013). Data from the UK Higher Education Business and Community Survey indicate that 1% of income of third-mission sources originates from IP licensing, compared with 17% for contract research, 6% for consulting services and more than half of total income for the provision of continuous professional development services.

3.3 The relationship between HEIs and industry in Azerbaijan

Private sector innovation

Azerbaijan's economy is characterized by low levels of private sector innovation. In general, there is no "culture of cooperation" with universities on innovative solutions in the private sector. Only 1% of companies introduce new products or services, according to World Bank enterprise survey data, (Figure 14) and about 33% have their own websites. Such results are evidence of low innovation awareness across the Azerbaijani business community and deficiencies in the relevance of local innovating skills in the business culture.

Figure 14 Private sector innovation



Source: World Bank Enterprise Survey, 2013.

The lack of information on technology is the most important innovation gap among innovation-active firms in Azerbaijan. Two-thirds (66%) of large innovative firms confirm this challenge (UIS data from 2014)[8], followed by other factors as the lack of information on markets (indicated by 22% of surveyed firms) and the cost of innovation (22% of firms).

Commercialization and technology transfer in Azerbaijan

8 UIS Information Paper Nº37 (2017), http://uis.unesco.org/sites/default/files/documents/ip37-summary-report-of-the-2015-uis-innovation-data-collection-2017-en.pdf

Azerbaijan's R&D investment generates minor innovation results as measured by patents. Patents are a frequently-used indicator to assess whether HEIs or countries are successful in transforming public research into innovation. In patent applications, Azerbaijan obtains lower results than its regional peers like Belarus and Georgia (Table 4). In 2016, Azerbaijan had 163 national patent applications, compared to 513 patent applications by Belarus or 274 applications by Georgia. As can be expected, the statistics are much lower with international patenting activity: in 2016, only 4 Patent Cooperation Treaty (PCT) applications were filled by Azerbaijani nationals, compared to 14 and 13 applications by the nationals of Belarus and Georgia, respectively. However, the positive trend is that in 2017, an increase was observed, and 10 PCT applications were submitted by Azerbaijan.

Table 4 National and international patent applications (2016)

Country	National applications (total)	PCT international applications by origin
Azerbaijan	163	4
Belarus	521	14
Georgia	274	13
Bulgaria	241	58
Austria	2315	1422

Source: WIPO.

Several Azerbaijani universities have formed TTOs, which is a positive signal, yet TTOs do not yet effectively fulfill their mandate to support research commercialization. Efforts in the field of technology transfer have been undertaken by selected HEIs—such as UNEC, University of Architecture and Construction, and Azerbaijan Technical University. However, none of the existing TTOs can yet be considered as fully functioning "traditional" TTOs. These university TTOs perform little in the way of actual commercialization of research; they lack sufficient experience to properly manage and commercialize inventions. As of 2018, no university in Azerbaijan has dedicated funding or specialists to carry out expensive IP registration (related primarily to the registration of international patents).

The existing TTOs have limited understanding of the needs of industry or the business aspects of commercialization. These include, for example, the need to establish deep connections with industry, conduct patent analysis, search for licensees, carry out market research, and guide scientists toward commercially relevant research through IP landscape and industry analysis. There is no significant funding for proof-of-concept of early stage innovation. Thus, the much needed support for early stage innovations for which spin-out may be the ideal route of commercialization (as opposed to licensing) is lacking. Besides the lack of clear government and institutional policies, universities and research institutes also do not have access to appropriate funding to finance the technology transfer process internally.

At the institutional level, universities are missing a clearly defined "commercialization process." A finely defined process—from idea creation up to establishment of a spin-off resulting from the IP—is necessary to enable research commercialization. Universities and research institutes in Azerbaijan, which have the potential to produce valuable IP, have not yet developed a predictable framework for invention disclosure, allocation of IP rights, or mechanisms for compensation.

The existing evaluation process of researchers does not encourage the university's "third mission." It is common in Azerbaijan for researchers to be awarded more promotion "points" for publishing in scientific journals; hence their incentives are to publish more frequently (especially with fundamental research) rather than put their efforts into carrying out applied and commercially relevant R&D. Yet, positive developments are occurring in several universities (including UNEC, ADA University, and BSU), which are already implementing diversified salary systems and incentive mechanisms to encourage researchers to get involved in applied, commercially viable research. These efforts are largely done with the universities' own internal funds and depend on the will of a rector. More private sector and government support for applied industry-relevant research is needed to fully realize the opportunities that may exist in the commercialization of ideas being created within Azerbaijani HEIs.

3.4 The Way Forward—Recommendations to Strengthen HEIs' Third Mission and Connection with Industry

This idea of HEIs as agents for engagement with the broadest swath of society is not a new one. For centuries, HEIs have served as cultural and economic hubs for their nations and communities. While this may be a new perspective for Azerbaijani HEIs, there is no question that Azerbaijan can learn from the lessons of other nations on how best to utilize the skills, intelligence, and creativity of the higher education community to meet the needs of its society and economy. Innovation as a specific idea for economic growth may be still somewhat new for Azerbaijan. Decades of a centrally planned economy precluded the need for competition, and recent economic stability based on natural resource exports may have slowed the drive for economic diversification in Azerbaijan.

Among the existing reasons for the continued modest performance of commercialization and IP in Azerbaijan are:

- limited awareness about innovation and commercialization;
- low enforcement of IPR in Azerbaijan;
- insufficient capacities of the existing technology transfer intermediators (such as TTOs);
- costly international IP application processes;
- suboptimal levels of university-business cooperation;
- a lack of incentives for researchers.

However, opportunities exist in introducing reforms that would tackle the existing challenges and ignite the development of an innovation ecosystem in Azerbaijani HEIs. These include:

Recommendation 6:

Review the capacity of existing TTOs and ensure that they assume a broader role in fulfilling the "third mission" of HEIs by developing links with the private sector. Among technology transfer models for consideration could be establishment of a collective technology transfer office for several entities. The TTO would provide direct hands-on support to scientists who are willing to start the commercialization of their know-how, but also oversee building relationships with the business and financial communities; improving awareness of institutional research activity; educating Faculty and Students about intellectual property, market research and commercializing innovative technology, among others.

Recommendation 7:

Encourage universities to develop a "Commercialization Agenda". Such a document should specify how the university intends to support commercialization of scientific results thanks to a set of clear, transparent and understandable rules and procedures. Ideally such a policy should be linked to the Azerbaijani legal framework (such as the forthcoming Law on Innovation).

Recommendation 8:

Introduce incentives for commercialization of innovation for various stakeholders through revenue sharing and career performance systems by:

- Developing clear mechanisms defining distribution of revenues from commercialization in a manner that rewards all players in HEIs (researchers, departments and faculties);
- Revising the academic recruitment/career progression system to reflect a broader range of research outputs. For example, encourage recruiting, hiring and reward systems to include third mission activities. In such a policy, R&D staff are evaluated and rewarded according their ability to share knowledge (training), to generate knowledge (science), and to disseminate knowledge (transferring).

Recommendation 9:

Encourage HEIs to offer faculty consultancies, contract research, and educational/training programs of relevance to the private sector. This can be accomplished by identification of in-house expertise and possible services followed by preparation of an offer in demand by external clients. A contact unit could be appointed or a website created as a single-entry point for dialogue with the private sector within each HEI.

4. ENTREPRENEURSHIP AND INFRASTRUCTURE SUPPORTING INNOVATION

4.1 Global trends in research and innovation infrastructure

Research infrastructure (RI)[9] is an essential component of every R&D system. RIs may take diverse forms, which serve to advance scientific research and enable complex or even interdisciplinary scientific issues to be addressed. Research infrastructures are defined as wide-ranging instruments, resources or service facilities used for the purpose of research in any scientific field, which stand out due to at least national significance in their particular field of science and to a certain longevity (more than ten years, as a rule).

Access to wide-ranging research infrastructures provides a basic framework that enables scientists to continue their training and fosters the transfer of technology and knowledge. By their very nature, decisions relating to research infrastructures are long-term, as they shape the research landscape over the next 10-15 years.

Advanced economies develop national research infrastructure roadmaps to strategize investment in research infrastructure. Roadmaps enable countries to identify existing and future research capabilities; set national priorities; identify opportunities for increasing inter-connectivity; support development of country's long-term investment plan; and set out the major steps needed to reach the long-term vision. In the EU, the development of national roadmaps for research infrastructures is a pre-condition for member states and associated countries to the use of European Structural and Investment Funds.[10]

To promote innovation, access to various types of innovation infrastructure is needed, including proof-of-concept labs, technology parks, business incubators, and others. Their purpose is to support prototyping and piloting of product innovation at the level of university students, faculty, researchers, start-ups, and existing firms.

Business incubation is one type of comprehensive business support programs designed to nurture business ideas and innovation-based start-up companies for certain time duration. Incubator programs help first-time entrepreneurs and start-ups with their establishment and accelerate their development; support companies to either graduate out after the specified acceleration/incubation period or drop them from the program should they fail to meet the established goals and benchmarks. Incubators bring a number of benefits, especially in locations with underutilized entrepreneurial potential. They create a supportive environment for business development experiments, focusing on educating, mentoring and networking to ensure that non-feasible business ideas fail early in the process, effectively reducing up-front entrepreneurial

[9] Research infrastructure is defined by The Directorate-General for Research European Commission as: "facilities, resources and related services that are used by the scientific community to conduct top-level research in their respective fields and covers major scientific equipment or sets of instruments; knowledge-based resources such as collections, archives or structures for scientific information; enabling Information and Communications Technology-based infrastructures such as Grid, computing, software and communication, or any other entity of a unique nature essential to achieve excellence in research. Such infrastructures may be 'single-sited' or 'distributed' (an organized network of resources)."

[10] Examples of EU member states' Research Roadmaps are available at: https://ec.europa.eu/research/infrastructures/?pg=esfri-national-roadmaps

costs, and in the process refining good business concepts to increase their chances of succeeding in the marketplace.

4.2 Status of research and innovation infrastructure in Azerbaijan

Uneven availability of modern research equipment is observed across Azerbaijan's HEIs. Although about 5% of the public budget for R&D is spent on equipment, this level is typically insufficient for the development and maintenance of complex research equipment. Although a number of investments in modern research equipment have been pursued in recent years, a considerable number of universities still require additional investment and replacement of outdated research infrastructure.

A crucial challenge is the lack of widely accessible information on the existing research infrastructure in Azerbaijan. ANAS, as the main player in R&D, has 360 scientific laboratories. Moreover, recent investments in new R&D solutions have been made at some universities, technoparks, and other locations (including BEU, ASOIU, UNEC). Yet, not all research system stakeholders are fully aware of the existing capacities. As a result, a number of scientists and enterprises claim a lack of access to modern R&D equipment. At the same time, modern research infrastructure is often underutilized due to restrictive HEI internal procedures that limit the access to the infrastructure by outside users.

Three technoparks operate in Azerbaijan, yet there is space for improvement in terms of the efficiency of their utilization. The three technoparks with an official status that receive a tax exemption[11] for a 7-year period of operations are: (1) the Chemical Industrial Park under the Ministry of Economy (established in 2011); (2) the High Tech Park under the Ministry of Communication and High Technologies; and (3) the ANAS High Tech Park[12] (established in 2016, in operation since 2017).

A number of initiatives promoting entrepreneurship have developed in Azerbaijan in recent years. About 18 incubation centers currently operate in Azerbaijan. These include Barama Innovation and Entrepreneurship Center, UNEC Business Center, Eazi Start-Up School, Business Incubation Center at ANAS, and others. Box 7 presents details on selected business incubators operating in Azerbaijan.

HEIs support the activities of several business incubators and enable them to access the HEIs' research infrastructure. Many incubators are located at HEIs, which is in line with international best practice. Incubators require access to innovative ideas to be effective and universities are the natural environment in that respect. HEIs support incubators through access to their laboratories, small investment into equipment, provision of space for the incubation process, and so forth.

[11] Tax exemption relates to corporate income tax, property tax, land tax, and value-added tax of imported equipment.
[12] The ANAS HTP currently has 11 resident firms. The HTP has a management team of 10 and a total staff of 55 employees.

Box 7 Examples of Business Incubators in Azerbaijan

Barama Innovation and Entrepreneurship Center

- The first incubation center in Azerbaijan, established in 2009
- Objective is to grow the country's digital ecosystem
- Funded by Azercell Telecom LLC and Pasha Bank
- Supports 16 start-ups every 6 months
- Focuses on start-ups that can potentially partner with Azercell
- Incubated over 200 start-ups, out of which about 20 have been successful
- Over 2000 start-up applications received
- 5 branch offices including Baku State University, Barama Media Center, Technical University in Ganja-Gazakh region, University in Lankaran region, AS school (foreign)
- Examples of services provided: training sessions (on entrepreneurship, marketing strategy, IT coding, media, and so forth), workshops, seminars, online courses, monthly demo days, breakfast with mentors, legal advice, networking events, access to selected prototype facilities, business venue, all free of charge for the participants.

Eazi Start-Up School at Azerbaijan State Oil and Industry University

- Created in 2015, in operation since 2016
- Staff receive salaries from the university as its employees
- 14 teams are presently in the incubation program, including 3 companies
- Open only to ASOIU students (in July 2018, the Eazi Start-Up School plans to obtain new space of around 600 square meters with workshops and up-to-date technology; will then open the incubation program to other universities)
- Examples of services provided: access to space, university labs, university staff and PR support, legislative work and accounting, assistance in grant applications, networking (contacts with the industry leaders), mentoring (mentors from Israel and Ukraine are invited every 2 months for trainings)

Business Incubation Center at ANAS High Tech Park

- 13 start-ups are presently in incubation process
- The start-ups have been selected from four different state start-up competitions
- Space of about 110 square meters
- Reaches out to HEIs and offers assistance in technology and knowledge transfer through Business-to-Government models by making start-up support available
- Co-organizes start-up competitions (New Idea, Climate Launchpad, and others) and boot camps and workshops for HEIs to ignite, develop and support innovation and entrepreneurship spirit on campuses
- Examples of services provided: boot-camps, trainings, access to mentors, co-organization of international events, space for various events, scientific mentorship from ANAS and access to 360 ANAS Labs

Sources: Public information and interviews with the management of Barama Innovation and Entrepreneurship Center, Eazi Start-Up School at Azerbaijan State University of Oil and Industry, and Business Incubation Center at ANAS High Tech Park.

Azerbaijani business incubators confirm that there exist plenty of ideas among young people and opportunities on the market for innovative start-ups. Incubators experience high levels of interest in idea competitions, indicating promising opportunities for the role of HEIs is promoting the concept.

Despite significant potential, start-up activities are often constrained by a number of legislative and regulatory factors. These include: (1) high taxes on start-up activity due to lack of clear definition of a "start-up" in the law; (2) limited access to funding for start-up activity that is reflected in the absence of innovation investment legislation (including venture capital), lack of angel networks or seed funding opportunities, and aversion of domestic investors to risky and innovative ideas.

HEIs have a chance to enhance entrepreneurship though equipping the students with entrepreneurial skills. Among students there is a need to (1) enhance soft skills (team work, management and presentation skills, and others); (2) improve knowledge of English in order to understand external research, technological trends, and ease international cooperation on joint projects; and (3) update IT skills taught at universities to meet global standards.

The role and results of the existing business incubators could be further strengthened by the application of international best practices in several areas. Best practice indicates that the governance model and the quality of management are one of the most critical success factors. In order for an incubator to succeed it needs professional management with strong private sector expertise, entrepreneurial experience, technical capacity, innovative character, a wide network of contacts, and the ability to effectively market the incubator to potential clients, sponsors, and stakeholders.

4.3 The Way Forward—Recommendations to Support Entrepreneurship Education and Innovation Infrastructure

Uneven distribution of modern research equipment exists in Azerbaijan yet a challenge is lack of commonly accessible information on the existing research infrastructure. A number of business incubators has been developed in recent years and are playing a crucial role in entrepreneurship promotion in Azerbaijan. Incubators have potential to play an important role in initiating cultural change at HEIs towards innovation. To support the development and effective utilization of innovation infrastructure and grow the base of entrepreneurial skills in Azerbaijan's HEIs, the following recommendations can be considered:

Recommendation 10:

Develop a research equipment registry and promote shared access by different stakeholders. To make HEIs and other innovation system stakeholders aware of all existing research and innovation equipment in the country, an electronic registry (or an app à la *Uber* or *Airbnb* for scientific equipment) can be developed. Adopting regulations at HEIs to make accessing the existing infrastructure easier for all innovation system stakeholders (including firms and other external clients) would increase the efficiency of equipment utilization and can generate revenues for HEIs.

Recommendation 11:

Consider developing a national Research Infrastructure Roadmap. The Roadmap—similar to the EU members states' roadmaps—can set out proposals on establishing priorities for investment in new research infrastructure and using existing infrastructure more efficiently with a focus on priority areas of the Azerbaijani economy.

Recommendation 12:

Promote business incubators and Fab Labs within HEIs and strengthen the existing ones by application of international best practices. Consider establishment of business incubators with pre-seed financing. Such incubators could become dynamic tools for fostering new ventures across a variety sectors by linking talent, technology, capital, and know-how in a single facility. Fab Labs are proof-of-concept labs that provide catalytic stimulus for knowledge sharing, entrepreneurship, and research. Creation of five Fab Labs has been already recognized by MOE in the concept of the Azerbaijani Innovation Ecosystem.

REFERENCES

Azerbaijan National Academy of Sciences (ANAS): http://www.science.gov.az/

ANAS High Technology Park: http://www.ameaytp.az/

Clarivate Analytics: http://clarivate.com/

European Commission (2018). "ESFRI National Roadmap." Retrieved from: https://ec.europa.eu/research/infrastructures/?pg=esfri-national-roadmaps

Eurydice (2017). "Modernization of Higher Education. Academic Staff 2017." Retrieved from: https://eacea.ec.europa.eu/national-policies/eurydice/content/modernisation-higher-education-europe-academic-staff-%E2%80%93-2017_en

Higher Education and Research for Innovation and Competitiveness Project (HERIC): http://www.heric.me/en/

Jacob, M. (2014). "Public Research Funding Instruments and Modalities Program on Innovation, Higher Education and Research for Development." Research Policy Institute. Lund University Sweden. Retrieved from: https://innovationpolicyplatform.org/advanced-search?publisher=&query=%E2%80%9CPublic+Research+Funding+Instruments+and+Modalities+Program+on+Innovation%2C+Higher+Education+and+Research+for+Development%E2%80%9D.+&sort_by=search_api_relevance&sort_order=DESC

Ministry of Education of the Republic of Azerbaijan: http://edu.gov.az/

OECD Data: https://data.oecd.org/

OECD (2013). "Commercializing Public Research: New Trends and Strategies." OECD Publishing. Paris. Retrieved from: http://www.oecd.org/fr/sti/sci-tech/commercialising-public-research.htm

Science Development Foundation under the President of the Republic of Azerbaijan (SDF) (2018). "Scientific Potential of Azerbaijan: Indicators for 2016/2017." Retrieved from: http://sdf.gov.az/en/generic/menu/Detail/175/menu//

Scimago Journal & Country Rank (2018). "Country rankings." Retrieved from: https://www.scimagojr.com/countryrank.php

State Statistical Committee of the Republic of Azerbaijan (SSC) (2017). "Education, Science and Culture in Azerbaijan." Statistical Yearbook of 2017. Baku. Retrieved from: https://www.stat.gov.az/source/education/?lang=en

UNESCO Institute for Statistics (UIS): http://uis.unesco.org/

US Association of University Technology Managers (US AUTM), 2012. "Highlights of the AUTM U.S. licensing Activity Survey: FY2011."

World Bank (2013). "Public Policies to Foster Knowledge Transfer from Public Research Organizations."

_____ (2017). “Designing Regional Technology Transfer Office: Podkarpackie Center for Innovation.”

_____ (2018). “Government expenditure on education, total (% of GDP)” Retrieved from: https://data.worldbank.org/indicator/SE.XPD.TOTL.GD.ZS?view=chart

_____ (n.d). “Kazakhstan: Technology Commercialization Project.” Retrieved from: http://projects.worldbank.org/P090695/technology-commercialization-project?lang=en

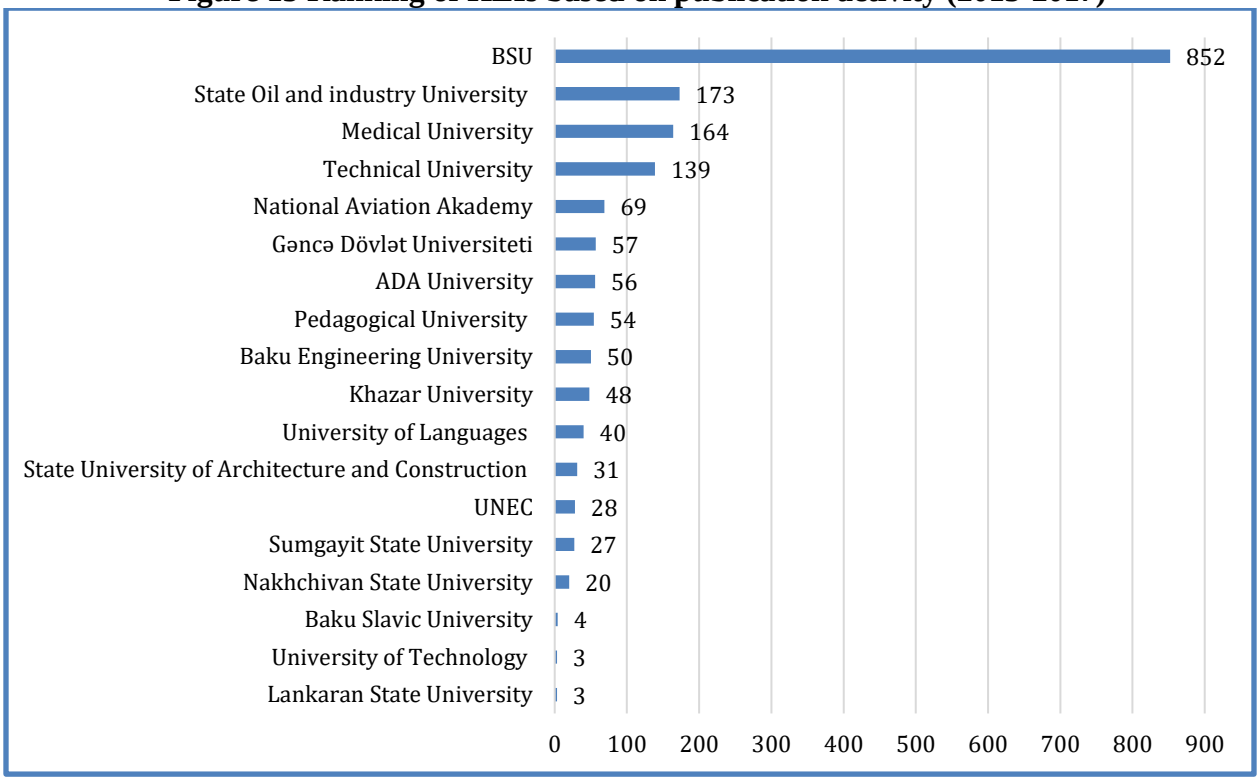
_____ (n.d). “Uzbekistan: Modernizing Higher Education Project.” Retrieved from: http://projects.worldbank.org/P128516?lang=en

World Intellectual Property Organization (WIPO) (2016). “World intellectual property indicators: 2016.” Switzerland. Retrieved from: http://www.wipo.int/edocs/pubdocs/en/wipo_pub_941_2016.pdf

ANNEXES

Annex 1. Ranking of HEIs Based on Publication Activity (2013-2017)

Figure 15 Ranking of HEIs based on publication activity (2013-2017)



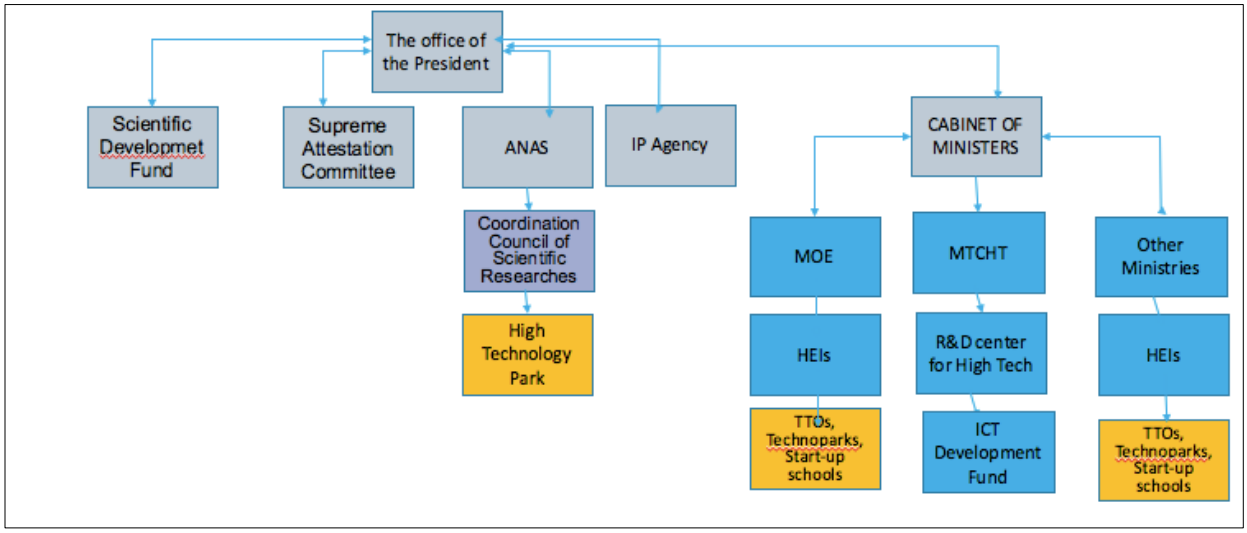
Source: Clarivate Analytics, 2018.

Annex 2. Azerbaijani R&D System Governance and Legal Framework

1. Key actors of the R&D system in Azerbaijan

The R&D and innovation system in Azerbaijan comprises numerous stakeholders within the public and private sectors. These include universities, research institutes, the ANAS, different ministries, R&D centers under industry, private entrepreneurs, and others. All of them are spending on R&D and interacting as parts of a value chain that should move ideas from the laboratory to the market.

NATIONAL R&D AND INNOVATION SYSTEM OF AZERBAIJAN



Source: World Bank own elaboration.

Important state players responsible for the R&D sector in Azerbaijan are the following: The office of the President and institutions under its direct jurisdiction, such as ANAS, Sumgait Technologies Park, Supreme Attestation Committee, and Scientific Development Fund.

1) Sumgait Technologies Park (STP) first Technological Park in the region and Industrial Center with a complex production plans - launched by the President of Azerbaijan Ilham Aliyev on 22nd of December 2009, covering 250 ha and employing more than 4500 people in the production and construction-installation.
2) Established by the President with the charter signed in October 21, 2009, Scientific Development Fund stimulates and support scientific activities in the country and allocates competitive funding to research institutes as well as HEIs.
3) Supreme Attestation Committee is responsible for implementation of state policies on the training of labor force and their accreditation. It organizes dissertation defense and expert committees, assigns specialization and topic indexes for doctoral research works, nostrifies PhD levels obtained from the universities abroad, and most importantly, grants doctoral degrees regardless of the types of HEIs.
4) ANAS connects and directs scientific research activities of all research institutes and HEIs in the country, and is the major implementer of the science policy in the country. According to it

statue, ANAS carries a responsibility of supporting development of innovation potential and activities in the country by creating fertile environment for innovative entrepreneurship, transfer and adoption of high technologies, and organizing establishment of innovation supporting institutions, such as innovation zones, incubation services and TTOs.

- Coordination Council of Scientific Researches of the Republic of Azerbaijan, established in 2009 carries out accreditation of scientific institutions. Its key responsibility is to coordinate scientific researches, remove duplication, engage different scientific structures in joint scientific researches, supervise implementation of fundamental and applied researches, scientific-technical programs across different fields, and to improve their productivity and efficiency

5) After recent merge of Patent and Trade Marks Center with the IP Agency, Copy Right Agency was established. It is "central executive power" that carries out the state policy in the field of copyrights, related rights, Azerbaijani folklore expressions (traditional cultural expressions), topographies of integrated circuits and data collections (hereinafter called as intellectual property rights) and providing the normative-legal regulation and development of intellectual property".

Cabinet of Ministers is the major implementer of all state reforms and decrees including in innovation and science. CM determines task implementing bodies of the government, assigns actions plans and budgets.

- Ministry of Finance is responsible for funding of academic, researcher's salaries, etc.
- Ministry of Economic Development – takes part in the formation of national innovation and science policies.
- Ministry of Education is responsible for higher education policy.
- Ministry of Transport, Communications and High Technologies (MTCHT) develops and implements scientific-technical and innovation policies for high technologies.
    - State ICT Development Fund under MTCHT functions on the funding from budge of the State Oil Fund of Azerbaijan and support project through loans and grants to companies, such as high-tech start-ups, and small innovative businesses.
    - Research and Development Center for High Technologies was established under the which aims to "bring advanced technologies to Azerbaijan and develop knowledge-based industries in the country".
- Other ministries:
    - 18 HEIs are under other ministries (for example, Azerbaijan Medical University is under the Ministry of Health)

*NOTE: Rectors of the public universities are assigned by the president of the country not depending with what ministry they are affiliated with.

"State Program on Realization of "National Strategy For Development of Information Society In The Azerbaijan Republic For 2016-2020" signed by the President in 2016, states establishment of scientific research registry on High-technology as a joint project of ANAS, MTCHT, and SDF. Yet currently, there is no unified database that encompasses the R&D capacity of research institutes as well as HEIs. Building database of current equipment's can boost resource sharing within research community can lead to efficient use existing facilities. Due to present absence of

central database of equipment at HEIs and their auditing procedures. Establishment of such a database can eliminate and avoid duplication of investment and research activities, lead to efficient use of current infrastructure and resources, ignite more public-private sector collaborations and to promote cross- disciplinary working between different groups.

As Coordination Council of Scientific Researches carries out attestation of researcher, accreditation of research institutes, possessing rich knowledge of the facilities under ANAS, merging data with CCSR could lead to comprehensive resource to be used by all the stakeholders. EU model of Open Science and Open Access can be implemented for excellence of science, elimination of plagiarism and duplication.

2. Ongoing activities toward introducing reforms in innovation ecosystem

There have been several reforms by the government in place to support development of science as well as innovation. In 2008, the President signed the decree on "National Strategy on the Development of Science for the years of 2009-2015" which envisioned a state program that would implement this strategy. The strategy set goals of aligning science in the country with the global priority research areas and directing it towards bringing social and economic solutions and developing knowledge based economy; modernization of scientific management as well as scientific infrastructure; achieving integration of science, education and production; and training of highly qualified scientific work power. The strategy also highlighted importance of developing and maintaining analysis, evaluation and monitoring mechanisms for measuring scientific efficiency and potential; and determining focus and priorities of scientific-technological and innovation policy of the country.

New legislative documents are opening to possibilities for MOE as well as HEIs. Adopted in 2016, Law on Science, governs science in Azerbaijan. The Law states government's responsibilities and principles in regulation of scientific work, development of innovation policies, creation of conditions to support scientific employees, highlighting major issue of integration of science, education and economy. The new law encourages entrepreneurship and innovation activities of scientists to contribute towards competitive scientific-technological development in the country.

The Law also defines a Research University as "a higher education institution or scientific-educational center that performs scientific and educational activity equally effectively based on real integration of scientific activity and teaching process, carries out advanced scientific researches, ensures quality learning environment, and has high-quality scientific and scientific-pedagogical personnel" (Article 1.0.36). This provides an opportunity for MOE to work with universities to guide and assist them in becoming research intensive institutions and grant them the status of Research Universities.

Moreover, the Law lists "experimental-constructor, design-constructor, experimental-manufacturing, and design- technological institutes under HEIs as well as other research institutes that carry an objective of ensuring application of scientific outcomes, by providing prototyping, business planning, and investment projects.

Concept of the Innovation System

Recent purposeful activities carried out in Azerbaijan were oriented towards the development of the non-oil sector and have created ample opportunities for diversification of the economy and formation of new production and service areas. New goals and priorities were defined by the Presidential Order dated February 6, 2016 in line with the "Strategic Road Map on National Economy and Key Sectors of the Economy of Azerbaijan" to assure sustainability of economic policy and reforms to develop a competitive economy.

The roadmap approved within the order highlights the importance of building an innovation ecosystem, which would support the development of new technologies and thus contribute to the economic sustainability and competitiveness, as well as inclusivity and social prosperity, of the nation.

Taking into account the above mentioned, the Ministry of Education has initiated a collaboration with the world's leading universities, such as UC Berkeley and Stanford University as well as with Global Innovation Catalyst LLC and Global Venture Alliance to cultivate the major drivers of an innovation ecosystem – human resources. The main purpose of the partnership is to provide capacity building of human resources for the innovation ecosystem that would support advancement and commercialization of high-tech. As the first phase of the partnership, the representatives of the Ministry of Education took part in a "High-Tech Entrepreneurship and Investment" workshop held on July 5-15, 2016 at UC Berkeley. The participants were introduced to modern concepts of high-tech entrepreneurship, learned business management practices, and met with Silicon Valley founders and investors.

As the next step of the project, the "Building an Innovation Ecosystem" seminar was organized by the Ministry of Education, Ministry of Economy, Ministry of Transport, Communications and Higher Technologies, Azerbaijan National Academy of Sciences, and Baku Engineering University on October 19-21, 2017 in Baku. The main goal of the event was to support the decision-makers in relevant state bodies in the development of roadmaps for building an innovation ecosystem. More than 150 participants from several ministries, committees, and other state agencies, as well as universities and the private sector attended the three-day seminar organized by Global Innovation Catalyst LLC and experts from UC Berkeley and Stanford University.

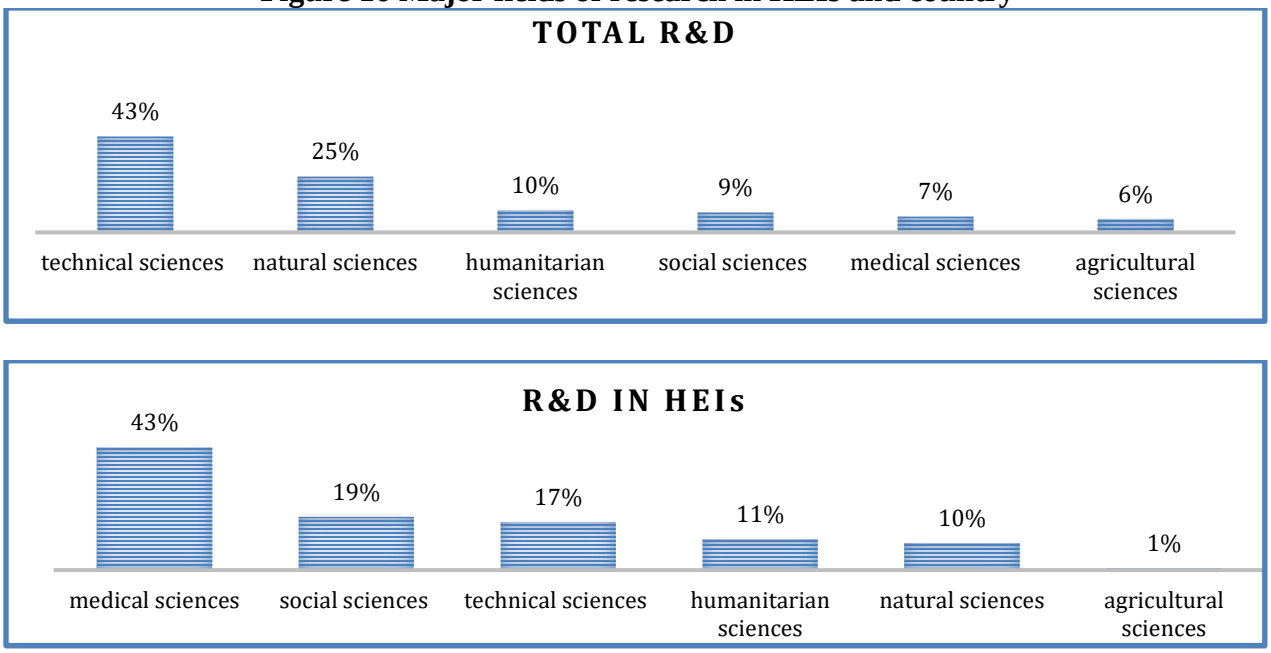
Annex 3. Legislation of the Republic of Azerbaijan in the field of Research and Innovation

- The Constitution of the Republic of Azerbaijan (1995);
- "Law on Education" of the Republic of Azerbaijan (2009);
- "Law on Science" of the Republic of Azerbaijan (2016);
- "Law on Patent" of the Republic of Azerbaijan (1997);
- "Law on Grant" of the Republic of Azerbaijan (1998);
- "Law on Copyright and Related Rights" of the Republic of Azerbaijan (1996);
- "Law on Legal Protection of Data Compilations" of the Republic of Azerbaijan (2004);
- "Law on Standardization" of the Republic of Azerbaijan (1996);
- "National Strategy for the Development of Education in the Republic of Azerbaijan" (approved by Presidential Order dated 24 October 2013);
- "Charter of the Science Development Foundation under the President of the Republic of Azerbaijan" (approved by Presidential Decree dated 19 February 2010);
- Presidential Decree "On Establishment of High Tech Park" (2012);
- "Rules for Competition on Grant Financing of Scientific Activities" (Resolution of the Cabinet of Ministers of the Republic of Azerbaijan dated 11 October 2017);
- Other legal acts, and international agreements ratified by the Republic of Azerbaijan.

Annex 4. Key Scientific Fields of Azerbaijan

The main scientific fields funded in Azerbaijan are the technical sciences and natural sciences. These two fields are responsible for about two-thirds (68%) of all R&D output in Azerbaijan. HEIs in turn concentrate their research heavily in the medical sciences, which account for 43% of all research output (Figure 16). Most competitive research grants are awarded in physics and mathematics, biology, medicine & agriculture, chemical sciences, and earth sciences. Research institutes in these fields are represented by historically strong ANAS departments (Figure 17).

Figure 16 Major fields of research in HEIs and country

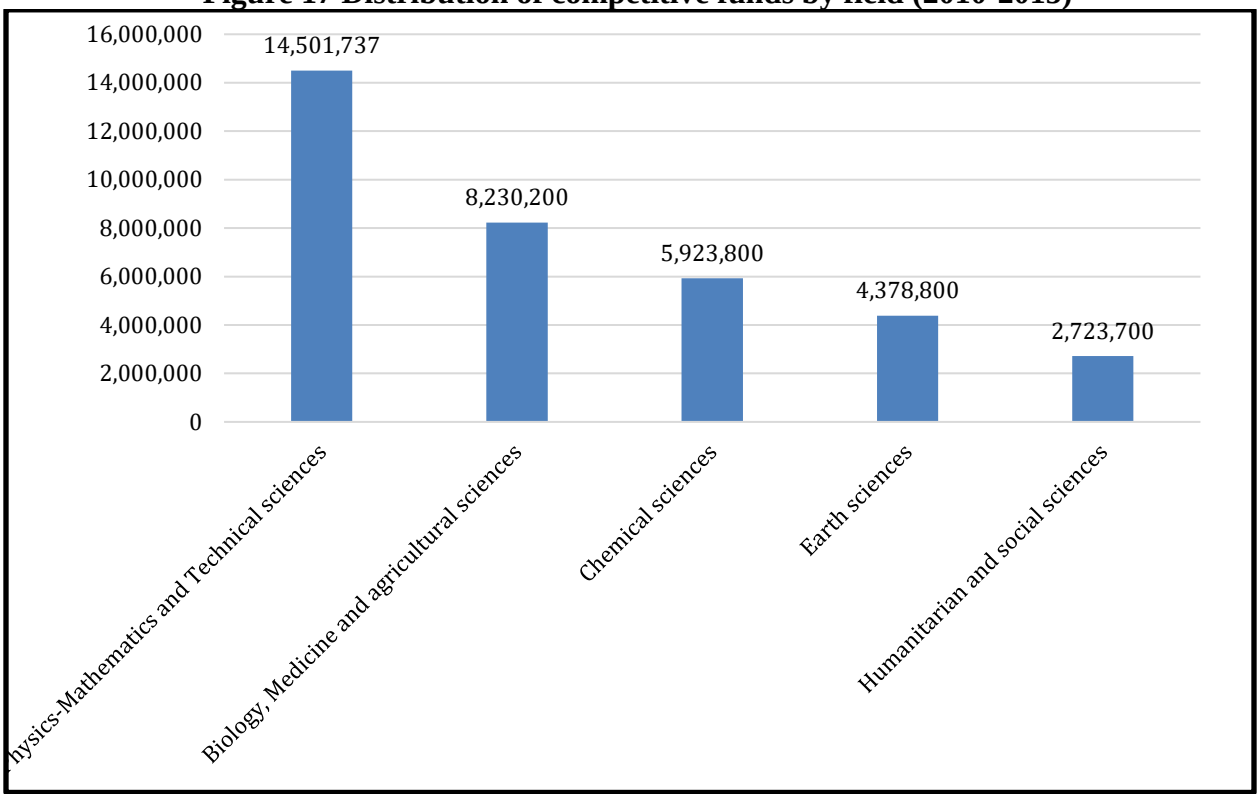


Source: SDF, 2016.

The same fields as the ones receiving the bulk of public R&D funds show relative strengths in the quality of research, as measured by the number of citation and the H-index[13]. Taking into consideration the H-index that measures the scientists' productivity and impact of the published work, the most relevant scientific fields in Azerbaijan are physics and astronomy, engineering, medicine, material science and chemistry (Figure 18). These fields could serve as the basis for precise evaluation of the Azerbaijani research capacity and offer insights for the formulation of a National Research Strategy and the selection of priority research sectors.

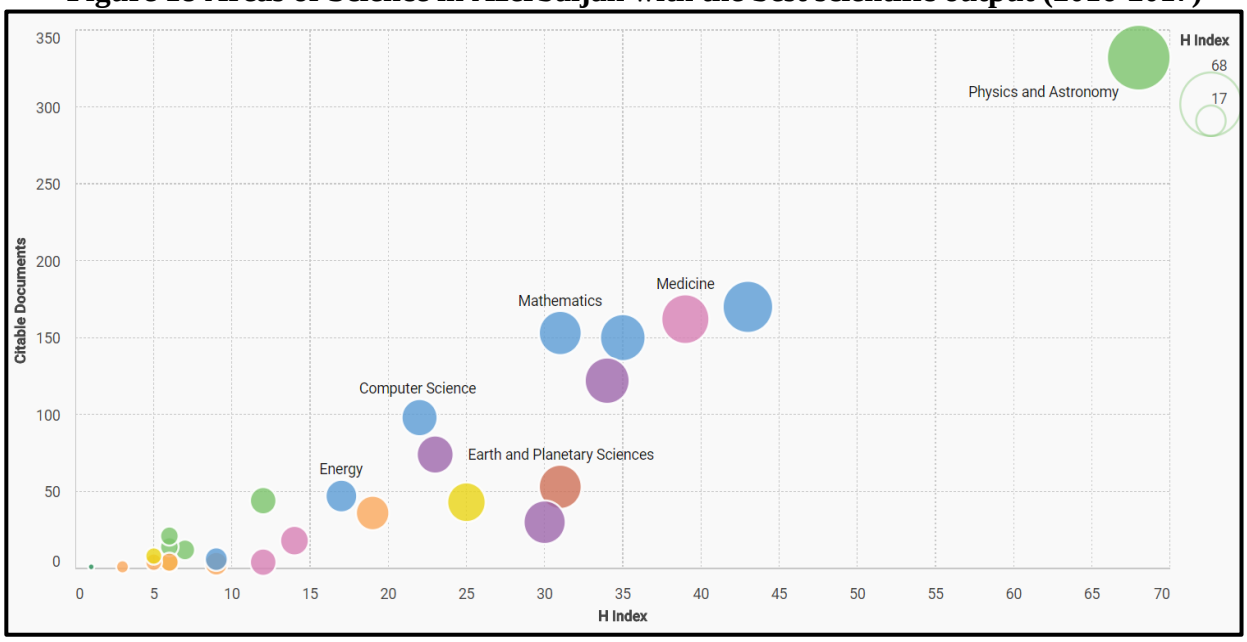
[13] The index is based on the set of the scientist's most cited papers and the number of citations that they have received in other publications. The index can also be applied to the productivity and impact of a group of scientists, such as a department or university or country, as well as a scholarly journal. The index was suggested by Jorge E. Hirsch, and is sometimes called the *Hirsch index* or *Hirsch number*.

Figure 17 Distribution of competitive funds by field (2010-2015)



Source: SDF, 2016.

Figure 18 Areas of Science in Azerbaijan with the best scientific output (2016-2017)



Source: Scimago Journal & Country Rank.