European Commission

Specific Support to Armenia

Raising the bar: a new mission for science in Armenia's development

Horizon 2020 Policy Support Facility

Research and Innovation

Specific Support to Armenia – Raising the bar: a new mission for science in Armenia's development

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EUROPEAN COMMISSION

Specific Support to Armenia

Raising the bar: a new mission for science in Armenia's development

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2020 Directorate-General for Research and Innovation EN

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LIST OF ABBREVIATIONS

AMD	Armenian Dram
CAS	Czech Academy of Science
EC	European Commission
ECTS	European Credit Transfer and Accumulation System
EIF	Enterprise Incubation Foundation
ERA	European Research Area
EU	European Union
FAST	Foundation for Armenian Science and Technology
HEI	Higher Education Institution
GDP	Gross domestic product
MEcon	Ministry of Economy
MESCS	Ministry of Education, Science, Culture and Sport
NAS	National Academy of Science
PBRF	Performance based research funding
PSF	Policy Support Facility
REA	Research evaluation arrangements
R&D	Research & development
R&I	Research & innovation
RI	Research institutes
RTD	Research and technological development
SC	Science Committee
STEM	Science, technology, engineering and mathematics
STI	Science, technology and innovation

THE PSF SPECIFIC SUPPORT PANEL

Luc Soete, Chair, (Netherlands), is board member of the UNU-MERIT and until September 2016 was Rector Magnificus at Maastricht University. Before that he was Director of the United Nations University Research and Training Institute (UNU-MERIT) located in Maastricht, the Netherlands and Professor of International Economic Relations and Director-Dean of the Maastricht Graduate School of Governance (MGSoG) at Maastricht University. He is a member of the Advisory Council for Science and Technology Policy (AWT) and the Royal Dutch Academy of Science (KNAW). He was also the Chair of the H2020 PSF Peer Review of Bulgaria in 2016.

Alasdair Reid, Rapporteur (Belgium), has 20-plus years of experience in public policy research in the fields of regional economic development and innovation systems. He is founder and managing director of the European Future Innovation Systems Centre, a non-profit scientific research organisation working on contract research and studies on European innovation policy, performance and systems. Previously, he founded and led the Technopolis Group Brussels and Baltic offices for 12 years. During his career, he has provided advice and support to the European Commission, international organisations (OECD, World Bank) and national and regional governments and agencies throughout the EU and in third countries. He has published extensively in peer-reviewed journals and books, notably focusing on the design and evaluation of regional development and innovation policies and the links with economic trends.

Maria Nedeva, Expert (United Kingdom), Professor of science and innovation dynamics and policy at the Alliance Manchester Business School (AMBS), the University of Manchester and a long-standing member of the Manchester Institute of Innovation Research. Intellectually, her research is on science dynamics, more specifically on 'policy-driven' change that affects both the social conditions (national-level organisation) of research and epistemic properties of knowledge. She has researched and published on: universities, governance and management; changing research spaces; the effects of policy on the science system; and evaluation and selection practices in science.

Göran Melin, Expert (Sweden), Associate Professor at Stockholm University and Assistant Director at Technopolis Group Sweden. He has conducted studies and evaluations for ministries/governmental authorities and higher education institutes in Sweden, Denmark, Finland, Czech Republic, Lithuania, Norway and the UK, targeting issues such as research-funding mechanisms, the organisation of higher education institutes, mobility, doctoral training, alliances and mergers between higher education institutes, academic careers, and cooperation between universities and the surrounding society. Matters related to participation in the EU Framework Programmes have repeatedly been in focus. In 2011-2012, he supported DG EAC's Thematic Working Group of Higher Education as an expert. He also has experience as a national expert in a CREST OMC Working Group ('Mutual learning on approaches to improve the excellence of research in universities', 2009).

The expert team was complemented by two peer experts:

Agrita Kiopa, Vice-rector for Research at Riga Stradins University. She was formerly Deputy State Secretary and Director of the Higher Education, Science and Innovation Department at Ministry of Education and Science of Latvia.

Indrek Reimand, Deputy Secretary General for Higher Education and Research, Estonian Ministry of Education and Research, since 2012. He is currently chairman of the board at the Estonian Research Council, the main research financing organisation in Estonia.

The project was overseen by the PSF Team in the EC's Directorate-General for Research and Innovation. Eugenija Pučiūtė coordinated the exercise and liaised with the Armenian authorities. The PSF contractor supported the EC's PSF Team in this activity. This involved work by Asel Doranova, project manager at Technopolis Group, Manfred Spiesberger, (ZSI, Austria), who acted as the quality reviewer, and Sevak Hovhannisyan**,** (EV Consulting), who prepared the background report based on a structure proposed by the rapporteur and then revised based on comments from the experts' team.

The Armenian authorities provided data and background documentation useful for the panel's work and supported the visits to Yerevan (i.e. inviting the representatives of government ministries, agencies, universities, research institutes and other relevant stakeholders). Coordination on behalf of the Armenian authorities was assured by the Science Committee (SC) in liaison with the Ministry of Education, Science, Culture and Sport (MESCS). The SC also provided meeting facilities and interpretation services to the expert team.

EXECUTIVE SUMMARY AND POLICY MESSAGES

In October 2018, the Ministry of Education, Science, Culture and Sport (MESCS) of Armenia confirmed a request to the European Commission (Directorate-General for Research and Innovation) for the Horizon 2020 Policy Support Facility (PSF) to assist in reforming and reinforcing the performance of Armenia's research institutions and enhancing cooperation between higher education and research institutions.

Almost 30 years after regaining independence (in 1991), Armenia retains a diverse network of research institutes, notably those under the National Academy of Science (NAS). However, the higher education sector is mainly focused on the education function with limited research activities. While reforms have taken place, the structure of the research system remains highly fragmented with over 69 research-performing organisations (including 13 universities). The consolidation of the public and higher education research and development (R&D) sector is a process that will take time. To support this process, the PSF Specific Support team was requested to provide recommendations and good practice examples on the following:

- Development of a model for the evaluation and assessment of the performance of publicly funded research institutions;
- Assessment of the current funding system for research, design of a performance-based funding system and advice on future implementation;
- Measures aimed at bridging the gap between higher education and research systems, and notably supporting a shift towards research-based education in universities.

The PSF expert team conducted two in-country visits (in May and October 2019) to build on information collated in the background report and explore through interviews and discussions with Armenian stakeholders specific or additional lines of investigation (see list of stakeholders in annex 7.1). The first visit examined the challenges facing the Armenian science system, the role and contribution of science to national development, the governance of science policy and funding and the current practices relating to the three topics set out in the request for support. During the second mission, the preliminary conclusions and tentative recommendations were presented to, and discussed with, a broad group of stakeholders during a workshop.

The PSF team wish to thank the management and staff of the Science Committee (SC) for their support during the preparation of the report.

The conclusions and recommendations in this report are based on the findings of the missions complemented by additional insights from a number of comparator countries, notably Estonia and Latvia. The report's conclusions are the sole responsibility of the authors; however, we trust that they reflect in a fair and balanced manner the concerns and aspirations formulated by the many people who took time to discuss with us in Yerevan.

Key challenges for the development of Armenia's research system

To formulate recommendations that are expected to have a far-reaching impact on the structure, funding and, hopefully, performance of a national research system requires more than pulling off the shelf a model or recipe used in one or other 'similar' countries. Hence, the PSF team has carefully taken stock of the current situation, to identify what works in the current system, who does what (governance and institutional structures), and what needs to be developed or what structures or processes need to evolve for Armenian science to take a qualitative step forward in the new decade (2020s).

We have identified fundamental problems in terms of the strategy and operation of the Armenian science system. These problems are 'fundamental' in the sense that it is highly unlikely that the Armenian science system will improve before they are tackled. These four key aspects of a science system are:

1. The governance of the science system (strategic and operational authority);

2. The vision and role of the science system in future national development;

3. The funding system for science; and

4. The institutions and structure of the research-performing system.

Governance of the R&I system: The Armenian R&I system lacks cross-sectoral (inter-ministerial) and strategic advisory functions (including mechanisms for consulting with societal and business stakeholders) that can enable the development and implementation of a long-term strategy for Armenian science.

At operational level, the SC fulfils the role of the research funding agency[1] managing the science budget provided via the MESCS. Beyond a role as a funding agency, the SC is also an active player in policy formulation and in developing bilateral, European and international cooperation agreements in the field of science. In the context of the implementation of the recommendations of this report, the SC will need to be strengthened in terms of operational capacity and financial and legal autonomy.

Vision of the science system: The PSF team found limited evidence of a clear concept of a science system that the relevant players in Armenia could unite behind. Instead, it appears that there are rather different visions coming from policy, science and user domains. There is a need for a strategic reflection on the priority areas that the Armenian system should focus on with an emphasis on balancing those few (sub-) fields where Armenia can be internationally competitive in scientific terms, with a better understanding of the fields of

[1] There is no Government agency responsible for funding innovation and industrial R&D

sciences where there is a sufficient level of competence (excellence) and where there is a high relevance for Armenian economic and societal development.

Funding of science: In absolute terms, the allocation of state funding has stagnated since 2015 at around €25 million per annum. Independently of the restructuring of the research system, the Armenian Government should commit to an absolute and relative (to GDP) increase of Government expenditure on R&D. The PSF expert team appreciate that it will require time to adapt annual and multi-annual budget planning, however Armenia's science base is not sustainable at the current level of per capita funding.

Research-performing organisations: The expert team considers that the Armenian science system requires significant consolidation and reorganisation to both improve the (cost) effectiveness of public investment in research and the results in terms of research outputs and innovation performance. From a higher education perspective, there is also a need to reinforce research-based education. However, due care should be taken when attempting to 'force' mergers in a top-down steering of the system.

The **scenarios** for a future consolidation of the research system are as follows:

- Maintaining the status quo with three main types of research institutes (RIs) and with an effort to promote collaboration and 'voluntary' mergers over time of RIs on a case-by-case basis;

- Integration of the National Academy of Science (NAS) and other RIs into higher education institutes (HEIs) with staff of RIs becoming personnel of the universities. In other countries, this has happened over a time, e.g. in Estonia the integration of former NAS RIs into universities took at least a decade; and

- Strengthening university-based research and restructuring NAS and other RIs into one or more publicly supported research organisations similar to those in place in European countries (e.g. CNRS in France, Fraunhofer, Leibniz, Helmholtz and Max-Planck institutes in Germany, etc.). In this model, researchers will often have a dual status as personnel at both universities and institutes and public RIs may be 'co-located' at universities.

A set of criteria can help guide decisions on the future research landscape:

- The positioning of RIs in terms of the spectrum of fundamental versus more applied research, and the need to foster greater inter-disciplinary research;

- The expected balance in terms of sources of funding ranging from 100% State funding to a mix of public, business, foreign (e.g. Horizon 2020, diaspora) and third party (e.g. charitable foundations) sources; and

- The mission of the RIs, including those that are tasked to support ministries in implementing policy (e.g. metrology, testing and certification functions, agricultural extension and modernisation, defence, etc.), those that focus on industrially oriented research and prototyping, those that contribute to resolving societal challenges (sustainable development goals), etc.

Whatever scenario is chosen, there is a need to foster and incentivise collaboration in the system, to ensure an optimal investment and use of research equipment and infrastructure, develop inter-disciplinary and cross-institute teams with sufficient scale and experience to compete for international (e.g. EU) funding, reinforce cooperation with business, and translate research results into economic and socially relevant applications, etc.

However, the capacity of Armenian universities to provide a framework within which RIs can undertake quality research is weak. The results of the higher education quality assurance process underlines that few HEIs have satisfactory strategies in place to manage their research and development function. Armenia should carefully consider the lessons of similar reforms in Georgia and Moldova and avoid making mistakes, such as an incomplete reform leaving RIs with an uncertain status, without sufficient funding, making researchers transferred to universities a "third category" of staff, etc. The risk of a 'big bang' reform is that it undermines, rather than solidifies, Armenia's research base.

Policy messages and related recommendations

Based on our work, the PSF team highlights **three main policy messages** for the attention of the Government of the Republic of Armenia:

- Unless Government R&D funding as a share of GDP is increased, the Armenian science system's capacity to retain qualified young researchers and produce high-quality research and innovations will decline even further;

- The higher education and research institute landscape is too fragmented. However, an overly rapid restructuring should be avoided. In particular, a rapid merger of research institutes into universities risks weakening performance given the current lack of strategic agendas and limited R&D management capacities in HEIs; and

- In evaluating research institutes and allocating future funding, a balance should be struck between research that has an international impact and research that is locally relevant and contributes to national social and economic development objectives.

Based on our findings, we formulated **19 recommendations** in four categories.

Necessary conditions for a successful reform

The reform of the higher education system is a pre-condition for the reinforcement of research-based education and scientific research within higher education. We recommend a significant consolidation of the higher education sector resulting in a limited number (five or six) of full universities conducting both higher education and research. Thereby enhancing the quality of research-based education. Two key factors for this consolidation are a stricter application of the process of accreditation and licensing of HEIs; and the introduction of measures such as a minimum number of students per course or capital requirements for HEIs. Moreover, university teaching staff should be required to

conduct research; and researchers from RIs should have full access to teaching positions at HEIs.

We recommend strengthening the governance structures for research and innovation policy design and implementation in Armenia. This should include: the creation of a national R&I council to oversee a cross-cutting approach (inter-ministerial, inter-sectoral, multi-disciplinary, etc.) of the design and implementation of R&I policies (including the proposed research infrastructure roadmap). At operational level, the SCs should be strengthened in order to perform its role as a national research-funding agency (staffing and training) managing a potentially larger flow of funds delivered through an updated portfolio of programmes.

We recommend a change to the role of the National Academy of Science which should become a learned society as in most European countries. The NAS RIs network should become, over time, legally independent (becoming autonomous public research organisations, merging into universities, etc.) from the NAS. The NAS should retain and develop certain functions such as scientific information and advisory services, science diplomacy role, etc.

We recommend that the Government increases the share of government expenditure on R&D as a share of GDP by 2025. Thereafter, it should ensure average growth of Government expenditure on R&D at least comparable to other Eastern Partnership countries. Without this increase, it will be difficult to ensure that the process of consolidation and restructuring triggered via the research evaluation leads to a significant increase in performance.

Implementing an evaluation of research capabilities and performance

We recommend the implementation in 2020-21 of a first national research evaluation covering all RIs (those of the NAS, department/units in universities and branch institutes reporting to specific ministries, etc.). The first research evaluation is an urgent priority as it should support a restructuring of the RI system and the prioritising of Government investment. Thereafter, the Armenian authorities should implement a periodic (every 5 years or at the end of a funding cycle) evaluation to assess improvements in performance.

To ensure that the first research evaluation is credible, it should be managed and organised by a dedicated unit with sufficient independence from existing research performers to ensure objectivity. We recommend the establishment of: a unit within the SC with responsibility for organising the research evaluation exercise and of a steering committee, reporting to the Government, to ensure oversight of the process.

We recommend that the research evaluation management team and the implementation of the first research evaluation should be supported by international experts via a technical assistance contract funded by the European Commission.

We recommend that the evaluation should be based on a combination of self-assessments by the RIs, a set of objective criteria and a peer review. The 10

criteria proposed for the first evaluation give a priority to the conditions for carrying out high-quality research and the relevance of research to Armenian development (rather than on research outputs).

We recommend that the peer panels per scientific field should include, and each scientific field panel chaired by, international experts.

We recommend that an additional appropriation during the period 2021-2025 could be (part)-funded by the European Commission via a budgetary support conditioned on the implementation of a research institute evaluation and the strengthening of R&I policy governance.

Boosting higher education and research cooperation

In order to ensure both a 'vision for the role of science in society' and provide a framework for research-performers to develop their own strategic agendas, a medium-term research and innovation strategy that sets priorities for future funding at a cross-government level should be developed as a matter of urgency. Such a strategy could build on the proposed process set out in the EU SMEDA funded study on an innovation strategy for Armenia.

We recommend the development of a research infrastructure roadmap for Armenia. This 'landscaping' exercise will identify existing capacity, overlaps and gaps in equipment, and define future investment needs.

We recommend the development of an open access system to research equipment, data and archives to ensure that researchers (including doctoral and post-graduate students) are able to carry out their research as efficiently as possible.

A shift to research-based education implies that universities should provide a complete cycle of tertiary education (including doctoral education). We welcome the pilot initiatives for doctoral education and recommend that they should be scaled up and sufficiently funded, from the State budget and/or donor support, to fully develop, over time, doctoral studies in Armenia.

We recommend that the development of doctoral schools should be complemented by specific financial measures and reforms to the employment status of early-stage researchers to strengthen the researcher career path.

Based on the updated R&I priorities, the research infrastructure roadmap and the research evaluation results, we recommend a competitive call be launched to create a limited number of inter-institutional centres of excellence (basic research focus) and competence centres (applied research focus).

A shift to performance-based funding of research

We recommend that the introduction a functional and effective funding system that combines a sufficient level of direct appropriations (baseline funding) and a performance-based research funding (PBRF) component.

We recommended that the Armenian Government set, initially, the performance-based component at 20% of institutional funding.

We recommend that, after a pre-defined period (e.g. three years), the PBRF's effects should be evaluated and adjustments made to optimise the impact.

1 Introduction – objectives and scope of the review

Due to its role in the industrial and R&D system of the former Soviet Union, an independent Armenia inherited a diverse and developed network of research institutes, notably those under the National Academy of Science (NAS), and higher education institutions focused largely on education rather than research. The consolidation of the public and higher education R&D sector is a process that will take time. Three immediate challenges were identified by the Armenian authorities to tackle the current fragmentation of the R&D system: the evaluation of the performance of the public research organisations; a shift to the distribution of funding based on performance; and action to close the perceived gap between research and the higher education systems.

To address these challenges, the Policy Support Facility (PSF) Specific Support team was requested to provide recommendations and good practice examples on the following:

- Development of a model for the evaluation and assessment of the performance of publicly funded research institutions;
- Assessment of the funding system for research, design of a performance-based funding system and advice on future implementation; and
- Measures to bridge the gap between higher education and research systems.

1.1 Methodology and process

The PSF process for Armenia was structured in three main steps as set out in Figure 1. In early 2019, an expert team[2] was commissioned to provide support to the Armenian authorities and, notably, the Ministry of Education, Science, Culture and Sport (MESCS) and the Science Committee (SC). The PSF expert team's work was informed by a background report[3] prepared by a national expert.

The kick-off meeting[4] was a first opportunity for the PSF expert panel to meet the Armenian authorities. Discussions covered the study's work schedule, including the research, meta-analyses and interviews with Armenian experts, national authorities and other stakeholders necessary to fully understand the needs of the national research and innovation system, especially in terms of evaluation and performance-based funding. Following the kick-off meeting, the

[2] A presentation of the expert team is available at:

https://rio.jrc.ec.europa.eu/en/file/12705/download?token=2e9-_48_

[3] The background report is available at:

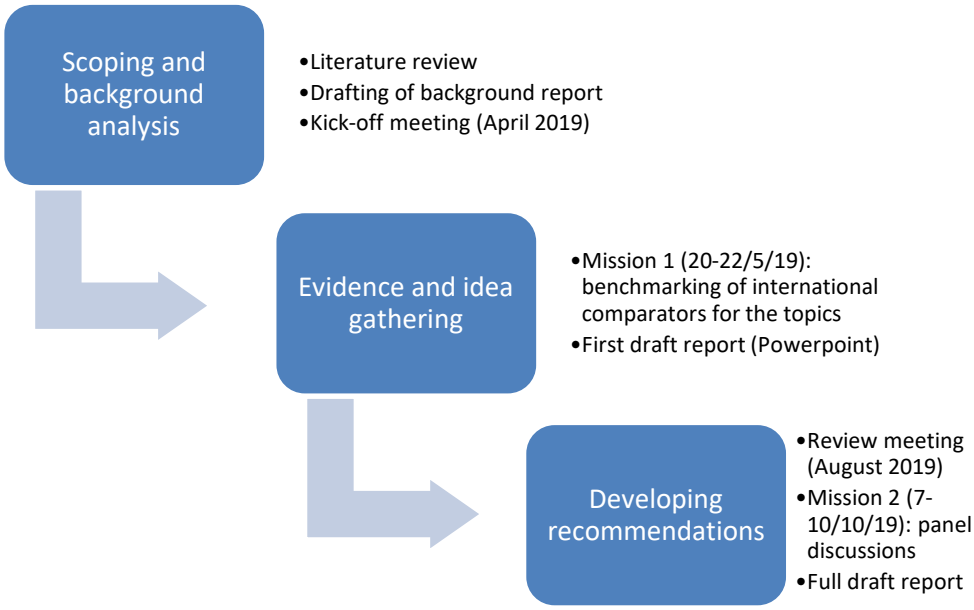
https://rio.jrc.ec.europa.eu/en/file/12730/download?token=C96BE0bq

[4] Presentations from the kick-off meeting can be downloaded at:

https://rio.jrc.ec.europa.eu/en/policy-support-facility/specific-support-armenia

background report was finalised based on the feedback from the expert team including requests for additional data on the Armenian research system.

Figure 1: PSF Armenia – process steps



The background report and discussions at the kick-off informed the formulation of the agenda for the first mission (May 2019) structured into a number of working sessions with the Armenian authorities and research and higher education stakeholders (notably from the natural and life science fields). During this first mission, the expert team conducted on-site visits to selected research institutes, universities and relevant initiatives in Yerevan (see the list of meeting participants and institutions visited in annex 0). Following the first mission, additional background documents were translated from Armenian into English to ensure the expert team had access to all relevant documentation.

The expert team discussed initial conclusions and policy options in Brussels in August 2019. A first outline report was prepared and summarised in a PowerPoint presentation for discussion with Armenian stakeholders during the second country visit in October 2019. Additional interviews were carried out to ensure full coverage of the main scientific fields, notably with scientists from the social science and humanities, and agricultural and environmental fields, as well as with actors working at the interface between business and science and tech-based start-ups, and experts knowledgeable in the area of higher education quality assurance and reform.

This report outlines the conclusions and recommendations of the PSF expert team and sets out a plan for implementation.

2 Key challenges for the Armenian science system

The background report (Hovhannisyan, 2019) sets out a detailed analysis of the current socio-economic situation in Armenia and provides a clear context to the ongoing reform of the research and innovation (R&I) and higher education systems. Armenia has faced a significant population decline due to emigration (sharply after 1989 but with a steady, though less significant, decline in recent years). Despite this trend, the economic activity rate (ratio of the total labour force to the working-age population) has remained unchanged and is close to the average in high-income countries. Armenia has a growing share of people with tertiary and postgraduate education, but this is offset by a high share (just under 50%) of the population that has no professional education (post-secondary level). The science system is under significant strain both due to under-funding and from an ageing scientific workforce due to emigration and unfavourable career conditions (salaries, access to equipment, funding, etc.).

Despite the negative situation faced by the research system, publications per million population are above those of other Eastern Partnership countries and the share of cited publications in total publications is above that of Lithuania, Ireland and just below Estonia and Israel. Scientific output is dominated by natural sciences (71.6% of publications in 2018) with a strong relative showing in physics and astronomy (H-Index of 146). Another characteristic of the Armenian research system is a relatively high rate of international co-publications, explained in part by long-established cooperation patterns in physics and astronomy, but also the international linkages with Armenian diaspora in Western Europe and North America. Hence, the Armenian science system still has a potential to 'compete' on the international scientific playing field in selected areas.

This report examines how to improve a research system that is not a lofty peak like Masis (Mount Ararat), high above the plains and valleys of the rest of the country, but rather should be adapted to the specific Armenian culture and geopolitical situation. A well-performing research system should interact with and support educational, social and economic development. A research system can only excel if certain pre-conditions are in place and it should contribute to both long-term national development as well as helping to put Armenia on the global map in terms of scientific specialisation or innovation. A concern is the estimated (no official statistics exist) low level of R&D carried out in the business sector and limited cooperation between the research system and economic players.

We would do no service to Armenia if we copied and pasted recipes from other societal, cultural and institutional contexts. The Armenian science (and higher education) system today is still heavily influenced by the institutional framework that derives from the pre-1991 period. The legacy is a dichotomous system with research largely, if no longer exclusively, carried out in NAS research institutes, as well as in a number of 'branch' RIs linked to line ministries, while the majority of universities remain teaching institutions.

While 'history matters' it should not limit future ambitions to improve the performance of the research and higher education system and their contribution to Armenian development. Our panel includes experts from the Baltic States, these countries started from a similar 'historical context' and have undertaken

significant reforms over the last decade to improve their science systems. Such examples, while not fully transferable, provide inspiration and point to the benefits of a medium-to-long-term consolidation of the science system.

Our report takes stock of the current challenges and seeks to develop a set of proposals tailored to the Armenian context which, if implemented, can help support a qualitative transformation in Armenian scientific potential and performance. We have identified fundamental problems – in the sense that it is highly unlikely that the Armenian science system will improve before they are tackled – in terms of the strategy and operation of the science system. These 'fundamental' problems correspond to four key aspects of a science system:

1. The governance of the science system: the distribution of the strategic, operational and performative authority (Nedeva & Boden, 2006);

2. The vision of the science system and its role in future national development and aspirations;

3. The funding system for science; and

4. The organisation, institutions and structure of the research performing system.

2.1 A research and innovation governance system in need of reinforcing

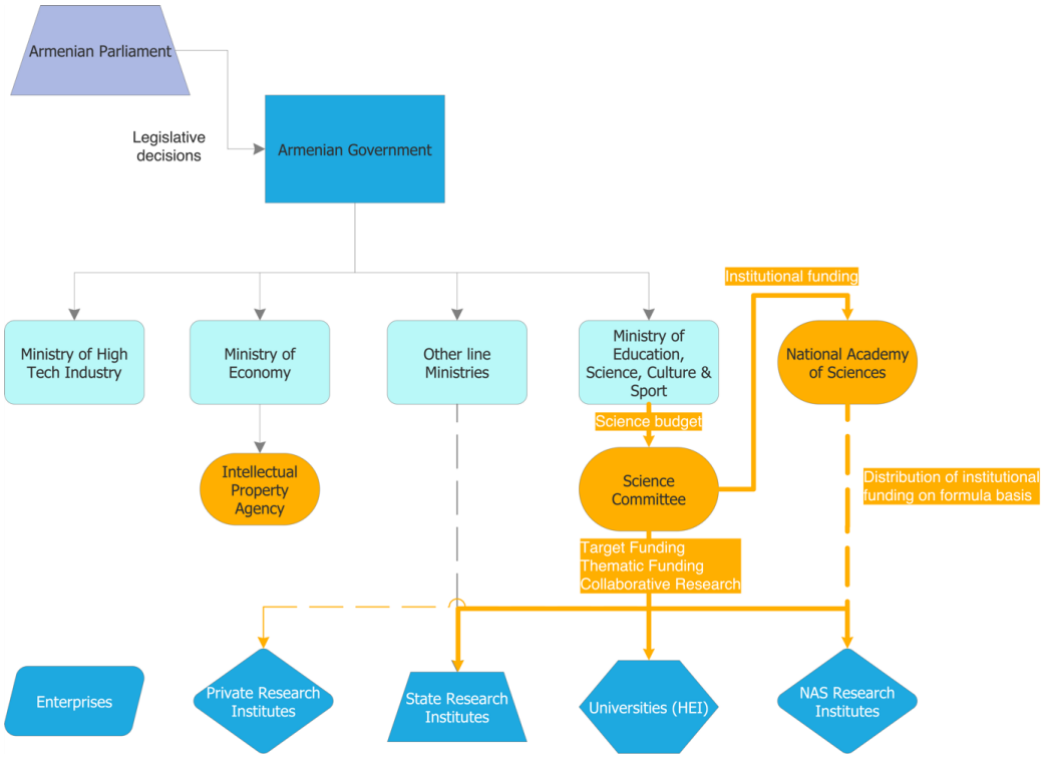
This section summarises the governance system for science in Armenia; more detailed information can be found in the background report. The Armenian R&I governance system is presented in diagrammatic format in Figure 2. Compared to most European Union (EU) Member States (see Schwaag Serger et al., 2015 and Table 1), the system is characterised by the absence of consultative bodies on R&I policy, either to the Parliament or Government. In the Armenian system, the advisory role on science to the Government is one of the functions fulfilled by the NAS 'Presidium'. However, as a main recipient of State science funding the academy is not a neutral observer. Otherwise, there appear to be few structured mechanisms for R&I stakeholders (education, business, civil society, etc.) to provide input into the formulation of priorities for R&I policy and funding.

Following the adoption of a Government Programme by the Parliament, the line ministries are mandated to develop and implement policy and legislative measures (e.g. the new law on Higher Education and Research). Ad hoc working groups support this process (e.g. the HERE expert group on higher education[5]). Science policy is viewed as one policy among others with limited cross-cutting linkages across government ministries and unclear strategic authority (e.g. in some countries the Prime Minister is the chair or co-chair of a national research and innovation committee). There is no mechanism for developing and implementing a consistent long-term policy for research and innovation.

[5] See: https://erasmusplus.am/here/

In the science system, the SC fulfils the role of the research funding agency[6] managing the science budget provided via the MESCS (see sections 2.3 and 4.2). Beyond a role as a funding agency, the SC is also an active player in policy formulation and in developing bilateral, European and international cooperation agreements in the field of science. We have not performed a review of the SC per se, but the panel considers that the SC performs well overall, given the (human and financial) resources available to it and the limited operational autonomy it has compared to national research funding agencies in more advanced countries. Nevertheless, in the context of the implementation of the recommendations of this report, the SC will need to be strengthened in terms of operational capacity and financial and legal autonomy.

Figure 2: Armenian R&I governance system and funding streams



Source: authors

The institutional funding allocated to the NAS is transferred from the SC to the NAS Presidium which distributes the funding to the NAS RIs. This transfer is somewhat archaic and a more direct line of funding from the SC to NAS RIs would be preferable with a view to fostering a consolidation and restructuring of existing RIs into a smaller number of centres of excellence with sufficient critical mass. As discussed below, in the future, the performance-related share of funding

[6] At the present time, there is no Government agency responsible for funding innovation and industrial R&D

should increase and this could include performance agreements for the financing of these main research institutes, agreed between the SC and each central management structure (not each laboratory or research team).

The SC also manages the 'competitive' funding programmes (see section 4.2) providing project finance directly to research institutes. For collaborative research projects (currently a small part of overall funding), co-financing by enterprises is required. However, it is noteworthy that there is no equivalent agency supporting R&D and innovation in the enterprise sector and no State funding for R&D in the business sector (or for supporting business cooperation with the research sector).

Overall, the R&I governance system lacks cross-sectoral (ministries) and strategic advisory functions (including mechanisms for consulting with societal stakeholders, etc.) that would enable the development and implementation of a long-term strategy to reinforce Armenian science. We return to this issue in section 6 when considering the necessary conditions underpinning reform.

2.2 The vision and role of the science system in Armenia

This first issue concerns the dominant views regarding what is 'good' science and what is the role of science in and for society and the economy. Put simply, this topic is about developing a vision of science and the science system's alignment within the country. Elaborating such a vision is key to developing, and consistently implementing, a viable, effective and efficient national-level science policy framework.

Retaining people with the right skills is not the only challenge in the science system. The recent National Competitiveness Report (EV Consulting, 2019) addresses the future of jobs in Armenia. It paints a stark picture of the challenges facing Armenia and notes that "job creation is a fundamental challenge for the Armenian economy", in particular the employment rate and labour productivity. Inclusive growth requires robust and diversified economic development, which can only be fuelled by a higher skilled labour force, to ensure wider participation of the economically active population in value creation. A strong and competitive science system feeding into research-based education, advising the public sector (Government, public agencies, local authorities) and collaborating with business is critical to the chances of Armenia developing a more diversified and skills-based economy.

In February 2019, the Government (elected after the 'Velvet Revolution' in 2018) set out a refreshed policy agenda for the period 2019-23.[7] The aim is to "build a competitive and inclusive economy that complies with high technology, industrial, as well as high environmental standards and is export-oriented". Four main objectives are set:

1. Enhancing the opportunities of economic activities;

[7] See: https://www.gov.am/files/docs/3562.pdf

2. Increasing the effectiveness of the state administration;

3. Developing the human potential; and

4. Developing reliable infrastructures and enhancing accessibility.

Under the third objective, the main focus is on education and notably "developing the professional potential required for structural changes in the economy through the modernisation of the areas of education and science". Science is thus seen as a key factor in resolving the challenges faced in terms of the skill levels and qualifications of Armenians.

Given Armenia's geopolitical situation, science is viewed as contributing to the modernisation of the national defence system, hence an emphasis on "defence-related science" (logically of an applied nature so as to provide rapid operational solutions) is part of the Armenian vision. The recent creation of the Ministry for High Technology has led to a higher emphasis on enhancing scientific and experimental activities in the field of defence technologies and related industries. The aim is to foster cooperation between the defence industry and scientific and educational institutes to attract young, talented specialists to this field.

Other than in the chapters on defence and high technology, as well as supporting the upgrading of the key agricultural sector,[8] the Government programme mainly addresses science within the specific chapter on Education and Science, which states that: "Development of education and science is an overriding objective for the Government, and only through the development of education and science will it be possible to achieve sustainable and inclusive growth and universal welfare." It is stressed that "strengthening the education-science-labour market relationship" is crucial. Science, technology, engineering, mathematics (STEM) are mentioned as an explicit priority at the level of general education, recognising the importance of promoting these fields from an early age.

In terms of higher education, the programme foresees certain measures to increase autonomy and academic freedom of higher education institutes (HEI), gradually increase the volume of funding and measures to improve the HEI quality and research performance, notably "an ongoing increase in the research component in higher education".

Turning to science, the programme sets out six priorities:

1. Increase the effectiveness of financing for science, direct the provided funds to areas that address the needs of the economy and meet the current requirements for academic research;

2. Create the right conditions for young scientists in Armenia and engage Armenian scientists abroad in national development programmes.

[8] Specifically: "Establish educational, scientific research, industrial clusters and facilitate [the] deepening of education, scientific, research and development and consultation centres in [the] agricultural and agrarian sector."

Armenian science must be an internationally competitive system, addressing international scientific priorities and directly promoting the competitiveness and security of the economy;

3. Create centres of excellence for science, education and technology in selected fields ensuring ground-breaking progress;

4. Strengthen the link between education and science, contributing to the establishment of a network of HEIs and scientific organisations, by fields of academic activity, and ensuring the mobility of students in a network of HEIs and scientific organisations;

5. Introduce financing mechanisms based on effectiveness in the field of science; and

6. Create the necessary conditions for the use of Armenian as a language of modern science.

To sum up, the Government frames the expected contribution of science as:

- A field of activity in which Armenia should improve its international competitiveness so as to develop and retain young, skilled people and better engage with the international scientific community;

- A means of upgrading skills levels (STEM, etc.) within the workforce through improved linkages between education and science (and the demand for specific skills), and supporting the required structural change in the economy; and

- A critical contributor to national defence and security.

As explained in section 3.1, the MESCS is currently developing a new Law on Higher Education and Research that addresses the priorities of the above policy documents, notably in terms of strengthening the link between education and science. In terms of the vision for the science system, the Government prioritises improving cooperation between higher education and science, increasing the research component in higher education and enhancing scientific excellence through financing mechanisms that ensure effective use of funds, etc.

Prior to the new Government being elected, two main policy documents had been adopted that provide a strategic framework for science and technology policies in Armenia:

- Science and Technology Development Priorities for 2015-2019; and

- An Action Plan for the Development of Science Sector, 2017-2020.

These two documents were developed under the auspices of the MESCS. Work on developing innovation and industrial strategies falls under the remit of the Ministry of Trade and Economic Development (now the Ministry of Economy, MEcon). More recently, the new Ministry of High Technology Industry has been

made responsible for designing strategies for the development of high-technology industries and digitalisation. This creates a crowded field for STI policies in a small country.

Under the **Action Plan**, the following objectives were set:

- Improving the S&T management system;
- Introduction of an effective system of renewing personnel in the R&D sector, modernisation of research infrastructures;
- Promoting fundamental and applied research, including knowledge used in economy and/or of dual importance;
- Establishing pre-conditions to form a synergistic system of education, science, technology and innovation;
- Promoting research in Armenian studies; and
- Developing international cooperation in RTD, including smart specialisation in the context of the European Research Area.

The Government, in December 2014, approved following priority areas:

- Armenology;
- Life sciences;
- Secure and efficient energy;
- Key enabling technologies, information and communication technologies
- Space, earth sciences, sustainable use of natural resources; and
- Basic research for key problems of scientific and socio-economic development.

These priority areas, while undoubtedly directly relevant to Armenian society, are not sufficient as building blocks for a coherent vision to guide Armenia's science system. Overall, the PSF team found limited evidence of a clear concept of the science system that the relevant players in Armenia could unite behind. Instead, it appears that there are rather different visions coming from policy, science and user domains. From the scientific side, the visions diverged according to different clusters with more fundamental fields (hard sciences like chemistry and physics) espousing a 'science as curiosity' view while applied physics and life sciences adopt more of a 'science should be useful' notion. Similarly, alternative 'visions' of the role of science were proposed and promoted by other groups (for instance,

by representatives of EIF,[9] FAST[10] and TUMO[11]). These alternate visions included the promotion of science, technology, engineering and mathematics (STEM) for young people as well as education focused on entrepreneurial and creative talent. The role of the diaspora – and how best to optimise international cooperation (e.g. bilateral relations notably with the EU, US and Russian science systems) – also influences these alternative visions.

There is a clear need for a strategic reflection on the priority areas that the Armenian system should be focusing on with an emphasis on balancing those few (sub-) fields where Armenia can be internationally competitive in scientific terms. The key is to develop a better understanding of the fields of sciences where there is a sufficient level of competence (excellence) and where there is a high relevance for Armenian economic and societal development.

Figure 3: Matrix of relevance and excellence for science funding

	Locally relevant	**Locally irrelevant**
Excellence	1. First best/virtuous cycle	2. Second best/islands of excellence but not relevant locally
Non-excellence	3. Third best/locally relevant but mediocre R&D	4. Bad strategic option/locally irrelevant and mediocre in terms of quality/vicious cycle

Source: Radosevic & Lepori (2009)

The framework proposed by Radosevic (2009) is highly relevant in this context of developing a more coherent and cross-cutting vision of the role of science for Armenian development. Given the limited budgetary means available, Armenia must focus on developing research capacity in locally relevant (i.e. with applications for economic or societal needs) research meeting international standards (excellence) in terms of methods and research outputs.

[9] Enterprise Incubator Foundation: http://www.eif.am/

[10] Foundation for Armenian Science and Technology: https://fast.foundation

[11] Centre for Creative Technologies: https://tumo.org/ (as well as the planned EU TUMO Convergence Centre for Engineering and Applied Science: https://www.convergence.center/)

2.3 Science funding in Armenia: a key challenge for the coming years

Armenia's gross expenditure on R&D (GERD) has remained largely unchanged as a share of gross domestic product (GDP) in the last decade, at roughly 0.2%. It has risen in absolute terms to AMD 14 billion (or €25.4 million) in 2018, of which 88.2% was performed in the government sector and 11.8% in higher education. No data is collected on business R&D expenditure. In budgetary terms, Government expenditure on science grew between 2013 and 2017, however, given inflation rates the real value is declining. According to the current medium-term expenditure framework plan (2019-2021) the annual science budget will remain at AMD 14.3 billion (or €25.1 million) level for 2019 and the next two years. Considering GDP growth forecasts, the R&D expenditure share in GDP will decrease further.

In terms of the existing science funding system, the main issues are:

- The level of funding is critically low. Indeed, in the view of the PSF panel, the Armenian science system risks further decline if funding is not increased. The limited State funding is not offset by significant private funding, although the absence of business expenditure on R&D statistics makes it difficult to reach a firm conclusion on this point. There has been a limited inflow of foreign funding to the system over the last decade of the order of €2-4 million)[12] per annum, including some multinational firms investing in R&D facilities in Armenia. Moreover, Armenia is now an associated country of Horizon 2020 and Armenian participants had secured €2.65 million by November 2019.

- *De facto*, there are no block grants to research organisations. While resources are presented as 'block grants' this is deceptive since the grant is to cover the basic operations and salaries (which are at a non-competitive level compared to the private economy). In most European science systems, block grants to research organisations (research institutes and universities) include some funding for maintaining and upgrading the conditions (equipment, etc.) for research.

- Competitive project based-funding grants, awarded by the SC, are on average approximately €30,000 per project for two years, which does not appear ideal for the medium-term development of research teams under a principal researcher. The overall fund and the scale of funding per project are not sufficient to support the upgrading or restructuring of the system.

- Allocation of project funding appears to be managed efficiently by the SC using a peer evaluation method (see 4.2) but this has limitations within a small research system that is also characterised by a great disparity of research quality.

[12] See: http://uis.unesco.org/en/country/am?theme=science-technology-and-innovation

We discuss the existing funding system and the modalities of funding in section 4.2 and recommendations for enhancing the effectiveness of the system in section 6.3.

2.4 An overly fragmented research-performing system

The background report (Hovhannisyan, 2019) underlines that the Armenian science base has shrunk significantly over the last three decades, both in terms of the number of scientists (from 25,344 in 1991 to between 5,000-6,000 currently) and the number of research institutes, from 124 to 83 over the same period. The shrinking of the system reflects the changes from a science system geared towards a large command economy and military-industrial complex to one operating in a small country transitioning towards a mixed economy model.

Currently, the NAS has 35 RIs and scientific centres in five main disciplines: mathematical and technical sciences; physics and astrophysics; natural sciences; chemistry and earth sciences; and Armenology and social sciences. Aside from the NAS system, there are 47 institutes which are under the remit of the State (MESCS and line ministries) including those at HEIs; the remainder are private. In 2019, 69 organisations received baseline funding from the SC: 56 research organisations (33 from the NAS) and 13 HEIs.[13] This suggests that some RIs are not fully operational or are sourcing funding from private or other sources.

Nevertheless, the number of RIs receiving baseline funding, particularly given the low level of total funding, remains excessive for a country of the scale of Armenia.

To provide a benchmark for the Armenian system, the research system landscape for four EU countries (the three Baltic States and the Czech Republic) with a similar 'historical' context is presented in Table 1. In population terms, the three Baltic States are closer in scale to Armenia. Estonia (with a smaller population) has 20 R&D performing organisations (6 public universities, one private, 5 public RIs under ministries, one public RI established by a separate act, one centre under the Academy of Science, and six private RIs) which have successfully passed the regular research evaluation to be eligible for State funding. In Lithuania, there are 13 State RIs and 14 public universities recognised by the Ministry of Education and Science.[14] In Latvia, there are 21 public RIs (including universities) funded by the State budget and 48 private RIs recorded in the national register.[15] The Czech Republic, a much larger country in population terms, has a more extensive system and has retained a network of RIs under the Czech Academy of Science (CAS), as is currently the case in Armenia.

A key difference with Armenia is that all four countries have had access to significant EU Structural Fund support for investment in R&D and innovation

[13] Data from presentation of Vardan Sahakian, State Committee of Science of Armenia, April 2019

[14] See: http://www.mab.lt/lt/istekliai-internete/153

[15] See: https://www.izm.gov.lv/en/research-institutions

infrastructure and programmes since 2004. This should be kept in mind when comparing the development trajectory and instruments applied to restructure the research and innovation landscape.

A clear trend in all four countries is the consolidation of research capacities through merging research institutes into universities, the application of research evaluation arrangements (REA) to guide funding decisions, specific collaborative programmes and instruments (e.g. centres of excellence, competence centres, 'Research, education and innovation valleys' and open access centres, etc.), and long-term planning of research infrastructure investments (research infrastructure roadmaps, etc.).

Table 1: Research and innovation landscape in selected European countries

Country (population)	Research & Innovation advisory bodies	Research institute system	Funding agencies
Czech Republic **(10,610,055)**	The Research, Development and Innovation Council. Advisory body to the Government chaired by the Prime Minister.	Over 200 research organisations of which universities comprise an essential part of the R&D infrastructure. The Czech Academy of Sciences (CAS) has 54 public (mainly basic) RIs.	Czech Science Foundation provides funding exclusively for basic research projects by both experienced as well as early-stage researchers on the basis of calls for proposals. Technology Agency of the Czech Republic (TA CR) focused on applied R&D.
Estonia **(1,319,133)**	The Research and Development Council advises the Government in matters relating to R&D strategy, and the systematic development of the national R&I system. The work of the Council is supported by two permanent committees on research policy and innovation policy.	Most R&I in Estonia is performed at universities. A total of 20 research- performing organisations (incl. universities) are currently positively evaluated and therefore eligible for State funding. Research collaboration is promoted by centres of excellence and competence centres.	The Estonian Research Council (ETAg) – a government foundation – is the main funding body for R&D. It manages a range of competitive R&D-funding instruments. The Archimedes Foundation implementing body of ERASMUS+ and for doctoral and academic mobility Enterprise Estonia provides grants for product development, applied R&D and development, etc.

Country (population)	Research & Innovation advisory bodies	Research institute system	Funding agencies
Latvia **(1,934,379)**	The Research and Innovation Council (RIC) (established 2013) is tasked to advise the Cabinet of Ministers on important matters concerning research and technology investments and the evaluation of policy proposals.	A total of 21 public research-performing organisations funded by the State budget. HEIs play an important role in the R&I system with around 58% of researchers in this sector. The competence centre innovation voucher programmes encourage collaborative research in smart specialisation priority areas including private firms.	The Central Finance and Contracting Agency (Ministry of Finance) implements EU Structural fund support including R&I-measures. The State Education Development Agency administers funding for postdoc research, etc. The Latvian Council of Science functions include acting as a funding agency of the MoES by evaluating and funding fundamental or applied research projects. The Latvian Investment and Development Agency of the Ministry of Economy administers the competence centre and innovation voucher programmes.
Lithuania **(2,808,901)**	The Strategic Council for Research, Development and Innovation is responsible for the overall coordination of the RDI policy.	The majority of research is conducted in 13 State RIs and 14 public universities recognised by the Ministry of Education and Science. There are also nine (private-not-for-profit) research institutes. Access for research equipment installed in HEI or public RIs is organised via 25 open access centres.	The Lithuanian Research Council is the principal agency for competitive research funding including top-down schemes with pre-defined research topics, such as National Research Programmes (NRP). The Agency for Science, Innovation and Technology (MITA) is responsible for implementation of innovation policy including cluster policy.

The expert team is of the view that the Armenian science system requires significant consolidation and reorganisation to improve the (cost) effectiveness of research funding and investments, and boost research and innovation performance. The issue of the fragmentation of the research system (NAS RIs, university labs/institutes and sector-specific research facilities) is developed in section 3 which discusses the 'separation' between the research and education systems, a legacy of the pre-1989 period. Recommendations to strengthen collaborative research investment and activities are developed in section 6.2.

3 Higher education and research in Armenia: two worlds or one?

After the restoration of independence in 1991, Armenia inherited a research and higher education system with HEIs providing teaching and research institutes (RIs) of the NAS or funded by and reporting to specific ministries, so-called branch RIs) that carry out research. This dichotomous framework remains, partly, in place today, even if certain universities have developed research activities. At the same time, from an education perspective, the NAS also plays a role in the delivery of Master's (31 full- and part-time degree courses) and PhD (doctoral) studies in Armenia through the International Scientific-Educational Centre, established in 1997.[16]

3.1 Reform of the higher education system and research-based education

In Armenia, the higher education system is overseen by the MES and regulated by two main laws: the Law on Education (1999) and the Law on Higher and Post-graduate Professional Education (2004), both of which have been amended several times. In addition, every five years, the Government issues an education development programme setting the objectives and priority directions and measures proposed to meet identified challenges.

A draft Law on Higher Education was developed in 2016 (with EU twinning support), however, the new Government decided to do a further review in order to better integrate the higher education and research systems. A new Law on Higher Education and Science has been drafted and was at the stage of public consultation in late 2019. It was expected to be submitted for approval to the Government in December 2019 and then to go to the Parliament for adoption in spring 2020.

The 2004 law sets out the structure, main principles of organisation, funding mechanisms, etc. for higher education. Related regulations cover quality assurance, national qualification frameworks, etc. In 2005, Armenia acceded to the Bologna process and education programmes are aligned with the European Credit Transfer and Accumulation System (ECTS). There are four types of HEIs:

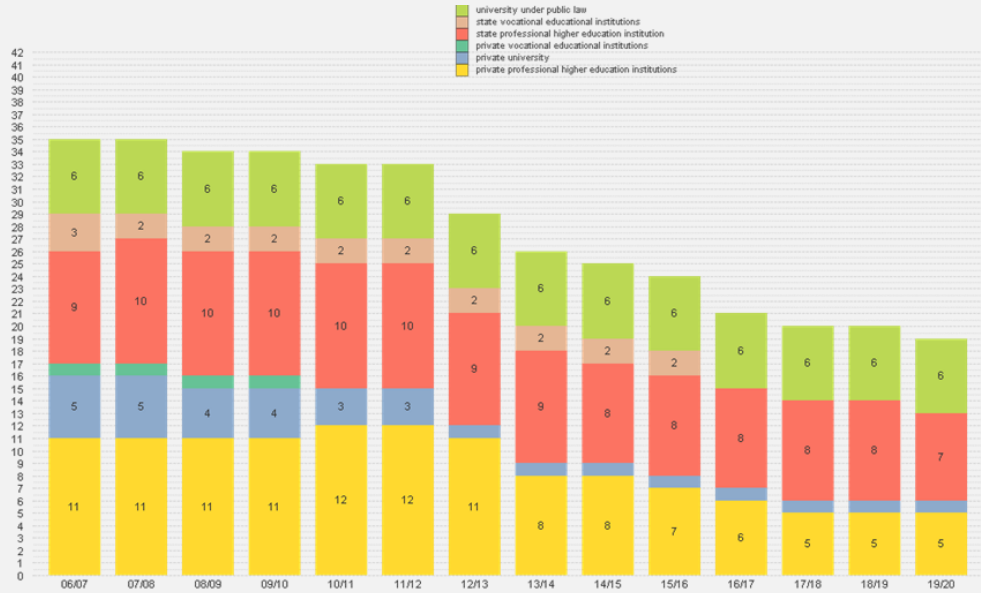
- University (Hamalsaran) providing undergraduate and post-graduate education in various fields as well as carrying out scientific research;
- Institute (Institut) conducting specialised and post-graduate academic programmes and scientific research in one or more scientific, economic or cultural branches;
- Academy (Akademia) conducts programmes preparing and re-training highly qualified specialists as well as post-graduate programmes; and
- Conservatory (Konservatoria) graduate and post-graduate programmes in music.

[16] See: https://www.isec.am/en/about-us/history.html

There are over 60 recognised HEIs: 22 state universities, 37 private universities, four universities established under intergovernmental agreements and 9 branches of foreign universities[17] (EACEA, 2017). Interviewees stressed that the number of students is low in most of the private HEIs that have not been accredited and some are no longer functioning.

Box 1: The consolidation of higher education institutes in Estonia

Estonia is an interesting benchmark as the number of universities dropped dramatically from 41 in 2000 to 29 in 2012/13[18]. Some 60% of this decrease was because of mergers and the rest due to closures. This contraction was, partly, a 'correction' following a rapid growth in the number of institutions in the 1990s.



Source: https://www.haridussilm.ee/ the Estonian "Eye on Education" website.

Most of the mergers were 'vertical', with large public universities absorbing smaller professional HEI and private institutions. An additional element that supported consolidation, but also provided a guarantee to students about the financial stability of their HEI, is the minimal 'capital requirement' of €380,000 for professional HEIs and €680,000 for universities. The latest figures indicate a further contraction to just 19 HEIs: 6 universities under public law, 7 state professional HEI, 1 private university and 5 private professional HEI.

[17] Information at: https://www.mfa.am/en/study-in-armenia provides slightly different numbers namely 26 state universities (of which 4 international), and 33 private (licensed) higher educational institutions.

[18] See: http://www.university-mergers.eu

Hence, compared to the official figures, the real number of operating private universities is estimated to be around 10. However, interviewees also underlined that overall too many students go to university due to a weakly developed professional (vocational) education system. Hence, as an interviewee noted, "Universities are spread too thin and try to cover all topics."

3.1.1 Autonomy of HEIs and funding of higher education

Universities in most European countries are increasingly autonomous in the sense that they decide on their own strategies, choose their own leaders and decide how to allocate their own resources (especially in deciding who to employ). Increasingly, RIs have much of the same freedom. Autonomy is a central feature of university reforms not only because of its relationship to academic freedom but also because, in principle, it means that control of the research-performing system is decentralised, making the system flexible and responsive. The corollary is that in so far as the State needs to influence the behaviour of the research system, it does so through incentives rather than commands.

From a legal perspective, Armenian HEIs are independent and autonomous and are free to carry out academic and/or applied education programmes at all levels of studies based on their profile. In practice (EUA, 2015), however, organisational and academic autonomy are more limited than in the majority of EU countries, while financial and staffing autonomy (university staff are not civil servants) are relatively high. There is a high level of Government involvement in the organisation and decision-making processes of Armenian HEIs (through participation in governing bodies). The legal status of public universities as non-commercial state organisations (NCSOs) limits the autonomy of Armenian HEIs, in the sense that commercial activities require Government approval and are considered to have a negative impact on university-industry cooperation.[19] There has been a move to grant selected HEIs the status of foundation (under the 2002 Law on Foundations) which enhances autonomy by enabling them to create legal entities and carry out commercial activities. We did not hear evidence on the extent to which this new status has improved HEIs' operational autonomy, capacity, research base, or commercial collaborations with business or other organisations (e.g. RIs).

Regarding the financial framework, public funding for HEIs is via an annual block grant determined by student numbers. This is more heavily weighted for doctoral candidates than for undergraduates and Master's students, which are funded at the same level. In addition, Armenian HEIs have full autonomy to set their own tuition fees. However, the very low share of public funding (about 20% of revenue for State HEIs), in comparison to more developed countries, in practice means that: "Even though Armenian universities have a relatively high degree of financial autonomy through the freedom to set tuition fees, the imbalance of public-private funding poses a threat to financial sustainability." (EUA, 2015).

[19] UNCTAD Investment Policy Review 2019
https://unctad.org/en/PublicationsLibrary/diaepcb2019d3_en.pdf

A first key issue is that the block grant is directed to teaching activities, while all research funding is delivered (via the SC) on a competitive basis. Hence, the "low level of core funding for research activities hinders the development of a modern, research-embedded higher education sector" (EUA, 2015). Interviewees noted that the share of funding from the State was, at best, in the range of a quarter of university revenue (the case of Yerevan State University, YSU). At YSU, about 20% of State funding is from the SC for labs and research projects, reflecting that, in addition to 1,060 academic staff, there are 200 'researchers' at YSU. However, it was stressed that, for most other universities, the share of budget allocated to science is much lower.

Indeed, YSU topped the list of HEIs involved in State science programmes in 2017 (5.8% of budget) followed by Armenian National Agrarian University (about 2%). The State Medical University, the National University of Architecture and Construction, and the National Polytechnic University are in the second tier, receiving about 1% of the State budget for science each year.

3.1.2 Quality assurance of higher education including research function

With a view to aligning Armenian HEIs to international standards in terms of academic quality, the external review of HEI quality assurance is carried out by the National Centre for Professional Education Quality Assurance Foundation (ANQA),[20] an independent but public-funded foundation established in 2008. ANQA is a full member of the European Association for Quality Assurance in Higher Education (ENQA). Institutional accreditation is a mandatory process both for private and public HEIs operating in Armenia.[21]

Institutional accreditation is a prerequisite for academic programme accreditation, the latter is carried out on the initiative of the HEI, on a voluntary basis, except for medical academic programmes for which accreditation is compulsory. Institutional accreditation is awarded for 4 or 6 years. Conditional institutional accreditation is awarded for a two-year period, and an institution with conditional accreditation cannot apply for programme accreditation. In the case of conditional institutional accreditation, the education institution cannot open a new speciality. Non-accredited universities do not get State funding and cannot open new programmes.

ANQA carries out a monitoring process in universities and vocational schools on an annual basis and reports on their respect of internal QA procedures. All State universities have internal quality controls in place. However, while the quality assurance system meets international standards, there is a clear distinction between complying with the need to undertake the process of accreditation and full compliance with the required standards.

[20] Further information on accreditation processes in Armenia is available (in English) at: http://www.anqa.am/en/accreditation/#Papers and https://erasmusplus.am/accreditation-in-armenia

[21] A State Register of accredited HEIs is maintained at: http://www.anqa.am/en/institutional-accreditation-state-register/

A second key issue relates to the 6th criterion of the HEI QA procedures, which requires that HEIs ensure "the implementation of research activity and the link of research with teaching and learning". This criterion is judged against four standards, namely that the HEI: has a clear strategy promoting its research interests and ambitions; has a long-term strategy as well as mid- and short-term programmes that address its research interests and ambitions; ensures the implementation of R&D through sound policies and procedures; and emphasises the internationalisation of its research. However, according to interviewees, almost all HEIs have received a negative conclusion for this QA criterion and the four standards. In fact, according to the expert reports available on the ANQA website, only three HEIs – the Yerevan State Conservatory after Komitas (2015), the Armenian State Institute of Physical Culture (2016) and the International Scientific Educational Centre of the NAS – were awarded a satisfactory rating for the R&D criterion to date.[22] Responding to these findings, some universities have taken measures to strengthen this link, for instance at YSU, a performance criterion for academic staff is that, over a period of three years, they should produce at least three scientific articles.

A third key issue is that there is no clear connection between accreditation and the licensing of universities. Prior to the creation of ANQA, all private universities had received a form of 'life-long' accreditation, but from 2011, ANQA began applying ENQA standards to universities and vocational schools. Two private universities got conditional accreditation, while two failed. According to interviewees, since accreditation was launched, two private universities have had their accreditation applications refused, but they remain in operation. Moreover, all private universities should have been accredited by the end of 2018, but this is not yet the case. The proposed changes to the Higher Education Law would give those universities that have not completed the accreditation process time to adjust to the recommendations before they are forced to close.

3.1.3 Doctoral education and research careers in Armenia

A fourth key issue is the organisation of doctoral education and research careers. Firstly, it should be underlined that Armenia maintains the distinction, deriving from the Russian practice, of the status of Doctor of Sciences, a post-doctoral degree, and Candidate of Sciences (PhD). The former is similar to the German *Habilitation* and is awarded in recognition of a substantial and sustained contribution to scientific knowledge. At the present time, doctoral education, the Candidate of Sciences Degree (PhD), is regulated by the Law on Higher and Post-graduate Education (2004), and the Law on Scientific and Scientific-Technological Activities (2000), and a range of other sub-legislative documents. The studies are organised at universities and academies, as well as RIs. These programmes last for three years (180 ECTS). Candidate's thesis defence is conducted by the Professional Councils of the universities or R&D institutes and is overseen and

[22] In addition, the National Polytechnic University of Armenia, the Armenian National Agrarian University, Yerevan 'Gladzor' University and Yerevan Brusov State University of Languages and Social Sciences were given a partly satisfactory ranking in 2015.

ratified by the Armenian Supreme Certification Commission (SCC) (EACEA, 2019).

In recent years, notably with support of the EU's ERASMUS+ and TEMPUS programmes,[23] there has been on-going work to reform the doctoral education system. The introduction of a stronger 'research component' in the new draft law on higher education and science is intended to contribute towards enhancing research-based higher education.[24]

Under the Veritas and C3-QA projects,[25] reviews of the current doctoral system against the Salzburg principles highlighted significant issues that require attention, and these include:

- Doctoral training remains too focused on the advancement of knowledge and not enough on developing transferable skills (lack of a research plan for doctoral candidates, weak educational component of doctoral programmes);

- Doctoral education is poorly integrated in HEI strategies and, along with weak supervision frameworks and over-prescriptive administrative procedures of the SCC, this leads to difficulties for doctoral candidates to complete their PhD in the required duration, quality, etc.;

- The weak links between universities and the labour market, and limited funding opportunities for testing research results in practice, undermine doctoral career development opportunities;

- Inter- and multi-disciplinarity is not encouraged in the current system where narrow specialities tend to be the norm. Doctoral programmes do not include international, interdisciplinary or inter-sectoral mobility as a norm, although such mobility is generally encouraged; and

- A lack of critical mass and insufficient funding limit the application of innovative practices, and doctoral candidates have limited opportunity to work at related RIs or access collaborative or virtual research environments (networks). There is little structured cooperation between HEIs and RIs.

Within the framework of the C3-QA project, QA criteria and standards for doctoral education based on the Salzburg principles have been developed and will become part of the national accreditation system after being piloted[26] and refined. The

[23] Notably the Tempus VERITAS and Erasmus+ C3QA projects

[24] See: https://erasmusplus.am/erasmus-meeting-on-quality-assurance-of-the-3rd-cycle-programs

[25] See: https://c3-qa.com/wp-content/uploads/2017/03/WP1_fact-finding-report_Armenia_new_correct.pdf, https://c3-qa.com/wp-content/uploads/2017/03/Armenia_Cycle-3-issues-and-propositions.pdf and http://www.anqa.am/en/publications/salzburg-principles-state-of-arts-in-the-republic-of-armenia/

[26] The Cycle 3 (doctoral) programmes in Biology at Yerevan State University, in Fine Arts, Design and Decorative Application Arts at Yerevan State Academy of Fine Arts and in Law at French

project results will be embedded in the concept of 'cycle 3' reforms, which is being developed within the Armenian Government's 2019-2023 Action Plan.[27] Moreover, several new ERASMUS+ projects are being funded to further support the reform of doctoral education and implement it in universities, notably the ARMDOCT project[28] starting in 2020 and the DPPHSS project supporting doctoral programmes in public health and social science.[29] The ARMDOCT project specifically aims to:

- Strengthen strategic, infrastructural and human capacities in HEIs and Institutes of the National Academy of Sciences and in the Ministry of Education and Science (MES);

- Develop a new national policy and legal framework, including by-laws for doctoral education in Armenia and receive the approval by MES for pilot implementation;

- Revise institutional policies and procedures based on the redesigned national regulatory framework, and design an Institutional Handbook for Doctoral Education; and

- Establish five Doctoral Schools creating synergies between HEIs, RIs and industry.

In addition to the reforms of the doctoral system set out above, during our missions, **the limited funding for, and status of, doctoral and post-doctoral researchers was underlined as a core challenge**. While all full-time doctoral students enrolled at State HEIs study free of charge and receive a small State stipend, this is not a full-fledged scholarship which could support their research activities. The majority of doctoral students have jobs outside of universities, while some have teaching duties (C3-QA project, 2017). Hence, doctoral candidates are not always treated as early-stage researchers (i.e. employees of an HEI) and do not have adequate standards of social security coverage and rights similar to those of academic staff. In this context, several foundations have begun providing additional grants to PhD researchers, such as FAST Foundation fellowships[30] and EIF grants[31] to encourage and support doctoral research. However, this lack of formal status, insufficient funding and equipment (or access

University in Armenia passed pilot accreditations. These pilots tested and improved the tools (guidelines, standards and procedures) for the quality assurance of Cycle 3 (doctoral) programmes for use in the Armenian higher education system.

[27] See: https://www.gov.am/files/docs/3347.pdf

[28] See: https://erasmusplus.am/course/reforming-doctoral-education-in-armenia-in-line-with-needs-of-academia-industry-and-current-eu-practices-armdoct/

[29] See: https://erasmusplus.am/course/doctoral-programmes-in-public-health-and-social-science-dpphss/

[30] See: https://fast.foundation/#/fellowship

[31] See: http://www.eif.am/eng/news/phd-support-program/

to equipment in RIs, etc.), limited interdisciplinarity and opportunities for mobility within research networks are clearly significant barriers.

The challenges to those considering a research career extend beyond the doctoral studies stage. There is limited dedicated funding for post-doctoral research, although a Young Researchers Support Programme and Action Plan is planned for 2019-2020. Interviewees stressed that the support programme currently in place for young researchers is not ideal, as there is a requirement to have a minimum of three years' experience before applying. This means that many postdocs either end up self-funding their own on-going research or become junior researchers in the labs they conducted their research in (hence limited inter-institutional mobility in Armenia), or they seek positions abroad (brain-drain risk).

More generally, the capacity for universities to promote themselves as a place for a research career is further limited, according to reports (EUA, 2015): "[They] *cannot use salaries as a tool for increasing institutional attractiveness. Likewise, there is a lack of career development opportunities and career paths are not well defined, further hindering universities ability to attract the best staff."* This has a direct effect on the appeal of HEIs as an employer both in the domestic labour market and in terms of attracting international talent.

Furthermore, the need to improve the competitive process for the appointment of teaching staff was underlined during the interviews. Although there is a formal objective and transparent process, in reality people from outside of a university have little real chance to compete. This limits the potential to attract graduates or researchers that could help develop new research-based education programmes.

3.2 Research institute system

As noted in section 2.4, the Armenian RI system is highly fragmented. In addition to the high number of RIs, the issue of the balance between researchers and other staff was raised during interviews, with a view that there is an excessive number of "administrative staff". It was argued that the balance between researchers and other staff is too often unbalanced (with a surplus of administrative staff). However, we did not have access to data that confirmed this.

The interviews conducted underline that while it is possible for researchers from the NAS RIs to teach at universities, this largely occurs through personal relations rather than via a structured institutional or strategic research-education agenda. Moreover, there are few incentives for researchers to teach or for universities to engage researchers as lecturers. There is little evidence of researchers being involved in the joint development of academic programmes. It was suggested that the supervision of masters or doctoral students by RI staff could be added as an objective criterion for performance-based funding for HEIs and RIs to encourage such cooperation.

From the HEI side, interviewees stressed that universities faced a problem of having enough hours for their own lecturers, as university professors are required

to teach up to 700 hours to obtain a full salary. Hence, even when the NAS RI offers to fund their lecturers, the offer is often turned down. There were calls for a reform in the university salary system so that professors/lecturers are not worried about losing pay and are more open to the inclusion of new ideas or experimental research into their curricula. Such a reform would also enable university staff to have more time to carry out research (it was noted that a lecturer with more than 4 hours a week of teaching will find it difficult to do research based on international practice). One researcher was offered a chair at a university which wanted an 'active scientist' but then turned it down due to the restrictions placed by the university on non-teaching activities.

Other interviewees (from the RI side) underlined that there seemed to be a shift in policy-thinking towards moving all science into universities, possibly a **gradual evolution rather than a revolution**. However, there was scepticism about whether developing a research-based education system meant carrying out all research in universities. Interviewees pointed to the case of neighbouring Georgia, where a rapid change forcing RIs to merge with universities had not resulted in an operational merger and instead left researchers in universities as a "third category" of staff. Similarly, in Moldova, the Academy of Science Institutes were simply transferred to the Ministry of Education and Science, which left them in uncertainty about funding. It was noted that there is no mechanism for RIs to have the cost of hosting university students in their lab, hence there is a need for a funding mechanism for RIs to ensure labs are used by students.

There was a general view that high-quality, up-to-date research infrastructure/equipment was not sufficiently available to support high quality research and enable Armenian researchers to compete for EU or international funding (charitable, etc.). Moreover, even when equipment is available, it is often not invested in an optimal manner (e.g. a case of equipment being bought by a line ministry research centre which does not have the specialists in place to use it, while in the NAS RI the specialists are lacking equipment). Stakeholders underlined that in the context of limited State funding (even assuming an increase) and of the fragmented RI landscape, it would be preferable to create a limited number of shared facilities that would provide services and equipment to, for instance, all biologists. As one interviewee noted, "*researchers currently working in one of 10 labs don't need 10 pieces of identical equipment, they need access to the equipment they require wherever it is located*".

3.3 Drivers and barriers to cooperation between higher education and research

Enhancing linkages between education and (public) RIs is critical to ensuring that teaching is based on the latest scientific and technological advances. This is normally achieved through university teaching staff being required to carry out research; or vice-versa, public researchers being invited to deliver courses/lectures or to oversee PhDs, etc. at universities. In some European countries this leads to a dual status, such as in France with the 'enseignant-

chercheur' (teacher-researcher) status that is used for university staff that carry out their research work in public RIs (e.g. the CNRS).[32]

The interviews conducted during the PSF mission underline that exchanges between university and RI staff do exist but that certain factors limit the current potential for cooperation. Currently, there are a limited number of incentives for collaboration. In particular, academics involved in SC-funded research projects receive supplementary remuneration both for their research activities and academic degrees. *"This allows many academics to receive higher salaries which allow them not to seek extra job positions in non-academic sector or in other HEIs." (EACEA, 2017)*

Another example is the World Bank-financed Competitive Innovation Fund[33] (CIF, established in 2011 under the Second Education Quality and Relevance project), which supports reforms in Armenian higher education through promoting innovation and the development of research capacity. The CIF grants support joint projects to "promote cooperation among universities, private sector and RIs". The CIF acts as a policy mechanism triggering innovation and advances in higher education through competitively issued grants. During the period 2013-2018, 15 universities implemented 22 grant projects[34] with a total budget of €7.6 million. Half of the projects were collaborations with private local companies. The last round of the grant allocation, under the current World Bank funding project, is planned in 2019.

Overall, the available evidence and the consultations carried out during the course of the missions point to **factors that inhibit or complicate the potential for cooperation**:

- The legal and financial framework for both RIs and universities places restrictions on their capacity to co-operate.

- The appointment and salaries of university teaching staff are driven by a logic of maximising revenue for universities through student numbers (institutional funding and tuition fees) and of ensuring the teaching staff reach a quota of hours taught required for them to be paid a full salary. This undermines the aim to shift to research-based education.

- Post-bachelor education (Master's, PhD studies) is not yet organised in line with the types of procedures and processes that would be common in more advanced countries.[35] This notably concerns the opportunity for practical experience in conducting experimental research as part of the curricula.

[32] See: https://carrieres.cnrs.fr/fr/accueil-en-delegation

[33] See: http://cfep.am/en/current/innovation-fund/

[34] See for instance: https://www.worldbank.org/en/news/feature/2017/04/18/state-of-the-art-labs-help-armenian-students-and-researchers-pave-way-to-the-future

[35] See, for instance: https://www.scienceeurope.org/media/r35nwieu/20160922-survey-postdocs-final.pdf

- Researcher careers (particularly young researchers at post-doctoral level) are not organised in a manner compatible with (for example) the European Charter for Researchers,[36] and salaries are relatively unattractive (compared to private-sector opportunities, research careers in more developed countries, etc.).

In section 6.2, we develop proposals to support the enhanced cooperation and integration of research activities between the universities and the NAS and public-sector RIs.

[36] See: https://euraxess.ec.europa.eu/sites/default/files/am509774cee_en_e4.pdf

4 Funding science in Armenia – the state of play

4.1 An overview of funding models for research

The term 'institutional funding' refers to government support to research and educational organisations. If we look to other countries, the support normally comes as a combination of non-competitive and competitive funding. Funding systems differ with respect to the proportion of the state budget for research that is allocated to non-competitive versus competitive funding. Depending on the system, institutional funding for research usually has one or more of the following components:

1. Block grant – fixed sum or proportion of the institutional funding budget allocated to a specific research organisation. In most cases block grants are historically based with no specific conditions attached. In some cases, however, they are linked to a 'performance agreement' between the responsible government body and the research organisation. In these agreement (or contracts), the research organisation commits itself to reaching some long-term strategic targets for development, defined by the research organisation itself and negotiated with the responsible Government body.

2. Formula funding – proportion of the institutional funding budget that is driven by certain indicators such as the size of the organisation (e.g. number of PhD students, number of study programmes, number of staff, etc.), and its role in the R&D system. Both research and education activities can impact the level of formula funding.

3. Performance-based research funding (PBRF) – proportion of the institutional funding budget that is specifically dedicated for the funding of research and is driven by indicators that assess the performance of the organisation, such as amount of the research output, quality of the research, relevance for innovation/society, etc. The proportion that is driven by these indicators as well as the characteristics of the indicators and, ultimately, the objectives of the PBRF, vary from country to country.

There are also other possible kinds of institutional funding, for example:

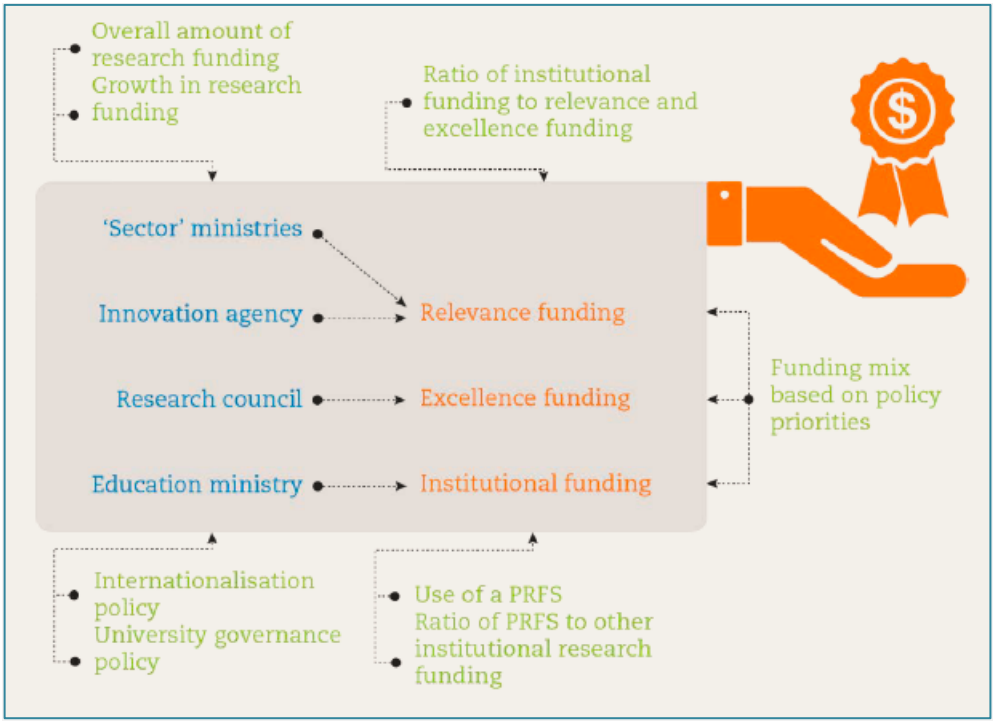
- Research organisations may also receive additional non-competitive funding, for example for purchase/maintenance of scientific equipment or other infrastructure; and

- Universities may receive separate 'teaching funding' as an institutional income stream separated from the research funding. Such teaching funding is normally indicator-based and reflects the number of students, graduates, professors, etc.

Figure 4 presents a schematic view of a typical national research funding system.[37] Typically, an education ministry provides institutional funding (non-competitive and performance based) and competitive project funding (grants) for 'excellence' research, often via a research funding agency (in Armenia the SC plays this role).

In countries which have developed a PBRF component within institutional funding, many use the amount of external research funding as a quality indicator and a sign of both the 'excellence' and 'relevance' of the research being carried out at HEIs and RIs. International research funding, such as the EU Framework Programme (currently Horizon 2020), can provide incentives for both relevance and excellence, in addition to those provided at the national level. Thus, external funding can function as leverage for PBRF.

Figure 4: A framework for national research funding systems



Source: OECD Science, Technology and Innovation Outlook, 2018, pg. 200. NB: PRFS in this diagram stands for Performance-based research funding system.

[37] For an overview of the main concepts behind research funding, the relative importance of different types of funding and trends in terms of the share of PBRF, see notably the reports available through the 2017 PSF Mutual Learning Exercise (https://rio.jrc.ec.europa.eu/en/policy-support-facility/mle-performance-based-funding-systems) and chapter 8, 'New Trends in Public Research Funding' in the OECD Science, Technology and Innovation Outlook 2018.

Ministries responsible for industry and various other fields (energy, environment, defence, etc.) may fund research (and innovation) of relevance to their policy objectives (societal relevance, industrial relevance, etc.) undertaken within the research and higher education system directly or through an innovation agency.

Institutional funding can be given unconditionally (the 'block grant' mentioned above) and that has often been the case in the past. A disadvantage with this is that researchers experience little pressure to make extra efforts to perform well. Therefore, the amount of institutional funding that research organisations receive has increasingly been linked to the production of a range of research and innovation outputs. For universities, education outputs are usually also considered. In principle, this allows the research system to evolve, growing in fields and places where it is strong and shrinking where it is not.

Performance can take place and be monitored at different levels. The most obvious distinction is probably between the individual level and the institutional level. PBRF primarily targets the institutional level, but in some countries it involves the individual level too. An obvious downside with a system that targets the individual level is that it reduces risk-taking in research as individual researchers dare not explore uncertain or apparently 'risky' fields. Such a risk-averse culture is negative to the development of overall research performance. If PBRF targets the individual level, it is important that the time frame for measuring the performance is relatively long, i.e. long enough for the research results to be reached. If it is, there can be room for risk-taking.

Many countries struggle to find a steering mechanism to enhance quality, diversity, profiling and performance. A comprehensive system of funding that encourages the overall performance of universities could include the following domains and indicators:

- Research
  - Indicators include PhD awards, research publication output, research impact, external research income as percentage of total income, and post-doctoral positions
- Teaching and learning
  - Indicators include completion/progression rates, pedagogical qualifications/training of academic staff, graduate unemployment rate vs. national average, and staff-student ratio
- Knowledge transfer
  - Indicators include start-up enterprises and spin-offs, patents and licenses
- Engagement
  - Indicators include internships, joint programmes and joint publications
- Access

- Indicators include participation by targeted (disadvantaged) socio-economic groups, share of learners with a disability, participation by ethnic minorities, etc.

- Internationalisation

  - Indicators measure the number or share of international students, number or share of international staff, participation in international research programmes, and joint publications

Clearly, there is a difference between funding of research and funding of education. In some countries, the performance-based funding separates the two, while in other countries the system does not. Evidently it is easier to identify a variety of performance indicators related to research than to education.

Indicators related to research performance can be manifold: bibliometrics, PhD graduates, research grants, external funding (amount of funding as well as number of funding organisations), post-doctoral positions, etc. By contrast, **indicators related to education** tend to be limited to the number of students, number of exams, and possibly proportion of PhDs among teachers. Furthermore, there is a difference between quantitative and qualitative indicators, where the former measure output or outcome, while the latter measure quality. Most countries that have some sort of performance-based funding in place relate this to quantitative output rather than quality. Though considered as an important issue in many countries, performance-based funding, where the quality of the performance is assessed and linked to funding, appear to be limited. The quantitative output that is measured through various indicators is often assumed, indirectly, to reflect the level of quality.

If we view PBRF in this systemic way, there are clearly policy choices to be made – and there needs to be a balance between forces that encourage renewal and flexibility, and forces supporting stability. There is no one size that fits all; the combination and balance may differ according to various characteristics that are unique to each country. However, many countries combine funding for higher education and research.

As a comparison, the funding system in three European countries (Austria, The Netherlands and Norway) is summarised in Table 2 While these countries differ in tradition and character compared to Armenia, with respect to the research system, they also differ between one another. These are examples; we see no reason why Armenia should not look towards countries beyond the former Soviet States and Eastern Europe for inspiration on how to design a PBRF system. We believe that there is much to learn from small and medium-sized countries throughout Europe and probably in other parts of the world as well.

In particular, we draw attention to the case of Norway, where 'external research funding' is used as an indicator that has impact on the level of government PBRF. As can be seen in the table, there are two indicators related to external funding: external funding from the EU, and external funding from the Research Council of Norway and other regional research funds in Norway (marked in bold). Using external funding of this kind as an indicator for government PBRF creates

incentives to attract funding from external sources, both from national public sources, like research councils or other research funding organisations, as well as from funding bodies abroad. The European Commission's Research Framework Programme is what first comes to mind, but there are others. The private sector, most likely knowledge-intensive large companies, is yet another category of external research funding organisations, as are charitable foundations.

Table 2: Summary of funding characteristics in Austria, Netherlands and Norway.

	Austria	The Netherlands	Norway
Government funding (direct appropriations)	• 3-year funding periods • Performance agreements + performance-based funding	• Combined funding of research and higher education	• Combined funding of research and higher education • Non-competitive block funding + performance-based funding
Sources of funding of universities	• Ministry funding: 80% • Competitive external funding: 20%	• Ministry funding: 57% • Project funding of research and higher education: 26% • Tuition fees: 8% • Other: 9%	• Ministry funding: 64% • Research Council of Norway (RCN): 17% • Other public funding organisations: 8% • Industry funding: 5% • International funding: 3% • Other private funding organisations: 3%
Performance-based components	• No. of active students • No. of exams • Knowledge transfer • Participants in PhD schools	• No. of students • No. of awarded Bachelor and Master's degrees	• Study points • No. of foreign students, incl. ERASMUS+ students • No. of awarded Bachelor degrees • No. of doctoral candidates • External funding from the EU • External funding from RCN and regional research funds • Income from specific

	Austria	The Netherlands	Norway
			• commissioned activities • Publications
Performance agreements	• Performance agreements constitute 92% of government funding	• Test of performance agreements 2011-2016	• Performance agreements with some HEIs (not all)

Source: Melin G. et al. (2018): 'Statlig finansiering av universitet och högskolor i Nederländerna, Norge och Österrike' (Government funding of higher education institutions in the Netherlands, Norway and Austria). Confederation of Swedish Enterprise, 2018

4.2 The current funding system in Armenia

In Armenia, government research funding through the science budget is managed by the SC via four main financing mechanisms (Hovhannisyan, 2019):

1. Financing the maintenance and development of science infrastructure (about 60% of total budget) which is allocated to state-owned RIs;

2. Special purpose R&D, such as defence-related projects (about 11%);

3. Thematic funding based on calls for proposals from the research community (about 7%); and

4. A small portion for collaborative and applied research (less than 1.5%).

The research funding provided via the SC is split between institutional funding (covering fundamental and applied research, maintenance and development of research infrastructures, support to PhD students and 'bonus' payments to scientists with academic degrees) and competitive grant funding, including competitive schemes. More precisely, funding was distributed as follows in 2018:

- Basic or 'institutional funding', including premiums for those with a scientific degree (73%);

- Financing of state programmes or 'target funding' (18%); and

- Contract-based research or 'thematic/topic financing' (9%).

None of these funding streams are allocated due to the institutions' performance; although the SC does take into account the expected research outputs indicated in funding requests. Individual researchers' applications for funding through any of the programmes (target funding) are evaluated on a competitive basis by independent experts or a board, but this is not the same as a PBRF system.

The process for selection of applications by the SC received under national grant programmes with the support of a 'professional expert commission' is well regarded in the Eastern Partnership and Eurasian community. First implemented

in 2010, the research community and NAS were initially somewhat reticent, as they wanted to be reassured that it would be an objective assessment. After nine years, the scientific community has broadly come to accept the system. In a first step, an evaluation by two experts (and a third if required), selected at random from a list of approved experts, takes place. Scores are awarded for research interest, the team and the management of the project. The average of the expert assessment counts for 85% of the final score. An Expert Commission then reviews the proposal and the opinion counts for 15% of the final score awarded to the proposal. The SC has an expert database of 1,500 experts across various scientific fields, 500 of which are located abroad (generally of Armenian origin).

The basic funding is allocated by the NAS to RIs on a per capita (employee) basis of AMD 100,000 (average salary + 20% overheads). This approach appears to ignore differences in costs in different scientific fields and gives little room for competitive attraction/retention of top researchers. It was noted that the few larger universities with RIs are able to attract young scientists to those institutes, as they offer a positive salary differential. Overall, the low salary rates for research and the absence of post-doctoral funding were seen as negatively affecting the motivation for people to embark on a research career path.

The scale of projects funded was raised as an issue by interviewees. Most grants are in the range of €30,000 for two years. Researchers considered this level to be unrealistic, even given salary costs, and the argument was made that it would be better to award larger sums (say €200,000) to allow research teams to develop, based on a strategic plan, and then provide smaller sums as project-based funding in a second phase.

From 2020, it is foreseen that the SC will launch thematic calls. This will be based on consultation with other ministries to identify topics of strategic importance for Armenia. Annually, the aim is to organise four calls with five projects funded per theme with a planned maximum per project up to €30,000 for two years.

A limited number of projects (1.5% of total funding) are implemented with the support of the private sector with budgets up to €150,000 for two years (65% funded by SC, 35% by private sector). However, it is clear that the scale of collaborative funding for research-industry cooperation in the Armenian R&I policy system is insufficient to incentivise greater cooperation. Moreover, the absence of an innovation agency providing funding (e.g. innovation vouchers, funding for feasibility studies, etc.) and advice and support to businesses seeking to engage in contract or collaborative R&D is a weakness.

Finally, in terms of leveraging external financing, notably the EU's Framework Programme (Horizon 2020 will soon be replaced by Horizon Europe), Armenian research organisations lack funds to co-finance (their own financial contribution) to such research grants. The SC has implemented a Special National Bonus Programme, since December 2017, to encourage the participation of Armenian research teams in Horizon 2020. The programme provides a grant to Armenian research teams involved in winning proposals of up to €25,000 per project (for two years) and up to €30,000 if the Armenian organisation is the coordinator. It may be advisable to review the level of support provided and the SC could provide

a letter at the proposal stage guaranteeing that they will have the funds to cover their financial contribution if the Armenian RI wins the grant.

Consequently, the Armenian research funding system lacks economic incentives to perform well on an institutional level. This circumstance most likely hampers the quality development of the system, as a whole, as there are no incentives to change and try to perform better. Furthermore, the research programmes that are in place and to which Armenian researchers can apply, provide insufficient resources to build up a research profile and explore a research path of interest. The result is that the Armenian research system, despite some promising elements, remains in a 'steady state'. Protection of this steady state unfortunately has become a safer way to secure institutional funding for the RIs themselves, than to suggest and support changes of the system, as changes involve risk.

5 Evaluation of research – issues, lessons and experience in Armenia

In this chapter, we discuss the evaluation of research units in Armenia and the potential for the development and implementation of REA at a national level. In a first step, we distinguish between REA as a means to approaching, and solving, more fundamental problems facing the Armenian science, research and innovation system; and REA as a specific practice for selection (of research units, projects, programmes, etc.), and for introducing selectivity in the resourcing and support of these units.

In a second step, we discuss key concepts and frameworks as the literature on REA does not generally offer usable and helpful frameworks for selecting comparable and informative cases. In particular, there is a need to discuss the strengths and weaknesses of different REA frameworks for specific scientific communities and organisations, and tailored proposals for the design and implementation of such arrangements.

At the outset, it should be stressed that the **design and institutionalisation of REAs critically depend on the vision or purpose of conducting science within a country.** In other words, a vision of science as an important factor for social and economic progress is likely to demand something dramatically different from a research evaluation agreement that starts from a vision of science as purely a contribution to human knowledge. Hence, elaborating such 'visions', and achieving consensus about them, is a critical condition for the successful and useful implementation of REAs.

5.1 REA as a means for tackling wider issues of the Armenian science system

In a first instance, it is important to distinguish between a REA as means to tackling more fundamental problems of the science, research and innovation system and a REA as a practice for selection and selectivity. In chapter 2, we discussed the challenges facing the Armenian higher education and research system which need prompt resolution, the most relevant for the design and implementation of a REA in Armenia are:

- The lack of a shared vision about the nature and functions of science (and the science system);
- The level of public funding for the Armenian science system and the corresponding need for selectivity of funding to research units; and
- The fragmentation of the Armenian science system, the duplication of research effort and the need to align the science system to the scale and structure of the economy.

We believe that designing and implementing a systemic REA for Armenia could be helpfully used as a vehicle for discussing and resolving these problems. However, the introduction of a REA system raises several issues:

- There is only rudimentary experience in Armenia with the evaluation of research units;

- To the extent to which there is experience of conducting assessments, this is limited to the quality of research output; there is little experience and tradition of evaluating the conditions for research;

- High levels of complexity characterise REAs, and they require high levels of competence, organisation and commitment; and

- There is no dominant REA model that is employed elsewhere.

These issues, combined with the benefits that implementing a REA in Armenia could bring to the science and research system, guide the structure of the rest of this chapter.

5.2 Current research evaluation arrangements in Armenia

While Armenia has not established a research evaluation framework to assess the efficiency and effectiveness of all research units, there is some experience on which the Armenian stakeholders can build. In particular, within the NAS there is an annual reporting framework for research institutes. However, the process of annual reporting carried out by NAS RIs appears to be viewed largely as a bureaucratic, rather than an accountability, exercise. Other RIs, under ministries or within HEIs, have not been subject to any form of evaluation or annual reporting exercise to date.

Moreover, the ANQA higher education quality assurance and accreditation process has, since 2015, provide an assessment of HEIs' capacity to manage and organise research. The ANQA procedure covers R&D strategy and capacities of the HEI, rather than focusing on performance factors. This process, while not equivalent to REA does, in the Armenian context, provide an important indicator of the current capacity of HEIs to develop and implement research activities.

Of relevance for the design of a future REA system is that **a one-off evaluation of the NAS RIs took place in 2016**. This exercise aimed to assess the efficiency of the existing RIs and laboratories and enable the NAS Presidium to:

- Develop strategies for increasing the contribution of the RIs to the socio-economic development of the country;

- Increase the contribution of scientists in Armenia to the world science and allow them to compete successfully internationally;

- Improve the image of NAS among the public; and

- Increase in the efficiency of the NAS research network.

The evaluation was carried out by an expert group made up of Armenian scientists with thematic sub-groups headed by a non-academic chairperson. An effort was

made to ensure that experts included scientists/scholars from outside the NAS RI network (i.e. from Armenian universities or non-NAS RIs).

The management of each NAS RI was asked to complete a self-assessment template covering 10 specific criteria, namely:

1. Research topics in the institute/lab and how these relate to research at the forefront of the respective research fields;

2. Scientific capacity and efficiency of the research being carried out;

3. The degree of engagement of the research institute/lab in the national and international scientific and educational community;

4. Consulting activities of the research institute/lab;

5. Commercialisation of research results;

6. Human resources;

7. Infrastructure and resources for research fields;

8. Funds of the research institute/lab;

9. SWOT – analysis (self-evaluation); and

10. Strategy and scientific perspectives for the upcoming years.

The information to be provided was a mix of indicators, self-assessment and strategic vision. Based on these completed templates, the expert group conducted the assessment and summarised their findings in a report including recommendations for improvement.

While this provides a basis for designing a future REA, there are several weaknesses:

- First, this exercise involved only the NAS RIs. This is problematic because the results of the evaluation do not enable, and even may hinder, a broad approach to transforming the national science and innovation system that also involves higher education.

- Second, the evaluation seemed to assume organisational change rather than a more fundamental transformation of how research is organised in Armenia. In other words, the recommendations offer ways to improve the existing institutes rather than make suggestions for the rationalisation, integration and streamlining of the national research system.

- Third, a large number of indicators were drawn up but with insufficient attention to the relevance of the research (for society, business, environment, etc.) and linkages to HEIs

- Fourth, and most importantly, the outcome of this evaluation took the form of recommended changes that were not backed by clear incentives. As a result, members of the local knowledge communities reported that they were either not aware of this evaluation or that because there was no funding incentive linked to it, it degenerated into a bureaucratic exercise.

In April 2019, the Minister of Science and Education issued an Order on the "*approval of the main principles and criteria for evaluating the efficiency of scientific and technological activities, classification of categories and core funding of scientific or technological state organisations*". This Order sets out the main principles and criteria for evaluating the efficiency of scientific and technological activities and core funding from the state budget. It lays the groundwork for a future research evaluation arrangements for Armenia. Scientific activities are grouped in six 'spheres': natural sciences, engineering and technology, medical sciences, agricultural sciences, social sciences and Armenian studies and humanities. The order defines seven criteria for assessing the efficiency of research activities:

1. efficiency of research, calculated per employee worker (publications, patents, etc.)

2. human resource potential (percentage of scientific or engineering-technical employees in the total personnel; percentage of young (under 35 years of age) scientific employees in the total scientific workforce, etc.);

3. Logistics – availability of appliances, equipment and other means necessary for implementation of scientific and technological activities:

4. the level of integration into international scientific-educational system (e.g. the share of funds received from international organisations in total funding)

5. the level of integration into the national scientific-educational system (e.g. importance of doctoral candidates, specialised departments or joint scientific-educational departments, the percentage of scientific employees carrying out teaching/tutoring activities

6. the level of commercialisation of scientific and/or technological results (including funding for applied research from private sector, share of total research with an applied component)

7. efficiency of financial activities (e.g. the volume of finance for work implemented under contracts with state bodies or the private sector in total finance)

While the criteria are relevant, the proposed impact score is calculated as a composite indicator, applying a formula defined in the order, which risks resulting in a rather rigid interpretation of the results. Particularly as, the Ministerial Order proposes to categorise research institutes (or departments of universities) based on the results into four categories: 'high efficiency'; satisfactory efficiency;

unsatisfactory with recommendations for improvements to be made within three years; low efficiency resulting in a discussion on the continued existence of the RI or HEI department.

5.3 Research evaluation arrangements: critical aspects

A meta-analysis of the literature on REA found thick descriptions of evaluation systems, mainly in countries like the United Kingdom, Australia, and the Netherlands where such arrangements are firmly institutionalised (Thomas et al. 2019).[38] While being aware of how such evaluations are organised elsewhere can contribute to policy learning, this learning is by necessity limited because of vast differences in initial conditions. Put simply, **it is very unlikely that the research evaluation systems in place in such countries can be implemented, or even that their implementation is desirable, in Armenia**. To develop an appropriate REA for the Armenian science system, we first outline a typology of REAs, derived from international experience[39], and then illustrate the processes and outcomes by two relevant cases: the Czech Republic and Latvia.

5.3.1 Types of REA

Firstly, an evaluation may be framed by three main questions:

1. What is? (This is about collecting information regarding the current state of the object of evaluation relevant to the overall aim of the exercise);

2. What ought to be? (This is a vision of the desired state of the object of evaluation and involves the development of norms, standards, etc.); and

3. How to get there? (This is about the steps/action necessary to progress from the current state to the desired one were there to be a difference between them).

These questions correspond to three elements of any evaluation, namely:

- Information;
- Judgment building on established norms and standards; and
- Action.

REAs can vary according to the kinds and form of information that is collected, the group/organisation that is responsible for elaborating or judging the

[38] Thomas D., M. Nedeva, M. Morales Tirado, M. Jacob (forthcoming) 'Research evaluation and its effects on the science system: Meta-analysis of literature'; in Research Evaluation.

[39] This framework for designing REAs has been developed using the experience, and lessons, of research evaluations in over 30 countries. Furthermore, we have chosen examples only from countries that either emphasise a certain point or offer directly applicable ideas for Armenia.

information, and the type of criteria used to achieve this, and the type of action or incentives that follow the judgement.

Secondly, REA can be either 'steering' and 'enabling.' This distinction matters because it provokes very different responses from research organisations. In the case of steering REAs, the signal to research organisations is mainly about attracting block-grant research funding. In the case of enabling research evaluations, the signal to research units is about raising reputation and performing better in different rankings. Hence, research units are likely to implement very different performance requirements. Depending on the type of information used, these two types of REA can be either characterised as Mark 1 (based on narratives) or Mark 2 (based on indicators).

An example of a steering Mark 1 REA is the evaluation exercise in the UK (known as Research Excellence Framework, or REF) (See Barker, 2007 and Bence & Oppenheim, 2005). Similarly, an example of a steering REA Mark 2 could be the Australian Research Quality Framework (Donovan, 2008). An example of an enabling REA is the research evaluation practice in the Netherlands (Leisyte & Westerheijden, 2014).

To sum up, four types of REA can be distinguished as illustrated in the table.

Table 3: Four types of REA

	Steering REA Mark 1	Steering REA Mark 2	Enabling REA Mark 1	Enabling REA Mark2
Information	Research output Narrative	Research output Indicators	Research environment Narrative	Research environment Indicators
Judgment	Lay academic Proxies	Lay any Proxies	Lay any Proxies	Lay any Proxies
Action	Material	Material	Reputational	Reputational

NB: 'Lay academic,' refers to scientists and scholars that may be involved in systemic REA, but their research is not in the immediately assessed research field. For instance, string theorists will be lay academic members of an evaluation panel assessing developments in structural biology.

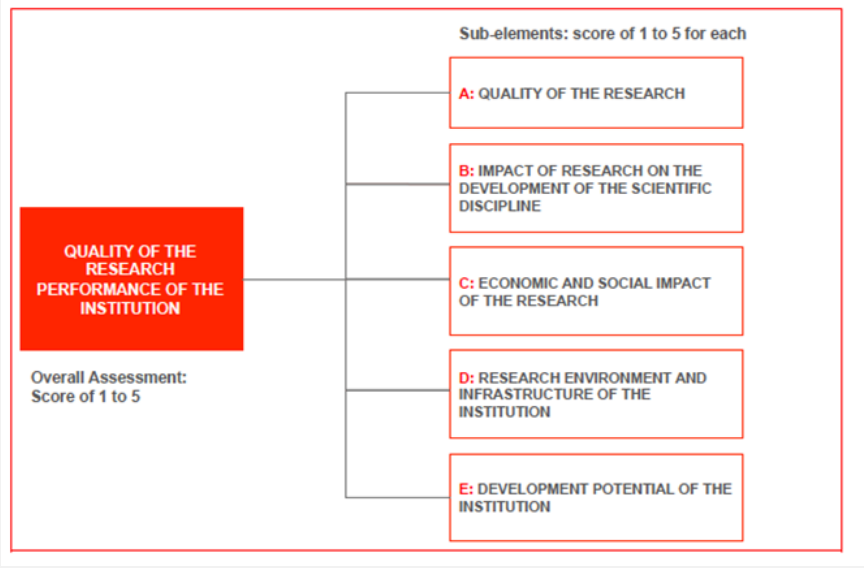
Irrespective of the type of research organisation, it is inevitable that 'gameplaying' on the part of research units will occur. The games that are played vary between the different types of REAs. For instance, a REA with the characteristics of 'steering Mark 1,' is likely to prompt games in the selection of evaluators, and lead to institutional rules instructing academics to target specific journals. Gameplaying in the context of 'steering Mark 2' REAs is likely to target the numbers of publications, numbers of citations and other established indicators. When it comes to 'enabling' REAs, gameplaying can be expected to be targeted at manipulating rankings and other 'reputational' policy tools. Finally, it

is worth mentioning that the four types of REA can be implemented at a systemic level (e.g. national or regional level) or the level of research organisations.

Box 2: A Baltic experience with REA – Latvia

In 2012, the Latvia Ministry of Education and Science launched a first International Evaluation of Science (IES) to assess all institutions listed in the Register of Research Institutions in terms of scientific quality, relevance, socio-economic impact, research environment and development potential. The evaluation was based on self-assessment reports, bibliometric analysis and peer review, which included both desk work and site visits. The research institutions prepared a self-assessment report and highlighted their most important research outputs.

With assistance of the Nordic Council of Ministers and NordForsk, the Ministry of Education commissioned an international consultancy to develop the methodology and support the six peer-review panels: one for Natural Sciences and Mathematics, one for Life Sciences and Medicine, for Engineering, for Agriculture and Forestry, for Social Sciences and for Humanities. The peer-review panels received self-evaluation reports, bibliometric analysis and other relevant data, such as the age structure of the research workforce and government investments in infrastructure. Panels assessed the research institutions and their units against five criteria: scientific quality, relevance, socio-economic impact, research environment and development potential, and awarded scores (1 to 5). They also awarded an overall score that was based on the discussion of the five scores and expert judgement about the quality of the research performance of the institution.



Technopolis Group (2013)

After the assessment, the Latvian Government made a decision to institutionalise the assessment and to carry it out every six years. Subsequently, the Law on Scientific Activity was amended to legitimise this decision. To incentivise consolidation of the research system, the Government made a decision to withdraw funding from those institutions with the lowest scores (scores 1 and 2) unless these institutions voluntarily merged with universities or other research institutes. The best-performing institutions (scores 4 and 5) received extra funding in the form of an additional 15% to annual base-funding through the institutional 'block grant' that research institutions receive from the Government.

To facilitate voluntary mergers, the Government launched several programmes that favoured those institutions that received higher scores and those who voluntarily merged. It also allocated funds for developing new research programmes to align research with the strategic goals of the country. The process of developing Smart Specialisation Strategy which was a pre-condition for allocation of European Structural Funds facilitated the search for the relevance of research and development of system-wide incentives.

As noted above, the cases of REA from more advanced or larger countries are not necessarily the most appropriate for Armenia. Two more relevant examples, the experience of Latvia and the Czech Republic, are presented in boxes.

Box 3: Research evaluation arrangements in the Czech Republic

The evolution of the arrangements for the evaluation of research organisations in the Czech Republic provide an informative case for other countries considering introducing a systematic REA and the adaptation these may need to undergo.

Following in-depth international advice and building on experience in countries with mature science and innovation systems and economies, the Czech Republic introduced a Methodology of Evaluation of Research Organisations and Evaluation of Finished Programmes, which ran between 2013 and 2016. This methodology was comprehensive, complex and structured around three pillars, namely:

Pillar 1) Field specific evaluation of publication results (organised by groups of fields and attempting to normalise research outputs for these groups, bibliometrics based);

Pillar 2) Evaluation of the quality of selected research results (peer-review-based exercise aiming to identify the top-quality research outputs in each field group and reward the contributing organisations); and

Pillar 3) Evaluation of patents and non-publication results.

This methodology was found to be over cumbersome, not very efficient and assigned a nickname: 'the paper grinder'.

Consequently, an alternative methodology for the evaluation of research organisations, known as Metodika 2017+, was developed and piloted. This is a quality

evaluation system incorporating five modules assessing: the quality of selected research results; efficiency of research; social relevance of research; viability of research; and research strategy and policy.

It is conducted as a combination between bibliometrics-based techniques, remote reviews and expert panels. There are six expert panels corresponding to the six Frascati research fields groups: Natural Sciences, Engineering and Technology, Medical and Health Sciences, Agriculture and Veterinary Sciences, Social Sciences and Humanities and the Arts. This evaluation is to run every five years and would have implications for research funding to research organisations.

What is interesting is that the evaluation framework applied to all kinds of research organisations (universities and research institutes) and allows for change of emphasis regarding expected performance.

More information at: https://www.vyzkum.cz/FrontClanek.aspx?idsekce=695512

5.3.2 One-off and periodic research evaluations

Evaluations in countries with highly developed science systems are largely self-regulating. Self-regulating here does not mean that these science systems are a 'Republic of Science', but that organisationally mature science systems develop organically. In other words, research units that have become redundant, or underperform severely, are phased out or reformed with minimal political intervention. This is clearly not the situation in countries where the broader arrangements for science and research are undergoing a rather dramatic transformation. In such systems, an initial rationalisation of organisational arrangements for carrying out research is needed. Hence, we distinguish between two phases in implementing a research evaluation exercise.

1. A first research evaluation to assess the viability and positioning of existing RI in the context of the restructuring of the national R&I system; and

2. Adapt the method based on the experience of implementing the first evaluation and realise periodic (every 3-5 years) research evaluations to optimise the system.

The two research evaluation phases are likely to be different, notably in terms of the action that is taken, with the first round focusing more on relevance and viability of RIs within the system and taking account of the pre-existing 'conditions' (access to equipment, etc.) for RIs to carry out research. Both rounds should address the quality and performance of RIs.

5.3.3 Organisational aspects of research evaluation

The organisational aspects of REAs involve a reflection on the distribution of authority and tasks. For instance, this concerns:

- Who collects information;
- Who is responsible for developing the judgment (including who sets the criteria, how are these elaborated etc.); and
- Who decides on the policy action and implementation.

These aspects are context sensitive and the final choice should be made by national stakeholders. Designing the organisational aspects of a REA also needs to be based on detailed, and mainly local, understanding of the roles and limitations of local policy, expert and research actors.

5.3.4 Key principles of REA

For the successful implementation of a research evaluation and the follow up of its results, it is important to observe the following four principles.

1. **Congruence** (with broader national aspirations for wellbeing, wealth and defence) – The choices made in the context of designing REA ought to be congruent with the national aspirations for future development. Agreeing on the role that science, education, technology, and innovation play for this future is an absolute pre-condition for introducing REA;

2. **Transparency** – It is important anywhere for building trust in the exercise and engendering the broad support it demands were it to succeed. Ensuring that decisions regarding the design and implementation of research evaluations are transparent is particularly important in countries with the historical background of Armenia. Transparency from an early stage contributes greatly to confidence in the outcomes and willingness to act;

3. **Legitimacy** – The REA ought to have legitimacy with all relevant actors; e.g., the organisation managing the REA must have recognised authority; and

4. **Trust** – Mechanisms for selection, including variants of peer review and REAs, can suffer from a break down in trust. It is a serious matter anywhere. Building trust in system(s) and rules is especially important in small countries.

These four principles are important when it comes to designing and implementing REAs in Armenia. Enforcing these requires specific and concerted policy action. In the next chapter we suggest ideas for a first-round evaluation followed by suggestions regarding the design and implementation of a periodic evaluation.

6 Future options for increasing the performance and societal and economic relevance of Armenian science

This chapter sets out recommendations for developing a stronger research system in Armenia through the implementation of specific measures in the three areas addressed. We begin with **four over-arching recommendations** to the Armenian authorities on the necessary conditions for a successful reform of the higher education and research systems.

Recommendation 1: There should be a significant consolidation of the higher education sector into a limited number of full-sized comprehensive universities conducting both higher education and research.

The on-going reform of the higher education system is a pre-condition for the reinforcement of scientific research. This reform should lead to a **significant consolidation of the higher education sector** into a limited number (5-6) of full-sized, comprehensive universities conducting both higher education and research and, thereby, enhancing the quality of research-based education. A stricter application of the process of accreditation and licensing of universities and the introduction of measures, such as a minimum number of students per course, will help to reduce fragmentation. A shift to research-based education implies that, in the future, universities should provide a complete cycle of third level-education (including doctoral education), that university teaching staff should be required to conduct research (implying a reduction in the required number of hours of teaching per staff member).

Recommendation 2: A significant increase in the level of Government funding of research in Armenia.

In a first instance, this could take the form of an additional 'appropriation' linked to the introduction of the REA and/or the PBRF (see below) and providing additional funding to higher ranked RIs. Doubling the current levels (in share of GDP) would place Armenia on the level of Ukraine (0.5%), while a more ambitious target could be to move towards the levels of investment of Serbia or Lithuania (about 0.9%). Clearly, this may not be achievable overnight. Without an increase in Government funding, it will be difficult to ensure that the process of consolidation and restructuring triggered via the REA will lead to a significant increase in performance. At the same time, we agree that simply increasing funding without measures to improve performance and encourage the structuring of the research system will not lead to a better overall result. The two elements need to be closely inter-linked, as we set out below. An option to be considered is that the additional appropriation during the period 2021-2025 could be (part)-funded by the European Commission through a budget support mechanism conditioned on the implementation of the REA and reinforced governance of R&I policies.

Recommendation 3: The role of the National Academy of Science should be changed to become a learned society, as in most European countries.

This should involve a process of change rather than a 'big bang'. The legal status and governance structure of the NAS RIs should be adapted over the coming three to five years (e.g. becoming autonomous public research organisations, merging into universities, etc.). The NAS could retain and develop certain functions such as scientific information and advisory services, science diplomacy role, etc.

Recommendation 4: Measures should be taken to strengthen the governance structure for R&I policy in Armenia.

These could include: the creation of a national R&I council to oversee a cross-cutting approach (inter-ministerial, inter-sectoral, multi-disciplinary, etc.) of the design and implementation of R&I policies (including a proposed research infrastructure roadmap – see section 6.2.1), and the strengthening of the SC's autonomy as a national research funding agency (in terms of staffing and training and to manage a potentially large flow of funds delivered through an updated portfolio of projects). The absence of an innovation support agency on the enterprise side is an unresolved issue. In the short term, the SC could develop measures targeting industrial applied R&D funding.

6.1 Research evaluation arrangements for Armenia: ideas for design and implementation

In this section, we outline our ideas on how to design and implement system-wide research evaluation in Armenia. These ideas concern the following points:

- Revisiting the critical aspects of research evaluation arrangements, which are important for proposing an appropriate model for Armenia;
- Sharing relevant experience elsewhere; and
- Clarifying the key features of the existing REA in Armenia.

We have elaborated the key steps and a timeline for the REA design and implementation in Armenia. These proposals are aligned with those of the other two topics addressed by this report.

6.1.1 Level of evaluation arrangements

We recommend the design, and implementation, of a national level research evaluation executive covering the NAS RIs, university research laboratories and institutes in universities, and the branch (or sectoral) RIs. Furthermore, this evaluation ought to be aligned with an assessment of the higher education system in Armenia and its economic and industrial strategy.

6.1.2 Type and periodicity of REA

We believe that it is urgent to carry out a **first research evaluation in Armenia,** to rationalise the organisation of research and select priority areas for future investment. The first evaluation should explicitly aim to assess the research capacity and link this capacity to the national research priority areas and national development priorities. In a second phase, the Armenian authorities may adapt the REA and implement a periodic (e.g. every five years) research evaluation to optimise performance (and inform the PBRF element in the system). Table 4 presents the key elements for successfully carrying out both the first-round evaluation that will focus on selectivity; and subsequent periodic evaluations that seek to optimise research performance, inform strategic investment and increase the relevance of research for society.

Given the eroded, and eroding, conditions for science in Armenia, and that increased reputation does not currently appear to be a sufficiently strong lever for change, we recommend a variant of a 'steering' type research evaluation. Put differently, we believe, and strongly recommend, that the results (outcomes) of any evaluation of research units in Armenia must be linked with funding. We also believe that this will be most effective if judgement regarding the conditions and quality of research is linked to funding streams above and beyond the ones that cover the basic needs of the organisational units.

The focus of the research evaluation must not be on research output alone. Currently, the Armenian knowledge communities (scientists and scholars) are, mainly, not central in their global research fields and their contribution to advances in global knowledge is limited. There are, of course, exceptions such as in physics and astronomy.

Recommendation 5: a first research evaluation should assess the conditions for high-quality and relevant research output to be produced.

The research assessment should be based on a combination of quantitative and qualitative indicators and a peer review.

6.1.3 Responsibility for organising the research evaluation

In line with the principle of ensuring the credibility of the research evaluation, we strongly believe that the first-round research evaluation should be managed and organised by a dedicated unit or task-force with sufficient independence from existing research-performers to ensure objectivity.

Two organisations currently have experience of research evaluation processes: the NAS and the SC; while ANQA has experience of running expert assessments of HEIs including international peers.

The NAS is not the appropriate body to organise a nation-wide research evaluation because it represents a particular set of research-performers, its own network of RIs, and may be viewed by other stakeholders as not impartial in decisions concerning the organisation of a research evaluation that includes university and other public RIs.

The SC has a remit that includes organising the peer review of competitive, project-based funding. Extending this remit to include the evaluation – and by inference, future decisions on institutional funding of research units – may raise fears among the research community of a high level of concentration of funding decisions. In a small country, such arrangements are vulnerable to accusations of partisan decision-making.

We are mindful of the need to avoid creating new agencies and of ensuring that the expertise in running a research evaluation is embedded in the appropriate organisation(s) to ensure learning and capacity building. In the context of reinforcing the autonomy and strengthening the capacity of the SC to evolve into a full-fledged national research agency:

Recommendation 6: The establishment of (1) a dedicated unit within the SC responsible for organising the research evaluation, and (2) a REA steering committee to ensure oversight of the REA process.

The REA management unit should be staffed by at least five people with the head of the unit having a status equivalent to deputy director of the SC. The REA steering committee should be composed of representatives of the MESCS, other line ministries with RIs, a representative each from the NAS and ANQA, at least two experts from the HEI sector (e.g. from HERE group, ERASMUS plus) and two representatives from a users' perspective (business, environmental, societal actors, etc.).

Recommendation 7: The REA management team and the implementation of the first research evaluation should be supported by international experts via a technical assistance contract funded by the European Commission.

Once the evaluation process is complete, the final decisions on required actions based on the results will be made by the Government based on a synthesis report prepared by the REA unit and approved by the REA steering committee.

6.1.4 Responsibility for evaluating the research organisations (judgement)

Where REAs are concerned, the judgement is usually in the hands of evaluation panels. There are different ways to organise these panels, however, and these largely depend on the type of evaluation criteria used (linked to the shared vision regarding the nature and use of science and its results).

- An evaluation building on notions of scientific excellence alone, for instance, will tend to use panels of top scientists and scholars in several neighbouring research fields (e.g. particle physics, life sciences, etc.).

- An evaluation aiming to incorporate considerations on the economic and social impact of research, for instance, should include potential users in the evaluation panels.

Recommendation 8: Include foreign experts on the evaluation panels.

We believe that the evaluation of RIs will have high credibility and the best chance of achieving benefits not immediately related to selection (e.g. consensus, change of beliefs, negotiating areas of conflict, etc.) if the panels include, and are chaired by, respected scientists/scholars and domain experts from other countries. The funding for the involvement of the foreign experts could be covered, fully or in part, via the proposed technical assistance contract.

Table 4: Proposed research evaluation arrangements for Armenia

Topic	First-round evaluation	Second and subsequent evaluations
Focus	State-of-the-art research conditions (secondary on impact/engagement, research output and importance for higher education)	Conditions for research including strategic positioning in global research networks Contribution of research to the quality of higher education Research impact (economy and society) Research output
Responsibility	Research field peers from overseas, local peers Decision: highly political	Peer panels consisting of local scientists and scholars and at least one international expert (can draw on diaspora) Organised by the dedicated (and by this time experienced) research evaluation unit Resources allocated through formula on the basis of results from evaluation; approved by the SC
Criteria	Relevance/importance of research for national development goals; Importance for (research-based) higher education State of equipment and facilities; Accreditation and compliance with international standards Financial capacity Human resources (early-career researchers, etc.); Collaboration with other research institutes in Armenia Engagement with the global research community Research output Impact on society and economy	Strategic vision for the research field (and adjustment to revised national development priorities) Engagement with the global community (conferences, visits, training) Provisions for training (and retaining) junior scientists Impact on and engagement with society and economy Importance for (research-based) higher education Research productivity
Action	Categorise research institutes or units by:	Link the evaluation outcomes with streams of funding on a performance basis.

Topic	First-round evaluation	Second and subsequent evaluations
	Group 1. Maintain and develop Group 2. Integrate with another unit Group 3. Close unit (in the first round this may be the case with whole research fields) Provide an additional funding appropriation for categories 1 and 2	

6.1.5 Criteria for research evaluation arrangements

Taking account of the 2019 Ministerial Order and the evaluation criteria used by the NAS (2016) evaluation, we propose a set of 10 criteria for undertaking the first full research evaluation. These criteria place are ordered so to place an emphasis on relevance (for national development, education, etc.) and capabilities (infrastructure, financial and human resources) in the first evaluation. The current performance in terms of research outputs (publications, etc.) and the impact on the Armenian economy and society need to be put in the perspective of the baseline situation in terms of the capabilities. Some research institutes that

Recommendation 9: Apply 10 evaluation criteria for the research evaluation giving an emphasis to relevance and current capabilities.

1. Relevance and importance of research for national development goals;
2. Importance for (research-based) higher education (involvement in teaching, doctoral students tutoring, etc.)
3. Existing state of equipment and facilities;
4. Accreditation and compliance with international standards
5. Financial capacity to sustain research in the field (sources of finance, share of funding from competitive sources, including international).
6. Human resources: age structure of researchers; provisions for training (and retaining) early-career researchers, etc.;
7. Collaboration with other research institutes in Armenia (e.g. avoiding duplication of research activity, sharing equipment)
8. Engagement with the global research community (conferences, visits, training)
9. Research output (bibliometrics) over previous five years)
10. Impact on society and economy (knowledge transfer and commercialisation, contract research for public or private funders, consulting, etc.)

It will also be important to consider, at the overall system level, whether sustaining research in Armenia in certain fields may require investments that are too expensive to be viable or put at risk investments in other scientific fields of higher priority for Armenian development.

6.1.6 Action following the research evaluation

The outcome of the initial research evaluation will be to group the RIs as follows:

Group 1: Invest and grow

Group 2: Integrate with other units and rationalise

Group 3: Close unit

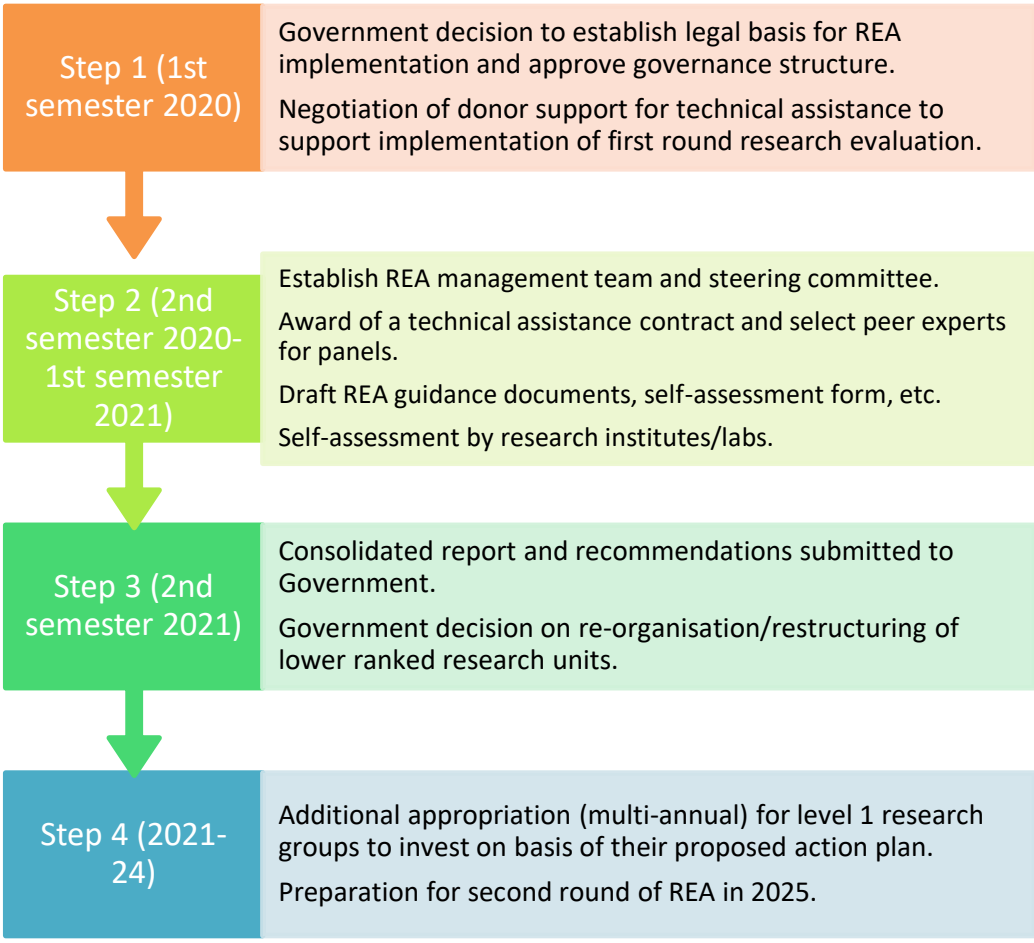
Evaluation outcomes must be linked to the baseline funding and hence with the recommendation to increase overall science funding, influencing research areas and topics, developing training programmes for junior academics, collaboration with other research units working on similar issues, equipment sharing, etc.

Recommendation 10: An additional appropriation' for research units 'to provide incentive to improve performance and encourage restructuring and rationalisation.

6.1.7 Implementation timeline: Research evaluation arrangements

While the specifics of the organisation, focus and implementation of the research evaluation will require further fleshing out, we suggest the following steps.

Figure 5: Timeline for implementation of research evaluation arrangements



It will be important to ensure that the employees of the evaluation unit are trained in evaluation methods (e.g. summer school type courses available in several EU countries) and undertake study visits to countries with relevant experience (e.g. Estonia, Latvia, the Czech Republic). A consultation with the national scientific and scholarly communities to identify potential (foreign) members of the peer evaluation panels will be important to ensure credibility, transparency and trust.

6.2 Measures to encourage consolidation and increased cooperation

As discussed in chapters 2 and 3, the Armenian higher education and research system is highly fragmented and, while there are 'pockets of excellence', the medium-term perspectives in terms of maintaining even current performance levels are poor. The measures proposed aim to support the consolidation of the research potential by building on the results of the first research evaluation.

The purpose of this report is not to pre-empt decisions on mergers or amalgamation of RIs from the three main types currently operating (NAS RIs, State RIs and laboratories and RIs at universities) in Armenia. The **scenarios** in

terms of a future consolidation of the research system can, however, be traced out as follows:

- Maintain the status quo with three main types of RIs and with an effort to promote collaboration and 'voluntary' mergers over time of RIs on a case-by-case basis.

- Integrate NAS and other RIs into HEIs with staff of RIs becoming personnel of the universities. In other countries, this has tended to happen over a certain time, e.g. in Estonia the full integration of former NAS RIs into universities took at least a decade.

- Strengthen university-based research and restructure NAS and other RIs into one or more publicly supported research organisations similar to those in place in European countries (e.g. CNRS in France, Fraunhofer, Leibniz, Helmholtz and Max-Planck institutes in Germany, etc.). In this model, researchers will often have a dual status as personnel at both universities and institutes and public RIs may be 'co-located' at universities.

A set of criteria can be applied to help guide the decisions on the way in which the future research landscape in Armenia is organised, these include:

- The positioning of RIs in terms of the spectrum of fundamental versus more applied research, and the need to foster greater inter-disciplinary research;

- The expected balance in terms of sources of funding ranging from 100% State funding to a mix of public, business, foreign (e.g. Horizon 2020, diaspora) and third party (e.g. charitable foundations such as the Wellcome Trust)[40] sources; and

- The mission of the RIs including those that are tasked to support ministries in implementing policy (e.g. metrology, testing and certification functions, agricultural extension and modernisation, defence, etc.), those that focus on industrially oriented research and prototyping, those that contribute to resolving societal challenges (addressing sustainable development goals), etc.

In all three scenarios, there is a need to foster and incentivise collaboration in the system to ensure optimal investment and use of research equipment and infrastructure in the country, develop inter-disciplinary and cross-institute teams (among RI-HEI and RI-RI) with sufficient scale and experience to compete for international (e.g. EU) funding, reinforce cooperation with business, and translate research results into economic and socially relevant applications, etc. Given the above reflections, the measures proposed in this section are designed to support enhanced collaboration within the Armenian research system (across types of RIs, disciplines, etc.). The five proposed key measures are:

[40] See: https://wellcome.ac.uk/funding

1. A medium-term research and innovation strategy that sets priorities for future funding at a cross-government level;

2. An Armenian Research Infrastructure Roadmap (2021-2030 time period);

3. The creation of a catalogue of research equipment and services and the launch of an open access system for researchers on an inter-institutional basis;

4. The development of an inter-institutional doctoral school programme; and

5. Competitive call for Armenian Research and Technology Centres Partnerships.

Each of these proposals are developed in more detail below.

6.2.1 Updated research and innovation strategy

As outlined in chapter 2, the current Armenian research priorities are relatively broad and the link between research priorities and national economic and social development are not explored in sufficient detail. There is a need for a medium-term strategic framework for research and innovation to structure future public-private investment decisions and prioritise funding channelled through competitive programmes.

An outline innovation strategy was developed in 2018 with EU SMEDA support[41] and a detailed method for the development of a full strategy based on stakeholder consultation and co-design proposed in this document.

Recommendation 11: The proposed full strategy development process outlined in the EU SMEDA innovation strategy report should be undertaken during 2020-21 to ensure the development of a 'smart specialisation' type strategy that would provide a vision for the future investments in research and innovation in Armenia.

The development of a full research and innovation strategy should be done with a view to taking account of cross-government (inter-ministerial) priorities where scientific expertise or innovative solutions are required, as well as a broad consultation with other stakeholders, notably business, to identify key enabling technologies, STEM careers and key skills required to support Armenia's development both in terms of knowledge generation but also, critically, knowledge absorption, adaptation and early use (EV Consulting, 2019).

[41] See: https://www.smeda.am/uploads/libraries/Strategic%20approach%20for%20fostering%20innovation%20in%20Armenia%20-%20towards%20%20excerpt%20SMART%20Armenia.pdf

6.2.2 A national and research infrastructure roadmap

The European Commission[42] defines research infrastructures as facilities, resources and services that are used by the research communities to conduct research and foster innovation in their fields. They include:

- Major scientific equipment or sets of instruments;
- Knowledge-based resources such as collections, archives or scientific data;
- E-infrastructures, such as data and computing systems and communication networks; and
- Any other infrastructure of a unique nature essential to achieving excellence in research and innovation.

Recommendation 12: A national research infrastructure roadmap should be developed. This roadmap should identify the existing capacity, overlaps and gaps in equipment, and define future investment needs.

There is significant expertise in developing roadmaps in EU Member States to be drawn on. The option of an EU-funded technical assistance or twinning contract should be considered. The recently completed IN-ROAD project[43] recommended that national research infrastructure road-mapping processes contain at least the following minimal key elements:

- An inventory (regularly updated) of existing research infrastructures and identification of needs and gaps (i.e. through a landscape analysis);
- Long-term strategic priorities and a transparent prioritisation of national needs (that take into account synergies with international/European research infrastructure priorities);
- Evaluation of research infrastructures' relevance according to scientific, managerial, strategic and societal dimensions, and corresponding monitoring mechanisms, which consider national strategic priorities and scientific needs as well as lifecycle stages, types and missions of the RI; and
- Prioritisation of new and existing research infrastructures in view of available funding.

[42] Article 2 (6) of Regulation (EU) No 1291/2013 of 11 December 2013: 'Establishing Horizon 2020 – the Framework Programme for Research and Innovation (2014-2020)'.

[43] See: https://www.inroad.eu

Box 4: Research infrastructure roadmaps – an overview of European practices

At European level, the European Strategy Forum on Research Infrastructures (ESFRI) is a strategic instrument to foster the scientific integration of Europe and strengthen its international outreach. ESFRI has established a European Roadmap for research infrastructures (new and major upgrades of pan-European interest) to stimulate the implementation of these facilities. Since the first edition in 2006, the Roadmap has been updated four times. The latest version, Roadmap 2018, includes 37 Landmarks – ESFRI projects that have been implemented and are providing services or in final phase of construction – and 18 projects that have been selected for their excellence are in the design and preparation phase. The ESFRI Roadmap is structured in six thematic fields (Energy, Health and Food, Environment, Physical Sciences and Engineering, Social and Cultural Innovation, and Digital RIs).

In addition to ESFRI, the opportunities for Armenian computing and data centres to align with, and become part of, the developing European Open Science Cloud (EOSC)[44] initiative should be explored. The EOSC Portal developments include a catalogue and marketplace of e-infrastructure (computing, data, etc.) while the FAIR principles[45] and other related measures to develop rules of procedure for participating in EOSC are important. Several projects are supporting this integration, such as EAPConnect[46] which aims to establish and operate a high-capacity broadband internet network for research and education across the six Eastern Partnership (EaP)[47] countries. ASNET is the Armenian partner[48]. The objective is to integrate them in the pan-European GÉANT network and facilitate collaboration with local scientists, students and academics, also through the deployment of shared services. Investment in national nodes of e-infrastructures and their interconnection is an increasingly important tool for effective research.

At national level (INROAD, 2018), there are a range of examples to choose from with two of the countries used as benchmarks in this report providing good

[44] See: https://ec.europa.eu/digital-single-market/en/european-open-science-cloud and www.eosc-portal.eu

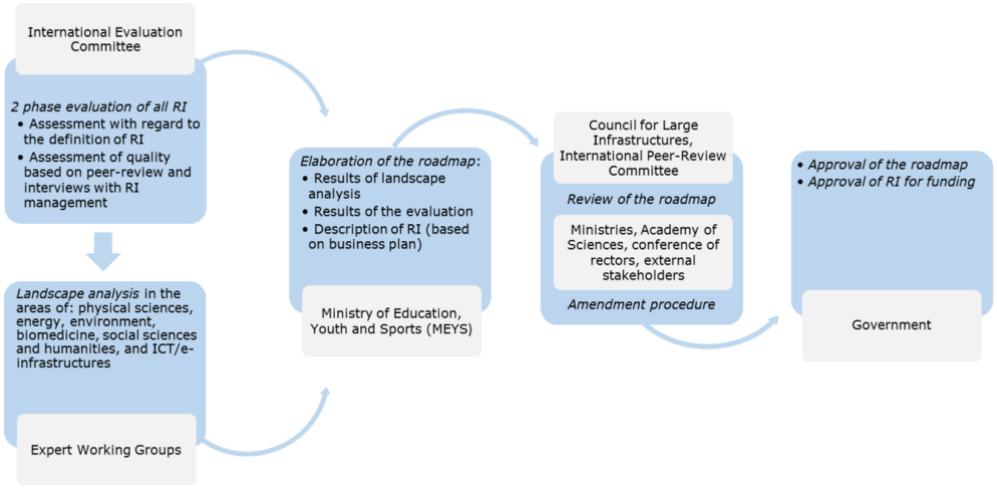
[45] See: https://www.go-fair.org/fair-principles/

[46] See: https://www.eapconnect.eu

[47] See: https://ec.europa.eu/neighbourhood-enlargement/neighbourhood/eastern-partnership_en

[48] See: https://asnet.am/about.php?lang=en

examples: the Czech Republic[49] and Estonia. The Czech Republic has a structured approach to selecting large research infrastructures as summarised below.



Source: Ruecker et al (2018)

The Estonian Roadmap 2019[50] identifies 17 research infrastructures of national importance (14 planned and 3 existing) and confirms Estonia's participation in 14 international programmes (notably ESFRI projects). Estonia also has eight core infrastructures (all are part of the roadmap) belonging to R&D institutions. These core infrastructures, which are necessary for carrying out research in identified themes, were established in the public interest and can also be used by researchers/innovators who are not staff members of the research institution pursuant to the conditions and procedure established by the host institution. Core infrastructures feature a high level of scientific equipment or technology and highly skilled manpower. Their main task is to serve the research community through providing expertise and analytical support.

[49] See: https://www.vyzkumne-infrastruktury.cz/en/2019/11/update-of-roadmap-of-large-research-infrastructures-of-the-czech-republic

[50] See: https://www.etag.ee/en/funding/infrastructure-funding/estonian-research-infrastructures-roadmap/

The Czech Roadmap applies three criteria for distinguishing a 'large' research infrastructure from a standard laboratory or facility, and could be usefully applied in Armenia:

1. The operation of unique technological R&D facilities;

2. Having at least a nation-wide importance and impact and potential international synergies; and

3. The research infrastructure is managed on the basis of an open access policy consistent with international good practice.

In the context of a smaller country, the Estonian Roadmap (2019) defines research infrastructures as "*tools (laboratories, equipment, devices, collections, archives, structured information or a body thereof) and the conditions, expertise, methods, materials, activities and services related thereto, which are used to create, transfer, exchange and/or preserve new knowledge gained through research and development*". Research infrastructures can be single-sited (e.g. telescopes and synchrotrons), distributed (e.g. a networks of biobanks), and can have central/shared or virtual services (e.g. databases and archives) that end users can access from their workplace.

This emphasis on (shared) tools (and services) for researchers and organised access to such resources is probably more relevant for the Armenian case, where the key priority is upgrading the basic conditions for researchers to carry out research and developing access to a core set of research facilities and services. Adopting a hybrid road-mapping model for Armenia could be done in a first round by carrying out a mapping exercise (which would also feed into the open access catalogue under the next sub-section) while the first-round research evaluation could be used to identify a limited number of existing (e.g. the Candle Synchrotron Research Institute, ASNET-AM) or required future core facilities/large(r) research infrastructures in Armenia. The road-mapping should also identify the required involvement of Armenia in international- or European-scale research infrastructures that would support Armenian scientific cooperation and mobility.

6.2.3 Open R&D facilities – catalogue of research equipment and services

During the missions, Armenian researchers pointed out that access to equipment installed in RIs was not facilitated and that, on occasions, expertise was located in one institute while equipment was in another. Given the limited scale of the science budget in Armenia, it is clear that there is a need to optimise the current access regime for researchers to, and use of, equipment and infrastructure in Armenia.

Encouraging open access to installed research equipment can be used to foster:

- More effective public (State) investment in the research system through avoiding duplication of equipment and optimising usage time of existing equipment;

- Learning networks and new cooperation in the research system through laboratories and facilities hosting researchers from other institutes for short periods;

- Stronger financial sustainability of RIs by proper cost accounting of the use of research equipment; and

- Improved research management practices required to operate as an open access centre.

Recommendation 13: An open access system should be created to ensure that researchers (including doctoral and post-graduate students) are able to use research equipment, data and archives on an inter-institutional basis to carry out their research as efficiently as possible.

This requires the establishment of specific guidelines and standards (e.g. cost accounting for equipment use). Moreover, given the limited operating budgets of Armenian RIs, it may require a specific instrument or adaption to current funding grants to enable researchers to claim for costs charged by RIs hosting them while using the equipment.

An example of a national register of research equipment is the Hungarian National Registry for Research Infrastructures.[51] All publicly supported investments in research infrastructures require beneficiaries to provide open access to the data of devices and equipment purchased and investment projects completed from the funding. This ensures the broadest possible use of publicly financed capacities by the researcher community. Other examples of such 'catalogues' exist at both national (e.g. the UK http://equipment.data.ac.uk/) and European level (e.g. EOSC Catalogue and Marketplace).

An example of an organised national system of access to R&D facilities is the Lithuanian Open R&D network.[52] Open R&D Lithuania network is a newly launched platform of cooperation between the open access R&D centres/laboratories of 12 Lithuanian Universities, 13 public RIs as well as 7 S&T parks. All of these institutions united their high-level R&D intellectual potential, infrastructure and resources in order to provide scientifically based solutions to the problems raised by business and society.

6.2.4 Armenian doctoral schools programme

As noted in section 3.1, there is on-going work on the reform of the Armenian doctoral education system. This includes projects working to define quality standards for the third cycle of higher education and to develop new doctoral programmes, as well as the previously mentioned ERASMUS+ ARMDOCT project (starting in 2020), which specifically aims to establish five doctoral schools.

[51] See: https://nkfih.gov.hu/english-2017/national-registry-for/national-registry-for

[52] See: https://openlithuania.com/about-open-rd/

Recommendation 14: The pilot initiatives for doctoral education should be scaled up and sufficiently funded, from the State budget and/or donor support, to fully develop, over time, doctoral studies in Armenia.

There are a range of doctoral school programmes existing in EU Member States that could serve as a model for further developing doctoral education in Armenia. For instance, in Estonia[53], during the period 2014-20, 13 doctoral schools are funded based on inter-institutional cooperation. They support: winter and summer schools; interdisciplinary research projects of doctoral candidates; developing curricula in order to improve the quality of teaching of doctoral candidates; promoting cooperation between the private and public sectors; developing interdisciplinary Estonian scientific and research terminology in Estonian; and facilitating the mobility of doctoral candidates, etc. For instance, the Estonian Graduate School of Linguistics, Philosophy and Semiotics (GSLPS) is a joint initiative of the University of Tartu, Tallinn University, the Estonian Literary Museum and the Institute of the Estonian Language.

Similar pooling of resources for doctoral education and research exist, in Flanders (Belgium) via inter-university doctoral training networks (Flames,[54] f-Tales, etc.), Scotland (e.g. the EastChem doctoral school of the universities of Edinburgh and St Andrews), etc.

Recommendation 15: The development of doctoral schools should be complemented by specific financial measures and reforms to the employment status of early-stage researchers that help to strengthen the researcher career path in Armenia.

These measures should include:

- The introduction of post-doctoral research grants for early-stage researchers with high potential to develop new or renew existing research groups. Such post-doctoral or early-stage career grants are common in the Baltic States and Eastern Europe, for instance in Estonia.[55] The grants should be linked to the development of priority research fields based on the medium-term R&I strategy and taking account of the first-round evaluation (i.e. priority to grant holders employed at a highly ranked RI). The grants would support the launch of a research career for doctoral degree-holders obtained from an Armenian university or at a foreign HEI/RI (e.g. bringing Armenian researchers who have gone abroad back home to complete their doctoral studies). The aim would be to boost the development of research groups, encourage mobility within Armenian system (e.g. doctoral graduates moving from their 'alma

[53] See: https://www.hm.ee/en/activities/research-and-development/doctoral-schools

[54] See: https://www.eua-cde.org/the-doctoral-debate/5:inter-university-collaboration-the-case-of-flames.html

[55] See for instance: https://www.etag.ee/en/funding/research-funding/personal-research-funding/

mater' to carry out research at another HEI/RI) and to contribute to educating the next generation of researchers (including doctoral students).

- A review of the conditions that act as barriers or drivers for early-stage researchers (post-doctoral) to integrate RIs/research teams at HEIs. The aim, over time, should be to align research career paths to European standards and to ensure a move away from precarious temporary employment/stipends or informal contracts towards stable employment contracts and support for long-term career development. For Armenian HEIs, this supposes an improvement in their current performance in terms of the ENQA criterion 6 for research and development and, hence, such measures could be rolled out as a pilot in those HEIs which have (partly) satisfactory grades for this criterion.

6.2.5 Armenian research and technology partnerships

As noted above, the process of restructuring/consolidating Armenian research resources should be guided, first and foremost, by the evaluation of the existing research potential (through the first evaluation) and in line with the strategic priorities set for the coming five years. With a working hypothesis that additional funding could be made available following the first-round evaluation, the current suite of policy measures proposed by the SC should be adjusted and reinforced to better cover the needs of the research community, enhancing collaboration within the system:

Existing funding measures should be adjusted to prioritise proposals from inter-institutional research teams of university and NAS and State RI researchers. This should be accompanied by a change to the funding formula or an additional measure to fund longer-term projects led by a principal researcher aiming to build larger and more competitive research teams than exist in single institutions.

Recommendation 16: Based on the updated R&I priorities and the research infrastructure roadmap, launch a competitive call to select a limited number of centres of excellence (more basic research focus)/competence centres (applied research focus).

These centres would bring together researchers, equipment, data, scientific collections, etc. from existing institutes. Depending on their research focus (basic to applied) the consortium could be opened to business partners or international investors in order to source private funds and reduce the pressure on State budgets. Selected cases are provided below to illustrate measures used to strengthen collaboration in national research systems.

Figure 6 : Examples of collaborative research initiatives in European countries

Science Foundation Ireland Research Centres (SFI)

Since 2012, SFI has funded the development of 17 Research Centres[56] which aim to support basic and applied research with strong industry engagement and economic and societal impact that address critical and emerging areas of the economy. The Research Centres are collaborative platforms bringing together research teams from Irish universities and public RIs as well as industrial partners. They cover a broad range of scientific fields, from smart manufacturing (CONFIRM), additive manufacturing (I-FORM), neurological diseases (FutureNeuro), the bio-economy (BEACON) to future milk/precision agriculture (Vista Milk), in partnership with the Ministry of Agriculture. By 2017, the original 12 Research Centres had signed collaborative research agreements with over 300 industrial partners representing cumulative company commitments of over €120 million, and had secured €132 million from EU and international funding agencies.

Scottish Research Pooling Initiative (RPI)

The RPI[57] was created in 2004 by the Scottish Funding Council (SFC) to encourage researchers across Scottish higher education, public research organisations and government agencies in specific fields to pool their resources and respond to increasing international competition. Since 2005, SFC invested over £155 million in 11 research pools: the bulk of the funding was allocated in Phase 1 (£150 million, 2005-2017). Phase 2 (£5 million, 2015-2023) has largely funded the continued administration of the research pool collaborative networks. A recent evaluation found that the research pools had a particularly strong impact on improving doctoral education (through graduate schools) as well on improving performance (highly cited publications), growth in international collaboration and increasing total research income.

The RPI has produced strong disciplinary pools; thematic or challenge-facing pools, and some of the more discipline-based pools are growing a stronger thematic focus or industrial engagement (e.g. ScotCHEM).[58] Collaboration between pools is beginning to emerge, usually around leverage opportunities such as medical imaging, involving three research pools.

[56] See: https://www.sfi.ie/sfi-research-centres/

[57] See: http://www.sfc.ac.uk/research/research-pooling/research-pooling.aspx

[58] https://www.scotchem.ac.uk/

Czech Centres of Excellence – the example of Central European Institute of Technology (CEITEC)[59]

During the period 2007-2013, the Czech Government invested European Structural Funds in the development of eight European-level centres of excellence as well as regional centres of excellence. The centres of excellence are international-standard teams that have a clear set of common research objectives and work under the same management but are formed from the research teams of one or several R&D institutions (including the private sector).

In 2008, the research community in the Czech city of Brno began preparations for a project which would concentrate high-quality scientific teams under one label. The idea was to create a critical mass of scientists and their teams, to encourage higher standards of research performance and PhD training, while encouraging interdisciplinary investigations in the fields of life and material sciences. The founders were Masaryk University, Brno University of Technology, Mendel University, University of Veterinary and Pharmaceutical Sciences Brno, Institute of Physics of Materials of the Czech Academy of Sciences and Veterinary Research Institute, all located in Brno.

Within the individual institutions participating in CEITEC, autonomous departments were established (CEITEC MU, CEITEC BUT, etc.) which are financially independent of the other CEITEC partners, but still operate under one brand, cooperate mutually on interdisciplinary subjects, and are linked to one another through the international CEITEC PhD School. Research activities within the area of life sciences includes structural biology, molecular medicine, research of plant systems, and brain and mind research. A concentration of scientific instrumentation is housed within 12 core facilities and technologies. These laboratories work as shared worksites, not only for all CEITEC scientists and researchers, but also within an open access system which allows access for external users as well.

The examples underline that developing critical mass and a collaborative research culture takes time, and the impact of investment will not be immediate (at least in economic terms). They were also implemented in financial frameworks vastly different from those of Armenia, with all three countries benefiting from EU Structural Funds. The inflow of external research funds (EU Framework Programme, charitable foundations and diaspora) to Armenia is unlikely to come close to that of an EU Member State from European programmes.

However, they do point to the potential for RIs to self-organise and self-direct their research activities, although in all cases there is a degree of 'top-down' steering in terms of national funding programmes objectives and conditionalities. The funding context in Armenia, public funding notably, is much more restrictive

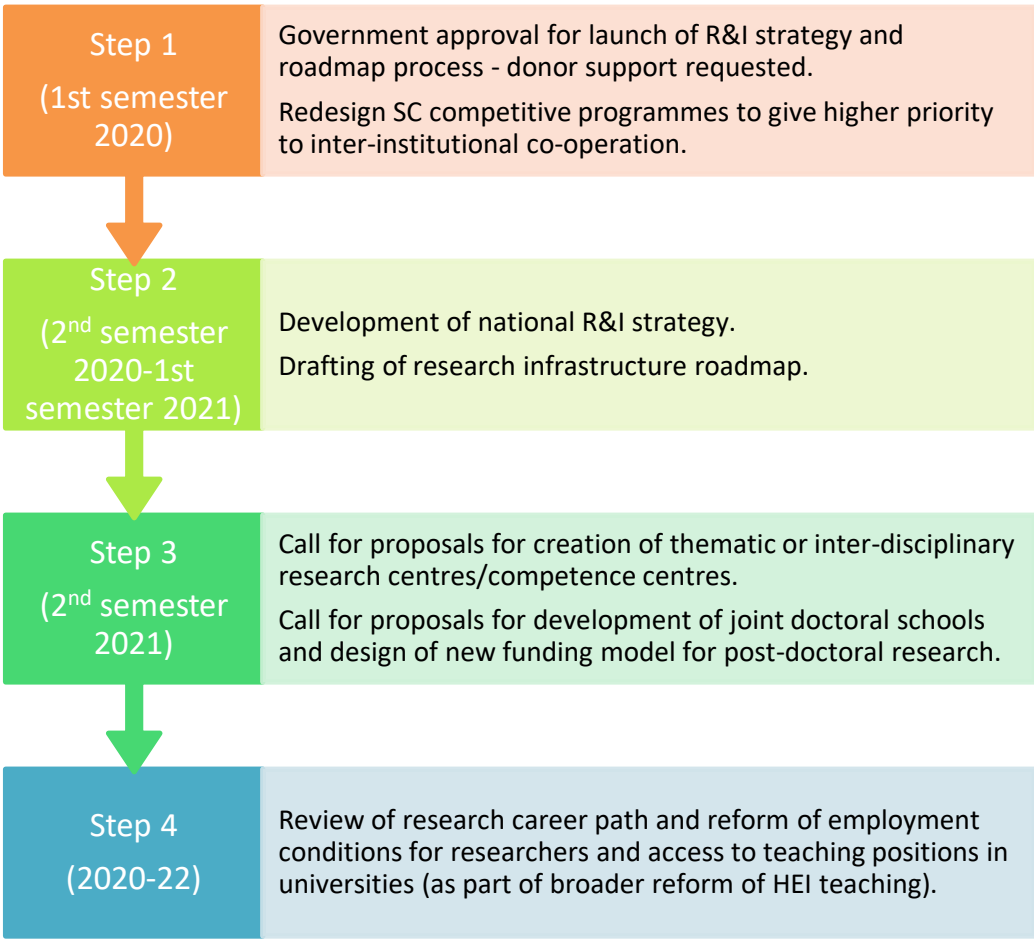
[59] https://www.ceitec.eu/

but this, in turn, is an additional reason to encourage collaboration, pooling of resources and equipment leading to critical mass.

6.2.6 Implementation timeline: research-higher education cooperation

Given the proposed actions, the expert team proposes the following broad steps and timelines to implementing the recommendations.

Figure 7: Timeline for collaborative measures between research and HEIs



6.3 Transition to performance-based funding in Armenia

6.3.1 Recommendations for the introduction of a PBRF component

The Armenian authorities have initiated steps for the development of performance-based funding, considered as one of the central mechanisms to increase the effectiveness and performance of its public research sector.

Recommendation 17: The Armenian authorities should introduce an effective funding system that combines a sufficient level of direct appropriations (also called block funding, or baseline funding) and PBRF.

While it is reasonable to introduce a PBRF system in Armenia, it would not be good to shock the scientific community with dramatic change. Institutions and individual researchers need some time to adapt and adjust to a new system. Even a relatively small performance-based component of the total government funding can have substantial game-changing effects, both in terms of creating incentives to perform better, but also to pave the way for organisational reform on a system level. For example, institutions that lose 10% of the funding due to low performance can soon be in a critical financial position and need to start closing down study programmes or other activities. Another way to cope with decreasing budgets is to merge with another institution; a desirable outcome for the Armenian Government. And correspondingly, an additional 10% funding may mean that an institution can open a new department or dare to engage and invest in a large international research project, for example. Thus, a majority of the Government funding should still come in the form of non-competitive block funding (or perhaps formula funding).

Recommendation 18: The Armenian government should set, initially, the performance-based component at 20% of institutional funding.

Box 5. Example from the PSF Specific Support exercise in Georgia

The recommendation in the PSF report for Georgia was to introduce baseline funding to public research organisations and create a level playing field. The proportion of direct public funding allocated to research organisations [in the report called baseline funding, which is equivalent to block funding, as described above] should be increased to extend beyond covering only low-level salaries and very basic expenditure (e.g. electricity, heating, etc.). Experience gained elsewhere does not allow us to make a recommendation for a specific ratio of baseline to project-based competitive funding. In well-established and successful R&I systems, the proportion of baseline funding ranges from 70% down to 40-45% of the total funding for research. Georgia currently has a share of about 50% institutional and 50% competitive public R&D funding. The competitive share, which is allocated primarily via the Nation Science Foundation, has increased in recent years. This has been a positive development as it has enabled the allocation of resources based on transparent criteria and peer evaluation. It has provided a way out of institutional funding, which was the norm in the past and which has been (and still is) allocated without an assessment of performance.

Source: Specific Support to Georgia (2018): 'Improving the Effectiveness of Georgia's Research and Innovation System through Prioritisation, Selectivity of Funding and Science-Business Links', European Commission, Directorate-General for Research and Innovation

Inspiration can be found in the report from the PSF in Georgia that was provided by the European Commission in 2018 (Box 5), and with respect to the level of PBRF, the report from the PSF in Estonia (Box 6).

Box 6. Example from the Policy Support Facility exercise in Estonia

Estonia was the first of the Central-Eastern European countries to merge the Academy of Sciences' RIs into universities (with four exceptions). At the same time, the Estonian Research Council (ETAG) was established to provide competitive research funds. That Council operates according to the good practices of modern research funding organisations, requiring applications to be written in English and using international experts for peer review.

The Estonian performance-based research funding system has two components – both managed by ETAG – and applies to any research-performing organisation, not only to universities:

1. A 'Regular evaluation' process based on peer review, in which success entitles an organisation to compete for both performance-based institutional funding for research and for competitive calls at ETAG; and

2. An annual, metrics-based research assessment, which determines the level of performance-based institutional funding paid. In parallel,

institutions benefit from the projects they are able to win in ETAG's competitions.

In general, competition boosts quality but the ratio between external and institutional research funding was too high and created an overly competitive system. This undermines the universities' sustainability and prevents them from developing long-term strategies, within which they can anchor measures and funding decisions. Average institutional funding in public universities was 12.4% of total research income in 2017 and 17.8% in 2018, whereas in European countries with mature research systems it tends to be in the range 50-80%.

Source: Policy Support Facility (2019): 'Final Report – Peer Review of the Estonian R&I System', European Commission, Directorate-General for Research and Innovation

The Estonian example shows that evaluation is linked to funding. We have proposed a comprehensive so-called one-off evaluation to be undertaken in Armenia during the spring of 2021 (with planning and preparations starting in spring 2020). The outcome of this evaluation ought to provide the basis for a **revised level of institutional funding to all RIs** in Armenia, i.e. NAS institutes, sectoral institutes, and universities. As suggested, the RIs should be assigned one of three different groups: those to be **kept and developed**; those to be **re-organised**; or those to be **closed down**. Quite naturally, the resources that today go to those RIs that will be closed can instead be distributed to remaining RIs.

Following the outcome of the one-off evaluation and a new baseline for institutional funding to all RIs, **it is recommended that a 20% additional funding pot is allocated from 2022 for distribution according to performance** (20% of the total government funding to RIs in 2020). In this way, the research system in Armenia benefits from a 120% total research funding boost compared to 2020, but this increase will be distributed only to those RIs that can show positive performance outcomes. From 2022, it is recommended that this 20% share is distributed according to two performance-based indicators:

- **Publications**: We recommend that publications in peer-reviewed journals that are listed in Web of Science or Scopus, as well as published books, should be included and counted. A weighted system is advised where publications are awarded points: publications in journals that, according to a normalised journal impact factor, are among the top layer in a given scientific field are given more points than publications in less cited journals. Books are given more points than journal articles. For all publications, the authorship fraction is taken into account. The *Norwegian Register for Scientific Journals, Series and Publishers*[60] could serve as a role model; several other countries are using it besides Norway due to its functionality and good coverage. Publication patterns of different scientific disciplines need to be taken into account. The

[60] https://dbh.nsd.uib.no/ Following an easy registration which is open for any individual, the full list of journals and publishers can be retrieved. New journals or publishers can be suggested. The list is continuously updated. Part of the site is in English.

exact composition of the publication indicator needs to be further developed and specified by bibliometric experts.

- Amount of external funding secured in the previous five years. We **recommend the Armenian government to include external funding when deciding an institution's level of PBRF**. By including external funding as an indicator in a PBRF system, incentives are put in place that stimulate institutions and individual researchers to actively apply for external research funding. Both national and international funding sources should be included; among the national ones, the various SC programmes with thematic funding, as well as any private funding, are benchmarks to observe. Funding from Horizon 2020 and its sub-programmes, such as Marie Skłodowska-Curie Actions, is an example of international funding sources.

Recommendation 19: After a pre-defined period (e.g. three years), the PBRF's impact should be evaluated and adjustments made to optimise the effects.

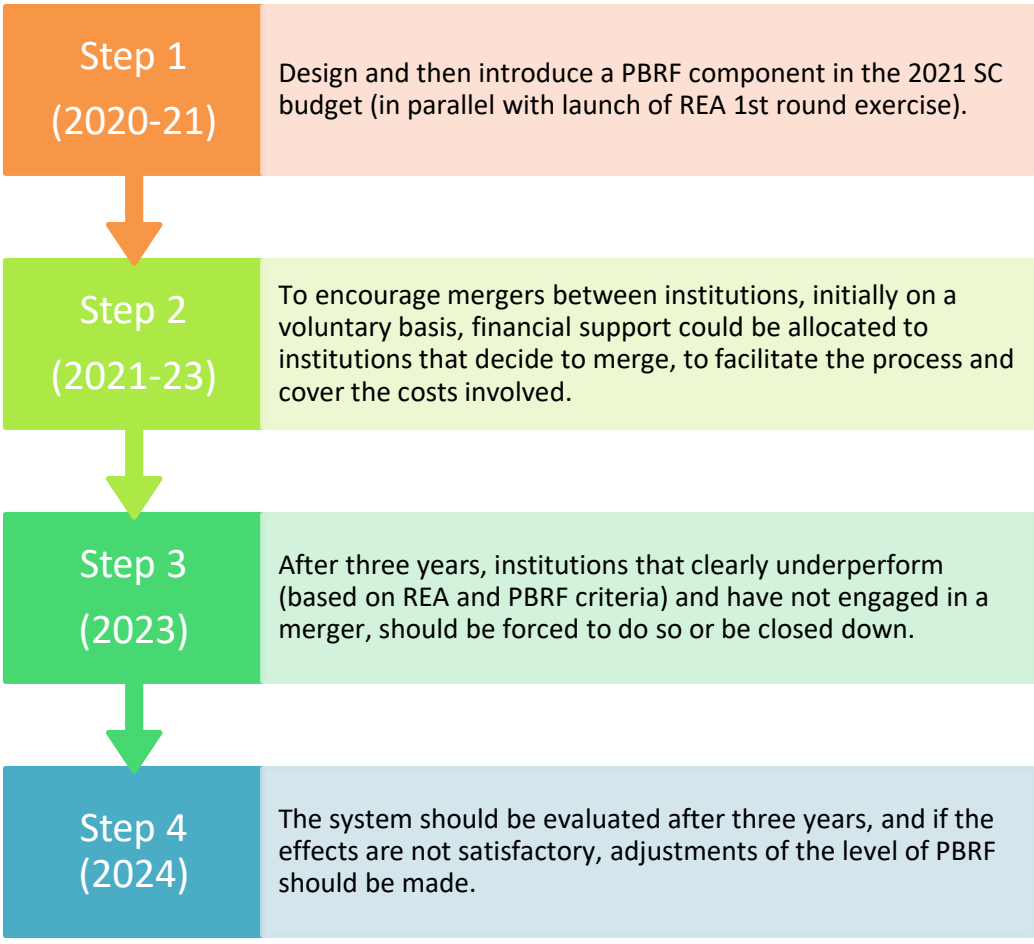
The Armenian government should consider if it is only the research funding system that should be complemented with a performance-based component, or if higher education should also be partly funded according to performance.

6.3.2 Implementation timeline: performance-based research funding

The following key implementation steps are proposed:

- Armenia establishes a PBRF system on a level that is sufficient for a game-changing effect, but without shocking the research system. We suggest 20% on top of the level of institutional funding in 2020;
- The system should be evaluated after approximately three years, and if the effects are not satisfactory, adjustments of the level should be done;
- Following the suggested one-off evaluation, the Armenian government should call for mergers between RIs. In order to create incentives for change, the government should not select which institutions to merge, but leave this decision and action to the institutions themselves. However, funding support should be allocated to institutions that decide to merge with each other, to stimulate the process but also to cover the actual costs involved; and
- After three years, institutions that clearly underperform and have not engaged in a merger, should be forced to do so or be closed down.

Figure 8: Timeline performance-based funding



ANNEX

Stakeholders consulted (list from both missions)

Representatives of Institutes and Universities (specialised in physics):

- Yerevan State University
- National Polytechnic University of Armenia
- Alikhanyan National Science Laboratory
- Byurakan Astrophysical Observatory of NAS
- Institute for Physical Research of NAS
- Institute of Radiophysics and Electronics of NAS
- Center for the Advancement of Natural Discoveries using Light Emission (CANDLE)

Representatives of Institutes and Universities (specialised in biology and related fields)

- Yerevan State University
- Yerevan State Medical University
- Institute of Molecular Biology of NAS
- Institute of Physiology of NAS
- Institute of Biochemistry of NAS 'Armbiotechnology' Scientific and Production Centre of NAS
- Scientific Centre of Zoology and Hydroecology of NAS

Representatives from social sciences and humanities institutions:

- RA National Academy of Sciences Presidium
- RA NAS Institutes of Oriental Studies; History; Language; Literature; Arts; Archaeology and Ethnography;
- Armenian State Pedagogical University
- Brusov State University of Languages and Social Sciences
- Research Center for Historical- Cultural Heritage

- Armenian Russian (Slavonic) University
- Armenian National Agrarian University
- Heratsi State Medical University
- Yerevan State Medical University

Authorities responsible for research policy and implementation

- Arayik Harutyunyan, RA Minister of Education and Science
- Arevik Anapiosyan, Deputy Minister of Education, Science, Culture and Sports
- Samvel Haroutiunian, Chairman of the RA MES Science Committee
- Radik Martirosyan, President of the RA National Academy of Sciences
- Board of the National Academy of Sciences

Other stakeholders

- Researchers/Grantees from a wide spectrum of fields
- Representatives of TUMO Centre
- ERASMUS PLUS representatives and the National Team of Higher Education Reform Experts
- Representatives of FAST diaspora initiative
- Representatives of Engineering City
- Representatives the National Centre for Professional Education Quality Assurance Foundation(ANQA)

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The Horizon 2020 Policy Support Facility (PSF), set up by the Directorate-General for Research and Innovation (DG RTD) of the European Commission under the EU Framework Programme for Research and Innovation, supports Member States and countries associated to Horizon 2020 in reforming their national science, technology and innovation systems.

The aim of the PSF Specific Support for Armenia, carried out by a panel of independent European research and innovation policy experts from April 2019 to February 2020, was to assist in reforming and reinforcing the performance of the Armenian research institutions and enhancing cooperation between higher education and research institutions.

Drawing on the experience of other EU and associated countries, notably the Baltic States, the PSF team developed 19 recommendations and a roadmap for their implementation covering three main topics:

- A proposal for research evaluation arrangements and the launch of a first national level evaluation of publicly funded research institutions;
- Design of a performance-based funding system and advice on future implementation; and
- Development of a set of policy measures aimed at bridging the gap between higher education and research institutes, and notably supporting a shift towards research-based education in universities.

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