WAYS TO INCREASE THE EFFICIENCY OF THE NATIONAL RESEARCH SYSTEM

Manush MINASYAN
PhD, Associate Professor, Senior Researcher, IE, NAS of Armenia

Key words: knowledge-based economy, national research system, efficiency, scientific and technical work, Black Sea Basin countries, scientific publication

Introduction

In the 21st century, the knowledge-based economy has become one of the key factors determining the competitiveness of nations. In this context, the effective functioning of national research systems (NRS) is of vital importance both for scientific progress and for the socio-economic development of a country. The efficiency of a national research system directly influences economic growth, the introduction of innovations, and the advancement of society. However, in many countries, including Armenia, the system faces serious challenges such as limited funding, the outflow of scientific personnel, a low level of international cooperation, and issues related to the commercialization of scientific results. The quality and effectiveness of research in any field of science determine the state's sovereignty, security, the well-being of the population, the preservation and strengthening of national identity, and the continuity of legal, political, and cultural traditions. The purpose of this article is to analyze possible ways to improve the efficiency of the national research system by comparing international experience, various assessment methods, and the current situation in Armenia. The following key issues are discussed: the need for policy reforms, new funding mechanisms, the creation of collaborative platforms, and strengthening the link between science and the economy as essential factors for the sustainable development of the system.

Methodology

During the study, comparative, descriptive, economic-statistical, and correlation methods of scientific research were applied. The informational basis for the article included scientific works related to the field, regulatory legal acts, official statistical data, and various reports. Assessing the efficiency of a country's research system is quite complex, especially considering the limited base of official statistics. To select the appropriate methodology, we examined international experience. As a result, for our research, we sought to apply a combined methodology, which involves integrating both quantitative and qualitative research methods. Quantitative methods allow for the measurement and analysis of data related to the efficiency of the research system, while qualitative methods complement quantitative data by providing a deeper understanding of the underlying causes and processes. Franceschet proposed a method for grouping bibliometric indicators into clus-

ters of highly correlated metrics. Applying his clustering method to evaluate a sample of 13 computer science researchers, he grouped the 13 indicators into four indices:
1. number of articles – to measure the researcher's productivity
2. number of citations – to measure the researcher's absolute impact
3. average number of citations per article – to measure the researcher's relative impact
4. m-index – to measure the sustained impact over time [Franceschet, 2009].

In our view, rather than starting with a large set of indicators and then moving toward a final composite index as a basis for ranking, it is preferable to select a limited set of indicators that clearly define the performance criteria to be measured. Subsequently, depending on the nature of their activities, we suggest leaving it to individual institutions or agencies to choose which indicators to use and what weight to assign to each.

Literature review

Improving the efficiency of national research systems has become a key component of the global academic and political agenda. According to some scholars, the strategic planning of a national research system should be based exclusively on the priorities of science and technology [Georghiou et al., 2014]. Today, knowledge is recognized as an important factor of production. In his 1945 publication "The Use of Knowledge in Society", Friedrich Hayek viewed knowledge as a commodity [Hayek, 1945, 519].

According to a number of studies, the main factors behind the success of national research systems include effective funding mechanisms, institutional autonomy of scientific organizations, the development of human resources, cooperation between science and business, as well as the applied nature of research results [Etzkowitz & Leydesdorff, 2000; Salmi, 2009]. Special attention is paid to the strategic planning of national science policy, where long-term vision and sector-specific targeted initiatives are prioritized. In this context, upgrading human capital and engaging young researchers are key components for achieving high efficiency [Aghion et al., 2010].

Contemporary studies widely discuss mechanisms that enhance the quality and impact of research. These include the growth of scientific publications and citations, the expansion of international cooperation, the modernization of research infrastructure, as well as the integration of digitalization and open science principles into research practice [UNESCO, 2021; Moed,2005]. Hanney, Kanya, and others propose five steps to strengthen a country's research system: analyze the situation, develop a comprehensive strategy, engage stakeholders, assess impacts, and ensure collaborative participation [Hanney et al., 2020].

Valuable contributions to the topic have been made by G. Abramo and D. D'Angelo, who proposed a methodology for evaluating scientific productivity at the sectoral and institutional levels, using Italy as an example [Abramo et al., 2018]. They presented an input-oriented approach based on the quality of interdisciplinary characteristics, which is inde-

pendent of the country's size [Abramo et al., 2018]. This input-oriented approach is particularly relevant in Armenia's context, as it enables the assessment of research quality regardless of the country's size or funding volume.

For research evaluation, Herb addressed open science indicators, concluding that open access, open peer review, and other altmetric indicators contribute to the transparency of research systems, but may also lead to metric-driven pressures [Herb, 2025].

B. Lepori and colleagues conducted a comparative analysis of the development of national research policies in six European countries(Austria, Italy, France, the Netherlands, Norway, and Switzerland) over the last three decades, with a special focus on changes in public project funding schemes. They systematically used indicators on the volume of funding allocated by each instrument and agency, developed within the European Excellence Network's PRIME project. Three common trends were identified: a significant increase in project funding volumes, diversification of instruments, and a general shift toward instruments oriented to thematic priorities. They concluded that countries choose different paths in shaping the organizational structure of funding agencies, and that national differences in funding portfolios persist over time [Lepori et al., 2007, 372-388]. In addition, research should not only identify problems but also propose policy reforms aimed at solving them.

For assessing Armenia's national research system, it is important to analyze both local challenges and successful global practices – in particular, the European Union's Horizon Europe programs and the integrated innovation models of Asian countries [European Commission, 2020]. Based on WoS data from 2017–2021, a scientific study assessed the strengths and weaknesses of Armenia's research system in comparison with Italy's. This approach can be applied in developing strategic policy recommendations for the sector [Scientometrics, 2025].

Scientific novelty

By analyzing the dynamics of the main indicators of the Armenian national research system, we have identified its strengths and weaknesses, and based on the conclusions, we have made proposals aimed at improving the system.

Analysis

The term "knowledge economy" became widely popular thanks to renowned economist P. Drucker, who defined it as the application of knowledge to generate economic benefits [Drucker, 1969]. Today, all countries recognize that the creation and dissemination of knowledge should be central goals of economic policy. It is no coincidence that developed countries began actively applying national research evaluation methods. In the current knowledge-based economy, governments of industrialized nations face a range of

challenges, particularly in building more efficient scientific infrastructures aimed at enhancing the competitiveness of entire economic systems.

Since the culture of evaluation knows no borders and spreads quickly, researchers, institutional managers, and policymakers are compelled to compare themselves with others – both nationally and internationally. At the global level, comparative analysis has potential strategic applications, such as identifying strengths and weaknesses of domestic research infrastructure or revealing capacities to play a leading role in the global growth of technological and scientific knowledge. Analysis can also highlight centers of excellence by field and by administrative region.

Performance indicators. The primary indicator of a researcher's efficiency is the total number of publications authored within a given period. Fractional productivity (FP) measures the total contributions of a researcher across authored publications, where a "contribution" is defined as the reciprocal of the number of co-authors on each publication. Scientific strength (SSPII or SSPIR) is the weighted sum of publications authored by a researcher, with each publication's weight equal to its quality index (PII or PIR). Fractional scientific strength (FSSPII or FSSPIR) is similar to fractional productivity but applies to scientific strength.

Quality indexes (QIPII or QIPIR) measure the average impact of a researcher's publications, i.e., the average PII or PIR value across their works. Each indicator can be expressed as an absolute or percentage value. The percentage form allows for comparing research performance among scientists from different disciplines. It is also important to evaluate the widely used h-index and its variations, although impact and volume indicators together provide more information than the h-index alone.

In our view, the optimal bibliometric indicator for measuring research performance is the one that reflects a contribution to the advancement of knowledge – namely, fractional scientific strength. A high value for this indicator depends to varying degrees on its determining factors: productivity, average impact of publications, and contribution. Understanding the performance of each factor can help in assessing their relative weights and informing further interventions. The proposed evaluation model involves five steps:
a) Identifying the academic rank of all researchers for a given period;
b) Cataloging the scientific output of each named researcher during that period;
c) Calculating bibliometric indicators of productivity and impact for each researcher;
d) Comparing all researchers of the same academic rank and calculating a national performance percentile for each indicator (0=worst, 100=best);
e) Summarizing performance by research group or department.

This methodology enables comparisons at both the individual and institutional levels with the results required to be made public.

The National Research System in Armenia. Armenia's NRS includes research organizations represented by around 30 institutes under the National Academy of Sciences, the university science system, and non-state or private research centers, which are generally small-scale or application-focused. The governing bodies of Armenia's NRS include the Ministry of Education, Science, Culture and Sports(responsible for policymaking and decision-making), the Science Committee(which organizes state grant competitions), and, to a certain extent, the National Academy of Sciences, which coordinates research activeties. Funding is primarily provided from the state budget, supplemented by limited private and international sources. However, funding is often non-competitive, limited in scope, and based on outdated methodologies.

Table 1. Share of science in GDP 2000-2023 [SC of the Republic of Armenia, Statistical Yearbooks, https://armstat.am/am/]

Years	GDP, billion AMD	Volume of scientific and research work, billion drams	Share of science in GDP, %	Contribution of science to GDP growth, %
2000	1031,3	3.6	0.4	0.02
2001	1175,9	4	0.4	0.04
2002	1362,5	4.9	0.4	0.05
2003	1624,6	5	0.31	0.06
2004	1907,9	4.9	0.26	0.03
2005	2242,9	5.9	0.26	0.04
2006	2656,2	6.5	0.24	0.03
2007	3149,3	7	0.22	0.03
2008	3568,2	7.8	0.22	0.02
2009	3141,7	9.4	0.3	-0.03
2010	3460,2	8.7	0.25	0.01
2011	3777,9	9.2	0.24	0.01
2012	4266,5	9.7	0.23	0.02
2013	4555,6	10.2	0.22	0.01
2014	4828,6	11.5	0.24	0.02
2015	5043,6	12.6	0.25	0
2016	5067,3	12.1	0.24	-0.01
2017	5564,5	12.2	0.22	0
2018	6017,0	10.9	0.18	0.02
2019	6543,3	11.8	0.18	0.01
2020	6181,9	12.3	0.2	-0.02
2021	6991,8	14.4	0.21	0.03
2022	8501,4	16.7	0.2	0.05
2023	9453,2	15.9	0.17	0

As it follows from Table 1:

- Over the past 24 years, the share of science in Armenia's GDP has averaged 0.26%, a very low figure compared to other countries;

- The average annual growth rate of R&D activities (4.7%) lags significantly behind GDP growth (6.3%);
- Science's contribution to Armenia's economic growth during the observed period is extremely low – averaging only 0.018%.

Table 2. Trends in the number of researchers per million population in the Republic of Armenia, 2000-2025[SC of the RA, Statistical Yearbooks, https://armstat.am/am/]

	2000	2005	2010	2015	2020	2025
Population, million people	3802.4	3219.2	3262.6	3010.6	2959.7	3076.2
Number of researchers, people	4971	5401	5460	4164	3657	3778
Number of researchers per 1 million people	1.3	1.7	1.7	1.4	1.2	1.2

From 2000 to 2025, the number of researchers per million inhabitants in Armenia has fluctuated between 1.2 and 1.7, a low figure maintained largely due to population decline. In comparison, in 2018 the leading EU countries were Denmark(8,066 researchers per million), Sweden (7,536), and Finland (6,861).

Using the latest UNESCO Science Report published in 2021, we have analyzed some indicators of the Black Sea Basin countries, and also made comparisons with the indicators of the European Union member states.

Table 3. Level of economic openness of the Black Sea Basin countries, 2013–2015 and 2016–2018, million dollars [UNESCO Science report 2021]

Countries:	**Inflow of direct investments from abroad**		**Foreign-funded research**		**Export of goods**		**Product export**	
	2013-2015	**2016-2018**	**2013-2015**	**2016-2018**	**2013-2015**	**2016-2018**	**2013-2015**	**2016-2018**
Armenia	309	281	5.0	4.3	1495	2150	326	499
Azerbaijan	3699	2923	1.0	0.2	25518	16695	620	581
Belarus	1920	1333	264.5	357.5	33330	28831	15750	15610
Georgia	1502	1528	3.4	10.6	2659	2734	1206	1016
Moldova	267	163	19.8	6.6	2245	2392	782	863
Turkey	15391	12840	615.2	970.8	151084	155830	118563	120039
Ukraine	2802	2915	1281.3	955.6	52221	42324	28875	20200

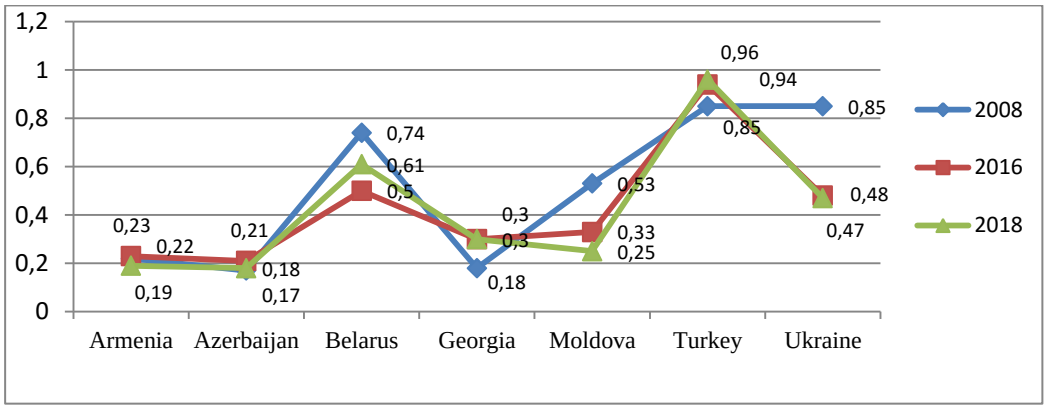

Figure1. Trends in research spending relative to GDP in the Black Sea Basin countries [UNESCO Science report 2021]1

The chart shows that research spending relative to GDP is quite low in the Black Sea Basin countries, with Turkey having the highest figure in 2018 at 0.96, while Armenia is only ahead of Azerbaijan. The picture becomes more complete if we compare it with the figure for the European Union member states, which was 2.03 in 2018.

In most EU member states, the business sector leads in research performance, except in Cyprus, Estonia, and Latvia, where higher education dominates.

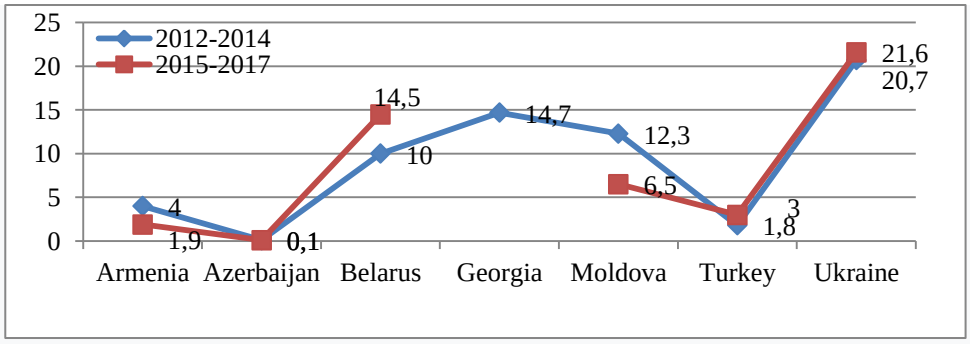

Figure 2. Share of foreign-funded research and development in total domestic expenditure in the Black Sea Basin countries, 2012–2014 and 2015–2017 (%) [UNESCO Science report][2]

[1]Note: GERD data for Armenia are partial, and data for Georgia for 2006–2012 are not available.Georgia's 2013data includes only the higher education sector, and 2014–2017data excludes the business and private non-profit sectors. Ukraine's 2014–2017 data excludes some regions.

[2] Data for Georgia is not available for 2015-2017

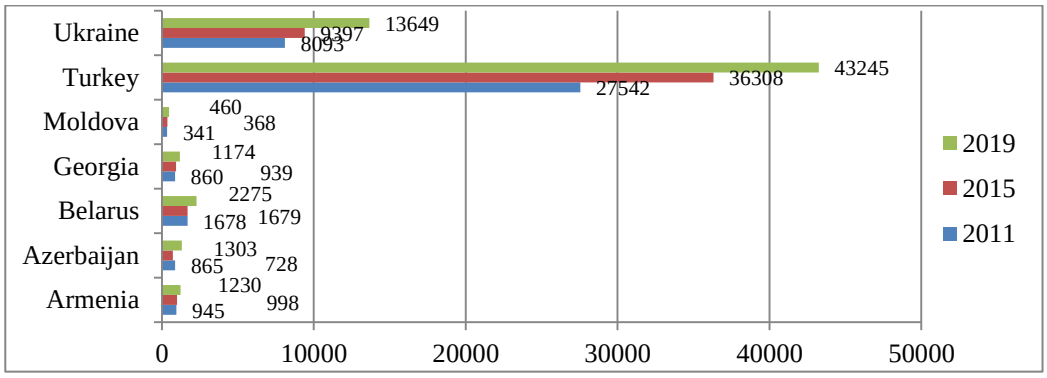

Figure 3. Trends in scientific publications in the Black Sea Basin countries, 2011-2019 [UNESCO Science report 2021]

When it comes to scientific publications, Armenia cannot compete in volume with Turkey, Ukraine, or Belarus, but surpasses Georgia and Moldova and is only slightly behind Azerbaijan.

On the other hand, the countries of the Black Sea basin cannot compete with the member states of the European Union, in particular, the indicators of the top five in 2019 are as follows: United Kingdom: 160,174, Germany: 152,348, Italy: 103,577, France: 101,081, Spain: 81,343 [UNESCO Scientific report 2021].

Within the Black Sea region in 2017–2019, Armenia led in the share of publications in astrophysics (50%), followed by Belarus(39%), Georgia(32%), and Azerbaijan(30%). In Turkey, the leading field was health sciences (39%), while in Ukraine it was applied strategic technologies (26%). In the EU, health sciences dominate in almost all member states [UNESCO Scientific report 2021].

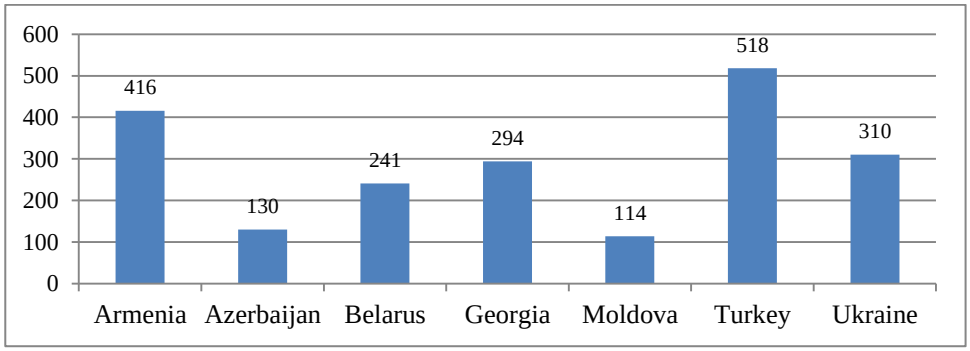

Figure 4. Number of scientific publications per million inhabitants in the Black Sea basin countries in 2019 [UNESCO Scientific report 2021]

As the chart shows, among the countries of the Black Sea basin, Armenia is second only to Turkey in the number of scientific publications per 1 million inhabitants and is 3.2

times higher than the same indicator of Azerbaijan. However, the EU's per capita rates are roughly ten times higher, with Denmark (4,332), Sweden (3,690), Finland (3,244), and the Netherlands (3,009) leading in 2019.

Identified weaknesses of Armenia's NRS:

- Low share of science in GDP (0.26%) and extremely low contribution to economic growth (0.018%);
- Low funding level (0.2% of GDP), compared to over 2% in the EU;
- Aging scientific workforce (average age above 55) and limited youth involvement;
- Weak link to the economy – minimal private sector demand for science and rare transfer of research results to market or industry;
- Partial international isolation, with limited integration into the global research system;
- Institutional fragmentation – lack of systemic coordination between NAS, MoESCS; and universities; absence of sufficient state support for private research centers;
- Lack of a modern system for evaluating the efficiency of scientific organizations.

Identified strengths:

- International recognition in physics and mathematics, largely due to the Yerevan Physics Institute;
- Achievements in biotechnology in recent years supported by private laboratories and innovative startups;
- Strong potential in IT and artificial intelligence, driven by the private sector;
- Although Armenia's per capita scientific publication rate lags behind EU countries, it leads among Black Sea states and has shown rapid growth in recent years.

Conclusions

Armenia currently has a national research system that is on a development path but faces a number of structural, financial, and strategic challenges. The system was largely shaped during the Soviet era and, while it retains scientific heritage and potential, it now requires modernization. Improving the efficiency of the NRS calls for a comprehensive approach that encompasses governance, financing, technology, and human resource development.National policies aimed at boosting the efficiency of scientific systems should be based on reliable strategic analysis that identifies the sector's strengths and weaknesses.The results of such evaluations can be compared with industrial analysis outcomes to define intervention priorities.

Armenia has a traditional yet renovation-needing scientific system, which can progress if the following reforms are implemented:

- Adoption of a clear national strategy with well-defined directions and priorities, along with improved accessibility of information on the achievements and prospects of Armenian science;

- Provision of adequate, competitive, and fair funding (1.5–3.0% of GDP), targeted allocation of existing financial resources, and development of competitive funding models based on quality and results. European practices of private sector involvement in science funding could be introduced;
- Establishment of modern infrastructure, including laboratories equipped with state-of-the-art technology and electronic libraries to ensure access to global scientific resources;
- Creation of flexible mechanisms to support scientific publications, including assistance in registering local journals in international scientific databases and supporting Armenian scientists in publishing in existing indexed journals;
- Development of systemic cooperation along the chain: government – research organizations and universities – industry – society;
- Increased engagement of young scientists through adequate remuneration, housing solutions, and other forms of moral recognition. Talented young researchers should be involved in R&D starting from the university system;
- Strengthening science–business links through the creation of technology transfer centers, expansion of startup programs, and introduction of clear mechanisms for assessing scientists' contributions to the country's socio-economic development during certification. Initiatives such as "Science for the Whole Family" – large-scale public events dedicated to science and technology – could be implemented, along with the development of "scientific tourism" to raise awareness of Armenian science among both young Armenians and international visitors;
- Reform of the management system through the creation of independent agencies, setting clear evaluation criteria, eliminating bureaucracy in the science sector, and simplifying and accelerating administrative processes. Researchers and developers should be actively involved in solving the most important issues of national and societal development.

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The purpose of this article is to analyze possible ways to enhance the efficiency of the national research system by combining international experience, various evaluation methods, and the current situation in Armenia. The following key issues have been discussed: the need for policy reforms, new funding mechanisms, the creation of collaborative platforms, and the strengthening of ties between science and the economy as fundamental factors for the system's sustainable development.

To select the research methodology, we examined international experience. As a result, for our study we sought to apply a combined methodology, integrating both quantitative and qualitative research methods.

The analysis allowed us to identify the strengths and weaknesses of Armenia's national research system. At present, Armenia has a developing NRS that nonetheless faces several structural, financial, and strategic challenges. The system was largely formed during the Soviet era, and while it possesses scientific heritage and potential, it now requires modernization. Improving the NRS's efficiency demands a comprehensive approach that includes improvements in governance, financing, technology, and human resources.Based on our analysis, we have proposed a number of recommendations aimed at advancing Armenia's national research system.