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THEORY AND PRACTICE OF RESEARCH EVALUATION IN MODERN REALITIES

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The problem of research evaluation arises from mismatch between evaluation methods relying on quantitative indicators of publication activity and the needs of determining the quality and socio-economic impact of research as a criterion for fair distribution of public funds between the entities involved in the research process. This problem has become especially important for Ukraine amidst its integration in global research networks, and due to the need to counteract the Russian armed aggression and recover of the national economy in future.

The monograph can be a useful and interesting source of information for researchers, lecturers, employees of science management bodies, post-graduates, and students.

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FOREWORD

The issue of research evaluation as a critical component of the decision-making system remains relevant, being consistently in the focus of researchers and R&D administrators. The need to evaluate the quality and effectiveness of the government-supported research is widely acknowledged, as it pertains to the cost-effective use of public-budget resources. The crucial issue lies in determining which evaluation approaches are able to provide most adequate and accurate data on the current R&D performance. It has been intensively debated within the scientific community over the past decade. Special emphasis is placed on improvements in the methodology and practice of evaluating the effectiveness and impact of R&D, to achieve a balance between quantitative (metric-based) and qualitative (expert-based) indicators. Increasingly, evaluation employs indicators and criteria that encourage the adoption of best research practices in both basic and applied research, foster a robust research culture and a developed research ecosystem, guarantee creative freedom, promote collaboration with industry and education sectors, and support the training of a new generation of researchers, particularly by engaging talented youth in R&D.

Today, Ukraine, in addition to participating in global competitive processes, must counter Russian armed aggression and plan the future reconstruction of its national economy with extensive use of scientific advancements. This requires regular monitoring and evaluation of the national research, technological and innovation capacities.

With the introduction of open science policies in Ukraine, evaluation also plays a significant role in ensuring open access to research results, expanding scientific communications and interactions with society, building trust in science, and facilitating the implementation of various measures outlined in the National Plan for Open Science.

This books presents selected articles of the participants of the International Symposium "Evaluating results of scientific research in present-day realities: the evolution of approaches in cognitive, socio-economic and administrative dimensions," dedicated to the memory of Borys Paton, academician of the National Academy of Sciences of Ukraine. The symposium took place on November 28, 2024, in Kyiv under UNESCO patronage and with the participation of experts from the National Academy of Sciences of Ukraine, national branch academies of sciences of Ukraine, higher education institutions, and scientific organizations from Azerbaijan, Lithuania, Moldova, Poland, and the United States.

The authors address core issues of research evaluation methodology and organization; the application of open science principles in advanced approaches to the evaluation of scientific results in research institutions and universities; the need to transition to the systemic evaluation of scientific results based on a produced piece of knowledge; and the interpretation of scientific results as a complex phenomenon of research activities.

I am convinced that the evaluation practices in research institutions of the National Academy of Sciences of Ukraine, other national branch academies of sciences of Ukraine and foreign scientific organizations will draw the readers' interest.

President of the National Academy
of Sciences of Ukraine, academician
Anatoly ZAGORODNY

CHAPTER 1

Evaluating research institutions and projects in Ukraine and abroad: experiences and problems

1.1. AN EFFECTIVE TOOL FOR ENHANCING THE QUALITY AND RELEVANCE OF RESEARCH IN THE NATIONAL ACADEMY OF SCIENCES OF UKRAINE

V.L. Bogdanov

A key factor for the R&D efficiency is performance evaluation of research institutions (RIs). In 2017, following a pilot phase, the Academy introduced the Methodology for Performance Evaluation of RIs of the NAS of Ukraine. This methodology relies on the approaches and evaluation methodologies used by the self-governing scientific organization Leibniz Association (Germany), as this association is most similar to the NAS Ukraine in structural and functional terms. Also, certain provisions were adapted from methodologies of similar research organizations, notably the Max Planck Society, whose institutes specialize in basic research. The methodology used by the Academy is based on the core principles of the Leiden Manifesto [1]. A significant feature of this method is that quantitative indicators are considered an important element of the evaluation procedure, but the results are determined by experts based on a qualitative analysis of information covering various dimensions of RIs activities over a five-year period. Another distinctive feature is that each research unit is subject to evaluation apart from RI as a whole. This approach enables experts to develop recommendations on improvements of the RI structure and optimization of the entire network of Academy RIs. Also, the evaluation results are used in determining the core funding of RIs and in the competitive selection of projects within one of the Academy's budget funding programs.

The first cycle of evaluations by the aforementioned methodology was conducted in 2016—2021 and covered 163 RIs of the NAS of Ukraine [2]. In 2022, due to the Russia's armed aggression, the Presidium of the Academy deemed it inappropriate to conduct evaluations and resumed them in 2023, given the RI's consent to the evaluation. The total 20 RIs were evaluated in 2023 [3]. The evaluation of 48 RIs was expected in 2024, with the results approved and presented to the Presidium of the Academy by an independent standing evaluation commission by the end of the year.

That the methodology applied by the Academy is a robust one is confirmed by the fact that the evaluation results of 75% of the RIs categorized by the Academy align with the results of evaluations conducted by the Ministry of Education and Science of Ukraine as part of the official evaluation. This alignment is largely due to the extensive involvement of external experts in the evaluation commissions. Overall, 938 experts participated in the evaluation in 2016—2021, of which 346 (37%) were non-Academy experts and 111 (12%) foreign experts from 25 countries worldwide. Active involvement of external experts continues this year as well.

The methodology used by the NAS of Ukraine is an important tool for enhancing the scientific level and productivity of research, as its primary purpose is to assess the RI's efficiency, highlight its contribution to the development of modern science while considering its inherent characteristics and uniqueness. The evaluation is based on a range of criteria: quality, originality, effectiveness, novelty, accuracy, relevance, impact, theoretical and practical significance, competitiveness, relevance to research and societal objectives, social significance. The conclusion of the expert evaluation commission on the efficiency of a RI and its units must include the expert opinion regarding the originality of thematic plan and main areas of research, their alignment with global R&D patterns; the priority of achievements and the RI's potential at national or international level; the prospects and the strategic importance of the obtained results for further development of the research field and the scientific community.

Importantly, the evaluation based on a broad set of criteria encourages RIs to place special emphasis on the quality of scientific results. This is confirmed by the results achieved by Academy RIs in recent years, despite challenging conditions and losses caused by military actions [4—6]. For instance, mathematicians developed a new method for controlling nonholonomic mechanical systems, enabling the solution of tasks such as stabilization of the conditions, trajectory tracking, and obstacle avoidance, and holds prospects for use in mobile robotic systems, including those for military purposes. For the first time in the probability theory, mathematical conditions for the maximum possible probability of a random point on a plane hitting a given polygon were formulated. This represents a significant advancement of the classical Chebyshev inequality regarding the extremal property of a one-dimensional random variable, enabling the creation of new technologies for object detection in the field and the development of guidance systems for artillery and missile weaponry.

Theoretical physicists investigated a new form of strongly interacting matter, quark-gluon plasma, which, according to modern theoretical predictions, occurs in the early stages of proton-proton and nucleus-nucleus collisions at the Large Hadron Collider at CERN. The rapid expansion of such matter leads to its transformation into a hadron-resonance gas. Additionally, the occurrence of another exotic phase, a pion Bose-Einstein condensate, is possible.

Astronomers identified and explained a broad depression in the spectra of M-dwarfs. This spectral feature indicates the presence of a new source of opacity in the atmospheres of late M-dwarfs and is sensitive to the star's gravity and metallicity.

Our materials scientists achieved remarkable results as well. They synthesized crystals for the first time that exhibit p-type electrical conductivity and demonstrate photoconductivity values and bandgap energy levels that make them highly promising materials for use in optoelectronics, nonlinear optics, thin-film solar cells, and water-splitting catalysts. New high-entropy materials with unique properties were developed, which could serve as the basis for ultra-high-temperature ceramics capable of operating at temperatures up to 2000 °C, making them undoubtedly applicable in the aerospace industry, aviation, and engine manufacturing. Among the notable achievements of the Academy's materials scientists are new technologies for producing defect-free ingots of titanium alloy.

Chemists proposed an innovative, environmentally safe method for converting CO_2 into compounds with unique structures and morphologies, opening prospects for creating new materials for industries such as energy, chemical production, environmental protection, and more. New nanomaterials with unique optical and electronic properties were created, and fundamentally new catalysts were developed, including an electrocatalyst that increases the efficiency of high-performance vanadium batteries by 1.5 times, as well as a catalyst that ensures complete conversion of hydrocarbons without producing toxic carbon monoxide. This is highly needed in industry, households, and on the front lines, where our soldiers widely use solid-fuel stoves for various needs. New promising polymer materials, unparalleled worldwide, were also developed — photoactive compositions with high sensitivity to visible light and special-purpose adhesives that harden through a polyaddition mechanism. For the utilization of toxic compounds in water purification and as adsorbents, new "smart" nanocomposites were synthesized.

Biologists at the Academy studied the impact *of* covid-19 on human cognitive abilities (while our scientists are also working on developing drugs to prevent negative post-covid effects) and the molecular-genetic mechanisms of Alzheimer's disease. In collaboration with specialists from the D.F. Chebotarev Institute of Gerontology of the National Academy of Medical Sciences (NAMS) of Ukraine, they implemented a new treatment method for Parkinson's disease. They also identified the properties of a gene affecting human reproductive function. Another extremely important development, artificial skin, is more relevant now than ever. It has already attracted the interest of the NAMS of Ukraine and the Ministry of Health of Ukraine.

Geneticists proposed new extra-drought-resistant, high-yielding varieties of winter grain crops. These varieties can replace fodder corn in the southern regions of Ukraine, where it has not been grown in recent years due to critical drought conditions.

Socio-humanitarian researchers are undertaking extremely important work, primarily focused on debunking the aggressor's ideology, identifying the reasons for its emergence, and finding ways to counteract it. Sociologists continue to study societal attitudes and the psychological conditions of society during the war. Demographers are analyzing the current demographic pattern, forecasting future demographic and migration processes. Economists have proposed a vision for the post-war recovery of Ukraine. Numerous scientific publications by our socio-humanitarian researchers have been released, e.g. a large-scale co-authored work, "Archaeology of Ukraine During the Years of Independence", the first book of the supplementary volume of the Encyclopedia of the History of Ukraine, the 6th volume of the new academic 12-volume "History of Ukrainian Literature", and the 13th volume of the 20-volume "Dictionary of the Ukrainian Language".

The Academy RIs strive towards the societal significance of research, prioritising scientific support and solutions to pressing societal and governance issues. Researchers from several institutes (hydrobiology, marine biology, zoology, and botany) have engaged in research, observations, forecasting and assessing the environmental consequences of the disaster at the Kakhovka Hydroelectric Power Plant. Academy staff are involved in repair works to stop water leaks in the area of the Demiivska metro station in Kyiv. For instance, a special polyurethane injection composition called Geopolymer composite, developed by our chemists, is used to reinforce soils, tunnel linings, and waterproofing in the metro system.

Energy scientists developed new models of relay protection and automation systems, along with their operational algorithms, which are critically important for preventing systemic failures in the unified energy system of Ukraine. A mathematical model and methodology for determining optimal modes and designs of electrical heat treatment of cables on the industrial line of PJSC "Yuzhkabel Plant" (located in the city of Kharkiv), created by energy scientists, enabled the serial production of power cables with an aluminum core that has enhanced flexibility and resistance to external impacts. Such products are essential for reducing the time required to restore all critical energy infrastructure facilities in Ukraine. Their exports to Sweden, Norway, Denmark, Estonia, Latvia, and Lithuania have begun. A gas burner device with a capacity of 35 MW for steam boiler units at thermal power plants was developed. Twenty-four burners were installed in domestic thermal power plants during the 2023/2024 winter period, significantly improving the stability of the energy system.

A successful example of critical import substitution is the first-ever development of a technology for the production of recovered granulated nickel powders with granule sizes 45—70 μm and a specified chemical composition, which was introduced in 2024 into the technological process of manufacturing oxide cathodes for klystrons at the "Generator" plant.

For monitoring the waters of the Black and Azov Seas, the State Border Guard Service of Ukraine uses a software-hardware complex for processing remote sensing data of the Earth, developed by Academy specialists, with a system for archiving, cataloging, and searching data to enable real-time monitoring of the situation during maritime border protection.

A modified bioactive ceramic developed by materials scientists was successfully used for the first time to restore large lost fragments of limbs in soldiers after gunshot wounds. The operations were performed at the Dobrobut clinic using the cutting-edge induced membrane technique (Masquelet technique), which allows the restoration of large bone fragments using crushed autologous bone. The functionality of the limbs was restored, and the soldiers have now returned to the front.

In response to the challenges of the time, there has been a significant *reorientation of the research areas* of the Academy RIs, with updating and expanding research for defense and security purposes.

Mechanical engineering scientists developed a scheme for installing onboard cavitators, which can reduce the hydrodynamic drag of a high-speed vessel by 10%, and optimized the hull shape of the high-speed ship of Project 58206 for the Ukrainian Navy. Comprehensive studies of fragments of captured weapon and military equipment samples were conducted at the request of the Central Research Institute of Armament and Military Equipment of the Armed Forces of Ukraine. This offers new insights into technological solutions and allows for feasibility studies of creating similar materials and technologies for Ukrainian defense industry purposes. *Physicists* conducted important studies on the mechanisms of the destructive effects of powerful pulsed laser radiation on video surveillance systems and developed effective schemes for actively countering small-sized UAVs. A hydrogen energy converter was created as a source of autonomous electrical power for unmanned aerial vehicles, utilizing new variants of fuel cells and an efficient hydrogen storage system in its design. The results were implemented at OJSC "Meridian" named after S.P. Korolyov.

An analysis of the destruction process of cast steel hollow modules for shelters under the impact of an explosion and the stress-strain state of the structures was conducted in collaboration with the Institute of Public Administration and Research on Civil Protection of the State Emergency Service of Ukraine. It revealed that shelters made of such modules met current requirements in terms of protective functions and the degree of attenuation of ionizing radiation. Single-row steel modules can be used to build structures to protect military equipment, infrastructure facilities, and civilians. A device developed by our scientists, which uses hydrophobic porous materials to absorb large shock loads (e.g., shock waves from military ammunition explosions), was handed over for further testing on military equipment.

In evaluating the Academy RIs, experts examined the profile of their international science and science & technology cooperation, especially the participation in international projects, admittedly a significant incentive for the development of such cooperation. It should be noted that our scientists have successfully participated in experiments at the Large Hadron Collider at CERN and observations using the Hubble, TESS, and James Webb space telescopes, achieving world-class results. For instance, observations with the James Webb Telescope allowed to explore the chemical composition of relatively young galaxies (one billion years old) undergoing secondary ionization of hydrogen atoms. These galaxies are very close in chemical composition to modern galaxies, indicating rapid chemical evolution of young galaxies over a short period of several tens of millions of years, because of which galaxies quickly "forget" the physical conditions that existed at the time of their formation. This is an extremely important discovery for astrophysics and cosmology.

I cannot overlook another achievement — with the participation of our scientists in experiments at the Borexino neutrino laboratory (Italy), the direction of arrival of low-energy solar neutrinos was measured for the first time, with refining the data on the concentration of heavy metals in the interior of our Sun. Also, world-class results were obtained at the domestic quasi-stationary plasma acceleration facility. These results pertain to the interaction of plasma with the materials of the first wall of thermonuclear reactors and were obtained in a joint project with the EUROfusion consortium under the Euratom program.

Striving of the Academy RIs towards excellent scientific results had positive impact on quantitative performance indicators: the publication, innovation and patent activity have remained stable despite extremely hard work conditions of the Academy RIs in recent years.

An important purpose of the results of the Methodology for Performance Evaluation of RIs of the NAS of Ukraine is their use by the Presidium of the NAS of Ukraine in elaborating measures on optimization of the RIs network. The methodology, allowing for a critical consideration of efficiency dimensions like the relevance of research topics or the results (scientific publications, patents, licenses, etc.), thus enables for the continuation of relevant research areas and the employment of involved staff when a RI is supposed to be reorganized or restructured. Issues of RIs network optimization were discussed at the meetings of the Presidium of the NAS of Ukraine in 2021 and 2024, with taking specific decisions on closures of certain RIs through liquidation or reorganization. These decisions resulted in the liquidation of five RIs that had failed to produce adequate research output or had consistently low rankings compared to similar organizations. Thirteen RIs were reorganized by merging with others. Additionally, the evaluation results entailed adjustments in the composition of the Academy divisions, as the latter had to incorporate the RIs performing research projects best aligned with division profile. Several RIs were renamed with their research profile updated. Many RIs underwent restructuring following the evaluation results, notably by closing inefficient units.

The evaluation results were employed in introducing elements of a new R&D funding model in the Academy, accounting for the RIs efficiency and the need for priority backing of competitive research teams. A procedure for distributing the core budget funding, proposed in 2022, relies on the results obtained from the methodology-based evaluation by the NAS of Ukraine and the official evaluation of RIs by the Ministry of Education and Science of Ukraine, quantitative and qualitative parameters of the staffing, the availability of unique research equipment, the development of research infrastructure, measures on optimization of internal structure and reduction of staff, etc.

A new important scheme for the reform of R&D funding system in the Academy, aimed at targeted support of priority research, is *the budget program 6541230 "Support for the Development of Priority Research Areas."* Under this program, funds are allocated for the Academy's RIs on a competitive basis. The principle criteria for the RIs admittance to the competition is the highest evaluation scores for performance efficiency, and significant theoretical and practical results recognized at international and nationwide level.

It should be noted that the developments created within this budget program address significant nationwide challenges. They are of great importance for the operation of the nuclear energy complex, as our scientists provide justifications for the extension of the operational life span of nuclear power plant units, participate in solving the nuclear fuel diversification problem and developing control and safety systems for nuclear reactors. Many developments are designed for defense industry companies. Also, funding under this budget program was allocated for projects addressing urgent research problems: the development of advanced models of missile, space, and transport systems; systems for protecting the stability of critical infrastructure in compliance with NATO standards during wartime and post-war periods; methodologies for predicting the lifespan of critical equipment; technologies for producing advanced titanium alloys and selective lithium concentration from natural resources; technologies for exploration and ecological conversion of hydrocarbon and ore critical raw materials; methods for selecting high-yielding, stress-resistant innovative varieties of winter wheat with improved grain quality. The Academy's researchers are also addressing important social and humanitarian issues: the development of institutional tools for the post-war development of a resilient Ukrainian economy; analyses of changes in the Ukraine's political system during the war and post-war reconstruction; sociological analyses of the persons' stresses in the war context.

To sum up, it can be reasonably argued that the performance evaluation in RIs, introduced in 2017, has become an effective tool for enhancing the level and relevance of research, obtaining new basic knowledge of global significance, and conducting relevant applied research that will contribute to the socioeconomic development of Ukraine. Its results are successfully used in optimizing the RIs network and implementing a new funding model for R&D, relying upon the efficiency of RIs and allowing for the concentration of resources on the top-priority research areas.

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1.2. THE OFFICIAL EVALUATION OF RESEARCH INSTITUTIONS IN UKRAINE: LEGAL, INSTITUTIONAL, AND METHODOLOGICAL ISSUES

V.A. Zhuravel

Assessment of the effectiveness of research activities of institutions is only one of the aspects of organizing the functioning of the research sector, the implementation of which undoubtedly requires a systematic analysis of the current legislation regulating this sphere of public relations.

Regarding the official evaluation, the mandatory conduct of which is stipulated in Article 11 of the Law of Ukraine "Science and Science and Technology Activities," it is worth addressing the institutional and legal aspect of this activity, where certain controversial issues arise, primarily those concerning the powers of the Ministry of Education and Science (MES) of Ukraine. In our opinion, there is a certain legal uncertainty in this matter regarding the legislatively defined powers and those implemented in practice. Thus, subparagraph 8 of paragraph 1 of Article 42 of the Law of Ukraine "Science and Science and Technology Activities" stipulates that the MES of Ukraine manages the system of official evaluation of research institutions, meaning, according to the explanatory dictionary, that the MES of Ukraine should direct this process, influence its development and condition. Additionally, according to paragraph 6 of the Resolution of the Cabinet of Ministers of Ukraine (CMU) No. 540 dated July 19, 2017, "Approval of the Procedure for Conducting Official Evaluation of Research Institutions and Higher Education Institutions in Terms of Their Research (Science and Technology) Activities," the MES of Ukraine is tasked with ensuring the conduct of official evaluation, i.e., creating appropriate conditions for its implementation.

At the legislative level, the MES of Ukraine is not assigned the authority to directly conduct the official evaluation. Managing and ensuring do not mean conducting evaluation — these are different things. At the same time, pursuant to its own order No. 1485 dated October 21, 2024, the MES of Ukraine undertakes actions for the direct conduct of official evaluation, namely establishing its schedule, refusing in case of failure to provide all necessary materials, forming expert groups, approving evaluation results, issuing certificates of evaluation completion according to the established form, and more.

This situation requires clear regulation of the MES of Ukraine's powers in this regard. Furthermore, there is some doubt about the MES of Ukraine's ability to conduct a sound evaluation of many research institutions and higher education institutions, especially within the tight deadlines set by legislation. According to CMU Resolution No. 465 dated April 24, 2024, "Some Issues of Official Evaluation of Research Institutions," all research institutions and higher education institutions of all forms of ownership and subordination must undergo the official evaluation in 2025, which amounts to more than 600 entities subject to evaluation. In view of this, we consider it possible to propose a return to the practice of independent conduct of the official evaluation by the National Academy of Sciences (NAS) of Ukraine and national sectoral academies of sciences for the research institutions under their jurisdiction, as was the case until January 2016, which would fully align with the principle of their self-governance. In turn, the MES of Ukraine, the Scientific Committee of the National Council for Science and Technology Development, the State Audit Service of Ukraine, and the Accounting Chamber of Ukraine would exercise appropriate oversight of the objectivity of such evaluation.

Regarding the procedure for forming expert groups and the expert commission, it should undoubtedly be considered a positive development that a significant portion of the experts evaluating research institutions will consist of international specialists, which will help enhance the objectivity of the evaluation. However, there are certain questions in this area as well.

Regarding the formation of expert groups, there are difficulties with registration on the MES of Ukraine's website, and a lack of proper transparency in the selection of candidates for these groups is observed. We consider it necessary to more actively involve the academic councils of higher education institutions and research institutions, as well as the presidiums of the NAS of Ukraine and national sectoral academies of sciences, in this process. It seems that these structures can recommend and delegate the most knowledgeable, experienced, and reputable specialists to the expert groups and, most importantly, bear responsibility for the quality of their work.

Certain positive developments should also be noted in the formation of the expert commission, which, according to CMU Resolution No. 540 dated July 19, 2017, "Approval of the Procedure for Conducting Official Evaluation of Research Institutions and Higher Education Institutions in Terms of Their Research (Science and Technology) Activities," includes representatives of the NAS of Ukraine and national sectoral academies of sciences. An encouraging signal for improving the evaluation activities of research institutions can be considered the MES of Ukraine's request to the presidiums of national academies of sciences to provide candidates for this commission.

Certain critical remarks are also raised by some regulatory acts adopted by the CMU, in particular Resolution No. 465 dated April 24, 2024, "Some Issues of Official Evaluation of Research Institutions." Paragraph 2 of clause 2 of the resolution states that "official evaluation certificates of research institutions issued before January 1, 2024, for research institutions mentioned in the second paragraph of this clause, shall expire on December 31, 2025." This quoted provision contradicts the domestic legal doctrine, according to which "laws do not have retroactive effect if they worsen the condition of individuals or legal entities." The termination of certificates can be regarded as a deterioration in the condition of those research institutions that underwent official evaluation in accordance with the norms of the current legislation and approved methodology, received certificates of the established form, and were supposed to undergo the next evaluation in five years, i.e., in 2026 or 2027. However, these certificates are being annulled without any additional arguments or explanations. This practice can hardly be considered consistent with the principles of legal certainty and the rule of law.

Additionally, in the context of analyzing CMU Resolution No. 465 dated April 24, 2024, "Some Issues of Official Evaluation of Research Institutions," it would be desirable to hear the position of the Scientific Committee of the National Council of Ukraine for Science and Technology Development regarding the arguments they relied on when providing, in accordance with subparagraph 6 of paragraph 8 of Article 21 of the Law of Ukraine "On Science and Science and Technology Activities," an expert opinion on the possibility of adopting this resolution in the specified version.

Regarding the methodological support for official evaluation, due credit should be given to the MES of Ukraine's efforts to align the Methodology for Evaluating the Effectiveness of Research and Educational Activities of Research Institutions and Higher Education Institutions with international standards, in particular by intensifying the implementation of the principles of "open science" and modern digital tools. At the same time, certain concerns should be expressed regarding the potential bureaucratic nature of the new methodology and the insufficient readiness of domestic institutions for the digitalization of processes. There are also concerns that international evaluation may not consider the specifics of local research, which could negatively affect the assessment of some institutions.

Certain provisions of the proposed methodology also raise some critical remarks:

1.The attempt to introduce a unified, identical methodology for evaluating the effectiveness of activities for the entire diversity of research institutions. Research institutions of the National Academy of Legal Sciences of Ukraine annually prepare draft laws and other normative acts in the context of conducting scientific research, provide up to 300 scientific-legal opinions on draft laws at the request of state authorities and local self-government bodies, people's deputies, judges of the Constitutional Court of Ukraine, and the Supreme Court. This is a significant scope of work that requires both time and effort. However, this work is not accounted for as performance indicators during an official evaluation, and thus the motivation to carry out this critically important activity for the state is lost. This once again confirms that, within its competence, the MES of Ukraine should develop only a standard, basic form of performance evaluation indicators for research institutions, while the NAS of Ukraine and other national sectoral academies of sciences, relevant ministries, and agencies should refine and specify these standard indicators, considering the specifics of their activities.

2.The change in the timeframe for submitting performance indicators for evaluating the effectiveness of research activities in research institutions. According to the updated methodology, the procedure for submitting performance indicators for research evaluation has changed, and it now covers a period covering not the last three years, as stipulated in the previous methodology and by which research institutions prepared their performance indicators, but the five years. Because research institutions are not prepared for such changes, their indicators will be significantly worse.

3.The abandonment of traditional research performance indicators, like presence of members (academicians) or corresponding members in the staff of a research institution, specialized scientific periodicals published by a research institution, number of scientific events held (conferences, seminars, roundtables, symposia, etc.). At the same time, while increasing the number of indicators related to the publication of scientific articles in journals indexed in the scientometric databases Scopus and Web of Science, it should be born in mind that domestic researchers have more limited opportunities compared to their foreign colleagues, especially in the humanities. Moreover, such publications are a rather costly procedure, and not all researchers, given their salary levels, are able to afford it.

To achieve high performance in a publication activity like this, adequate official support is needed. Certain discriminatory approaches are observed toward researchers who understandingly accept the impossibility of implementing Article 36 of the Law of Ukraine "Science and Science and Technology Activities" regarding a real increase in salaries, as the government lacks funds during these challenging times, while at the same time, the government seeks to increase the number of such publications without providing adequate funding sources for them.

To enhance the significance of official evaluation, it is necessary to strengthen incentive measures, in particular by providing legislative guarantees of stable funding for the declared needs throughout the validity of the certificate for the research institutions that are granted the first category.

Otherwise, given the absence of proper incentives, the official evaluation will remain purely formal, no matter how updated a methodology is proposed. We are aware of the MES of Ukraine's plans to ensure the implementation of these incentives, particularly the creation of special funds. These efforts are perceived and evaluated very positively.

The basic Law of Ukraine "Science and Science and Technology Activities" has been in effect for eight years. This is a period that provides grounds for its systematic analysis, performance evaluation of the institutions defined therein, which are supposed to ensure a successful operation of the research sector. We, as researchers, would undoubtedly like these institutions, and above all the Scientific Committee of the National Council for Science and Technology Development, to perform not only oversight functions but also to actively assist national academies of sciences during the budget process, determining priority directions for scientific research, reforming the academic environment, developing a methodology for performance evaluation of research institutions, and providing expert opinions on the adoption of normative acts related to the research sector.

Science system can develop only through close cooperation, knowledge exchange, and joint efforts of researchers, educators, government and society. Teamwork, comprehensive discussion of ideas, and support for young researchers, all this contributes to progress and innovation. Therefore, only together can we achieve true scientific breakthroughs and make the world a better place!

1.3. CONCEPTUAL FOUNDATIONS OF THE PERFORMANCE EVALUATION OF RESEARCH INSTITUTIONS OF THE NATIONAL ACADEMY OF SCIENCES OF UKRAINE IN LIGHT OF THE SCIENTIFIC LEGACY OF ACADEMICIAN BORYS PATON

I.V. Krivtsun

An efficient national R&D system is crucial to the sustainable development of a country amid the rapid science and technology progress and global competition for knowledge. Science is increasingly viewed not only as a cognitive tool, but also as a key factor for socio-economic growth, national security, development of human resources, and the innovation-driven economy. Hence, the issue of performance evaluation in research institutions gains relevance, as it serves as a mechanism for strategic management, optimal resource allocation, prioritization of research, ensuring transparency in the R&D sector, and building public trust in the research results.

However, an effective evaluation of research institutions requires not only formal indicative metrics, but also a deep understanding of the societal role of R&D, its dynamics, links with other sectors, and development prospects. Importance lies in the need to combine quantitative and qualitative evaluation criteria, taking into account the specifics of different research fields, their integration into the international context, impact on national priorities, and ability to generate new knowledge and technologies.

The intellectual and managerial legacy of academician Borys Paton — a prominent Ukrainian scientist and long-serving president of the National Academy of Sciences of Ukraine, who consistently advocated for building a national research system based on principles of effectiveness, responsibility, interdisciplinary interaction, and societal significance — holds significant interest in this context. While being at the head of the Academy, Borys Paton proposed a series of conceptual approaches to R&D management that encompassed both organizational and ideological foundations for the operation of research institutions. His vision of performance evaluation of R&D activities was inseparably linked to the mission of science as a public good and its ability to address the challenges of the time, from national security to high-tech development.

Hence, turning to Borys Paton's scientific legacy allows one to trace the evolution of approaches to performance evaluation in research institutions, but also to justify the need to update these approaches in line with contemporary realities.

Academician Borys Yevhenovych Paton (1918—2020) is a unique figure in the history of the Ukrainian science system, who left a profound mark not only as a world-class scientist but also as an architect of the national R&D management system. The scientist's intellectual legacy encompasses high-tech research in electric welding, advanced materials, biomedicine and space technology, and conceptual approaches to the strategic development of research institutions. Over more than half a century (1962—2020), B. Paton led the National Academy of Sciences of Ukraine and shaped it as a leading center for research, innovation and interdisciplinary interaction [1].

Unlike many heads of research institutions whose activities were limited to administrative and managerial functions, academician Borys Paton combined managerial work with deep immersion in the substantive aspects of research activities. His leadership style was based on full understanding of the essence of research processes, the ability to assess the prospects of specific research areas, and constant professional interactions with research teams. B. Paton placed great emphasis on the substantive analysis of research results, not confining it to formal indicators; for him, the leadership of an Academy institution meant an integration of scientific, strategic, and organizational thinking. This approach ensured the depth of managerial decisions and helped create a holistic system for R&D development, based on principles of effectiveness, relevance, and scientific responsibility [2].

Borys Paton's science policy was distinguished by the strategic consistency, forward-looking nature, and a high degree of adaptability to changes in the internal and external environment. The scientist's active participation in R&D priority setting was grounded in deep understanding of the inseparable connection between the development of academic knowledge and the practical needs of the nation. B. Paton paid particular attention to critically important areas: providing scientific support for the defense-industrial complex, developing energy and engineering sectors, healthcare, supportive research in aviation and space technologies. This approach ensured not only the relevance of research, but also its integration into solutions of nationwide strategic tasks [3].

A graduate of "Paton school" of his father, Yevhen Oskarovych Paton, Borys Yevhenovych Paton memorized his father's saying: "Working on solutions to abstract topics detached from practice has never been attractive to me. I was striving to align the content of my work and that of my colleagues with the needs of today and tomorrow. What could be a greater reward for a person than seeing his thoughts and labor embodied in life?"

This approach to research work as a responsible work aimed at achieving concrete results became a guiding principle in Borys Paton's own activities. From the beginning of his science & technology career, he combined deep theoretical research with practical implementation of its results in the form of technologies, designs or equipment. B.Y. Paton's ideas immediately found response in the real sector, and this was what he considered the highest criterion of science's value. The scientist was convinced that the research work efficiency could not be evaluated solely by quantitative or formal indicators. In his view, what mattered was not so much the scope of work done but the depth and value of what was achieved — its ability to change reality, open new opportunities, and solve problems [4].

A principal criterion used by Boris Paton in performance evaluation of a researcher or a research organization was the practical value and the possibility of real-world implementation of the obtained scientific results. The scientist was not satisfied with general phrases about "importance" or "prospects" — he demanded clear examples and concrete impacts. B.Y. Paton believed that science should serve not only to expand and deepen knowledge about nature but also to address pressing tasks of the economy, society, and the nation [5].

When B.Y. Paton was first elected president of what was then the Academy of Sciences of the Ukrainian Soviet Socialist Republic, he set the goal of making the "science-production" links as close as possible. The scientists understood that without this, it was impossible to speak of the development of either the nation or the scientific community. In Borys Paton's view, scientists are not an end in themselves or for themselves; the results of their work must be implemented in practice, providing obvious and tangible benefits to the society and the nation. This was the scientist's main imperative. Therefore, B.Y. Paton insisted that the research topics in all Academy institutions, without exception, be determined not only by scientific interest but also by the tasks facing society today and those that will arise tomorrow [4].

Borys Paton also emphasized the need for a holistic approach. The most important aspect of this approach was not only the focus on applied research and development but also the concept of targeted basic research proposed by B.Y. Paton. The orientation of all research, from purely basic to purely applied, on comprehensive solutions of major practical problems, in the scientist's opinion, is the principle that ensures the sustainability of science progress [6].

"From the outset I strived to ensure that basic research in the Academy was not limited to understanding the laws of nature and society but culminated in the results that could be used in production and other spheres of human activity. With the support of colleagues, we could to concentrate research capacities and resources of the Academy of Sciences on the most important natural, technological and socio-humanitarian problems that were critical for the nation's economy and development," B. Paton believed [7, p. 136].

The inseparability of applied and basic research characterized the entire subsequent research and organizational activities of the scientist, and Borys Paton considered the achieved result as the primary performance measure for any kind of research activities [8]. He repeatedly emphasized that the value of science lies in its ability to work proactively, creating a foundation for solutions to challenges that the society has yet to face: "I stand for results in R&D, but not at the expense of abandoning basic research to focus only on applied and so-called innovative projects. If that happens, it won't take long before nothing remains, because the foundations on which all developments in applied sciences and technologies are built will have nowhere to come from — there will be no foundation for them. Hence the term 'basic sciences.' That's how it seems to me" [7, p. 135].

It should be noted that B. Paton's unwavering demand to both applied and basic research was its actual world-class level. According to B. Paton, the actual performance is measured not by the loudness of claims but by the recognition of results within the professional community. The relevant criteria included publications in high-impact international journals, presentations at prestigious scientific forums and conferences — their quantity, impact and high citation index reflecting the scientific value of research results. Another important criterion was the innovation capacity — the number of obtained patents, their uniqueness, and readiness for commercialization. B. Paton emphasized that the number of patents should correspond to the intensity of the institute's activity, but their content was no less important. Patents should have the potential for implementation in industry, economy or society [8].

To gain a deeper understanding of the operation of the research organizations within the Academy, evaluate their performance and assess the research results, Borys Paton personally visited various institutes, delved into their business, helped prioritize specific R&D areas or recommended to conduct interdisciplinary research. He delved into the processes, conversed with researchers not as an administrator but as an equal — a person who understood scientific inquiry from within [2].

B. Paton constantly strove for a clear definition of the research profile of each institute. He ensured that each became a leader in its field, both nationally and globally. Regarding the relevance criteria of R&D areas, B. Paton insisted on their social significance, as scientific developments must address the real needs of society. He believed that R&D should contribute to solutions in healthcare, quality of life, new job creation, environmental safety, etc. He placed particular emphasis on R&D related to national defense, including the development of new materials, technologies, and systems for the needs of the military. R&D addressing global challenges, such as climate change, energy crises, food security or new energy sources, held an important place. At Paton's initiative and with his direct involvement, the Ukrainian R&D actively developed interdisciplinary areas combining physics, chemistry, biology, medicine, informatics, and other fields. The scientist believed that the integration of diverse knowledge enables for more effective solutions to contemporary problems [2].

Thanks to B. Paton's leadership, the National Academy of Sciences of Ukraine transformed into the country's top research center performing extensive R&D on pressing problems in natural, engineering and socio-humanitarian disciplines.

The Academy's institutions hold leading positions in certain areas of mathematics, theoretical physics, solid-state physics, plasma physics, low-temperature physics, radiophysics, radio astronomy, materials science, cybernetics, neurophysiology, molecular biology, microbiology, virology, and many other fields [1].

In Borys Paton's view, training of research personnel, engaging youth in R&D, and the development of scientific schools are key indicators of the research organization's performance. The scientist repeatedly emphasized the need to create conditions for the professional growth of young researchers, their motivation to work in R&D, and their integration into the global scientific community. He demanded that Academy institutions develop training programs to equip young researchers with modern knowledge, practical skills and research methodologies. He attached great importance to the transfer of knowledge and experience from senior researchers to the younger generation. He viewed mentorship as an integral part of youth training, fostering not only professional but also ethical standards of research work. Borys Paton actively supported initiatives for collaboration between the Academy and leading Ukrainian universities, to ensure a continuous "science-education" link [8].

B.Y. Paton was convinced that "...youth is everything. Without youth, there will be no scientific schools, and scientific schools are what science relies on" [7, p. 149].

These requirements and indicators established by Borys Paton were laid in the basis of the performance evaluation system for the Academy's research institutions. This system facilitated priority setting, concentration of efforts on strategically important projects and their alignment with societal needs. Paton's approaches contributed to the modernization of Ukrainian R&D, enhancing its competitiveness and integration into the international scientific community. Paton's efforts laid the foundation for further development of the Ukrainian R&D as a high-performing sector with a practical value.

"Today, every scientist must clearly understand what he is working for, in the name of what, and what will be achieved as a result of this activity," — Borys Paton's words remaining highly relevant today [7, p. 77].

The conceptual foundations of the R&D evaluation system must be rethought and adapted to the modern R&D context in light of the scientific legacy of academician Borys Paton. This approach should build on the key principles set by Paton: focus on results, practical significance of research, strategic orientation of basic research, and integration of knowledge in addressing complex problems.

Contemporary challenges — primarily the full-scale war, the transformation of the global R&D landscape, and the growing role of interdisciplinary and cooperative research — require greater flexibility and multidimensionality from the evaluation system. Apart from of scientometric analyses, improvements should cover the evaluation of research impact on the nation's resilience: defense capabilities, technological independence, the development of critical infrastructure, digital transformation, healthcare, and environmental safety.

Special emphasis should be placed on the elaboration of schemes for evaluation of institutional capacities, including personnel dynamics, engagement of young researchers, preservation and development of scientific schools, and the quality of research environment. Apart from the publication activity, the system should stimulate the ability of institutions to engage in strategic thinking, achieve innovative breakthroughs, and participate in international cooperative programs.

Further improvements also entail a shift from a formal-indicative evaluation model to an expert-analytical model based on a qualitative analysis of the content, relevance and prospects of research. It is crucial to maintain the Paton's balance between basic and applied nature of research, between the freedom of scientific inquiry and the responsibility for societal value of scientific results.

A conceptual guide could be the creation of a dynamic institutional monitoring system combining regular internal self-assessment of research institutions with external independent expert review. This approach will not only ensure robustness but also enhance the R&D system's capacity to respond to national challenges and implement R&D results in the real sector. It embodies the continuation of Borys Paton's managerial philosophy focused on results, trust in science, and its responsible role in the societal development.

Academician Borys Paton created a unique model for performance evaluation of R&D activities, with the performance being a product of not only formal quantitative indicators but, first and foremost, of practical feasibility, societal significance, and long-term impact on the national economy, security, and social environment. The Paton's approach was designed as a response to the need to align basic scientific inquiry with national priorities, with deep understanding of science as an effective tool for nation-building being a principle novelty of the Paton model.

The legacy of academician Borys Paton lies in a combination of traditions in Academy R&D with new challenges of the time: interdisciplinarity, result orientation, openness to innovation, and integration into the global scientific community. B. Paton consistently emphasized the need to support scientific schools, professional development of young researchers and continuity of generations, i.e. the factors remaining critical today for the institutional resilience and competitiveness of research institutions.

The managerial and methodological approaches introduced by B. Paton facilitated the modernization of the Ukrainian R&D, made it adaptable to modern international standards and a more flexible, open and result-oriented evaluation system. Hence, B. Paton's ideas hold not only historical significance but also great practical value for science & technology policy setting nowadays.

The relevance of the conceptual foundations formulated by B. Paton grows in the context of transformations in the global scientific landscape and the need to enhance the effectiveness of public investment in R&D. They can continue to serve as a guide in revisions of the national system for performance evaluation in research institutions — with an emphasis on quality, innovation capacity, alignment with societal challenges, and international visibility.

To sum up, Borys Paton's legacy is not only a valuable intellectual asset but also a framework for further reforms of R&D management system in Ukraine. If used in the new context, it will enable for sustainability, effectiveness, and strategic orientation of R&D as a key resource for national progress.

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1.4. SCIENCE ADMINISTRATION AND RESEARCH EVALUATION IN MOLDOVA

V. Ursachi

Before the disintegration of the Soviet Union, by the end of 1980s the Academy of Sciences of Moldova (ASM) had been the main research & innovation (R&I) centre of Moldova, incorporating 31 organizations, including 21 research institutes [1]. The ASM staff had exceeded 5,000, including more than 1,300 researchers, while the total personnel in the Moldovan R&I system, including those in research institutions and universities, had been around 30,000, with more than 2,000 doctors of sciences and nearly 600 doctors habilitat.

Significant changes occurred in ASM after the proclamation of sovereignty (June 23, 1990) and independence (August 27, 1991) of the Republic of Moldova, leading to the consolidation of the autonomy of ASM. It became a true republican R&I forum due to the development of the legislative and normative framework on science and innovation, along with the reorganization of R&D management. The institutional and functional autonomy of research institutions also increased. The cooperation with European and global scientific community acquired a dynamic character. However, economic transformations of the last decade of the 20th century led to destructive phenomena both in the real sector of the national economy and in the spheres of social, cultural and spiritual life. The R&D sector faced problems like degradation of infrastructure, brain drain, and shrinking numbers of young specialists. As a result, the number of researchers in the domestic R&D plummeted, although the number of scientific publications, including in renowned international journals, increased, especially due to the intensification of international cooperation.

The evolution of R&I system in Moldova in these years saw different phases. It was administered by a number of government departments and institutions, including the Ministry of Economy, the Ministry of Education, and a specialized department in the government. A new stage in the development of ASM and the R&D sector as a whole began in 2004 with the adoption by the Parliament of a new law entitled "The Code on Science and Innovation of the Republic of Moldova".

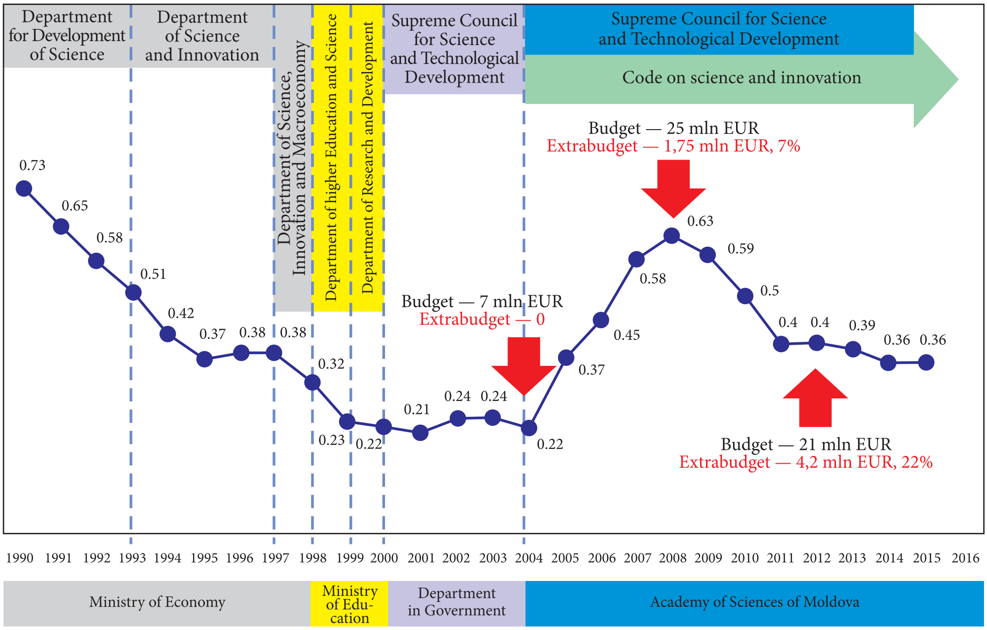

Fig. 1. The evolution of research management system in the Republic of Moldova
Source: Academy of Sciences of Moldova. Official website. URL: https://asm.md/en/about (last accessed: 25.10.2024); Code of Science and Innovation of the Republic of Moldova No. 259-XV of July 15, 2004. URL: https://www.wipo.int/wipolex/en/legislation/details/9803 (last accessed: 25.10.2024); National Agency for Research and Development. Official website. URL: https://ancd.gov.md/en/content/nard (last accessed: 25.10.2024); Republic of Moldova. Official website. Science. URL: https://moldova.md/en/content/science (last accessed: 25.10.2024).

The responsibility for elaborating and implementing the government science and innovation policy was delegated under this law to ASM. This law enabled for a substantial increase in R&I financing from the state budget, creating premises for improving technological and research infrastructures in research institutions and universities in parallel with working conditions and remuneration of researchers, whose average salary increased by 1.5—2 times.

The reform made the ASM Assembly the supreme governing body of ASM, while the 17-member Supreme Council for Science and Technological Development became the executive body of the Assembly. The Assembly elected the Supreme Council for Science and Technological Development for four years. It included representatives from ASM, research institutions, universities, and the State Agency for Intellectual Property. The reform could consolidate the scientific community and interactions between domestic research institutions and universities.

At that time, ASM comprised six Sections of Sciences: Economical and Mathematical; Biological, Chemical and Ecological; Physical and Engineering; Medical; Agricultural; Humanities and Arts. Several types of R&D institutes were related to ASM with the status of institutional members, profile members, and affiliated members. Three auxiliary organizations were linked to ASM: the Agency for Innovation and Technology Transfer (responsible for the funding and implementation of the respective type of projects); the Centre for International Projects (coordinating the implementation of international projects); and the Public Institution Agency for Development and Research (funding and implementing national projects financed from the public budget).

The outcome of the reform launched in 2004. The structure and organization of ASM evolved over time, so that in 2017 it comprised six Sections of Sciences: Natural and Exact; Medical; Agricultural; Engineering and Technological; Social and Economic; and Humanities and Arts. 51 accredited institutional, profile, and affiliated members were linked to ASM at that time, including research institutions and universities subordinated to the Ministry of Education, Ministry of Health and Ministry of Agriculture.

After the reform of 2004 until 2017 ASM performed R&I management functions through the Supreme Council for Science and Technological Development. The evolution of this management over 1990—2017 is illustrated in Fig. 1.

A peer review assessment of the Moldova's R&I system was performed from November 2015 till April 2016. The panel of international experts included five independent experts from Poland, Austria, Greece, Netherlands and Romania acting in their personal capacity and two peer reviewers as policy-makers from Austria and Estonia. The panel acknowledged the relevant contribution of ASM as the leading research institution in Moldova in preserving a valuable research capacity in the country[1]. A major focus area of the ASM effort was consolidating the scientific community and developing skills required for success in national and international R&D projects. At national level, the ASM goal was to reinforce domestic R&D facilities; at international level, the main objective of this effort was to step up integration into the European Research Area.

ASM played a key role in the association of Moldova to the EU's Seventh Research Framework Programme (FP7) through signing the Memorandum of Understanding for the association in October 11, 2011, and the association to the Horizon 2020 EU Programme in July 01, 2014. The participation of research institutions and universities in the FP7 is shown in Fig. 2.

In the Horizon 2020 Programme, there were 130 project applications until 2016 from 186 applicants (68 from research institutions, 56 from universities,

[1] Peer Review of the Moldovan Research and Innovation system. European Commission Directorate-General for Research & Innovation Directorate A — Policy Development and Coordination Unit A4 — Analysis and monitoring of national research policies. URL: https://projects.research-and-innovation.ec.europa.eu/sites/default/files/rio/report/Moldova-PSF_PR-KIAX16004ENNOP.pdf (last accessed: 25.10.2024).

27 from small and medium enterprises, 19 from non-government organizations (NGOs), 16 from other types of institutions). The European Commission accepted 15 projects with the EU contribution of € 1.94 million. The Republic of Moldova became one of the most active participants of the H2020 Programme among the Eastern Partnership states.

ASM supported internationalization of Moldovan R&D within and beyond EU. Several bilateral funding schemes have been established with e.g. Romania and Russia. ASM set up cooperation through 41 agreements with international research and research funding entities, mostly in the European Research Area. Also, ASM enabled for participation of Moldova in EU activities on the better coordination of national R&I programs, including ERA-NETs and JPIs (e.g. WaterWorks). Due to the efficient international cooperation, the number of publications in international journals was constantly increasing since 2004 and on, as shown in Fig. 3.

Despite the tricky environment, some Moldovan research institutes achieved an international scientific record in their research areas, including the Institute of Applied Physics, the Institute of Electronic Engineering and Nanotechnologies, and the Institute of Chemistry. Positive developments occurred in 2007 with the Law on Science and Technology Parks, and Innovation Incubators. As a result, science and technology parks, as well as seven innovation incubators became operational in 2014 with 33 companies gaining a resident status.

Institutions responsible for accreditation and attestation. While ASM and the auxiliary institutions were responsible for implementation and evaluation of research projects until 2017, the National Council for Accreditation and Attestation (CNAA) was responsible for accreditation of research organizations located in Moldova, and attestation of research and teaching staff (with conferring relevant degrees and titles). CNAA was created in 2004 in accordance with the Code on Science and Innovation by expanding the powers and increasing the staff of the Superior Commission of Attestation (CSA) established in 1992 with the aim of creating and coordinating an integrated system for training and certification of research and teaching staff in the Republic of Moldova. CNAA included two commissions, whose members were permanent employees of other organizations (research, education or public administration). The commissions were led by the two vice-presidents of CNAA and included:

• The accreditation commission for organizations in science and innovation field: six members of ASM, proposed by its President, six members representing higher education institutions, proposed by the government, and four representatives of the government.

• The attestation commission for research and teaching staff: eight members of ASM, proposed by its President and eight members representing higher education institutions, proposed by the government.

The accreditation conducted by CNAA was highly relevant for institutions seeking to become eligible for public R&I funding. Accreditation was granted

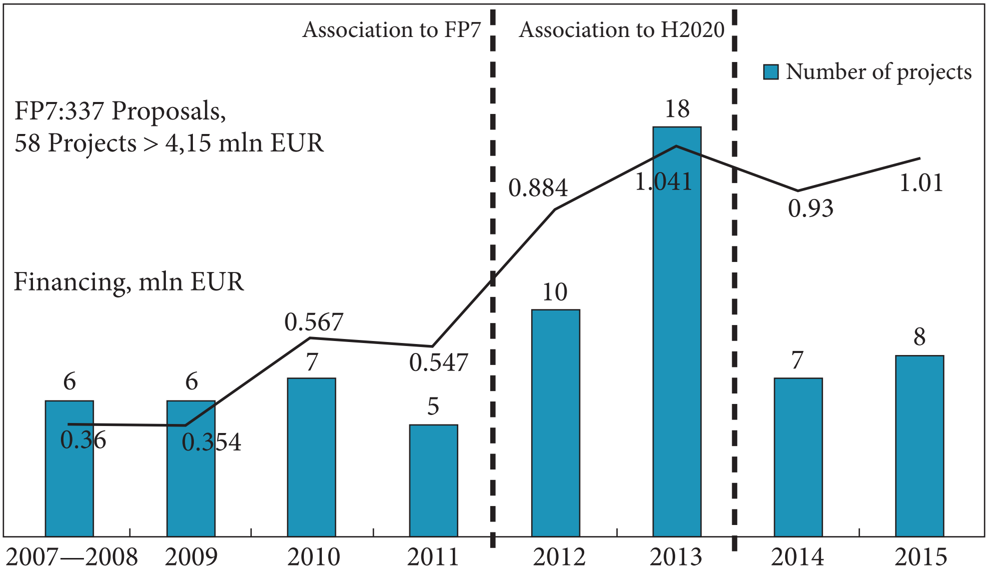

Fig. 2. The dynamics of participation of the research institutions from the Republic of Moldova in EU Projects
Source: Horizon Europe. URL: https://horizoneurope.md/ro/most (last accessed: 25.10.2024).

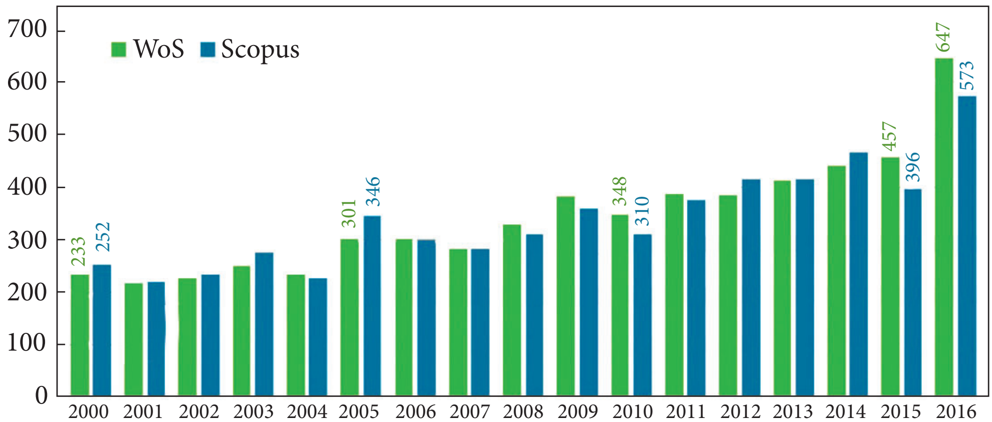

Fig. 3. Research papers published by authors from the Republic of Moldova
Source: Academy of Sciences of Moldova. Official website. URL: https://asm.md/en/about (last accessed: 25.10.2024).

for a period of up to five years. Under the Code on Science and Innovation all research organizations accredited by CNAA become members of ASM. They were divided into three groups: institutional, profile, and affiliated members of ASM.

In 2010—2014, most organizations underwent the second evaluation and accreditation procedure. However, according to a recommendation of the panel

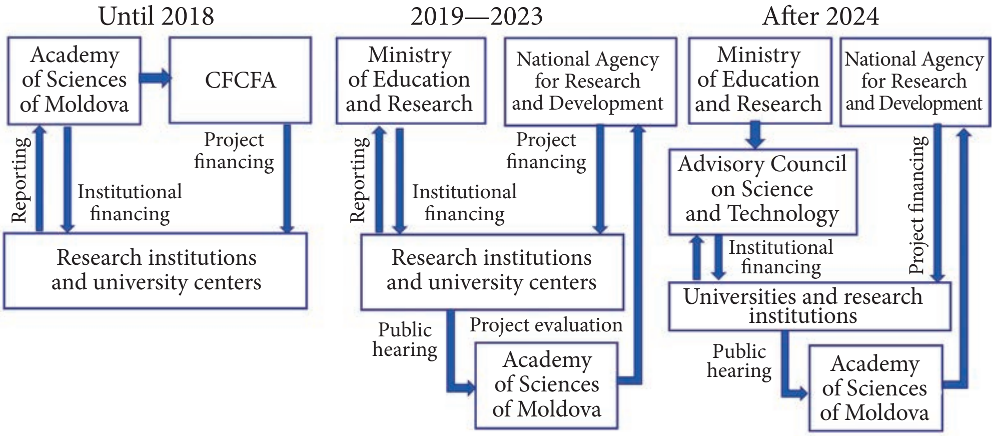

Fig. 4. Funding and reporting on research projects
Source: Code of Science and Innovation of the Republic of Moldova No. 259-XV of July 15, 2004. URL: https://www.wipo.int/wipolex/en/legislation/details/9803 (last accessed: 25.10.2024). National Agency for Research and Development. Official website. URL: https://ancd.gov.md/en/content/nard (last accessed: 25.10.2024). Republic of Moldova. Official website. Science. https://moldova.md/en/content/science (last accessed: 25.10.2024).

performing peer reviews assessment of the Moldova national R&I system, it was suggested that the accreditation process for eligibility for public research funding should be abolished since it constituted an artificial administrative barrier for research actors and especially for business sector and NGOs.

Other implementing agencies outside the ASM structure were:

• The State Agency on Intellectual Property of the Republic of Moldova (AGEPI), responsible for the protection of intellectual property, and

• The National Environmental Fund (FEN), managing dedicated research funding under the Ministry of Environment.

CNAA was abolished in 2018, with its functions transferred to the National Agency for Quality Assurance in Education and Research (ANACEC), a successor of the National Agency for Quality Assurance in Professional Education (ANACIP) created previously in 2014 as a legal public body, responsible for quality assurance in education and research. The ANACEC Department of Research and Innovation Evaluation (DECI) consists of two sections: Section for attestation of research and teaching staff and habilitation of doctoral supervisors, and Section for evaluation of research and innovation organizations.

In spite of several attempts to elaborate a comprehensive evaluation methodology, the final document is yet to be approved, and the evaluation of research and innovation organizations has not been performed so far, except for a partial evaluation of institutes incorporated in universities.

Evaluation of the research projects performed by the Academy of Sciences of Moldova after the reform of 2017. The recommendation of the panel performing peer reviews assessment of the Moldova national R&I system in 2016 to abolish the accreditation process of research organizations in Moldova performed by CNAA was one of the measures proposed as part of a fundamental reorganization (reform) of the R&I system suggested by the Panel. The ideology of this reform was opposite to the reform launched in 2004 by the adoption of the Code on Science and Innovation. While the reform of 2004 aimed at centralization of ASM functions, turning ASM into the main policy-making institution on a par with a ministry of science, the reform of 2017 focused on decentralization. As a result of this reform, ASM should lose many of its R&I management functions. In fact, the reform followed an even worse scenario: ASM was deprived of its research institutions, even though this measure had not been suggested by the peer reviews panel. Most of the research institutions were transferred from ASM to the Ministry of Education and Research in 2018. However, just four years later, in 2022, this step was found to be bad, and the research institutions were transferred to universities with the loss of the legal entity status. Another recommendation of the panel was to establish an independent R&I agency under a ministry(ies) with dual functions: an advisory body for R&I policy-making and an executive body responsible for R&I evaluation and funding. These activities should include publishing calls for R&I proposals, evaluation of proposals, and project funding and monitoring.

The National Agency for Research and Development (NARD), founded in 2018 as a central administrative authority under the Government of the Republic of Moldova, was a legal successor of the Centre of International Projects, the Agency for Innovation and Technology Transfer and the Agency for Research and Development, public institutions previously under ASM. NARD is responsible for the implementation of the national policy on research, development and innovation, the EU Framework Programme for Research and Innovation Horizon 2020, other European programmes, and for the coordination of Moldovan Office for Science and Technology in Brussels (MOST) [2]. While NARD is responsible for the evaluation of project proposals, their funding and monitoring, it does not evaluate the outcomes of project implementation. This function is performed by ASM. The evolution of funding and evaluation of reports on project implementation is illustrated in a chart of Fig. 4.

Until 2018, ASM via the Supreme Council for Science and Technological Development was responsible for institutional financing of research institutions, while the Center for Fundamental and Applied Research Funding (CFCFA) administered the research projects through the evaluation and monitoring of project proposals from research institutions and universities. The reports on financed projects were evaluated by scientific councils of research institutions

[2] Government of Republic of Moldova. National Agency for Research and Development. URL: https://ancd.gov.md/en/content/nard (last accessed: 25.10.2024).

Table 1. **Evaluation criteria by project type**

Project type	Project in the State Program	Bi/multilateral	For young researchers	Stimulation of excellence in research	Resilience of the country in crisis situations	Mitigating the impact of the COVID-19 pandemic
Evaluation criterion	Criterion weight	Criterion weight	Criterion weight	Criterion weight	Criterion weight	Criterion weight
Extent of reaching goal and objectives	0.4	0.4	0.4	0.4	0.4	0.3
Dissemination of results (publications, conferences, exhibitions, patents, etc.)	0.3	0.3	0.3	0.3	0.3	0.2
Socio-economic value of results	0.2	0.2	0.2	0.2	0.2	0.2
Collaboration with co-partner organizations or other domestic or foreign organizations	—	0.2	0.1	0.1	—	—
Involvement of young researchers, preparation of doctoral theses	0.1	0.1	—	—	0.1	0.1
Contribution to the resolution of the crisis situation and the resilience of the problem addressed	—	—	—	—	0.2	—
Effectiveness of the technology (methodology) in diminution of the COVID-19 impact	—	—	—	—	—	0.1
Implementation of results in COVID-19 impact diminution	—	—	—	—	—	0.1
Maximum total score	30	30	30	30	30	30

Source: National Agency for Research and Development. URL: https://ancd.gov.md/en (last accessed: 25.10.2024).

and universities with the participation of experts from ASM Sections of Sciences. Most of these projects were institutional projects. The share of public research funding allocated through institutional projects increased from 67% in 2010 to 75% in 2014.

In 2019—2023, when most of the research institutions were subordinated to the Ministry of Education and Research (MER), their institutional financing was performed by MER, while the research projects were financed and monitored by NARD as described above. Similar to the period until 2018, most of the research projects were institutional ones, but they were called State Program Projects, because they were funded by the State Programs in 2018—2019, and by the National Program on Research and Innovation in 2020—2023. The reports on the projects funded by NARD were evaluated by ASM in a public hearing organized by ASM Sections of Sciences.

Since 2024, the institutional projects have been funded by the MER via a newly created Advisory Council of Science and Technology as sub-programs of the National Program on Research and Innovation in 2024—2027, with other types of projects funded by NARD. The reports on the projects funded by NARD are further evaluated by ASM in a public hearing. The reports on sub-programs are expected to be evaluated by ASM, and the evaluation procedures are currently under elaboration.

Public hearings for the evaluation of reports on research and innovation projects at ASM are organized according to the regulation on public hearings approved by NARD in coordination with ASM in 2018. Under this regulation, each project report is to be submitted to at least two reviewers, and then discussed at a meeting of an ASM Section of Sciences. The evaluation sheets submitted to reviewers contain various criteria depending on a project type, as shown in Table 1.

Each evaluation criterion has its own weight depending on its importance for a specific type of projects. The experts have to evaluate each criterion by 0 to 5 scores: 0 — lack of information; 1 — insufficient information; 2 — unsatisfactory; 3 — satisfactory; 4 — good; and 5 — very good. Also, they are supposed to

Table 2. **The evaluation criteria for innovation projects, technology transfer projects and innovation vouchers**

Evaluation criterion	Extent of reaching the goal and objectives	Functionality of the technology / product / service	Socio-economic value of results	Availability of the infrastructure for project continuation	Collaboration with co-partner organizations	Results of dissemination
Criterion weight	0.3	0.3	0.2	0.1	0.05	0.05

Source: National Agency for Research and Development. URL: https://ancd.gov.md/en (last accessed: 25.10.2024).

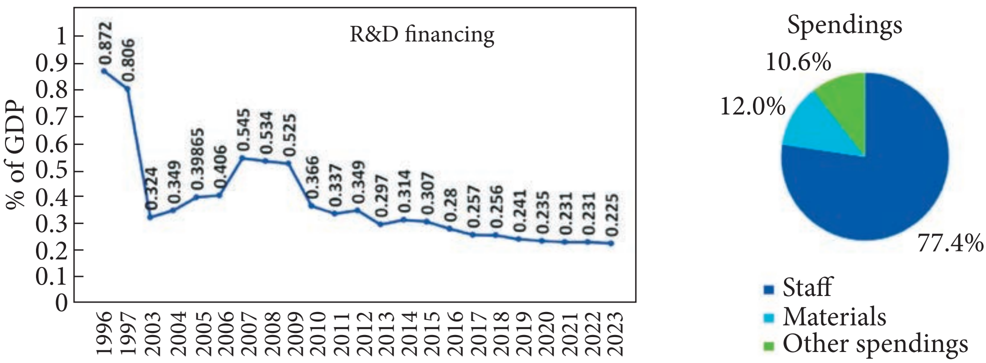

Fig. 5. R&D financing in the Republic of Moldova and the structure of expenditures in 2023
Source: National Agency for Research and Development. URL: https://ancd.gov.md/en (last accessed: 25.10.2024).

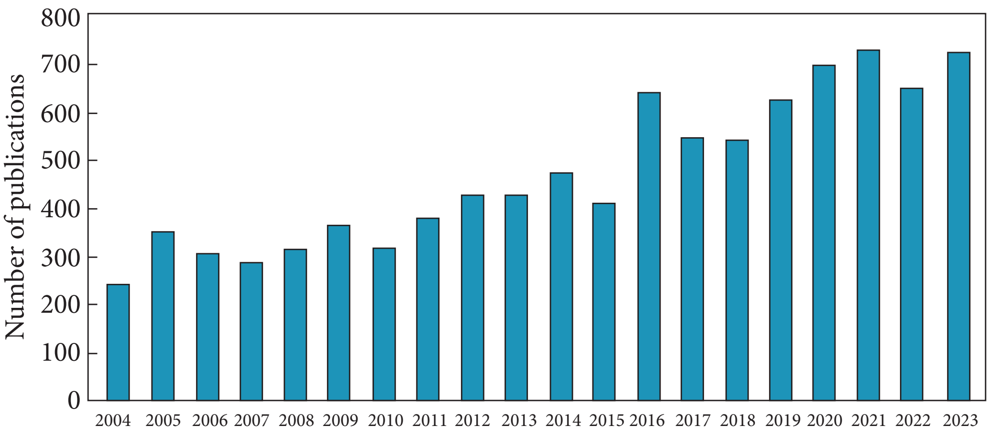

Fig. 6. Number of Moldovan researchers' publications in Scopus journals in 2004—2023
Source: Scimago. URL: https://www.scimagojr.com/countrysearch.php?country=MD (last accessed: 25.10.2024).

give a convincing argumentation for each score for every criterion, and to formulate a conclusion. The total score of evaluation is counted by Excel and normalized to a maximum of 30 points. Depending on the obtained final score, the overall evaluation of the report is as follows: very good ($26 \le p \le 30$), good ($22 \le p < 26$), satisfactory ($18 \le p < 22$), unsatisfactory ($p < 18$). The passing scale is 18 points.

The evaluation criteria for innovation projects, technology transfer projects and innovation vouchers are presented in Table 2. These types of projects are evaluated by a special mixed commission created by NARD and ASM.

In 2023, NARD coordinated management and financing of 166 research projects within the National Programme of Research and Development on five strategic priorities: health (40 projects); sustainable agriculture, food security and safety (25); environment and climate change (27); societal challenges (45); economic competitiveness and innovation technologies (29).

Apart from the above mentioned, the public hearings have evaluated the following projects at ASM: bilateral and multilateral projects (17); technology transfer projects (6); open science call projects (7). The public hearings procedure is as follows: project reports are presented by project managers, each project is discussed, and results of the discussion, with account to the expert evaluation, lay grounds for a decision on the final evaluation grade of a project and the recommendation on further funding of the project by NARD. After that, ASM Sections of Sciences prepare recommendations on each project to be submitted to NARD for further actions. Information about public hearings containing a project abstract and recommendation prepared by Sections of Sciences is available on ASM website[3].

The evolution of R&D funding in the Republic of Moldova in 1996—2023 is shown in Fig. 5. A downfall in funding in 1990s was followed by an increase once the reform of R&I system was launched in 2004. The funding peak, occurred in 2007—2009, was followed by a continuous decrease unabated even after a new reform of the Moldovan R&I system launched in 2017.

This trend in R&D funding had implications for the R&I system performance reflected in the data on publication activity of Moldovan researchers, shown in Fig. 6. The R&I system performed well after the reform of 2004, with the number of publications being up until 2016. This can be considered as an indication on the favourable character of the reform, which is not the case for the reform of 2017. The stagnating number of publications after 2016 could be attributed to the inertia of the system, and the things can get even worse if adequate measures are not taken.

[3] Academy of Sciences of Moldova. URL: https://www.asm.md/audierile-publice (last accessed: 25.10.2024).

1.5. THE EXPERT FUNCTION OF SCIENCE: EXPERIENCE OF THE NATIONAL ACADEMY OF SCIENCES OF UKRAINE AND FOREIGN RESEARCH INSTITUTIONS

O.N. Kubalskyi

A hallmark of the modern society is the necessity for expert activities of scientists, caused by global environmental threats and dangers, technogenic risks, political instability, perpetual regional conflicts and wars. The complexity of these issues and the ambiguity of correct solutions heighten attention to expert knowledge, expertise, expert assessments, and to the overall phenomenon of the expert as a source of qualified, unbiased conclusions — an entity to be heeded, offering relevant explanations of problems and pathways to their resolution. However, there are situations where the knowledge, competencies and experiences of an individual expert or even a consensus group of experts prove insufficient. To provide competent recommendations, a specialized scientific study, i.e. scientific expertise, is required, engaging appropriate theoretical developments and experimental research, highly qualified specialists, often from various disciplines, and organization of their collaborative efforts.

The need for scientific expert conclusions becomes particularly acute in times of societal cataclysms. The Covid-19 pandemic boosted interactions between science, politics, and society. Governments worldwide sought to involve the expertise of scientific communities in combating the virus. Representatives from various disciplines exerted professional efforts to overcome the virus, while scientific advisors were at the center of political decision-making processes.

Scientists are consulted to make informed decisions when addressing problems that require competencies far exceeding those typical of ordinary citizens and government officials. Ignoring expert conclusions provided by the scientific community can be not only dangerous but also detrimental to the society. Such a situation occurred in the past with the decision to construct the Chornobyl Nuclear Power Plant. Based on a comprehensive study of the issue, experts from the Academy concluded that building a nuclear power plant near Prypiat was hazardous [1]. But the position of Academy experts position was disregarded. The Chornobyl disaster ensued, which consequences Ukraine will continue to address for a long time.

The example of the nuclear power plant construction is not only telling but also demonstrates a broader trend — the spread of nihilism toward scientists' conclusions, the emergence of so-called "armchair experts" [2], the degrading professionalism of scientific expertise [3], and the growing nihilism toward scientific findings in general. These phenomena have several causes: the proliferation of diverse information sources disseminating both truthful and false information, as well as numerous environmental and technogenic disasters, for which blame is often placed on science. Yet, in most cases, science was insufficiently involved in the expertise of such projects. Nevertheless, confidence in the power of expert knowledge has now vanished [4]. The lack of interest in scientific expert conclusions can be explained by the fact that decision-makers are accustomed to operating under uncertainty and do not seek to gather comprehensive data provided by scientists. Additionally, political goals may sometimes conflict with conclusions grounded in scientific data, which can pose danger for the society. These risks can be mitigated by assigning institutional status to scientific expertise and recognizing the results of scientific expertise as essential for decision-making and fostering societal trust in science. This raises the importance of studies devoted to theoretical and practical dimensions of scientific expertise.

General scientific methods (analysis, synthesis, and comparison) enabled the identification of the features, creative, and practical potential of scientific expertise, the formulation of its generalized definition as an institutional phenomenon, and the analysis of differences compared to expertise conducted by an individual scientist. Problem-oriented analysis allowed for the identification of the specificity of scientific expertise.

The expert function of science is an integral component of the social institution of science. The significance of scientific expert activities is increasing due to the complexity and multifaceted nature of contemporary global problems and the necessity to employ scientifically grounded solutions for their resolution.

Certainly, an individual scientist can perform expert functions, providing consultations on various issues using his knowledge and competencies. However, wherever the existing knowledge is insufficient, but the situation is complex and unique, there arises a need to obtain additional information through specialized research. Scientific expertise is appropriate for addressing complex, interdisciplinary problems that touch upon diverse societal values and needs. Therefore, scientific expertise is not based on individual knowledge and skills but on the collective production of knowledge and the application of interdisciplinary and transdisciplinary cognitive practices. In such cases, the expert conclusion is formulated by a group of colleagues and presented as a joint finding. A collective actor offers certain advantages, such as mitigating bias in the use of specific theories or methods. Consequently, scientific expertise, as a collective procedure, is more reliable than the conclusions of individual experts. Thus, scientific expertise relies on complex, sociotechnological and expanded competencies, which are only partially inherent to each individual expert. Scientific expertise is grounded in a non-individualistic concept of epistemic competence, carried out by a collective epistemic actor [5].

Scientific expertise has a social dimension, shaped by its mission and societal purpose. It is an activity that fulfills a corresponding social function, assisting non-specialists and clients [6]. In other words, scientific expertise is client-oriented. Its goal is not so much the advancement of science or pure knowledge but the service to society.

The Dutch researcher D. Uygun Tunç formulates a socially relational concept of scientific expertise, based on the concept of expanded epistemic competence. He views scientific expertise as a function of the science system implemented at the institutional level. In this context, the expert is a research team, and the expert assessment is the result of a teamwork. An individual expert functions as a node within a network of epistemic processes. This underscores the significance of interpersonal epistemic obligations among experts, revealing the socially relational properties of expertise as a collective evaluation. The concept of "relational" is considered in a broad sense, encompassing both interpersonal interdependence and certain social dispositions [7].

The interpretation of expertise as a function of an individual expert cannot be deemed entirely relevant when it comes to scientific expertise as an institutional phenomenon. This is primarily because modern scientific expertise is an epistemically interdependent, collective process based on disciplinary and interdisciplinary research collaboration, utilizing complex scientific tools. The expert conclusion is formulated as a collegial finding. Therefore, scientific expertise relies not so much on individual knowledge and skills but on the collective production of knowledge, epistemic dependence, and responsibility. A scientific expert is primarily a super-individual agent or an epistemic team; deep expertise in a field is achieved through teamwork, using of research results presented in scientific literature or testimonies of other experts. However, for each participant in scientific expertise, individual possession of virtues like intellectual honesty, sincerity, transparency or responsibility is crucial, indicating the ability to serve as a reliable informant rather than merely a specialist [7]. This observation should be supplemented, as the virtues of an expert have not only an individual dimension but also a collective or institutionally legitimized one — scientific ethos, scientific ethics, professional ethics, and disciplinary ethics such as bioethics, nuclear ethics, and others.

It follows that a scientific expert, whether an individual or a collective actor, must possess epistemic, moral and communicative qualities, combining professional, individual and social virtues while considering the social and cultural dimensions of the object of expertise. Expert activity must adhere to the requirements of professional ethics and scientific ethos. Intellectual honesty, sincerity and openness, along with epistemic responsibility toward the clients of the expertise and society at large, are of particular importance. In this context, the expert's adherence to the principles of scientific ethics and integrity becomes especially significant, fostering trust between scientific experts and ordinary citizens [8].

In practice, these theoretical principles are implemented by engaging scientific organizations with the necessary human resources and experience in scientific expertise, which requires a comprehensive, interdisciplinary assessment of pressing, socially significant issues. These are typically large scientific institutions where scientific expertise holds institutional status.

For example, the National Center for Scientific Research (*Centre National de la Recherche Scientifique*, *CNRS*), the leading public scientific institution in France and the largest French research organization, incorporates public institutes specializing in applied and basic research. CNRS is also renowned as a performer of collective scientific expertise. The primary goal of this expertise is to analyze complex societal and environmental problems on behalf of decision-makers, involving leading researchers in relevant disciplines who prepare expert reports and conclusions. These are published and posted on the CNRS website, with the results of expert reviews presented during an open reporting conference accessible to a wide audience. Currently, expertise is being conducted on pressing issues such as the use of plastics in agriculture and food production, the impact of offshore wind farms on marine and coastal biodiversity and socioecosystems. Completed studies and reports have been presented on topics including eutrophication (enrichment of water bodies with biogenic elements), sexual violence against minors, the environmental impact of deep-sea mineral resource extraction, and the agronomic, Environmental and socioeconomic consequences of using herbicide-resistant plant varieties [9].

The institutional nature of scientific expertise is widely realized by numerous academies of sciences, which serve as a form of scientific organization uniting diverse institutions, distinguished scientists and specialists from various fields. For instance, the Swiss Academy of Arts and Sciences operates the Foundation for Technology Assessment (TA-Swiss) [10], which investigates the societal impact of technologies. The recommendations of this organization form the basis for technology policy decisions made by the Federal Council, Parliament, and administration. The findings of TA-Swiss studies are brought to public discussion through mass media, allowing concerned citizens to voice their concerns. TA-Swiss primarily focuses on controversial developments in the fields of biotechnology, digitalization, energy, and environmental conservation. Specifically, interdisciplinary teams of experts from this foundation assess the opportunities and risks of modern technologies such as artificial intelligence, blockchain, digital currency, digital democracy, and genome editing. The foundation's experts also address more routine issues, including the consequences of using meat and milk substitute products, the application of bioelectronics in healthcare, and the social and medical implications of egg cell cryopreservation.

The expert functions are realized in a somewhat different form within the Polish Academy of Sciences [11]. The Academy hosts several problem-solving councils and committees addressing complex issues at the intersection of multiple scientific fields and providing expert support to government decision-makers. For example, the Committee on Water Sciences and Water Management conducts diagnostics of flood threats and prepares proposals for effective solutions promoting safe, nature-friendly protection of river basins from flood disasters. The Committee on Research and Forecasting conducts multi-scenario studies of global trends, particularly those that may impact Poland, as well as new phenomena and processes occurring within the country that will be shaping the Polish society in the long term, along with opportunities and threats for the future. Based on this, the Committee develops a concept for a future socioeconomic development strategy and submits its conclusions on key future issues to the highest authorities of the Republic of Poland. Various expert conclusions, analytical materials and forecasts for government bodies, local self-government and socio-educational institutions are also prepared by committees on energy, spatial development, and the Council for the Polish Language. A notable feature of these advisory bodies is that apart from expert work they carry out wide-scale popularization campaigns, e.g. among youth (students, graduate students, journalists, etc.).

Annually, members of the National Academy of Medicine, National Academy of Engineering, and National Academies of Sciences of the United States prepare over 300 analytical reports on a wide range of issues affecting the American society, including forensic expertise, invasive plants, vaccines, obesity, the country's energy future, transportation safety, climate change [12]. These reports are prepared by commissions involving approximately 6,000 experts. Funding for these commissions comes from federal agencies, private companies, and foundations.

The expert function is one of the key components in the activities of the National Academy of Sciences (NAS) of Ukraine. A distinctive feature of expertise within the Academy is its close integration with research activities, enabling the involvement of large expert teams in conducting comprehensive, interdisciplinary assessments of the current conditions and development prospects of objects, processes or phenomena across various spheres of social life, and in preparing well-informed conclusions and recommendations, often of a strategic nature.

The status of the NAS of Ukraine as the highest expert institution is confirmed by the Law of Ukraine "Science and Science and Technology Activities." Pursuant to this law, the NAS of Ukraine conducts independent scientific evaluations of strategic, prognostic, and programmatic documents (doctrines, concepts, strategies, etc.), develops proposals for the foundations of national science and science & technology policies, forecasts, information and analytical materials, proposals and recommendations regarding the sociopolitical, socioeconomic, science & technology, innovation-driven, and humanitarian development of the country, performs scientific expertise of draft laws, state decisions, and programs.

A broad range of expert documents is prepared by the Academy's institutions both upon request from government bodies and on their own initiative. The high quality of these documents is due to the implementation of various research organization forms within the Academy.

The results of several applied research programs implemented in the Academy laid grounds for detailed proposals and recommendations prepared by the NAS of Ukraine's institutions for organizations and enterprises in the mining, energy sectors, healthcare system, and environmental conservation. The implementation of joint activity programs of the NAS of Ukraine and national sectoral academies of sciences for 2023—2025 could enhance and consolidate the expert capacity in the Academy sector of R&D. This enables the organization of interdisciplinary research on relevant scientific directions and ensures the thorough preparation of expert conclusions on pressing science & technology issues in the development of the agricultural sector, healthcare, education, and inclusive education.

The NAS of Ukraine operates a network of advisory and consultative bodies performing coordination and expert functions. Specifically, the Council for Space Research of the NAS of Ukraine, at the request of the Ministry of Strategic Industries of Ukraine, conducted an expertise of the State Science and Technology Space Program of Ukraine. Members of the Scientific Council of the NAS of Ukraine on Environmental Issues and Sustainable Development participated in preparing a series of proposals and analytical materials on assessing the damage to natural ecosystems caused by military actions on Ukrainian territory; transitioning to rational models of production and consumption; and addressing climate change and the adaptation of economic sectors to it. On March 28, 2024, with the participation of experts from the NAS of Ukraine, the National Academy of Agrarian Sciences (NAAS) of Ukraine, and the Ministry of Agrarian Policy and Food of Ukraine, a meeting of the Interdepartmental Scientific Council of the NAS of Ukraine and the NAAS of Ukraine on Agro-Industrial Complex issues was held, focusing on the urgent problems of assessing the impact of Russia's armed aggression on Ukrainian soils and identifying directions, technologies, and methods for their restoration. Following the meeting, an analytical note titled "Restoration of Soils Affected by Military Actions" was submitted to the Cabinet of Ministers of Ukraine.

To ensure the reliable and safe operation of Ukraine's nuclear energy complex, the Division of Nuclear Physics and Energy was established within the Academy's structure in 2004. This division includes the National Scientific Center "Kharkiv Institute of Physics and Technology," transferred to the NAS of Ukraine, along with several institutes of relevant profile from other divisions. Experts from the institutions within this division, among other tasks, conduct extensive work on expert assessments of the residual resource and safe operational periods of structures, facilities, and machinery, including those of general and nuclear energy, pipelines, bridges, and construction and transportation structures. In particular, they have justified the safe operational periods for the reactor vessels of eight power units at the Zaporizhzhia, South Ukraine, and Khmelnytskyi Nuclear Power Plants for the next 10 years. The economic benefit from extending the operational life of one power unit by one year amounts to approximately 1.5 billion UAH.

Overall, academic institutions annually provide around 2,000 expert conclusions for normative-legal acts and programmatic documents, as well as information and analytical materials on various dimensions of socioeconomic development.

Significant importance is attached to the participation of the Academy's institutions in the legislative activities of the Verkhovna Rada of Ukraine. Approximately 200 conclusions and remarks on draft laws are submitted to its committees each year.

It should be noted that the Law of Ukraine "Law-Making Activities" designates the NAS of Ukraine as the primary expert institution for conducting legal expertise of draft laws, with the NAS of Ukraine also tasked with developing the Scientific Concept for the Development of Ukrainian Legislation. To organizationally support the fulfillment of these functions and tasks, the Science Coordination Council on Law-Making Activities was established under the Presidium of the NAS of Ukraine in 2024, with its regulations and composition approved.

Under the challenging conditions of martial law and Russia's armed aggression, the interaction between the NAS of Ukraine and the National Security and Defense Council of Ukraine has intensified. Last year, at the latter's request, analytical materials were prepared on topics such as the resilience and development of the national economy under martial law, humanitarian demining, the use and restoration of surface and groundwater resources, the implementation of the Action Plan for the Concept of Countering Terrorism in Ukraine, the reconstruction of Ukraine during wartime and post-war periods, the post-war model of Ukraine for the development of the agricultural sector, and the migration situation in Ukraine.

A substantial scope of expert work is carried out on behalf of the Cabinet of Ministers of Ukraine and central executive authorities. In 2023, over 600 expert conclusions and analytical materials were provided upon their requests, addressing the socioeconomic development and modernization. Analytical materials and proposals sent to the government were devoted to localized tasks and indicators of the Sustainable Development Goals, fundamental principles of public policy in affirming Ukrainian national and civic identity, the Concept of Ukraine's Post-War Model considering competitive advantages and development prospects.

With the participation of experts from the NAS of Ukraine, strategies for the development of various economic sectors have recently been prepared, including the Strategy for the Development of Ukraine's Chemical Industry until 2030; the National Transport Strategy of Ukraine until 2030; the Energy Strategy of

Ukraine until 2035; and the State Economic Program for the Development of Ukraine's Titanium Industry.

A large scope of activities in the NAS of Ukraine is devoted to forecasting and modelling of economic growth, conceptual approaches to prevention and overcoming of crisis trends, and addressing pressing issues of the Ukrainian society. A notable example of such activities is the preparation of national reports. In particular, the national reports "Ukraine's Euro-Atlantic Vector" (2019), "Ukraine as a Civilizational Subject of History and Modernity" (2020), "National Resilience of Ukraine: A Strategy to Respond to Challenges and Preempt Hybrid Threats" (2022) [13], and "Preservation and Development of Ukraine in Times of War and Peace" (2024) [14] have received high societal and professional acclaim. Notably, the most recent of these reports attempts to address the issue of preservation and development of Ukraine during wartime and what a just peace means for our country in the context of an emerging new world order.

Scientists of the Academy are actively working on outlining a comprehensive picture of Ukraine's post-war order. Economists have prepared an analytical study titled "Post-War Revival of Ukraine" and a detailed scientific report "Restoration and Reconstruction of Ukraine's Post-War Economy" [15]. These documents analyze the key opportunities, threats, and challenges facing Ukraine's future, presenting a conceptual and practical plan for the reconstructive post-war recovery of Ukraine's economy. Its implementation creates an opportunity to unify the diverse efforts of economic entities and public administration bodies into a purposeful process of sustainable technological and socioeconomic development.

A significant scope of expert work for Ukraine's energy, aerospace, mechanical engineering, metallurgy, and mining sectors is carried out under cooperation agreements between the NAS of Ukraine and major industrial enterprises, including "Pivdenne" design bureau named after M.K. Yangel, "Antonov" company, Zaporizhzhia Mechanical Engineering Design Bureau named after Academician O.G. Ivchenko, the public enterprise "Zorya"—"Mashproekt," "Motor Sich" company, and the public Enterprise "Energoatom" [15—17].

The year of 2020 saw a new dangerous disease, Covid-19, rapidly spreading worldwide. An interdepartmental working group was established within the NAS of Ukraine in April 2020, to analyze statistical data and mathematically model the spread of coronavirus in Ukraine. Academy scientists created a unique mathematical model for each Ukrainian region, regularly providing short-term forecasts of the epidemiological situation [18]. The results of analytical reports were utilized by public authorities, including the National Security and Defense Council of Ukraine (NSDC), the Ukrainian Ministry of Health, and the Public Health Center, to make decisions regarding response measures and the planning of preventive actions.

Significant efforts were devoted to the expert support of other nationwide issues. The Academy initiated the creation of a monitoring system for the domestic natural environment.

Experts from the NAS of Ukraine actively contributed to developing measures to address ecological and socioeconomic consequences of the destruction of the Kakhovka Hydroelectric Power Plant dam [17]. In 2023, a decision by the Presidium of the NAS of Ukraine established a Working Group which prepared proposals to minimize the disaster's consequences and submitted them to the Verkhovna Rada Committee on Environmental Policy and Nature Management, the NSDC of Ukraine, and other agencies. Additionally, proposals were prepared for public authorities on the accelerated restoration of water basins from pollution caused by toxic chemical and biogenic substances; the prevention of outbreaks of dangerous infectious diseases (such as cholera) and food poisoning; water disinfection in field conditions to ensure drinking water supply; and the development of analyzers to assess water and soil contamination.

The Ukrainian Hydrometeorological Institute developed a monitoring system for heat emissions and the detection of potentially hazardous fires based on the processing of satellite data across the territory of Ukraine. It has already been used by the State Emergency Service of Ukraine.

Certain institutions of the NAS of Ukraine regularly participate in standardization and metrology work, conformity assessment and certification. They provide organizational support for the activities of nine technical standardization committees of Ukraine and annually perform approximately 200 tasks under the National Standardization Program.

The outlined range of directions and specific examples of expert activities of the NAS of Ukraine demonstrate that its institutions, despite challenging conditions, have preserved a robust scientific, technological and creative capacities, actively involved in the preparation of management decisions across various spheres of social life.

Based on the analysis of advanced theories and practices of scientific expertise, it can be concluded that scientific expertise is an institutionalized, collective, context-dependent procedure shaped by its functions, including research, evaluation, analysis, forecasting, consulting, planning. Its purpose extends beyond the development of science and the pursuit of pure knowledge to serving the society. Scientific expertise involves disciplinary, interdisciplinary and transdisciplinary knowledge, methodological, procedural and organizational approaches, appropriate technological support, the authority of science within society, and its demand by governmental bodies and business sector. The performers of scientific expertise must possess professional, communicative, and social competencies, experience and moral qualities, as well as the ability to conduct responsible evaluations. Although expert knowledge is biased knowledge encompassing cognitive, methodological, axiological, deontic and social dimensions, scientific expertise as a collective procedure is more reliable than the conclusions of individual experts, as it mitigates individual biases regarding the use of specific theories, methods, data analysis, and more.

The institutions of the NAS of Ukraine possess robust scientific, technological, creative and expert capacities, actively involved in the preparation of management decisions across various spheres of social life. Given the need to build public trust in science and the societal importance of scientific expertise, it is advisable for the NAS of Ukraine to more broadly highlight this aspect of its activities through the media and on the Academy's website. Indeed, the expert conclusions made by the Academy's specialists address pressing issues in the economy, ecology, social sphere and beyond, making them not only interesting but also vital for the citizens of Ukraine.

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1.6. SCIENCE EVALUATION, EVALUATION IN SCIENCE: THE PROBLEM OF TAKING INTO ACCOUNT THE PATTERNS OF DEVELOPMENT

V.I. Lugovyi, I.Y. Regeilo

The article aims to confirm the hypothesis that neglecting the objective patterns of science development, its determining factors and parameters in the research evaluation process diminishes and distorts the role of evaluation and its impact on the situation in the research sector, and even creates risks for it. It is a conventional wisdom that evaluation of results is a key element in managing any field of activity, including research and development (R&D). To make a management effective, including evaluation as its part, it is necessary to understand the nature of the management (evaluation) object, which in our case is the R&D system, as well as the factors and parameters of its formation, operation, and development [1]. It is also clear that evaluation, as an integral part of the management, should contribute to the improvement of a system (preventing its stagnation or degradation) as a whole. Effective evaluation must be maximally objective (truthful) and minimally subjective (idealized). From the methodological perspective, this means that evaluation must meet the requirements outlined below.

First, it must consider the patterns governing the behavior of evaluated domains, systems or subsystems, regardless of one's preferences or perceptions.

Second, it must be systemic and comprehensive, rather than fragmented, eclectic, or taken out of context. In other words, it should involve a balanced evaluation of both the integrated whole and its differentiated components, determined by the mission (goal) of the whole and aligned with its inherent purpose, which in our case is the R&D sector. A decline of the integrated whole reduces the appropriateness of a separate evaluation of its differential parts degrading along with the whole, and instead of facilitating correction or improvement, it generates a crisis or inhibitory phenomena due to flawed interpretations of the evaluation. For example, there is a high likelihood that the unsatisfactory condition of a particular component in the R&D system, identified through evaluation, is primarily caused by a deep crisis in the entire system. Erroneous conclusions must be prevented during the evaluation process.

Third, the evaluation, being an act of measuring characteristics and diagnosing conditions, must be valid, reliable, unambiguous, and confidence-inspiring. This requires the development of a consistent terminological framework, its scientific justification and legislative regulation, a clear set of criteria, a reliable methodology for obtaining and interpreting data, and the minimization of subjective components in data processing and use.

Other caveats related to research evaluation in modern realities can also be noted, such as mechanical adaptations and transfers of best global evaluation practices working well in some conditions but poorly suited for others. Another caution is the need for careful handling of evaluation results. Formal applications of the results without clarifying and understanding the actual causes of these results can lead to irreparable consequences. It is necessary to avoid *a priori* declared measures based on evaluation results without *a posteriori* analysis of these results. So, evaluation, and especially the use of its results, must build on "do-no-harm" principle.

The relevance of the above said stems from significant losses suffered by Ukrainian research system during the independence period, the need to halt these losses, and the necessity to embark on a sustainable development path. A convincing evidence of this is found in research and publications of recent years, especially in works of scholars from the National Academy of Sciences (NAS) of Ukraine and the National Academy of Educational Sciences (NAES) of Ukraine [2—6].

Scientific methods of analysis and synthesis, analogy and comparison, descriptive and correlation statistics were employed. To obtain empirical data on the research system of leading countries, including the USA, EU, China, and Israel, statistics from the Organization for Economic Co-operation and Development [7], the National Science Foundation of the USA [8], the National Center for Education Statistics of the USA [9], the State Statistics Service of Ukraine [10, 11], analytical and methodological materials of the Ministry of Education and Science (MES) of Ukraine [12] [1], and Ukrainian legislative acts [2] were used.

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1 Ministry of Education and Science of Ukraine (2024). The Official Certification of Research and Higher Education Institutions to the Effect of Performing Scientific (Science and Technology) Activities. URL: https://zakon.rada.gov.ua/laws/show/z1743-24#Text (last accessed: 01.02.2025) [in Ukrainian]; Ministry of Education and Science of Ukraine (2024). Organizing and Carrying out, in 2024—2025, of the State Certification of Research and Higher Education to the Effect of Performing Scientific and Science and Technology Activities. URL: https://surl.li/vfwlvi (last accessed: 01.02.2025) [in Ukrainian].

2 Verkhovna Rada of Ukraine (2015). Science and Science and Technology Activities. URL: http://zakon3.rada.gov.ua/laws/show/848-19 (last accessed: 01.02.2025) [in Ukrainian]; Verkhovna Rada of Ukraine (2014). Higher Education. URL: http://zakon5.rada.gov.ua/laws/show/1556-18 (last accessed: 01.02.2025) [in Ukrainian]; Cabinet of Ministries of Ukraine (2025). Approval of the Procedure for Carrying out of the State Certification of Research and Higher Education Institutions to the Effect of Performing Scientific and Science and Technology Activities. URL: https://zakon.rada.gov.ua/laws/show/540-2017-%D0%BF#Text (last accessed: 01.02.2025) [in Ukrainian].

For the purposes of the article and to simplify the presentation, the terms "science", "research and development", "science system", "research system" are used synonymously, except where specified otherwise. It should be said that the authors deliberately (to draw attention to certain contradictions in the R&D) used the popular term "science" in the title of a "scientific" report at a symposium and in a subsequent article based on it for a "scientific" publication (monograph). At the same time, neither the basic Law of Ukraine "Science and Science and Technology Activities" nor other Ukrainian legislative acts provide a definition of this term, although it and its derivatives are widely used, particularly in titles. For example, "National Council of Ukraine on Science and Technology Development", "scientific committee", "scientific council", "academies of sciences", etc. In total, the words "science" and "scientific" in various forms and cases are used 2,129 times in the abovementioned Law of Ukraine[3]. So, "science" itself lacks a "scientifically" substantiated regulation. Meanwhile, a substantive distinction between the terms "science" and "research and development" can be found in [13].

A systemic analysis of global experiences in R&D indicates that its key factors and parameters that are subject to evaluation are:

1. *The share of GDP allocated for R&D.* In state entities with varying degrees of unitarity, which are major players in the global arena in terms of R&D scopes and competitiveness, as well as in Ukraine, this parameter is as follows: 3.5% in USA, 2.1% in EU, 2.6% in China *vs* 0.3% in Ukraine [7, 10].

2. *The share of researchers in the total employment (per 1,000 employed):* 10.6 in USA, 9.7 in EU, 3.6 in China *vs* 2.9 in Ukraine [7, 10].

3. *The competitiveness of researchers' salaries.* They are low in Ukraine. The average salary of researchers in the NAES of Ukraine is two-thirds of the average one in Kyiv. An evaluation of the Ukrainian R&D by these parameters will show that it is extremely weakened, resource-depleted, and de facto marginalized. Its efficiency forecast can be as follows: the impending stagnation on the brink of systemic degradation, with a likely decline of the institutional components in the R&D sector.

Given the above said, refocusing the evaluation to R&D components without trying to set up threshold values for the factors helping stabilize and develop the R&D sector becomes unproductive. Expectations that the performance of individual components can be improved without addressing the overall situation in the R&D sector and setting up the necessary conditions and parameters for its development resemble futile hopes.

The situation in the R&D sector can be illustrated by a simple school physics problem: will water boil under the following conditions: temperature of 60 °C, normal atmospheric pressure, no impurities? The answer is clear: no. From this

[3] Verkhovna Rada of Ukraine (2015). Science and Science and Technology Activities. URL: http://zakon3.rada.gov.ua/laws/show/848-19 (last accessed: 01.02.2025) [in Ukrainian].

example of ubiquitous "water", it is evident that ignoring the laws of nature is, at the very least, an unrewarding endeavor.

Regarding the transition of Ukrainian "science" from its current condition to another ("developed") one, it is not difficult to predict the same answer and conclusion, which, by and large, are not fully grasped and thus remain outside attention — a dangerous situation. The main question of *why* (?), whether deliberately or not, is obscured, veiled by secondary issues, and therefore remains without a clear answer.

In this regard, the conclusions of a recent foresight study involving 500 experts under the scientific supervision of O.S. Popovych, conducted in 2024, should be recognized as entirely justified:

- "Domestic science has suffered unprecedented losses over recent decades, which have significantly intensified due to the Russian invasion";
- "The majority of measures aimed at improving science management are so misaligned with today's challenges that they rather hinder than accelerate its recovery";
- "It is necessary to radically increase spending on research and development" [5, p. 83].

At the same time, Ukraine has a rich and valuable historical experience of adhering to key parameters enabling for R&D development. Much credit for this belongs to Borys Paton, President of the NAS of Ukraine from 1962 to 2020.

Israel (in the state of war): the share of GDP allocated for R&D is 6.35% (2023) [7]. The impact of R&D is high. The defense capability is highly intellectual and high-tech. Science is defense-supportive.

vs

Ukraine (in the state of war): the share of GDP allocated for R&D is 0.3% (2022, 2023) [10, 12]. The impact of R&D is insufficient.

The reserve for strengthening the Ukraine's defense capability, following Israel's example, lies in enhancing R&D.

The article [14] examines the significance of R&D in achieving sustainable competitiveness and security in the USA. The role of the federal government in elevating the R&D to lift the country out of a pre-crisis condition during 1953—2019 is illustrated in Figure 1.

Figure 1 shows that during the period of heightened confrontation between the USA and the USSR in the late 1950s and early 1960s, amid the threat of lagging behind in the science and technology race, particularly in the field of armaments, the U.S. federal government significantly increased R&D funding. As a result, by the mid-1960s, the share of federal government expenditure on R&D in GDP was twice that of the business sector, raising the total share of R&D expenditure to 2.8% of GDP. A well-resourced R&D sector quickly yielded re-

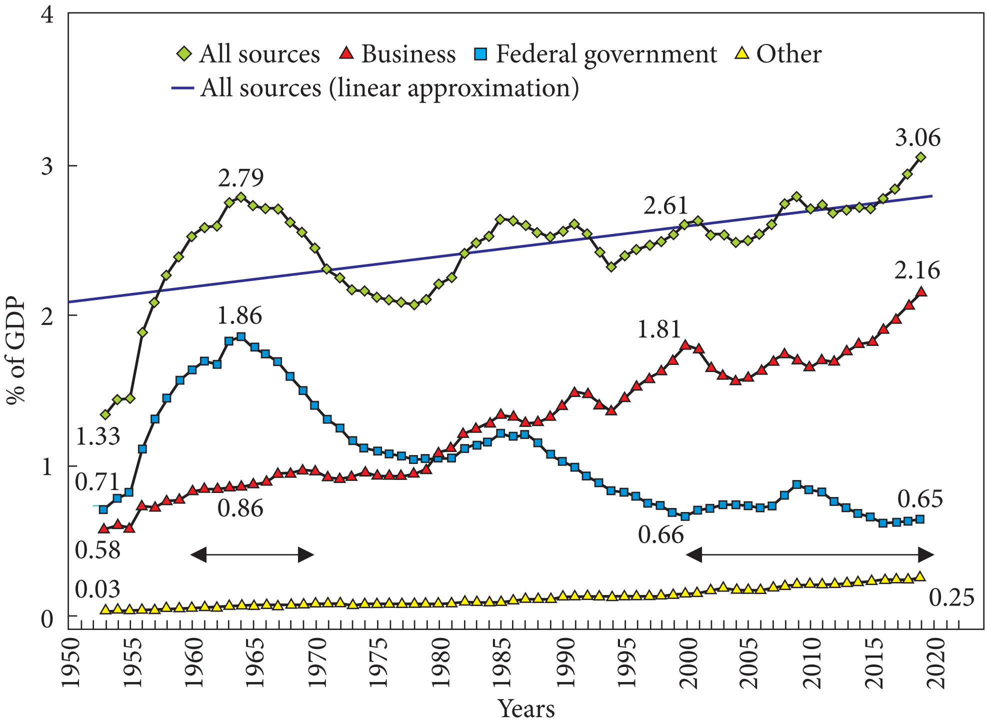

Fig. 1. The share of GDP allocated for R&D in the USA, by source of funding, 1953—2019
Source: [14, p. 95].

turns, piqued the interest of businesses, and subsequently, the contributions of the government and businesses reversed. Hence, in times of crisis, it is logical to start with providing the necessary and sufficient resources and then expect the results, rather than the other way around.

Notably, R&D funds in the USA, as well as globally, are primarily directed toward the non-university sector, a fact that is often overlooked. For example, in 2023, R&D was funded at a level of $956 billion, of which only $109 billion (11%) was allocated to universities [7]. In China (2023, at purchasing power parity), funding for university R&D amounted to $76 billion (8%) out of an expected total expenditure of over $917 trillion on R&D [7, 8]. At the same time, the primary source of support for R&D in higher education institutions, both globally and in the USA specifically, is funding of research and pedagogical activities of academic staff [14, 15]. In the 2021/22 academic year, approximately $700 billion was allocated for the higher education in the USA [9].

Importantly, the significant impact of the share of GDP allocated for R&D has another manifestation: fostering a culture of appealing science within society. This helps mobilize human resources for R&D by motivating young people to study mathematics, natural sciences, and reading.

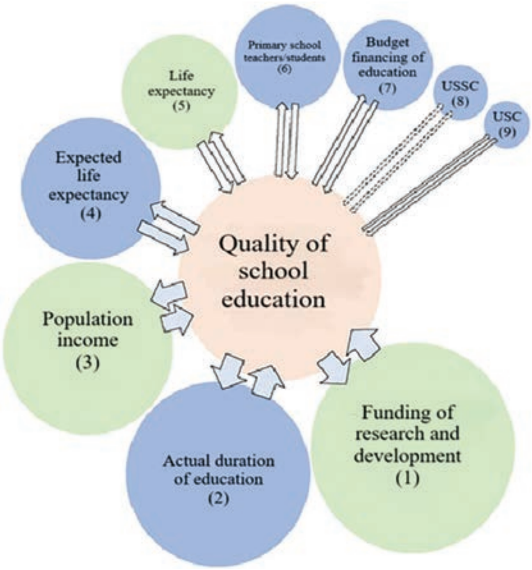

Fig. 2. The magnitude of correlation of nine factors of student success from in 76 countries in "Mathematics," "Natural Sciences," and "Reading" based on international assessments PISA, TIMSS, PIRLS
Note: the relative magnitude of correlation is visualized by the size of the corresponding circle.
Source: [16, p. 38].

In this regard, an article published in 2022 [16] contained a systematic analysis of the relationship between nine factors (six endogenous and three exogenous) of student success in 76 countries in "Mathematics," "Natural Sciences," and "Reading" based on the international assessments PISA, TIMSS, and PIRLS. Of the nine mentioned factors, the strongest correlation with student success is the share of GDP allocated for domestic R&D (Figure 2).

The policy of government support for science and higher education in Canada, another advanced country with the developed R&D, is succinctly expressed as "fighting for the budget." During a trip to Canada in 1990, one of the article's authors (V.I. Luhovyi) met the minister responsible for the development of science and universities in the province of Manitoba, who said that his primary task as a minister was "fighting for the budget" for his area of responsibility. "Fighting for the budget for R&D" is a relevant slogan for Ukraine as well, especially now. After all, a weak R&D is a burden, while a strong R&D is a driver for the development for defense capabilities, the economy and society. It is worth recalling the forgotten maxim "knowledge is power." Today, Israel demonstrates this power.

Bringing the actual funding of the Ukrainian R&D closer to the legally established norm of 1.7% of GDP should become one of the KPIs (key performance indicators) for government leaders. Best global experiences show that non-priority and residual funding of R&D contradicts the nature of civilizational development [7]. In recent years, Ukraine has effectively been conducting a harsh experiment to see how long the R&D sector can survive in the conditions of extremely low funding. Figuratively speaking, R&D is being kept "afloat" by the inertia of large systems' decline. However, its revival will be equally protracted.

This means that R&D funding in Ukraine in the current conditions must genuinely and urgently become a priority, especially during severe trials of war and the negotiation process for Ukraine's accession to the EU.

At the same time, the R&D sector, which should be a national priority, must be evaluated by the criterion of completeness of its priority areas, backed by a regulatory framework, to ensure the institutional development of R&D for each priority. For example, currently there is a clear lack of the priority "Human development throughout life from birth. Formation of competitive human capital." After all, humans are the main driver of progress. Incidentally, the ruthless test of war has shown that Russia's blitzkrieg in Ukraine failed due to the human factor — the ability of Ukrainians to resist and master advanced weaponry.

Addressing the acute personnel problem in R&D, the authors of the abovementioned foresight study rightly noted: "The human resource of R&D is currently in a critical state, and without radical steps to restore it, the rate of degradation may significantly accelerate. Only a multiple increase in the influx of new personnel into R&D can urgently compensate for the losses. Otherwise, in ten years, Ukraine will lose not only the ability to conduct its own world-class developments but also the capacity to implement advanced foreign technologies due to a lack of competent personnel" [5, p. 82]. To this, a conclusion of a 2023 study on open science conducted at the National Academy of Educational Sciences Ukraine should be added: "The scope and complexity of knowledge constitute two fundamental dimensions of open science. <…> The complexity of knowledge poses the issue of formal / factual openness / closeness of open science for research-capable/incapable universities" [17, pp. 16—17]. In other words, the declined R&D and its human resource component results in an ultimate loss of understanding of what is happening in the leading global research centers that are rapidly progressing, *with formally open science becoming effectively closed to the incompetent.*

Regarding the R&D priority setting, it is also necessary to proceed from the intrinsic purpose of science to subject everything that exists (both inanimate and animate (biological, societal), natural and artificial) to scientific reflection, rather than from subjective, situational views on what is important or unimportant, relevant or irrelevant, or the possible or impossible rapid commercialization of results [18].

Concerning research evaluation, it should be noted that the new Methodology for the Evaluation of Research Institutions (RIs) and Higher Education Institutions (HEIs) by Research Areas in Terms of Conducting Research Activities (developed and presented by the MES of Ukraine in Kharkiv on November 20, 2024) is generally worthy of support. The Methodology incorporates the best European experience (from the United Kingdom, Germany, Poland). In particular, the innovative experience of the United Kingdom regarding the creation and application of the REF (Research Excellence Framework) was analyzed and recognized as significant by scholars of the Institute of Higher Education of the National Academy of Educational Sciences of Ukraine as early as in 2017 [17, pp. 70—74]. The Methodology aims to conduct an evaluation laying grounds for increasing opportunities for the best RIs/HEIs through additional funding based on performance results. However, the Methodology implies several risks:

1. Lack of a sufficient experience in accurate data submission in a rapidly organized and hastily conducted evaluation.

2. For RIs weakened by prolonged reductions in R&D funding, the reorganization of a significant portion (within 25% of the points scored) of institutions based on the results of a single evaluation may prove destructive to their network. Unlike HEIs, the network of RIs has already been radically reduced since independence: from 1,198 (excluding HEIs) in 1991 [11, p. 85] to 378 in 2024. After all, the establishment and development of competitive research teams is a matter of years.

3. The intention to provide additional funding to the best RIs without redistributing funds from reorganized RIs is hardly feasible given that the budgetary spending for R&D remains at 0.17% of GDP in 2025 (the same as in 2024).

Regarding the risk implied in the Methodology for the Evaluation of RIs and HEIs, a pilot test even on a small sample (17 RIs/HEIs) showed that the number of uncertified institutions (4) tended to exceed the number of top-performing ones (3) [20].

As can be seen from Figure 3, the first quartile of certified institutions consists of three HEIs, while the last quartile (uncertified) comprises four RIs. This is predictable and logical. After all, research activities in HEIs is funded from two sources: the primary source under “Higher education” program (which in Ukraine typically accounts for 95% of funding or more), and the additional source under the “Research and development” program (average 5% or less) [10, 14, 15]. In contrast, for RIs, only the latter source is relevant. The evaluation should, therefore, be conducted separately for RIs and HEIs. The HEI network being excessively bloated and fragmented [19], the loss of separate R&D funding for weaker universities, not being critical, is supposed to encourage their integration with stronger ones.

Based on the above said, the following *conclusions and recommendations* can be drawn:

1. The arguments presented in the article confirm the hypothesis that neglecting the objective patterns of science development, its determining factors and parameters in the research evaluation diminishes and distorts the role of evaluation, its impact on the research performance, and even creates risks for the research sector.

2. Summing up best practices in advanced countries makes authors conclude that the determining factors and parameters of R&D to be subject to mandatory evaluation are (i) the share of gross domestic product allocated for R&D;

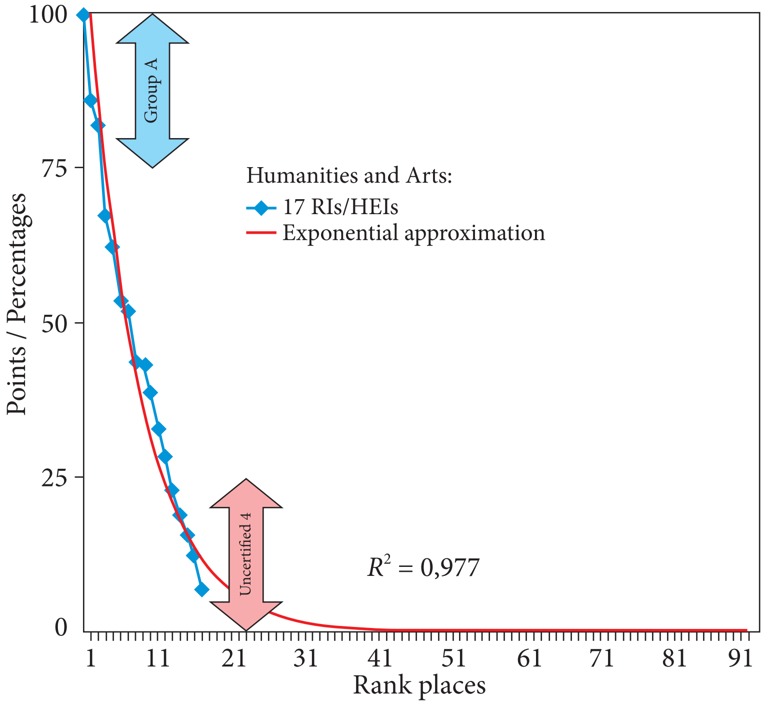

Fig. 3. The distribution of scores and their exponential approximation for 17 RIs/HEIs participating in a pilot experiment on evaluation by the new methodology
Source: constructed by the authors based on experimental data [20].

(ii) the share of researchers in the employed population; (iii) the competitiveness of researchers' salaries.

3. The level of R&D funding in leading countries can be considered a benchmark for the progress of the R&D sector. Its reported figure in Ukraine leads to stagnation and degradation of this sector.

4. Advanced methods of research evaluation cannot be efficiently applied to Ukraine's depleted R&D sector, because these methods can be successful only in the countries where this sector is a priority.

5. An evaluation of research institutions by the new methodology carries destructive risks. The R&D sector can only be revived through the resource support is really requires.

Hence, it is crucial to: make the evaluation of domestic R&D sector a higher priority than the evaluation of its institutional components; consider the science development patterns in the interpretation and use of evaluation results; include indicators of the performance of heads of public executive bodies responsible for the R&D (KPIs, key performance indicators) in the methodology for evaluation of domestic R&D sector. KPIs are determined by positive dynamics in the main factors and parameters of the R&D sector (the share of GDP allocated for R&D, the share of researchers in the total employment, and the competitiveness of researchers' salaries).

The urgent prioritization and real development of the Ukrainian R&D will help enhance domestic defense capabilities and security, the effective postwar recovery, and the European integration of Ukraine[4].

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1.7. EVOLUTION OF APPROACHES TO PERFORMANCE EVALUATION OF RESEARCH ORGANIZATIONS

I.Y. Yegorov, I.A. Zhukovych

The performance evaluation of research across management levels and economic sectors remains a significant challenge, despite the efforts of many experts, particularly when it comes to funding basic research. A wide range of specialized methods and indicators are used for evaluation, but their universal applicability is limited. The results of nearly every research project have unique characteristics that cannot always be captured using the same indicators. In a broader sense, the degree to which a set goal is achieved with the allocated resources can be considered the primary measure of success for research and development (R&D). However, this approach does not address either the problem of comparing the results of different projects or whether the predefined goals of specific R&D projects are valid (i.e., resources could, in principle, be spent on misguided objectives). Similar problems arise in evaluation of research institutions (RIs), but they are compounded by the need to formally define the mission of a given organization, which is often practically impossible, e.g. in multidisciplinary universities.

It used to be believed that the development of scientometrics, particularly bibliometrics, could resolve evaluation-related challenges. However, it became clear that formalized data could only be directly applied to a limited range of subjects, as the specifics of research across disciplines lead to significant variations in seemingly similar indicators.

Renowned experts in scientometric research, D. Hicks and P. Wouters [1], observed that using certain "derived" indicators, such as Hirsch index, as the sole basis for evaluating a researcher or RI was not valid. Moreover, the use of some scientometric indicators in globally recognized university rankings (e.g., *Shanghai* and *Times Higher Education*) leads to distorted conclusions.

To mitigate the negative effects from scientometric indicators, researchers developed the ten principles of the Leiden Manifesto [1], which has become a guiding framework for those working on transparent and responsible research evaluation methods. The Manifesto emphasizes the need for responsible use of scientometric indicators in performance evaluation, advocating for a cautious and balanced approach to quantitative metrics as a tool that complements qualitative expert evaluation. The key principles of the Leiden Manifesto are as follows:

1. Quantitative evaluations must be complemented by qualitative assessments from experts: decision-making should not be reduced to numerical comparisons.
2. The results of an organizations or researcher's work should be aligned with their mission.
3. The value of research should be seen from a local perspective, which is particularly important in performance evaluation of social sciences and humanities.
4. The evaluation process must be open and transparent; evaluation based on a "black box" approach is unacceptable.
5. Evaluators should have the opportunity to verify the accuracy of data and procedures used to obtain it.
6. Differences in citation practices and publication activity across disciplines must be considered.
7. Where possible, different data sources should be correlated: for example, the Hirsch index may vary many fold between *Google Scholar* and *Thomson Reuters*.
8. Excessive accuracy in calculated quantitative indicators does not lead to more reliable results (three or four decimal places should not replace qualitative assessments).
9. The evaluation procedure should incorporate multiple indicators; relying on a single indicator may lead RIs to adapt to it, potentially distorting incentives for research work (e.g., encouraging an increase in the publication activity through experimental studies).
10. A set of indicators should be periodically reviewed to adapt them to changing conditions [1].

The Leiden Manifesto emphasizes the importance of full disclosures of data and methodologies used in performance evaluation, to ensure transparency and openness in the evaluation process. The principles of the Leiden Manifesto have had a significant impact on the research community, being widely discussed and adopted by universities, research organizations, funding agencies, and individual researchers worldwide as guidelines for responsible research evaluation. These principles laid the foundation for "The methodology for performance evaluation in research institutions of the National Academy of Sciences of Ukraine" [2].

Although statistics based on the publication activity provide valuable information, their significance should not be overstated. Nevertheless, publications and citations remain among the few widely recognized quantitative indicators of research performance, particularly in basic research, and continue to be extensively used for evaluation. However, key challenges remain to be quality enhancement of professional training for experts involved in evaluation processes.

The Ministry of Education and Science (MES) of Ukraine is currently reforming the R&D sector. Some initiatives are undoubtedly beneficial and appropriate. However, the reform team does not always draw on positive domestic and international experiences. The reform of RI evaluation can be mentioned in this context, where, in our view, far from the best foreign models were chosen. The main problem is that these "new" approaches do not fully account for the most advanced trends in evaluation. Notably, in July 2022, the Coalition for Advancing Research Assessment (CoARA), comprising 399 organizations from 33 countries, published the "Agreement on Reforming Research Assessment", containing provisions about a unified approach to changing research evaluation practices for researchers and RIs, to enhance the quality and overall impact of their activities [3]. It defines the general direction of research evaluation reform while preserving the organizational autonomy, establishes evaluation principles, specifies commitments to improving evaluation procedures to maximize research quality and impact, and emphasizes the need to base assessments primarily on qualitative expert judgment supported by appropriate quantitative metrics.

"The methodology for evaluating science (science and technology) activities performed by research institutions and higher education institutions, by research area, as part of the official appraisal" (hereinafter referred to as the MES of Ukraine Evaluation Methodology) [4] takes an opposite approach, overtly prioritizing quantitative, formal assessments. While one could critique specific formulas or highlight the mismatch of weighting coefficients with the realities of various research disciplines, this is less significant given the overall focus of the attestation calculations: to derive a single, composite score for all institutions and rank them accordingly. This approach reduces the description of complex activities performed by institutions to a single figure. It is known that heuristic "aggregations" of diverse indicators were initially developed for international bureaucracies unwilling to delve into the details of real socio-economic processes. Such an approach may be justified for providing a simplified picture of reality, but when it comes to decisions about the future of a complex system like the domestic R&D sector, different methods are needed. Aggregation leads to the loss of critical information and serves as a "cover" for decisions that are not always rational. A more logical approach would be to consider vectors of indicators, placing objects that fail to meet certain threshold values of specific indicators into lower qualification groups. However, this approach also has its pitfalls, which methodology developers must address.

One issue is that the MES of Ukraine attempts to apply uniform indicators to evaluate individual researchers, RIs, and research projects, thereby erasing the specificity of these entities. Moreover, by evaluating individual researchers, the MES of Ukraine assumes functions typically reserved for higher education institutions and RIs. It is unclear how this aligns with the principles of academic freedom, which an executive authority like the MES of Ukraine is supposed to uphold.

Efforts to improve the MES of Ukraine Evaluation Methodology should obviously continue, but expecting a "magic" solution is unrealistic. It is crucial to recognize that the primary goal of evaluation is to help organizations identify problems and solutions. If an organization has lost its necessary capacity, it should undergo radical reorganization or even closure. For instance, in the Leibniz Association (Germany) — an organization structurally and functionally similar to the National Academy of Sciences of Ukraine — approximately 5—7% of RIs cease to exist based on a five-year evaluation cycle.

Expert evaluations of "composite" quantitative indicators can be better performing, when greater emphasis is placed on disciplinary specifics (e.g., citation, number of coauthors) and unjustified interdisciplinary comparisons is avoided. Instead of ranking RIs by a single "composite" indicator, groups of RIs with similar indicator values should be identified, as practiced by leading research associations in Germany: Leibniz Association and Max Planck Society.

The Czech Republic serves as an example of successful evolution in evaluation methodologies in post-socialist countries [5]. The reform of the evaluation system for RIs began nearly thirty years ago. The importance of R&D evaluation, fostering an evaluation culture within the research community, and the implementation of advanced evaluation methodologies was recognized at the national level. According to the Czech Republic's Law No. 130/2002 "Support for Research, Experimental Development, and Innovation from Public Funds" [6], the Council for Research, Development, and Innovation was tasked with developing a methodology for performance evaluation in RIs, with the resulting information laid the basis for allocating public funds.

The first evaluation methodology, introduced in the Czech Republic in 2004, was designed as an impartial and depoliticized tool to combat nepotism and corruption in the R&D system, while enhancing the performance of public-funded RIs. Developed primarily by researchers specializing in natural sciences, the methodology relied heavily on a composite quantitative assessment of results. Research results were evaluated in scores based on performance indicators over the previous five years. This information was used to determine the institutional funding for subsequent years. Based on the scores, RIs were divided into four groups: high efficiency, medium efficiency, below-average efficiency, and effectively zero efficiency. Proposals were then made to increase, maintain, or reduce public funding for each RI. Many experts considered a standardized methodology for evaluation of research results funded from various sources a major obstacle to adequate assessment, provoking multiple revisions to improve its content [7].

Significant transformations in the evaluation system occurred in the Czech Republic in 2009. The revised 2009 methodology aimed to increase the impact of R&D and innovation on the Czech economy and society, improve collaboration between R&D and industrial sectors, support RIs with better results, promote research excellence, and expand international cooperation. Research funding based on metrics was introduced at the level of funding bodies (ministries responsible for R&D and the Academy of Sciences) in 2009, and at institutional level in 2010.

According to the 2009 methodology, data was collected to estimate research performance indicators over the five years preceding the evaluation, grouped into categories: publications, intellectual property, and utilization of results. Scores were assigned to indicators based on approved rules (formulas). In the "publications" category, groups were defined as follows: scientific articles (separately for international and domestic journals), books and book chapters (in "international" and Czech languages), and conference proceedings. Article citations were not considered; instead, evaluations were based on the journal's impact factor.

Scores for articles were determined by a sophisticated scheme normalizing the journal's rank. Articles published in journals like *Nature* or *Science* received 500 points, those in influential journals with impact factors received between 10 and 305 scores, and publications in refereed journals without an impact factor could also receive high scores if indexed in well-known databases such as *Scopus*, *Web of Science*, and/or *ERIH (European Reference Index for the Humanities)*. Articles indexed in *Scopus* and *Web of Science* were assigned a fixed score of 12, while those indexed in *ERIH* received between 10 and 30 scores depending on the journal's category. Additionally, publications addressing "national" topics in disciplines like history or linguistics were given greater weight than articles on other topics. A separate category was established for articles published in Czech referred journals from a pre-approved list, classified as "national" by research field.

Books were assigned scores ranging from 20 to 40 based on the language of publication and research discipline. Works published in English, Chinese, French, German, Russian, and Spanish — considered "international" languages — received the highest scores. The score for a book chapter was calculated as a share of the book's total score with accounting for the book's volume. Conference proceedings indexed in *Scopus* and *Web of Science* received the highest score of 8, while materials from other conferences received lower scores [5].

The category of "other results" included results of applied research, such as patents, experimental developments, certified technologies, plant varieties, utility models, industrial designs, prototypes, functional samples, results implemented by a financial authority (e.g., reflected in legal documents), certified methodologies and procedures, specialized maps, software, and scientific reports containing confidential information.

The highest score (500) was assigned to patents issued by the European Patent Office, the United States, or Japan. The second-highest score (200) was given to national patents issued by the Czech Patent Office. The lowest score (40) was awarded to patents issued by patent offices in other countries (outside the EU, the United States, or Japan), provided they were commercially exploited under a valid license. Research results such as plant varieties and confidential scientific reports received 100 and 50 points, respectively. All the other research results could earn RIs a maximum of 40 scores. The total score of RIs performance was calculated as the sum of the scores earned. To prevent an excessive growth, the total score was adjusted using coefficients. For instance, if it exceeded 15%, a multiplier was applied for correction.

The 2009 methodology was applied to all types of organizations. The list of organizations eligible for institutional funding primarily included universities, RIs of the Academy of Sciences, RIs doing applied research, and organizations performing functions beyond research, such as museums and hospitals.

The initial phases of the 2009 methodology implementation saw a sharp increase in the number of publications indexed in *Web of Science* and patent applications. However, the methodology later led to unintended consequences. It incentivized researchers and RIs to prioritize short-term, monodisciplinary, and applied research. To boost publication numbers, researchers systematically published in journals with lower impact factors. As a result, many mediocre results were overvalued in the overall assessment according to the methodology. To maximize scores, RIs resorted to adapting results, to allow double-counting. For instance, scientific monographs were submitted as both monographs and textbooks, old works were republished, and series of working papers were created, to be presented as peer-reviewed journals. To inflate a journal's impact factor, low-quality articles were cited as frequently as possible [5].

To maximize scores from results of applied research, RIs displayed opportunistic behaviors. For instance, registering utility models or national "small patents" required only an administrative act. Since the quality, originality, or functionality of these results were not verified, RIs registered any possible solution to accumulate "cheap" scores.

The Czech experience demonstrated that an evaluation based solely on scientometric indicators disrupted the institutional stability and hindered long-term research projects. The share of funds allocated through the results-based funding system was significantly reduced, and the performance evaluation scheme using scientometric indicators required a refinement. Aggregating all indicators into a single composite metric made it impossible to accurately assess the RI performance, as bibliometric indicators heavily depended on the citation culture within specific research disciplines.

Since 2017, the Czech Republic has implemented a new "*Methodology for Evaluating Scientific Organizations and Programs for Targeted Support of Research and Innovation*" (M17+) [8]. The goal of this methodology is to assess the RIs performance, forecast RIs development while considering sectoral specifics and varying missions, incorporate informed and independent perspectives from partners in the evaluation process, evaluate RIs in national and international contexts, and provide data for allocating public funds from the core funding pool for Czech RIs. The methodology consists of five modules applied to all RIs: quality of selected results (M1), research performance (M2), societal relevance (M3), viability (M4), and strategy and policy (M5). Institutions listed in the Register of Public Research Institutions, maintained by the Ministry of Education, Youth and Sports, are subject to evaluation, with their results recorded in the National Information Register of Results. The evaluation covers universities, RIs of the Czech Academy of Sciences, and sectoral RIs.

The evaluation process prioritizes "informed peer review" involving international experts, which includes site visits to assess the RI's operations, reviews of the RI's SWOT analysis (strengths, weaknesses, opportunities, and threats), and using available metrics alongside other information to make decisions about the overall assessment. Based on the evaluation, Czech RIs are classified into one of four categories: excellent (A), very good (B), average (C), or below average (D). A detailed description of these categories is provided by the authors in [5].

According to the authors, this new approach to performance evaluation of RIs in the Czech Republic aligns more closely with advanced evaluation systems used in developed countries. Certain elements could be considered for adoption in Ukraine. However, it is also necessary to establish a system for monitoring key performance indicators, ensuring their reliability for use by experts during evaluations. Most importantly, there must be a shift in experts' attitudes toward evaluation and an increase in scientific integrity. This could be achieved through measures such as moral and material incentives, as well as "sanctions" for poor-quality evaluations, including barring from participation in research project competitions, expert reviews, or dissertation defenses. Greater involvement of external experts, particularly from abroad, beyond the scope of domestic institutions (e.g., the NAS of Ukraine, the MES of Ukraine), is also essential.

It should be noted that reforms in approaches to research evaluation is a complex and lengthy process that requires broad discussion and consensus among the research community, policymakers, and other stakeholders. The recognition of the need for change and active discussions in this area provide hope for the development of fairer, more balanced, and effective evaluation systems that will foster the growth of high-quality and impactful R&D in Ukraine.

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CHAPTER 2

Evaluating research: methodology and organization

2.1. AN INTRODUCTION TO THE THEORY AND PRACTICE OF EVALUATING SCIENTIFIC RESULTS

B.A. Malitsky

The central idea of the article is that the evaluation of a scientific result should be based on determining the specific contribution of this result to the global R&D and the creation of scientific innovations, rather than on manipulating quantitative indicators of a researcher's publication activity. Our studies demonstrate that scientific information databases widely used in research evaluation method should only be applied as a supplement to expert and team evaluation, as well as in scientometric analyses of specific R&D dimensions. There is substantial theoretical evidence from analysts of domestic and international R&D systems supporting this approach to evaluation, confirming that the phenomenon of scientific knowledge and scientific innovation as *a complex result of research activities* is a more fundamental phenomenon than it has been perceived in recent decades, particularly in management practices. The evaluation of a scientific result by counting of publications and citations is insufficient to fully reveal their scientific, technological, and socioeconomic value, leading to numerous problems within and outside the R&D sector.

1. When discussing research evaluation, it is necessary to draw attention to key trends in the R&D sector at global and national level, affecting in one way or another the quantity and quality of scientific results.

The R&D sector is becoming increasingly large-scale, complex, and costly.

• The number of researchers worldwide has reached nearly 8 million and continues to grow globally and in most countries, but there is a group of countries where it is declining.

Unfortunately, Ukraine is among them, with the number of researchers having decreased almost sevenfold since independence [1]. However, the producers of new scientific results have been increasing at a rate higher that the leading scientific journals, a trend slowing the publication activity and diminishing the credibility of expert evaluations of publications.

• Global and national R&D expenditure shows a upward trend, being 1.9% of GDP in the average and reaching 4% or more in some countries. Our research indicates that this trend, apart from reflecting a general increase in R&D expenditure, gives evidence of the rising cost of obtaining the scientific knowledge resulting from the research effort. In other words, conducting "disruptive" research and creating "disruptive" innovations is becoming an increasingly expensive process [2].

Unfortunately, Ukraine exhibits an opposite trend in R&D funding. The R&D intensity of GDP decreased from 2.5% in 1990 to 0.38% in recent years. Budgetary expenditures on R&D amount to only 0.18% of GDP, despite the legislative norm of 1.7% of GDP [3]. A similar trend is observed in the funding of the National Academy of Sciences (NAS) of Ukraine, which has been consistently decreasing, amounting to only 0.09% of GDP in 2023, even though the NAS of Ukraine institutions perform more than two-thirds of the total domestic R&D [4]. The scope of R&D funding in Ukraine makes it impossible to conduct high-cost, disruptive R&D without external assistance. This was convincingly demonstrated by the President of the NAS of Ukraine, Anatoly Zagorodny, in his report at the latest session of the General Assembly of the NAS of Ukraine, showing that the most disruptive results of the Ukrainian natural science research in recent times could be achieved through collaboration with researchers from foreign scientific centers [5].

• From a substantive perspective, scientific results are increasingly characterized by a complex dual nature: each result contains "pure new knowledge" and "seed of scientific innovation." The ratio between these two components of a scientific result depends on the level of fundamentality (theoretical nature) of the research. The share of "pure knowledge" is more significant in basic (theoretical) research. In applied research, and especially in development, "scientific innovation" holds dominant importance. However, the convergence of different forms of research intensifies with the growing scale and complexity of research, which in one way or another affects the structure of scientific results [2].

2. Given the specifics of scientific results influenced by the factors mentioned above, there arises a need to make appropriate adjustments to the research evaluation methodology and practice, both in science & technology and socioeconomic terms.

As far as Ukraine is concerned, unlike recent global trends, the domestic practice of evaluating the performance of a researcher or a research team has long been dominated by quantitative scientometric indicators overlooking the specific content of a scientific result as “pure knowledge” and “scientific innovation.” This has led to serious problems within and outside the R&S sector.

The notion that a scientific result — defined in regulatory acts as “new knowledge” — can be presented through quantitative information indicators (number of articles, monographs, Hirsch index, etc.) emerged and gained prominence during the era of the triumph of Garfield’s scientific information database. Today, several similar systems exist. Scientometric indicators can also be tracked on the *Google Scholar* platform [2].

3. It should be noted that the common method of evaluating a researcher’s productivity based on scientometric indicators indeed holds significant potential for studying various dimensions R&D [2]. Thus, researchers at Dobrov Institute for Scientific and Technological Potential and Science History Studies of the NAS of Ukraine used the Web of Science system to conduct studies aimed at:

• identifying scientific leaders in a specific field of science by analyzing citation networks and determining their center;

• determining the scientific specialization of countries and regions, and substantiating opportunities for their collaboration through the creation of targeted joint projects and programs;

• forecasting priority areas of science at country level by analyzing trends in the publication activity in a specific field of science.

The number of studies based on scientometric indicators has significantly increased in recent years. There has also been a noticeable expansion in the range of applications of indicators from scientific databases. For instance, a study by American researchers, using Web of Science data, identified the rates of growth or decline in the “disruptive” nature of research over a long time (from the 1950s to the present), which has become a new direction in the analysis of science development [2].

4. Given the above said, it can be argued that existing systems of scientific information databases can provide excellent opportunities for studying various aspects of science development. However, the mechanical use of these opportunities to determine the scientific “weight” of a researcher or a research team based on the number of publications and citations — without considering the specificity of the new scientific knowledge obtained through research — has numerous negative consequences. This method of evaluating scientific results is particularly problematic in the practice of public R&D management.

This evaluation method has become widespread due to the simplicity of obtaining input data on researchers’ activities, which does not require a deep understanding of the essence of the scientific result as new knowledge in cognitive, historical, socioeconomic, and security contexts. For example, in the methodologies of the Ministry of Education and Science (MES) of Ukraine, used for the official evaluation of research institutions and ranking of researchers, the most important criterion is the number of publications in journals indexed in well-known scientific databases, despite the lack of sound evidence that each publication in journals with impact factor is indeed of higher quality than those in other scientific outlets.

5. It should be noted that modern Ukraine inherited the preference of a quantitative approach to research evaluation from the late Soviet Union: when the Soviet Union was in a severe socioeconomic stagnation in the 1980s, with the financial support for R&D decreased, there were numerous attempts of bureaucratic evaluation of researchers' work using many indicators, which, as is well known, yielded no positive results. The Soviet Union collapsed, the Soviet science system disintegrated, and the quantitative evaluation system failed to prevent its collapse.

It appears that the modern Ukrainian methodology for evaluation of scientific results is based on the British *Resources for the Future (RFF) system*. However, British researchers have a bad look at it. Over 85% of respondents in a special survey believe that this evaluation methodology has led to the increased imitation of useful activities, the exaggerated impact of research efforts and their declined novelty. The final conclusion is that the losses of time and resources for evaluation procedures outweigh their benefits [6].

Particular attention should be drawn to critical views of the existing European systems of scientometric evaluation of researchers' performance, as expressed by Peter Higgs, a Nobel laureate who discovered a new fundamental particle of matter named the Higgs boson. As is well known, Nobel Prizes, being a globally recognized scheme for evaluating scientific results, are awarded for a new scientific knowledge and disruptive scientific innovations rather than quantitative scientometric indicators. In one of his interviews, P. Higgs observed that under current evaluation terms he would be deemed insufficiently productive for the academic system of today with his ten articles published after the discovery of the boson. Hence, by his own example he demonstrated how vulnerable and biased a system of evaluation based on the quantitative metrics of articles could be, without considering the specific scientific contribution of a researcher to the development of global science [7].

6. Going back to the analysis of the Ukrainian system for evaluation of scientific results, I believe it is necessary to highlight the problems caused by the dominance of the quantitative approach. The key one are as follows:

• Prioritizing the publications in foreign journals without providing necessary support and creating attractive conditions for Ukrainian scientific journals, apart from declining the scientific level of the latter, worsens the international image of the domestic R&D sector and diminishes the national social capital. Normatively, our journals are a priori considered second-rate, even though many of them are of a high scientific level.

• Prioritizing the publications by Ukrainian researchers in foreign journals creates a serious problem of preserving domestic intellectual property. The specific content, scientific, technological, and socioeconomic value of such publications are often lost to Ukraine. Given the lack of attractive terms for registering inventions and patents within Ukraine, the practice of patenting by our researchers abroad has become widespread, especially when an invention is a joint result with a foreign co-researcher.

• Various forms of incorrect and dishonest publication of scientific results have become widespread. In Ukraine, as well as globally, there are many "scientific factories" that, for significant fees, ensure publications for willing authors in journals with an impact factor. Essentially, money replaces objective peer review. In our country, this method of publication is used not only by early-career researchers but also by graduate students and even undergraduates. This is not surprising, as universities require publications in Scopus-indexed journals to prove scientific value, even when the opportunity to participate in serious research is absent in many universities. Many university lecturers, to confirm their research and pedagogical status, are forced to initiate and register financially "void" topics with the Ukrainian Institute for Science, Technology and Economic Information. The number of such topics is enormous (over 4,500), which is not only striking but also indicative of the declining research culture, as these studies are essentially conducted at an amateur level. This can explain the prevalence of scientific plagiarism. It is known that even researchers who are parliamentarians, university rectors or ministers engage in such practices.

• Attention should be drawn to the problem of averaged assessment of researchers' publication activity, which is currently used in all methodologies and even in the practical activities of research teams. The publication activity definitively changes with the researcher's age and experience. This fact has long been proven and substantiated in the so-called principle of phase dynamics of the research activities, demonstrating a complex bimodal age-related dynamic of the publication activity and other related features. Details of this conclusion can be found in [8].

• The current practice of a quantitative approach to the research evaluation does not encourage researchers to give a clear and intelligible formulation of their scientific results. These results are often presented in an incorrect form, without providing evidence of scientific novelty in terms of alignment with the forefront of the global science, which makes it impossible to see the result's scientific impact and innovative capacity. Frequently, the mere fact of conducting research is presented as a scientific result [2].

The below given data revealing the problems in the domestic research environment caused by a purely quantitative approach to the evaluation of scientific results and neglect of their scientific and social value expose not less acute sociopolitical issues:

• The scientific achievements of Ukrainian researchers are barely discussed in the Ukrainian society, public authorities or the Verkhovna Rada of Ukraine.

Even when scientific prizes are awarded, their widespread public promotion is not ensured.

• Unfortunately, as our special studies show, scientific achievements remain unknown in the student community, which prevents from fostering of a modern scientific consciousness in future professionals. This fact was brought to the attention of the MES of Ukraine through a special memorandum, with no response received.

• As public officials, politicians, businesspeople, and entrepreneurs have poor awareness of the scientific achievements and innovations that the domestic R&D can produce, they are concerned with neither its capacity to have a real impact on the nation's development nor with its needs. It is a reason why the domestic R&D has been sidelined from the national funding and innovation priorities.

• The neglect of R&D and innovation by public authorities is also evident in the substantive dynamics of the regulatory and legislative framework. The core Law of Ukraine "Public Policy in Science and Science and Technology Activities" has long been transformed into a bureaucratized regulatory act, effectively devoid of specific provisions on the government's responsibility for the development of science. In its latest version, only two such provisions remain: R&D intensity of GDP at 1.7% and the average salary of researchers as twice the average salary in industry. However, both legal commitments remain unfulfilled for the R&D sector. Moreover, as researchers have found, there is a persistent downward trend in R&D intensity of the general Ukrainian legislation, giving evidence of its de-intellectualization [9].

Unfortunately, this reflects a decline not only in the domestic R&D capacity, as discussed earlier, but also in the level of education, determining the science-based worldview in a broader community, especially among the youth. The so-called esotericism is spreading in the media space, with various pseudo-forecasters and futurists painting fabricated prospects for Ukraine, whereas evidence-based forecasts by experts regarding its economic, social and especially demographic future often appear bleak and hopeless amid the lack of proposals on improvement. In the meantime, people are intrusively offered miraculous methods and remedies for instant recovery from any illness, to which there is no adequate response from official medical science. In the conditions like this, given the lack of credible and evidence-based knowledge, it becomes harder for people to respond to reality from rational positions.

7. Addressing these problems requires transition to a substantive and qualitative evaluation of scientific results. Ukraine should have a national register of scientific achievements, rather than just an idea of the number of publications by Ukrainian researchers in prestigious foreign journals. All scientific achievements, including those intended for publication abroad, should be subject to collective discussions within research teams. Such a practice exists in many countries concerned with preservation of the intellectual property created domestically.

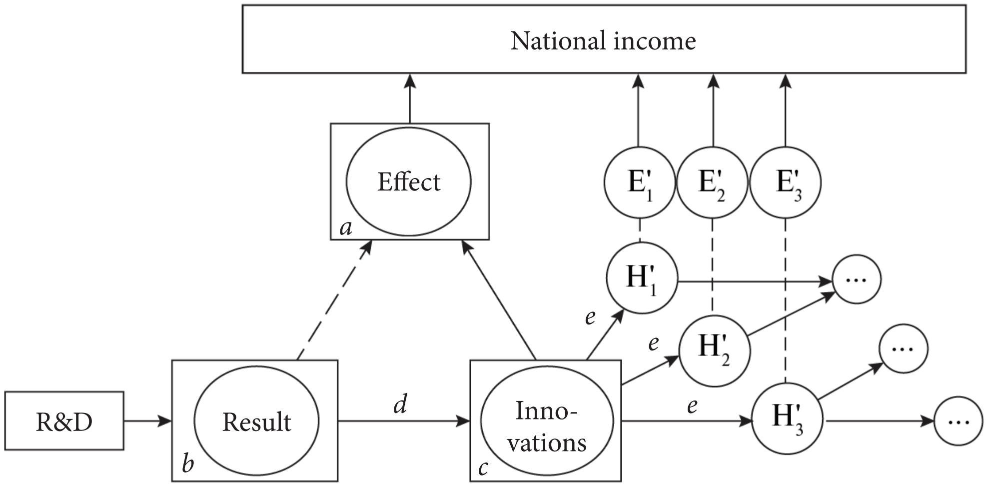
The national register should serve as a database for continuously informing society, authorities, businesses, and the entire scientific community, enabling constructive responses to ensure the real utilization of scientific results. This method of publicizing researchers' results has an image-building capacity for both the researcher and the country, no less significant than the publication and citation of an article in foreign journals.

8. Furthermore, it should be emphasized that the issue of evaluating scientific results is a constant key research topic for the Dobrov School of Scientometrics, with many large-scale projects performed by our staff. The most significant among them is an international project on studying the effectiveness of small thematic groups, conducted under the auspices of UNESCO with the participation of 18 countries from different continents. G.M. Dobrov used its results to develop the most comprehensive scientific concept of the genesis of R&D effectiveness, demonstrating the systemic correlation between the scientific result, the productivity (input-output ratio), effectiveness, and the impact of an innovation based on the acquired new knowledge on specific areas of social life (Fig. 1).

G.M. Dobrov demonstrated that the results help (i) save the socially necessary time in the production sector (economic effect); (ii) increase the attractiveness of certain types of labor (social effect); (iii) harmonize relationships with the environment (ecological effect); and (iv) enhance the science and technology capacity to address specific classes of problems (science & technology and security effect). When measured at the point of implementation and related to the costs of the corresponding R&D, they characterize the return on R&D.

An inherent property of the interaction process between science, technology, and production is the ability of already made scientific discoveries, inventions, and innovations to generate (or contribute to the emergence of) subsequent generations of innovations, thus increasing the final effects of a scientific result. This chain-like, "avalanche" nature of science & technology development predetermines the dynamics of all the substantive phenomena and organizational forms of the R&D process as a whole and its results. These dynamics is linked to the evolution of perceptions on the research activity effectiveness. Its century-long criterion is the achievement of scientific success recognized by peers and students. Today, the interaction between science, technology, and production has entered a phase where the ultimate success of science & technology activities is primarily determined by the teamwork of communities that are generators of science & technology progress [10].

The issue of scientific results evaluation has also been studied with our participation in EU projects, as well as in joint projects with Germany, China, and other countries. The evaluation-related research conducted by the staff of Dobrov Institute for Scientific and Technological Potential and Science History Studies of the NAS of Ukraine covers important issues, with significant atten-



Genesis of R&D effectiveness: *a* — effectiveness; *b* — productivity; *c* — return; *d* — transfer of results (implementation); *e* — impact; E' — secondary effects; H' — secondary innovations

tion devoted to the evaluation of scientific results for national security and defense purposes [11].

Currently, Dobrov Institute for Scientific and Technological Potential and Science History Studies of the NAS of Ukraine is working on the topic “Evaluating Scientific Knowledge: Cognitive, Historical, and Socioeconomic Dimensions.” The issue is being explored from scientometric, historical, philosophical, and socio-psychological perspective. It is the first time in scientometric studies that it is being examined from another perspective: *a quantum approach*. The first article devoted to this approach was published in the international journal “Science and Science of Science” [12]. This approach has revealed a certain analogy between the content of new scientific knowledge and quantum processes, laying grounds for interpreting the phenomenon of scientific knowledge as a more fundamental phenomenon, particularly in terms of its generation, dissemination, utilization, and evaluation. In proposing the new quantum approach, the author is fully aware that because the quantum theory is a highly complex science, its application to the phenomenon of scientific knowledge may be deemed inappropriate. However, there are numerous facts indicating that the phenomenon of scientific knowledge is indeed a more fundamental phenomenon than usually believed.

The properties, the process of obtaining, and the applications of new scientific knowledge are far more complex than the products of labor in other human activities. The interaction between pieces of knowledge in the cognitive activity of a researcher is the sole source of new knowledge generation, from which scientific ideas are formed as elementary quanta of knowledge, scientific theories, research areas and fields, and other scientific structures. As in physical quantum processes, the oversaturation of knowledge in a specific scientific field over time leads to the formation of a new scientific discipline. These processes can occur solely under the influence of internal scientific factors determined by the properties of science as a type of activity and are shaped by the ethos of science — a set of values and norms considered mandatory for researchers.

It follows that *the quantum approach* to defining the essence of new knowledge as a scientific result requires that the science management system, the national one in particular, account for the research process specifics and support the implementation of the principles of scientific ethos without interfering in the process of acquiring new scientific knowledge. This requirement cannot be met without a fundamental revision of the current legislative and regulatory acts in Ukraine determining the nature of the influence of management bodies on this process.

Unfortunately, many regulatory documents have been "printed" in this area, which content and purpose fail to consider specificities of science and its functioning in the scientific and social environment. The most striking example is the repeated revision of the main science-related law, which has been transformed from a law on public policy for R&D into a law regulating crude bureaucratic interferences in the internal scientific life, devoid of any government responsibility for the development of R&D.

Equally detrimental to the scientific ethos are the regulatory documents on training and evaluation of research personnel. They have no hint that a dissertation is, above all, the result of a research effort rather than a compilation of established knowledge, and its evaluation should not rely on educational criteria, as is currently stipulated. Specifically, these documents set requirements for mandatory publication of articles by dissertation candidates in prestigious journals, allow for the avoidance of responsibility for plagiarism in dissertations through voluntary renunciation of a scientific degree or academic title, i.e. a step humiliating a true scientist, and include many other rules that are inconsistent with the principles of scientific ethos and hinder the development of science on the democratic foundations of academic freedom.

Another conclusion is based on the consideration of the dual structure of scientific knowledge as the result of research effort, which bears similarity to the dualism of a physical particle like an electron. Scientific knowledge, as demonstrated earlier, combines two qualities: "*pure knowledge*" exhibiting wave-like properties, and *the seed of scientific innovation being a material particle*. This property helps induce a final innovation through the interaction of "pure" knowledge with the products of other activities (science & technology, design, engineering). Such interaction is triggered by the "field" of practical demand for scientific innovations. The formation of this demand is a mission of the public innovation policy that should have effective schemes stimulating the demand across the human life activities, including public governance, economy, sociocultural sphere, education, and national security.

Finally, it has long been proven that the status and performance of R&D is determined by the science policy. Unfortunately, this policy in Ukraine has never been science-centric. Following the effective repeal of the Law of Ukraine "The Foundations of Public Policy on Science and Science & Technology Activities," as mentioned earlier, its content has come to be dominated by schemes of bureaucratic interferences in internal scientific affairs, almost entirely ignoring government responsibilities for the development of the domestic R&D. Therefore, a central conclusion, based in part on the principles of the quantum approach to acquiring new scientific knowledge, is that reforms in R&D, constantly initiated by certain politicians and officials, will be impossible without proclaiming the general principles of a science-centric policy, establishing the necessary scopes, sources, and methods of R&D funding for the effective R&D performance, rehabilitating R&D personnel, *introducing an informed system for evaluation of scientific results*, actively promoting these results in society, accelerating the integration of the domestic research system into the global research space, and creating attractive conditions for the realization of the principles of scientific ethos.

The author believes that the conducted research can complement the existing array of valid scientometric proposals on organization of the domestic R&D sector. It demonstrates that the quantum approach is a tool really capable to explain several important properties of new scientific knowledge, refine the science management principles, and enhance the status of science in the societal life. This may stimulate further explorations by scientometrics and science policy researchers in this direction.

9. It should be added that, apart from scientific articles or monographs, results of our research lay the basis for numerous analytical reports and recommendations prepared by us, e.g. for government bodies, most of which, unfortunately, remain unnoticed by public officials. I believe it so happens because many of them misunderstand the issue of integrating domestic R&D into the European framework. Their attempts are confined to superficial adaptations of European practices without considering its essence and domestic experiences. It is, therefore, evident that we need to deeper integrate our achievements into the national science administration system. I also consider it appropriate to launch professional training in scientometrics and innovation studies in Ukraine, drawing on the foreign experience. The Presidium of the NAS of Ukraine has already taken the first step in this direction by approving "Scientometrics" discipline in the Nomenclature of Priority Research Areas. Perhaps, with the emergence of a broader pool of R&D management experts, Ukraine will be able to reform and manage the domestic science system in a way to fulfill a well-known admonition of the great Kobzar, Taras Shevchenko: "Learn from others, but do not forsake your own."

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2.2. INTERNATIONAL RANKINGS OF THE INNOVATION ACTIVITY: RISKS OF METHODOLOGICAL BIAS IN EVALUATION

O.V. Vasylieva

The research topic is important because of the need for a deeper understanding the innovation specifics in Ukraine under the martial law and during the post-war recovery. Apart from physical destruction of infrastructure and human resources, the war in Ukraine hit the innovation sector, particularly the performance of technological research, the development of technological startups, entrepreneurship, and the overall innovation activity. These factors require thorough investigation, to build up the schemes supporting innovation and technological recovery in the post-war period.

Importance lies in the need to create and implement innovation models capable of adapting to changing conditions and contributing to the restoration of material as well as intellectual infrastructure of Ukraine. Meanwhile, the scientific community needs new methods for the innovation performance evaluation in the Ukrainian environment, particularly in the context of international rankings, which do not always adequately reflect the situation in countries going through crisis or post-war recovery.

The problem statement is that traditional methods for the innovation activity evaluation, particularly those using international indices, are not always able to accurately reflect the actual innovation performance, especially amidst the war or post-war recovery. This raises doubts about their utility for making effective managerial decisions on R&D and innovation policy. It is crucial to develop adapted methodologies for the innovation performance evaluation, better aligned with the realities of post-war recovery, considering limitations in statistical data and the unstable socio-economic environment.

The novelty of the research topic lies in the analysis of international ranking systems used in the innovation performance evaluation at country level, particularly those recommended by the Ministry of Economy of Ukraine. The study emphasizes the risks for R&D and innovation policy setting due to the use of these indices, as they may distort the true picture of the innovative activity in countries.

Ukrainian scholars examine international standards for evaluation of R&D and innovation from a perspective of recent methodological changes, with emphasis on R&D and innovation performance indicators reflecting the overall efficiency of the national innovation system [1, 2]. Foreign researchers, analyzing international ranking systems for innovation activity assessment at country level, aim to reveal patterns and ranking-related problems [3, 4]. However, this problem requires further unbiased analysis with reference to the Ukrainian realities.

The research novelty lies in a comprehensive analysis of international rankings of the innovation activity performance at country level, with emphasis on the risks of methodological bias in their evaluation. The distinction from previous studies is that the author conducted a detailed examination of the ranking systems recommended by the Ministry of Economy of Ukraine, identifying their bias and incompleteness. The author's contribution consists in a critical review of existing methodologies for the innovation activity performance, enabling to reveal essential problems and shortcomings in the assessments provided by international organizations. This can serve as a framework for further improvements in the methodology based on theoretical and practical research aimed at enhancing the accuracy of assessment.

Comparative analysis was applied to identify weaknesses and gaps in existing methodologies of international rankings; critical analysis was used to assess the bias of methodologies for innovation activity measurement; the case study method was employed to analyze specific examples of countries with different positions in international innovation activity rankings. The research was made with reference to official reports of the Global Innovation Index, Subregional Innovation Policy Review, and Global Startup Ecosystem Index; publications by international organizations that issue these documents; scientific works by domestic and foreign scholars; official documents of the Ministry of Economy of Ukraine.

Since the onset of Russia's full-scale invasion of Ukraine, the scientific community has faced numerous challenges that have significantly complicated research devoted to science & technology and innovation performance. An essential obstacle has been physical destruction or damage of research infrastructure — universities, laboratories, and research centers — leading to the loss of the material and technical facilities necessary for full-fledged research activities.

A significant adverse factor for the research process has been the mass migration of skilled personnel, both abroad and within Ukraine, due to the need for evacuation from active combat zones. This has resulted in the disruption of established research teams, disorganization of scientific schools, and the suspension of numerous promising research projects.

Additionally, there has been a substantial reduction in the public funding for R&D due to a shift in budget policy priorities, with funds being redirected to security, defense, and humanitarian support for the population. This has made it impossible or significantly more difficult to obtain grants, hold competitions for research funding or renovate research equipment.

The impact of the war on Ukraine's international scientific cooperation deserves special attention. Despite the increased support from Western partners, domestic researchers faced the loss of established partnerships, particularly with research institutions in countries no longer deemed safe for collaboration. Limited access to international databases, research networks, and analytical tools has further complicated the conduct of high-quality research.

Another significant obstacle has been the lack of complete, reliable, and timely statistical information necessary for a qualitative analysis of the R&D performance. The official statistical system faced limitations in collecting and updating data, particularly in regions with active hostilities and temporarily occupied territories. This disrupted the monitoring of innovation activities, making impossible a comparative analysis over time and evidence-based strategic decision-making.

A telling fact is that the State Statistics Service of Ukraine published the latest statistical information in the "Science, Technology, and Innovations" section on October 23, 2024, covering data for 2021—2023 [1]. According to the footnote, the data was compiled based on reports submitted by enterprises, suggesting incomplete and potentially selective information. This situation makes it impossible to have a comprehensive view of the innovation performance in Ukraine, compare long-term dynamics or formulate informed conclusions for strategic planning. It significantly complicates empirical verifications of hypotheses, building up projection models or evaluations of institutional science & technology policies. Hence, the lack of current and representative statistical data is a key factor limiting researchers' analytical capabilities and reducing the quality of evidence-based decisions on innovation management.

Against this backdrop, international rankings where Ukraine is involved as an object of comparative assessments of the innovation capacity, the institutional capacity, and the innovation policy efficiency, gain particular importance. Comprehensive characteristics are provided by indicative tools: Global Innovation Index, Bloomberg Innovation Index, Composite Innovation Index, Global Talent Competitiveness Index, World Competitiveness Ranking, and Transitions Performance Index. Each is based on different methodologies, incorporating both quantitative indicators (R&D expenditures, number of patents, startups, publications, etc.) and qualitative assessments (institutional stability, availability of human capital, budget support for innovation, etc.).

It is logical to expect that the source of systematized information about the national innovation system would be official government portals, particularly

[1] State Statistics Service of Ukraine. URL: https://www.ukrstat.gov.ua (last accessed: 27.10.2024) [in Ukrainian].

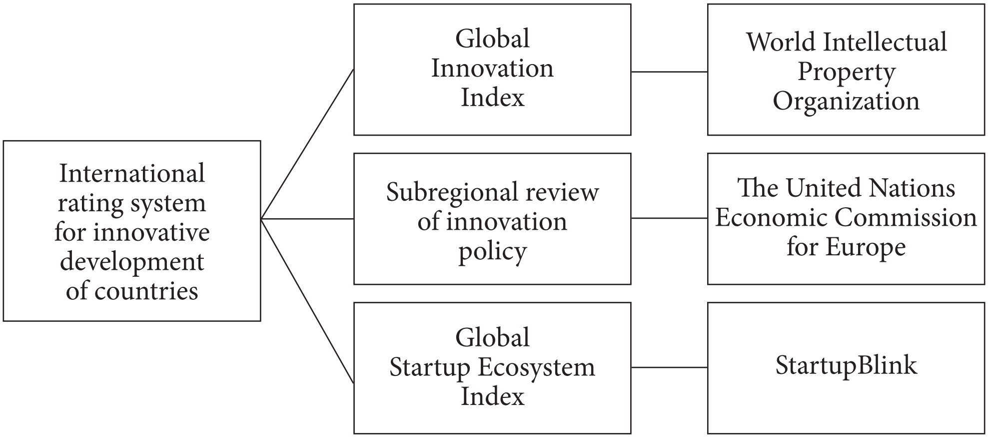

Fig. 1. International Ranking Systems for Countries' Innovation Development
Source: Information Materials on the Innovation Performance. Ministry of Economy of Ukraine. URL: https://me.gov.ua/documents/detail?lang=uk-ua&id=69b9a9bf-5fbc-4035-8c0f-ac26b853c0eb&title=informatsiinimaterialischodostanuinnovatsiinoidiialnosti (last accessed: 27.10.2024) [in Ukrainian].

the website of the Ministry of Economy of Ukraine. However, a review of published materials shows that information on the innovation activity is dominated by data from international rankings and reviews. For example, only selective results of the Global Innovation Index, Subregional Innovation Policy Review, and Global Startup Ecosystem Index are presented (Fig. 1) [2]. However, there is no detailed analytics on internal processes, national innovation policy priorities and barriers to innovation, which once again underscores the shortage of structured national data.

Hence, the martial law caused an asymmetry between international assessments of Ukraine in global rankings and the actual situation in R&D and innovation, which has no adequate statistical and analytical confirmation from national institutions. This limits opportunities for either internal strategic planning or transparent communications with international partners and investors in the Ukrainian innovation.

The most influential and widely recognized international ranking is the *Global Innovation Index (GII)*, which methodology is based on a comprehensive approach to evaluation of the innovation capacity of countries. GII is used as an analytical tool by international organizations, governments, and researchers. A country's overall score is calculated as the simple average of two sub-indices: *Innovation Input Sub-Index* and *Innovation Output Sub-Index*. The former

[2] Information Materials on the Innovation Performance. Ministry of Economy of Ukraine. URL: https://me.gov.ua/documents/detail?lang=uk-ua&id=69b9a9bf-5fbc- 4035-8c0f-ac26b853c0eb&title=informatsiinimaterialischodostanuinnovatsiinoidiialnosti (last accessed: 27.10.2024) [in Ukrainian].

Table 1. **The position of Ukraine in 2024 Global Innovation Index Ranking**

Country	GII rank	Output rank	Input rank	Income	Region	Popu-latiom, mln	GDP, PPP$, bn	GDP per capita, PPP$
Russian Federation	59	56	76	Upper middle	EUR	145.8	5,056.5	35,310
Ukraine	60	54	78	Lower middle	EUR	37.7	474.8	14,304
Colombia	61	62	65	Upper middle	LCN	52.3	1,016.1	19,482

Source: Global Innovation Index 2024. URL: https://www.wipo.int/web-publications/global-innovation-index-2024/en/ (last accessed: 28.10.2024).

consists of five elements: institutional environment, human capital and research, infrastructure, market sophistication, and business sophistication. The second comprises two elements: knowledge and technology outputs, and creative outputs. Each of the seven elements includes several sub-indicators reflecting specific aspects of the innovation system, quantitative and qualitative. In 2024, GII was estimated using 78 indicators covering a wide range of areas, from scientific publications, R&D expenditures, patent registrations and startup creation to high-tech product imports, online content activity, and government policies on innovation[3].

Despite the methodological complexity and widespread international recognition, GII features several objective shortcomings raising doubts about its full relevance for the innovation performance assessment in individual countries, particularly those hit by crisis or instability.

According to 2024 GII report, Ukraine ranked 60th out of 133 countries, positioned between Russia (59th) and Colombia (61st) with minimal differences in overall scores: 0.2 points below Russia and 0.3 points above Colombia. Formally, this position suggests a relative stability of Ukraine in the global innovation environment. However, a deeper analysis raises questions about the adequacy of such a comparison (Table 1).

For example, the countries "neighboring" Ukraine in GII ranking exhibit significantly different baseline socio-economic parameters, which undoubtedly affect their overall innovation potential:

• GDP (PPP) per capita in 2024: $14,304 in Ukraine, $19,482 in Colombia, $35,310 in Russia.

[3] Global Innovation Index 2024. URL: https://www.wipo.int/web-publications/global-innovation-index-2024/en/ (last accessed: 28.10.2024).

• The population size, also included in the GII methodology, was reported for Ukraine as 37.7 million people. However, this estimate raises significant doubts given the full-scale war, mass migration, internal displacement, population losses, and the absence of an updated general census in recent years. Hence, the actual demographic base for calculations remains unverified and potentially unreliable.

Also, it seems questionable that Ukraine, as a lower-middle-income country, is ranked between upper-middle-income countries. In other words, belonging to a specific group based on the economic innovativeness has no clear impact on the overall GII ranking. A separate review of sub-indices (Table 2) [7] shows that Colombia, ranking below Ukraine, has no orange markers, meaning that it does not have the worst position in any of the sub-indices, unlike Ukraine or Russia. The strongest sub-index for Ukraine is "Knowledge and technology outputs."

The examples (Fig. 2) illustrate the main methodological vulnerability of the GII ranking: it is built on data submitted to international institutions by governments or foreign analytical organizations, often without proper verification at the national level. In wartime conditions, when the official statistics system operates intermittently and some critical indicators are assessed using indirect sources or model forecasts, this evaluation method can create a distorted or overly optimistic picture.

An approach like this, if used for Ukraine, may lead to underestimations or overestimations of certain innovation dimensions, making it impossible to correctly use GII as the sole or primary tool for the national innovation policy setting. It also raises doubts about the appropriateness of comparing Ukraine with countries where statistical reporting is stable, complete, and unaffected by political or military pressures.

Table 2. **The position of Ukraine in individual sub-indices of Global Innovation Index Ranking (2024)**

Country	Overall GII	Institutions	Human capital and research	Infrastructure	Market sophistication	Bussiness sophistication	Knowledge and technology outputs	Creative outputs
Russian Federation	59	126	39	76	57	53	52	53
Ukraine	60	107	54	82	85	45	34	68
Colombia	61	80	87	64	70	42	61	66

Source: Global Innovation Index 2024. URL: https://www.wipo.int/web-publications/global-innovation-index-2024/en/ (last accessed: 28.10.2024).

From this perspective, the issues of reliability and completeness of the national reporting submitted to international institutions becomes particularly relevant. As noted earlier, existing gaps in the national statistics may reduce the accuracy of Ukraine's positioning in global rankings, affecting both the investment attractiveness and the international scientific cooperation.

GII designers claim that GII, covering a large number of indicators, offers an important tool for assessment of national innovation capacities, yet they do not account for its significant shortcomings:

• data bias: some indicators rely on surveys and expert assessments, which may suggest biased results;

• indicator heterogeneity: GII includes diverse categories and indicators that may carry different weights in different countries, complicating comparisons;

• limited coverage: certain dimensions of innovation activities, e.g. social innovations or environmental factors, may be underrepresented;

• economic pressures: results can be distorted by economic crises or other external factors that do not always reflect the actual innovation capacities;

• data dependency: the quality and availability of statistical data is country-specific, affecting the GII accuracy;

• tendency to averaging: the actual innovation capacity of countries with very high or low indicators may not be adequately estimated due to data smoothing.

These shortcomings demonstrate that GII should be used as one of many tools for innovation performance assessment, rather than the sole source of truth.

Another source for international evaluation of the innovation performance in Ukraine, recommended by the Ministry of Economy of Ukraine[4], is *Sub-regional Innovation Policy Outlook* (*IPO*), conducted by the United Nations Economic Commission for Europe since 2020 in six Eastern European and Caucasus countries: Armenia, Azerbaijan, Belarus, Georgia, Moldova, and Ukraine[5]. The IPO project in this region is designed as a contribution to the achievement of Sustainable Development Goals by improving institutions, mechanisms, and processes responsible for the innovation policy, and by creating an analytical framework for international comparisons.

The evaluation is based on 50 indicators grouped into three elements: innovation governance, policy instruments for promoting innovation, and the innovation policy process. Unlike GII, these elements focus not on the innovation performance or efficiency but rather on the qualitative characteristics of institutional capacity and the policy cycle. Notably, most indicators are qualitative or proximally quantitative, creating risks for soundness and cross-country comparability.

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4 Information Materials...

5 Innovation Policy Outlook. URL: https://unece.org/innovation-policy-outlook-ipo (last accessed: 30.10.2024).

A key point is that the questionnaires required for evaluation are filled in the form of self-assessments by public authorities coordinated by a national government focal point, and supplemented by a group from the UN Economic Commission for Europe with the involvement of local independent experts. However, the absence of a unified mandatory verification procedure or independent data audit raises justified doubts about the soundness of the final assessments, especially for countries with low political transparency, where there may be a temptation to present inflated results or avoid criticism.

Additionally, a problematic aspect is using identical methodological tools for countries with very different political systems, digitalization scopes, science & technology development, GDP, and resources, which increasingly complicates the interpretation of results and lays grounds for methodological bias.

In the case of Ukraine, the full-scale war and heavy external political pressures have adverse effects for the innovation performance and interactions between institutions. However, this situation may not be adequately accounted for in IPO, as self-assessments and questionnaires do not enable for the identification and analysis of all the challenges faced by the innovation management system in a crisis period.

Hence, IPO, like GII, requires critical rethinking regarding its accuracy, representativeness, and methodological adaptability to the country's specifics, especially under force majeure circumstances such as war, hybrid threats, or loss of the institutional capacity.

Another indicator of the innovation performance in Ukraine is *Global Startup Ecosystem Index* (*GSEI*)[6]. In 2024, Ukraine ranked 46th out of 100 countries in the GSEI by StartupBlink, rising three positions compared to the previous year. Kyiv, as the main hub of startup activities, ranked 75th among 1,000 cities, while Lviv, Kharkiv, Odesa, Ternopil, and Dnipro also made it into the top 1,000[7].

While these results may indicate positive trends in the Ukrainian startup ecosystem, the GSEI methodology warrants critical evaluation. The GSEI uses a combination of quantitative and qualitative indicators, including the number of startups, investment, and availability of infrastructure. However, a significant portion of the data is sourced from open platforms such as Crunchbase, Meetup, and SEMrush, which may lead to incomplete or outdated information[8].

The issue of data reliability is particularly relevant in the context of the full-scale war in Ukraine. The lack of complete statistics and limited access to up-to-date information can affect the accuracy of assessments. Once again, the popula-

6 Information Materials…

7 The Startup Ecosystem of Ukraine. URL: https://www.startupblink.com/startup-ecosystem/ukraine?utm_source=chatgpt.com&page=1 (last accessed: 30.10.2024).

8 The Global Startup Ecosystem Index Report 2024. URL: https://lp.startupblink.com/report/?utm_source=chatgpt.com (last accessed: 30.10.2024).

tion figure used in GSEI for Ukraine is 37.7 million people. Furthermore, the GSEI methodology does not always account for the regional specifics. For example, the significant rise in the rankings of Kharkiv and Lviv may be due to the activity of individual startups or initiatives but does not necessarily reflect the overall performance of the innovation ecosystem in these cities.

Hence, while GSEI by StartupBlink provides valuable information about the development of startup ecosystems, its results should be considered in light of the methodological limitations and national specifics. These data will not able to produce a true picture unless supplemented with national studies and analytics accounting for the realities of the Ukrainian innovation environment.

The war in Ukraine has significant impact on R&D and innovation performance, particularly due to the destruction of research infrastructure, loss of skilled personnel, reduced R&D funding, and limitations on international cooperation. These factors create serious obstacles to research and innovation performance evaluation. Another significant challenge is the lack of reliable and timely statistical information, which complicates significantly sound analysis of the national innovation capacity and international comparisons.

International rankings, e.g. Global Innovation Index, can be useful for general assessments of the innovation capacity at country level, but they do not always accurately reflect the real situation, especially amidst the war and instability. Methodological shortcomings, including the bias of certain indicators and the dependence on the availability of statistical data, raise doubts about the full relevance of such rankings for assessing crisis-hit countries like Ukraine. Using of standard methodologies in evaluating the innovation performance of countries with greatly varying socio-economic and political conditions increases the risks of methodological bias.

Future research will focus on developing new methodologies for innovation performance evaluation in crisis-hit countries. A key area is the improvement of national systems for statistical data collection, particularly ones on science & technology, which will enhance the accuracy of international rankings and better inform innovation policy decisions. An important aspect is recognizing the role of international rankings, as they have implications for investment attractiveness and international cooperation of a country, yet they do not always accurately reflect the national innovation environment. Additionally, it is crucial to conduct interdisciplinary research that considers not only quantitative indicators but also qualitative characteristics, e.g. social, political and economic adaptation of innovations in crisis conditions.

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2.3. INTELLECTUAL PROPERTY ANALYTICS AS A TOOL FOR EVALUATING THE RESULTS OF RESEARCH

G.O. Androshchuk

The research and innovation sector, a key factor for the future of the Ukrainian economy, is living though hard times. This is due to insufficient funding, the outflow of skilled personnel, a high degree of risk, inadequate attention from the government and society to this sector, and other factors, first and foremost the Russia's military aggression against Ukraine. The performance enhancement of scientific research, with setting clear evaluation criteria for researchers, research institutions, higher education establishments, and comprehensive reforms of the entire system — including funding schemes, management methods and the structure of production relations — has recently become ever more acute in Ukraine. This applies equally to both fundamental and applied scientific research.

Scientific research evaluation and its impact has been in focus of analysts worldwide over the past 10—15 years. The total number of articles devoted to research evaluation published in journals indexed in the *Web of Science Core Collection* (*WoSCC*) amounts to nearly 220,000. Performance evaluation of scientific research has been addressed by D. Pelz, F. Andrews [1], G.M. Dobrov [2], I.Yu. Yegorov [3], I.A. Zhukovych [3], B.A. Malitsky [4, 5], T.V. Pysarenko [6], T.K. Kuranda [6], O.S. Popovych [7], and others. At the same time, the issue of evaluating the societal impact of scientific research, particularly in engineering, social sciences and humanities, with due consideration to the national specifics of Ukraine, has not yet been sufficiently generalized and requires further studies, systematization and analysis.

The processes of European integration are encouraging Ukraine to utilize more intensely relevant international practices. A comparison of trends in research and innovation in Ukraine and leading countries of the world helps identify potential pathways for intensification and possible solutions to existing problems. In this regard, analytical tools of intellectual property (IP) that is interdisciplinary in nature, lying at the intersection of economics, law, sociology, statistics, and informatics, and requiring specialized knowledge, are noteworthy[1].

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[1] Intellectual property analytics: How to Use Intellectual Property Analytics and Gain Insights. URL: https://fastercapital.com/content/

A critical indicator of the innovation policy performance is the country's position in global rankings [6], particularly in the Global Innovation Index estimated since 2007 by the World Intellectual Property Organization (WIPO), Cornell University, and the international business school *Insead*.

Ukraine in the Global Innovation Index 2024[2]. WIPO has recently published Global Innovation Index (GII) 2024, ranking global economies by innovation capacity through analysis of over 130 countries by approximately 80 indicators (institutions, human capital, infrastructure, market sophistication, business sophistication, technological knowledge, creative outputs, etc.).

Ukraine ranked 60th in GII, dropping five positions compared to the previous year, and 4th among countries in the lower-middle-income group. At the same time, GII-2024 highlights positive trends in the Ukrainian innovation sector. Ukraine produces more innovative output relative to the share of investment in innovation in GDP. The innovation output is compared with the country's economic performance measured by GDP per capita. In this regard, Ukraine achieved a high sixth place. It was among the economies with outpacing rates of innovation development in 2014—2024. Ukraine demonstrated positive results in several GII sub-indices: market (85th in 2024 compared to 104th in 2023), business sophistication (45th compared to 48th), and online creativity (39th compared to 44th). Ukraine remains a leader in the sub-index of utility models by origin (first place in 2024 and 2023), maintains leading positions in the employment of women with higher education (second position), and software spending (fourth position). Negative trends are primarily linked to the Russia's ongoing aggressive war against Ukraine. These include indicators of institutions, human capital and research, higher education coverage, school attendance duration, foreign direct investment inflows; and infrastructure development slowdown [6].

Intellectual property analytics currently plays a pivotal role in the business environment. It involves systematic analyses of IP data to obtain valuable insights and make informed decisions. From a legal perspective, IP analytics helps identify potential infringements and protect the rights of authors and innovators, enabling businesses to effectively monitor and safeguard their IP rights. From a business perspective, IP analytics provides valuable insights into market trends, competitors' strategies, and consumer preferences. By analyzing patent data, companies can identify new technologies and potential areas for innovation, helping them stay competitive.

IP analytics enables businesses to monitor the market, to reveal potential infringements of their patents, trademarks or copyrights. By analyzing data from various sources, such as patent databases, trademark registrations or online

Intellectual-property-analytics--How-to-Use-Intellectual-Property-Analytics-and-Gain-Insights.html (last accessed: 03.04.2025).

[2] Global Innovation Index 2024: Unlocking the Promise of Social Entrepreneurship. URL: https://tind.wipo.int/record/50062?v=pdf (last accessed: 03.04.2025).

platforms, companies can detect unauthorized use of their IP and take appropriate legal action. IP analytics is a powerful tool providing valuable insights for businesses and legal professionals. By analyzing IP data, companies can protect their rights, identify market trends, assess competition, make strategic decisions, and foster innovation. It is a critical component of a comprehensive IP strategy. The following sections discuss some methods and tools helping analyze trends and patterns in the IP domain[3].

1. *Patent landscape:* Involves mapping and visualizing patent data in a specific technological field using various criteria: patent classification, citations, geography, assignee, date, etc. This helps identify key players, technologies, markets and gaps in the field, as well as emerging trends and hotspots. For example, a patent landscape can be used to compare the patent activity and innovation capacity across countries or regions in a specific sector, such as renewable energy or biotechnology.

2. *Technology forecasting*: Involves predicting the future development and impact of technologies based on the analysis of historical and current data, as well as expert opinions and scenarios.

3. *Competitive intelligence*: Involves monitoring and analyses of activities and strategies of actual or potential competitors using various information sources such as patents, publications, websites, social media or news.

4. Technology roadmap: Involves a graphical representation of goals, milestones and actions required to achieve a desired outcome or vision, using information and insights derived from the previous methods.

A patent landscape can be defined as an analytical study of patent documentation that provides an overview of the patent situation in a specific technological area or the patent activity of innovation entities, taking into account temporal dynamics and territorial characteristics: enterprises, regions, industries, countries, or on a global scale. The use of patent information reduces R&D duration by 60% and costs by 40%. A patent landscape report provides a snapshot of the patent situation in a specific technology or company, in a particular region, country, or globally. Patent landscapes can be used in shaping various areas of the national innovation policy; in strategic planning of innovation activities of economic entities; in determining the areas of scientific research; in selecting the areas of development; for understanding the essence and prospects of existing technologies; in competitive intelligence (analyzing competitors based on their patent portfolios); in setting the target indicators for intellectual activity outcomes; in state (regional, sectoral, targeted) programs involving R&D funding; in setting the criteria for selection of R&D funded by budgetary resources;

[3] Intellectual property analytics: How to Use Intellectual Property Analytics and Gain Insights. URL: https://fastercapital.com/content/Intellectual-property-analytics--How-to-Use-Intellectual-Property-Analytics-and-Gain-Insights.html (last accessed: 03.04.2025).

for identifying potential licensors and licensees; in determining technological trends; for identifying investment opportunities (detecting new technologies that could lead to the creation of new markets); in monitoring potential infringers of intellectual property rights. Patent landscapes enable faster decision-making and improve the quality of decisions [8—10].

The implementation of patent landscape tools in the practice of strategic management of innovation activities in Ukraine at company, regional or sectoral level can yield radically new effects: comprehensive protection of science and technology areas critical to the innovation performance of a company; and accelerated market entry of new technological solutions and services.

Currently under discussion is the draft Law of Ukraine "Amendments to Some Laws of Ukraine for Updating the set of Priority Areas in Science, Science & Technology and Innovation"[4]. The priority-setting procedure in science & technology must built on scientific grounds. When new approaches to the priority setting are introduced, it must be born in mind that the patent landscape construction methodology used by leading countries worldwide provides more acurate information about priority areas of science and technology at global level than the results of foresight studies.

We propose the amendment to Article 5 of the aforementioned law by adding the phrase "patent landscape methods" after the word "foresight" in the article's title and text; and the amendment to Article 6, "Implementation of priority areas for science and technology development" by adding the following phrase after the sixth paragraph: *prioritizing the review of invention applications that align with the priority areas for science and technology development and providing government support for foreign patenting of inventions.*

The amendments to the Law of Ukraine "The Priority Areas of Innovation in Ukraine," proposed by entities with legislative initiative, dismantle the existing clear system and scheme for setting and implementing the priority areas of innovation based on the strategic priority areas of innovation and medium-term priority areas of innovation at national and sectoral level. They are replaced with the priority areas for science and technology and priority thematic areas for R&D. The national level of priority setting is proposed to be limited to the sectoral level, i.e. to the Ministry of Education and Science (MES) of Ukraine, which contradicts the principles of setting, approval and implementation of the national science, technology, and innovation policy.

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[4] The Ministry for Education and Science of Ukraine proposes for public discussion a draft Law of Ukraine "Amendments to Some Laws of Ukraine for Updating the set of Priority Areas in Science, Science & Technology and Innovation". URL: https://mon.gov.ua/news/mon-proponuie-dlia-hromadskoho-obhovorennia-proiekt-zakonu-ukrainy-pro-vnesennia-zmin-do-deiakykh-zakoniv-ukrainy (last accessed: 03.04.2025) [in Ukrainian].

It should be noted that once Ukraine gained independence, the entities entitled to legislative initiative included the Academy of Sciences of Ukraine along with the members of the Parliament of Ukraine and the President of Ukraine. This important legal norm regarding the entities with legislative initiative should be reinstated in the Constitution of Ukraine.

The national research system is regulated by the Law of Ukraine "Science and Science & Technology Activities," where a scientific result is defined as new scientific knowledge obtained through fundamental or applied scientific research and recorded on information carriers. The research performance, according to this law, is to be determined by the official evaluation of research institutions and individual researchers[5].

The quality of science and science & technology activities is evaluated by expert assessments using scientometric and other indicators employed in the international expertise system. The performance evaluation of science and science & technology activities must account for the missions of a research institution.

In the Geneva Treaty on the International Recording of Scientific Discoveries (1978), a scientific discovery is defined as "the recognition of phenomena, properties or laws of the material world that were previously unknown and not subject to verification." According to Article 457 of the Civil Code of Ukraine, "a scientific discovery is the establishment of previously unknown but objectively existing patterns, properties and phenomena of the material world, radically changing the scope of scientific knowledge."

A review of national patent legislations in economically developed countries shows that in some of them the relations stemming from scientific discoveries are regulated by patent law norms. The U.S. Patent Law (§ 100, 101) states: "The term 'invention' means invention or discovery. <...> Whoever invents or discovers any new and useful process, machine, manufacture or composition of matter, or any new and useful improvement thereof, may obtain a patent." Based on this provision, Bell Telephone obtained patents for the discovery of the "Transistor effect" (USA), the "Diffusion effect" (USA, UK), IBM for the "Gunn effect" (USA), and Sony for the "Tunneling effect" (Japan) [11].

A systematic analysis of scientific discoveries conducted by the author and based on results of expertise over 1947—1991 shows that 403 scientific discoveries were recognized and entered in the State Register of the Soviet Union (including 31 made by Ukrainian scientists), making a significant contribution to the global and domestic R&D. Nearly 60% of these are scientific discoveries that led to "pioneer" inventions, e.g. radially new technical solutions [12, pp. 9—10].

Therefore, a scientific discovery acts as a multiplier of pioneer inventions, i.e. the ones that have no analogs and open new technology areas. The multiplica-

[5] Verkhovna Rada of Ukraine (2015). Science and Science & Technology Activities. URL: https://ips.ligazakon.net/document/T150848 (last accessed: 03.04.2025).

tive effect is the cumulative result that arises in an economic system due to the impact (change) in one of its elements. The magnitude of the impact on the element itself is considered the direct effect, and the ratio between the magnitudes of the direct and cumulative (multiplicative) effects is called the multiplier. The multiplier theory was further developed in the principle of acceleration proposed in 1913 by French economist Albert Aftalion (1874—1956). It was later elaborated by R. Harrod, J. Hicks, and P. Samuelson. The accelerator effect combined with the multiplier effect generates the multiplier-accelerator effect, which demonstrates the mechanism of self-sustaining cyclical fluctuations in the economic system.

A draft Law of Ukraine "Protection of Rights to Scientific Discoveries" was prepared in Ukraine in 2004, passed the first reading and was being prepared for the second one. It defined the rights of authors of scientific discoveries, the procedure for their examination and determining the priority of a created scientific discovery, issuance of diplomas, etc. It received support from the National Academy of Sciences (NAS) of Ukraine, with the submission signed by NAS President B.Ye. Paton. But this law did not come into force due to objective reasons. It was later, in 2010, that a Model Law "Protection of Rights to Scientific Discoveries," developed with the author's participation, was adopted at the Interparliamentary Assembly of the Commonwealth of Independent States, to regulate key issues of legal protection of scientific discoveries. The law is advisory for other countries where official registration and protection of scientific discoveries may be implemented[6].

To preserve the priority of created scientific discoveries and maintain the Register of Scientific Discoveries, since 1995 their official recording has been conducted by the Association of Authors of Scientific Discoveries of Ukraine, headed by NAS Academician A.F. Bulat. Today, the Association carries out the full range of procedural actions, from acceptance and review of applications for scientific discoveries to issuance of diplomas to authors confirming the priority of the created scientific discovery. According to the Association, as of 2025, 75 scientific discoveries have been registered.

Therefore, the opinion of Doctor of Law Ye.A. Bulat is entirely justified: currently, in view of recodification of the existing civil legislation, particularly the Civil Code of Ukraine, it is necessary to establish the legislation on the protection of rights to scientific discoveries and submit the draft Law of Ukraine "Protection of Rights to Scientific Discoveries" to the Verkhovna Rada of Ukraine [13].

In the dissertation [12] conducted under the supervision of Doctor of Economics B.A. Malytsky the author of the article proposed a conceptual model for the development of the science and science & technology creativity, identified

[6] Model Law "Protection of Rights to Scientific Discoveries". URL: http://www.iacis.ru/upload/iblock/af5/zakon1_07_04_10.pdf (last accessed: 03.04.2025).

the significance of the institution of scientific discoveries in the innovation process, determined the pathways for their transformation into a consumer value, their role and importance in evaluating scientific results and creating highly effective pioneer inventions; highlighted the main patterns of creation and absorption of scientific discoveries and inventions. An invention typically builds on already achieved scientific knowledge and utilizes it. Each scientific discovery potentially contains a multitude of inventions. The lag of inventions, sometimes significant, from corresponding discoveries is explained by the need for additional creative efforts to "transform" new knowledge about the material world into a tool to influence this world. This underscores the crucial importance of scientific discoveries for invention and innovation activities. When the invention activities are well-established, technological as well as research creativity will be high-performing.

Doctor of Economis B.A. Malytsky observes: "The complexity and specificity of scientific knowledge as a product of intellectual labor, which exhibits certain properties characteristic of physical phenomena, make it impossible to reduce the evaluation of scientific knowledge to simple scientometric indicators such as the number of articles and citations. Since these indicators only measure the researcher's publication activity and the intensity of scientific communication, they do not reveal the comprehensive essence of the new knowledge obtained, its radical distinction from tangible labor products or its scientific and societal value. <…> introducing qualitative characteristics of scientific knowledge as a result of scientific activity, based on the perception of its quantum nature, is crucial for the sound evaluation of the researcher's performance and making effective decisions based on it, aimed at improving research process organization, creating decent conditions for expanding the researcher's communicative opportunities in scientific and social spaces, and setting a science-centric state policy" [5, pp. 3—4].

The invention activities in Ukraine. Article 38 of the Law of Ukraine "Protection of Rights to Inventions and Utility Models," adopted 30 years ago, declares that "*the state encourages the creation and use of inventions (utility models), establishes preferential taxation and lending terms for inventors and users of inventions, and provides other benefits in accordance with the current legislation of Ukraine*." But it does not so happens in reality. The average time for processing invention applications until a patent is issued in Ukraine is about two years. There has been no database "Promising Inventions of Ukraine" for over 10 years. There are significant distortions in the invention activity: the number of utility model applications is 2.3 times higher than the number of invention applications, and the number of issued utility model patents is 3.2 times higher than the number of issued invention patents. However, it is known that an utility model patent is issued without a substantive examination. Nearly 75% of patents held by national owners lose their validity within a year due to non-payment of maintenance fees for invention and utility model patents [14].

Such low efficiency in the invention activities is unlikely to be found in other countries. This is a negative consequence of the resolution of the Cabinet of Ministers of Ukraine (CMU) (2007), by which the fees for filing applications and maintaining the validity of invention and utility model patents were increased 35-fold. Since then, applications have primarily been filed for utility models and by individuals. Instead of drawing appropriate conclusions, the CMU, through Resolution No. 496 of June 12, 2019, further increased fees fourfold for inventions and twelvefold for utility models. Such actions, being economically unreasonable, are suppressing the invention activity.

The explanatory note to the new draft CMU Resolution "Amendments to the Procedure for Payment of Fees for Actions Related to the Protection of Rights to Intellectual Property Objects" specifies that the draft resolution does not pertain to the science and science & technology activities. This raises the question: do the invention activities, being the highest degree of the science & technology creativity, not pertain to the science & technology activities? Regarding the rate of fee for utility models, the explanatory note specifies that it is set with account to the working hours and salaries of experts at the Ukrainian National Office for Intellectual Property and Innovation, as well as other relevant factors. However, it is known that an utility model patent is issued without a substantive examination. The explanatory note further specifies that the draft resolution contains no provisions creating grounds for discrimination. Discrimination refers to any distinction, exclusion, restriction or preference that prevents or limits the equal exercise of rights. Yet, this resolution unjustifiably restricts the inventor's right to file a utility model application.

The negative consequences of the aforementioned resolution for the innovation-driven development in Ukraine, its inconsistency with the legislative requirements for science and technology development, the heavy barriers to invention activities due to increased fees, and the lack of justification have repeatedly been highlighted by representatives of the NAS of Ukraine, the MES of Ukraine and public organizations. This issue has been thoroughly studied by Doctor of Law Yu.M. Kapitsa [15, p. 36].

A comparison of fee rates in Ukraine and EU member states reveals a discrepancy between domestic and European practices, as the EU does not have increased fee rates for actions related to the protection of utility model rights compared to inventions. "Such practice also indicates a complete lack of justification for the real costs for the protection of utility model rights. <…> This approach is a clear example of the Ministry of Economy of Ukraine's administration detached from practices and interests of the Ukrainian inventors community, *which uses fiscal methods to reduce the number of utility model patents through mechanisms absent in both the EU and countries with significant scopes of utility model applications.* <…> The primary focus, based on EU experience, should be on building an utility model protection system minimizing bad-faith use. EU countries have accumulated valuable experiences in this area that should be utilized in our country" (*emphasis by the citation authors*) [15, p. 36]. However, despite all the fiscal barriers to the development of invention activities, Ukraine remains a leader in the utility model sub-index by origin in the Global Innovation Index 2024 (the first position in 2024 and 2023). *Unlike European and many post-Soviet countries, Ukraine still lacks government support for foreign patenting.*

The patent activity in artificial intelligence in Ukraine. According to the report "Artificial Intelligence Industry in Eastern Europe" by "Deep Knowledge Analytics" company, Ukraine ranks among the top three Eastern European countries by number of companies in the artificial intelligence (AI) sector (57 companies). Ukraine hosts the largest number of companies in AI technology design in Eastern Europe. The application of AI in Ukraine is rapidly expanding, with the growing market of software design for AI and the increasing number of providers offering various AI solutions for businesses. Ukraine has over 2,000 institutions and software design companies specializing in AI. Among them are globally recognized companies such as *Grammarly, Reface*, and *RingUkraine (SQUAD).*

AI is poised to become a key driver of digital transformation and overall growth of the domestic economy. Ukraine should aim to enter the top ten countries with advanced AI. However, the share of registered inventions in the software sector remains low compared to the total filed applications and issued patents. An analysis of WIPO patent statistics for Ukraine shows a small number of patent applications (patent publications by technology) falling under the categories "Computer Technology" and "IT Methods for Management", with only 740 applications published in 1980—2018, accounting for 1.26% of the total (58,845). Between 2016 and 2021, Ukraine received only 16 (or 0.005%) patents out of the global total (320,878) in the AI sector. Overall, Ukraine as a priority country holds 130 patents, with 126 obtained in 2000—2021. The highest patent activity in Ukraine was in 2010—2014. Of these patents, 68 (or 54%) are "live" (valid), while 55 (or 4.7%) are "dead" (due to non-payment of fees or expiration) [16].

It should be noted that the European Patent Office (EPO) Guidelines for Examination (2018) introduced a section dedicated to AI and machine learning (G-II 3.3.1), initially defined as computational models and algorithms for classification, clustering, regression, and dimensionality reduction. A revised version of these guidelines was later published. There ia no regulatory framework like this in Ukraine. It is necessary to incorporate American and EPO guidelines on computer-implemented inventions in the national legislation. The new "Rules for Drafting, Filing, and Examining Invention and Utility Model Applications," approved by the Ministry of Economy of Ukraine's Order No. 23301 of September 9, 2024, do not address these aspects, as they contain no mention of AI. Only a comprehensive approach (amendments to legislation and bylaws, incentives, and improvements in the examination of invention applications) will enable an increase in the invention activity in this field.

Technology outflows from Ukraine. The uncontrolled outflow of innovative technical solutions from Ukraine to foreign countries has been on for a long time. Many inventors file applications in other countries, bypassing Article 37 of the Law of Ukraine "Protection of Rights to Inventions and Utility Models," which mandates the registration of a priority application for an invention (utility model) in Ukraine. The so-called patent migration from Ukraine is steadily increasing. The share of "runaway patents" accounts for 10—12% of the annual patenting. The most active sectors of patent migration are medical drugs, IT technologies (systems and equipment), and pharmacology. The geography of patent migration is expanding: the Russian Federation (51%), the USA (11%), South Korea (9%), Taiwan (3%), and Germany (2%). The group of "runaway patents" typically includes the most competitive inventions that later return to Ukraine as innovative products of foreign companies. The technical solutions patented in Russia include new models of weaponry, equipment, and dual-use technologies. The violators of the law are dominated by legal entities (80%), but the share of individuals is also significant (20%) [17]. The problem of patenting multinational inventions created by inventors from different countries remains unresolved in Ukraine. It is particularly acute when it comes to joint research projects performed with Ukrainian participants on line of EU research programs, such as the Horizon Europe program, as well as national research programs of EU member states.

It should be noted that in the aggressor country, violations of the established patenting procedure are subject to administrative liability (Article 7.28 of the Code of Administrative Offenses of the Russian Federation (CoAO RF)). If such actions lead to the disclosure of state secrets, criminal liability applies under Article 283 of the Criminal Code of the Russian Federation. Article 7.28 of the CoAO RF, "Violation of the Established Procedure for Patenting Industrial Property Objects in Foreign States," stipulates that a violation like this entails an administrative fine for individuals ranging from 1,000 to 2,000 rubles, and for legal entities from 50 to 80 minimum non-taxable income. Unfortunately, the national legislation in Ukraine does not involves a responsibility for such actions.

In the ranking "Champions of Inventions. Top-100 Patents of Ukrainian Inventors for Global Companies," presented by Innolytics Group, DLA Piper, and Advanter Group, based on a study of patents in over 100 countries where initial registration occurred outside Ukraine (referring to "runaway patents" issued in recent years in foreign countries for Ukrainian inventions), the value of the top-100 patents was estimated at nearly $400 million [18]. Hence, the outflow of highly effective technologies from Ukraine continues at full pace.

The evaluation of scientific results in dissertations. According to the Procedure for Awarding Doctor of Philosophy Degree and Revoking the Decision of Ad Hoc Specialized Academic Council of a Higher Education Institution or Research Institution on Awarding Doctor of Philosophy Degree, approved by

CMU Resolution No. 44 of January 12, 2022, the scientific results of a dissertation must be presented in not less than three scientific publications by the candidate. The scientific results include: not more than one invention patent that has undergone qualification examination and directly relates to the scientific results of the dissertation, which is equivalent to one scientific publication; when the dissertation is for Doctor of Sciences degree, it requires three invention patents that have undergone qualification examination and relate to the scientific results of the doctoral dissertation. This raises the question: why only one or three patents? The restriction on the number of invention patents is a discriminatory norm. Obtaining the patent for an invention that meets patentability criteria (global novelty, invention performance, industrial applicability) is significantly more challenging than publishing a scientific article. The process from filing an invention application to obtaining a patent in Ukraine takes an average of two years. Invention patents, as a result of R&D effort, are particularly important for candidates in engineering sciences. The restriction on the number of invention patents should, therefore, be lifted.

By the way, B.Ye. Paton was the author of over 720 inventions (500 foreign patents). These included underwater welding, electrometallurgy, welding in space, electric welding of soft tissues. He was the first to be awarded the honorary title "Honored Inventor of the Soviet Union."

According to paragraph 8, clause 5 of the aforementioned Procedure, supplementory scientific publications containing presentations of the scientific results of a doctoral dissertation include patents, textbooks, manuals, official standards, industrial designs, algorithms, and programs that have undergone novelty examination (*though they are not subject to novelty examination*); publications of historical sources, articles in thematic scientific collections, manuscripts of works deposited in institutions of the science & technology information and annotated in scientific journals; brochures, preprints; technological parts of projects for construction, expansion, reconstruction, and technical re-equipment of enterprises; information cards on new materials entered into the central data bank (*though no such bank exists*); abstracts, reports, and other materials from scientific conferences, congresses, symposia, seminars, schools, etc.

A doctoral dissertation is defined in the aforementioned Procedure as a qualifying scientific work prepared for the Doctor of Sciences degree, with the scope of text not less than ten author's sheets in the manuscript form, or not less than three author's sheets in the form of a scientific report when scientific achievements are defended in the form of a published monograph or a collection of articles (*though it needs to be referred to as works*) containing new science-based results.

The new requirements for publication of dissertation results for Doctor of Sciences and Candidate of Sciences degrees (*with amendments made by Orders of the Ministry of Education and Science of Ukraine* No. 496 of May 27, 2022, and

No. 285 of March 8, 2024) are surprising: no more than two invention patents that have undergone qualification examination (*again, a restriction on the number of patents*); no more than two monographs (or chapters in co-authored monographs); no more than one manual (for dissertations in pedagogical sciences); articles in scientific journals included in the nomenclature of scientific professional publications of Ukraine (instead of one article, a monograph or a chapter in a co-authored monograph may be counted (*though an article and a monograph are incomparable scientific works*)).

There is a clear lack of logic and common sense. The above given examples demonstrate that departmental bylaws create artificial barriers and hindrances for science & technology development.

Analysis of the publication activity. Ukraine has 1,699 professional journals and collections, of which 175 belong to Category "A" and 1,524 to Category "B." The founders of professional editions are primarily universities and research institutions. Some of them have 20, 30, or even over 60 editions. Professional editions cover all specialties, though unevenly. There are 10 most popular specialties, each with over 150 professional journals and collections. The leading specialty is "Economics," with 275 editions holding professional status [19].

The Procedure for Forming the Nomenclature of Scientific Professional Editions is being revised by the MES of Ukraine. The revision aims to set up new, clearer and higher-quality requirements for editions seeking Category "B" status. This decision is driven by several vital problems in this field: the significantly declined quality of scientific publications; the spreading unethical practices among media participants, e.g. the so-called predatory practices and editions; and the lack of effective tools for monitoring and control of the publication quality.

Based on analysis of international experiences, new approaches to assigning Category "B" status to Ukraine's best scientific periodicals have been proposed. They include: digitization the procedure for submission and evaluation of applications for inclusion in the Nomenclature of Scientific Professional Editions of Ukraine and assigning Category "B"; introduction of 14 scientific clusters with a limited number of editions with Category "B"; setting clear mandatory and supplementary requirements for editions seeking Category "B" status; the mandatory requirement for free publications for postgraduate students in editions of Category "B"; the three-year validity period for Category "B" status with annual monitoring of compliance with the requirements; creation of a specialized commission on publication ethics and formation of the Nomenclature of Scientific Professional Editions; prevention of unethical and predatory practices with editions of Category "B" and their collaboration with so-called paper mills; and encouragement of Ukrainian periodicals to be included in international databases such as *Scopus* and *Web of Science Core Collection* [20]. The Ukrainian scientific community, having chosen the path of European integration, draws the increasing attention to evaluating the publications of domestic scientists as a result of their research. This is reflected in various documents of the MES of Ukraine, which have tightened the requirements for obtaining scientific degrees and academic titles based on publications in foreign and domestic journals indexed in *Scopus* and *Web of Science* (*WoS*). Currently, the *Scopus* platform is positioned by the publishing company Elsevier as the largest, hosting over 30,000 scientific editions. However, the average cost of publication in journals indexed in *Scopus* and *WoS* is $500. This cost can rise to several thousand dollars depending on the edition's specialty, prestige, frequency or other factors. Therefore, working in science is currently not cost-effective. However, these platforms are not the only scientometric databases of peer-reviewed scientific literature. The *Google Scholar* system on the *Google network* platform is actively used. Less popular is the scientometric database *Index Copernicus* created in 1999 in Poland.

As regards regulatory activities of the MES of Ukraine, its documents initially introduced the term "academic plagiarism," followed by "self-plagiarism." Later, the term "academic work" replaced "work of a scientific nature," and terms such as "academic responsibility" (an entirely new concept in law) and "academic entrepreneurship" replaced "innovative entrepreneurship." The word "academic" is used indiscriminately, thereby diluting the meaning of "academic" as something pertaining to an academy.

Intellectual property analytics tools can be used for identification of the most promising areas for technological change, adjustment of innovation policies, and consideration of change across a wide range of sectors in a timely manner, to reap potential benefits and minimize risks and negative consequences of the innovation-driven development.

The scale of global profesional migration in recent years, including scientists and inventors, has grown tremendously, and it is now perceived as a serious threat to the economic security and future of many countries. Inventors play a special role in the innovation-driven economic development, as they are bearers of technologies and know-how, generating knowledge that leads to innovation-driven transformations in technology and industry.

It is evident that the measures taken by the Ukrainian government are clearly inadequate for stimulating the invention activities as a premise for innovation. A comprehensive set of organizational, legal, economic and technical measures must be taken to lay the foundation for a program of revival and further development of the invention activities.

The Ministry of Economy of Ukraine, in collaboration with the MES of Ukraine, must introduce an organizational and economic mechanism to stimulate science and technology activities, provide budgetary support for foreign patenting of inventions, and establish legislative sanctions for violations of the foreign patenting procedure. This is a matter of the national economic security.

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2.4. TRANSFORMATION OF APPROACHES TO DETERMINING THE SOCIETAL IMPACT OF SCIENCE

L.V. Ryzhko, O.V. Zhyvaha

The societal impact of science is diverse. The scientific worldview and the scientific vision of the world are based on the findings of scientific research, which contribute to the expansion and deepening the comprehension of the world around us. Scientific discoveries serve as the foundation for the development of technologies and engineering that alter the manner in which we produce, enhance the quality of life, and promote the advancement of medicine etc. Reflections on the role of science in society have always been in the focus of researchers' attention, but the approaches, methods, and tasks they have addressed in their work have changed. Scholarly reflections on the role of science in society have consistently captured scholars' interest; yet, the approaches, methodologies, and objectives they have pursued have evolved over time. This issue has gained significance recently as social effect has been applied as a key indicator in numerous national systems for assessing the performance of higher education and research organizations. However, the impact of science on society must be considered not only as an evaluation tool but also as a complex phenomenon with a history, problems, and potential. That's due to the number of possible manifestations of the impact of science, disciplinary differences in the impact, the difficulty of recording, and the inability to establish clear time limits when the impact should be measured.

Undoubtedly, the epistemological aspects of scientific knowledge —objectivity, truth, logic, novelty, etc. — are what give it its value. It is difficult to assess the social significance of scientific knowledge, despite the fact that it has a large economic potential for wealth creation. Attempts to determine the impact of science were long made at the theoretical, or more accurately, philosophical level. This manifested as contemplation on the social functions of science and its role in society. Theories of industrial and post-industrial growth, for instance, were developed using the metaphor "knowledge is power" and theoretical concepts like "science as a productive force" and "science as a direct productive force". In essence, the terms "direct productive force", "industrial society", "post-industrial society", "information society", "knowledge society", and "knowledge economy" highlight the position or significance of scientific knowledge in political, economic, and production spheres. In this instance, the focus is on how society and the economic system might employ scientific knowledge and encourage its creation rather than directly assessing the impact of that knowledge. Public understanding of the importance of information and the inventive potential of social and economic institutions is emphasized. The impact of science was examined in relation to its social functions — cognitive, educational, technological and production, cultural and ideological, prognostic, etc. — in the classic works of M. Weber, D. Haldane, V. Vernadsky, D. Crowther, D. Needham, and J. Bernal.

Up until the middle of the 20th century, scientists' scrupulous performance of their primary responsibilities — conducting research — was thought to be the key to their successful implementation of social tasks. The study will benefit society if it is pertinent, methodologically sound, has objective, confirmed outcomes, and advances new knowledge. And their influence will eventually be felt by society.

Approaches to applying the idea of the "impact of science" evolved at the close of the 20th century, and efforts were made to both consider and assess the impact of science. The theoretical advancements of G. Dobrov, the founder of the Kyiv School of science studies, on the issues of effectiveness of science were noteworthy in this regard. The book [1] contains the chapter "Primary problems of organization and management of scientific research", written by G. Dobrov. Remarkably, G. Dobrov connected the issues of research and development (R&D) management and organization performance with the impact and efficiency of scientific findings when applied in practical area. Efficiency can be defined as the quantity or quality of the results that are directly obtained in the process and are correlated with the amount of resources used to obtain them. Innovations resulting from the practical application of scientific findings have a variety of impacts and related consequences, including social, economic, environmental, and scientific and technical effects. The efficiency of R&D is shown by the cumulative impacts over time that are linked with expenditures [2, p. 20—21]. As a result, G. Dobrov theoretically proved the possibility and developed a methodology for assessing the effects of scientific and technological advancements on many aspects of life. Correlating the effects with research expenses is crucial since this ratio establishes efficiency. Although calculating the economic impact of innovations is a standard practice in economics, it mostly relates to applied research and developments. Nevertheless, for a long time, performance evaluation in Ukrainian research institution methods of measuring was restricted to calculating the number of implementation certificates and patents.

The situation altered in the early 21st century, when attempts were made to assess the impact of scientific findings, including those from the social sciences and humanities, both in applied and fundamental research. Notably, science impact has been seen as direct and connected to the dissemination of information in the social realm rather than solely being mediated by technology. The latter logically entails considering the effects on education, intellectual growth, the encouragement of creative activities, etc.

Thus, the idea of "social impact" has become crucial to a wide range of research methodologies, not simply those that are applied and focused on technology. Impact was first thought to be related to economic development, but it was later seen more widely as "impact on society and the economy". Tools for impact assessments started to be developed. It was thought that assessment ought to serve as an incentive to further boost and enhance social impact of research. Evaluation in science is currently shifting from the purview of professional communities to professional managers, consequently employing an indicator that defines the impact of research is becoming increasingly common [3]. Assessment of scientific institutions activity is becoming an element for accountability to sponsors, governments, and civil society; social impact assessments are increasingly being included in these evaluations.

Impact generally refers to the changes brought about by exposure to or implementation of research findings in education, economy, culture, social sphere, and society in general. According to the RAND Corporation [1], research impact is linked to social, cultural, or economic change among number of beneficiaries, including people, government organizations, businesses, communities, regions, nations, and other entities. New products and processes are introduced along with these changes, which might have an impact on institutional, societal, or individual habits, attitudes, and policies.

To show, for instance, social, cultural, or economic benefits and to convince funders to support research investments, it is essential to assess the impact of research findings. There are various methods to do it. In Australia it was developed a program based on the case study method of assessing evidence of impact, but it was never executed because of a change of government. In accordance with its strategic objectives, the US employed self-assessment questionnaires for government programs. There has been an integrated evaluation method that considered stakeholders' input, indicators, and self-assessment in the Netherlands [2].

In 2014 and 2021, the UK employed the most well-known approach for assessing university research that used impact tracking as a measure of research

[1] RAND Europe Project: Impact Finder Tool Helps Universities Measure the Impact of Research. URL: https://www.rand.org/randeurope/research/projects/2016/impactfinder.html (last accessed: 09.10.2024).

[2] Grant J., Brutscher P.-B., Guthrie S., Butler L., & Wooding S. Capturing Research Impacts: A review of international practice. Santa Monica, CA: RAND Corporation, 2010. URL: https://www.rand.org/pubs/documented_briefings/DB578.html (last accessed: 09.10.2024).

quality. Later, other countries adopted this system, and in 2024 and 2025, the Ministry of Education and Science of Ukraine benefited from this experience in state certification of research and higher education institutions[3].

While international peers have already begun to draw attention to both the changes that had taken place in scientific communities' activity and the problematic issues related to the necessity to track the impact of research, Ukrainian scientists would still have the chance to make conclusions regarding the assessment of the impact of research during state certification. Consequently, the review of these materials will serve as the foundation for the text that follows.

Vrublevska M. examined theoretical and practical implications of the inclusion of the "research impact" indicator in evaluation systems through discourse analysis. She highlighted the emergence of new theoretical and practical issues, such as the "problematization of the concept of "impact", the development of an "impact infrastructure", the emergence of a new genre of scientific writing that focuses on impact case studies, and new practices of "subjectivization" of the academic "Me". The British Research Excellence Framework's (REF2014) analytical materials and participant interviews served as the empirical foundation for this investigation. According to a researcher, the social impact indicator was introduced as an evaluation component under administrative pressure, in a short period of time, and without a defined plan. Constructive dialogue meanwhile was also developed rather rapidly; it was established an infrastructure that included special positions for staff members, who were preparing impact applications. Universities started to get commercial services from consulting firms to assess the impact of research. A website *Impact Story* appeared to showcase the impact of researchers. As a result, "social impact" was given institutional standing as an additional means of proving the quality of academic work and scientific findings; also it helped to establish an "impact culture". The description of impact has emerged as a distinct academic writing genre within the scientific community. This genre was established by the management system as a set of rules and templates for report writing, rather than developing naturally as the institution of science evolved. The description of impact is based on existing research reports, scientific publications, etc., but it employs particular lexical and stylistic devices. Particularly, "positive meaning" terms are used, such as "new", "unique", "important", "innovative", "influential", "outstanding", "groundbreaking", "remarkable", "vital", etc., and the phrase "for the first time" emphasizes the importance. The description of impact enables to demonstrate the connection between academic pursuits and civic engagement. Thus, it is possible to create new practices of "subjectivization" of the academic "Me" [4].

[3] The official evaluation of research and higher education institutions. URL: https://mon.gov.ua/nauka/nauka-2/derzhavna-atestatsiia-naukovykh-ustanov-ta-zakladiv-vyshchoi-osvity (last accessed: 01.06.2025) [in Ukrainian].

The high expense of employing case study — based methods to illustrate impact is a major drawback of utilizing a new assessment indicator[4]. Even yet, it is less expensive and simpler to automate the gathering of impact data by employing tools like ResearchFish[5] to track references to research in government papers and social media. Impact assessment, however, was acknowledged as one of REF2014's success stories despite the process's complexity, providing a picture of the range and quality of the contributions British research has made to the economy and society [5]. British scientists actually acknowledge the REF's advantages and disadvantages[6].

Institutions that took part in REF2014 provided feedback confirming that the new impact factor pushed university leaders to take action for long-term success, fostered a culture of wider participation, and improved the quality of research. Although not all universities reported using REF2014 data extensively, several claimed to do so in order to manage research performance because the evaluation process and its outcomes offer an unbiased view and can enhance the overall level of research. Universities can use the impact indicator to gain a comprehensive understanding of their strengths and shortcomings, which facilitate strategic planning and decision-making. High REF scores can also provide certain opportunities. For instance, they help universities recruit and retain top students, assist to start collaborations, and apply for some research funding competitions. When choosing partners for research investment, both public and private organizations occasionally use REF information. The impact assessment allowed to improve institutions' marketing and promotional materials, establish new strategic partnerships and strengthen the existing ones, provide useful information about the socio-economic activities of the institutions and the facilitate their presentation, and encourage researchers to develop and consider various aspects of their work[7].

In addition to new opportunities, new challenges have also emerged. Scholars stress that understanding the complex, possibly non-linear, and erratic relationship between research and impact is essential. Determining the time needed to achieve impact and finding tracking methods and instruments are the challenges in assessing impact. Additionally, you should also consider that impact may not always be necessarily good. The identification of impact as a sort of

[4] Assessing impact submissions for REF2014: An evaluation. RAND Corporation, 2015. URL: https://www.rand.org/pubs/research_reports/RR1032.html (last accessed: 09.10.2024).

[5] http://www.researchfish.com/ (last accessed: 01.06.2025).

[6] Understanding researcher views on the UK's national assessment programme, REF 2021. URL: https://www.rand.org/randeurope/research/projects/2021/understanding-researcher-views-on-ref2021.html (last accessed: 09.10.2024).

[7] Building on Success and Learning from Experience An Independent Review of the Research Excellence Framework. July, 2016. URL: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/541338/ind-16-9-ref-stern-review.pdf (last accessed: 09.10.2024).

activity that requires time and resources should also accompany the inclusion of the social impact indicator in national assessment systems, according to scientists [5]. In other words, in addition to assessing the impact when preparing reporting documents, this activity also involves creating the space and conditions necessary to generate impact and funding it.

The easiest, maybe most logical way to accomplish impact is to implement the "co-production" or "co-participation" approach. This is due to the fact that the social impact of research often occurs when scholars and stakeholders collaborate to develop research inquiries and find solutions to issues. To put it another way, enabling interaction and involving stakeholders in the co-production of knowledge are crucial for attaining impact. Involving stakeholders in research may guarantee that the results will be favorable. In other words, the research and its outcomes will be carried out in compliance with the principles of responsible research and innovation, and they will accomplish desired social purposes [6]. In co-production, it is important to note that research and impact may happen simultaneously. Under such conditions, the impact may even occur before or at the same time as the final research findings.

Scientific findings from interdisciplinary research teams are more likely to have an impact since interdisciplinary research is typically required to address societal issues. However, disciplinary quality requirements are the main focus of evaluation processes. As a result, interdisciplinary research may occasionally be excluded from the review process. The number of multidisciplinary studies subsequently will be reduced overall. In terms of guaranteeing multidisciplinary social impact, this may have negative implications [6].

Assessing the impact of multidisciplinary research is a counterintuitive and needs careful consideration [7]. Co-authored papers are more often cited; scientific collaboration fosters innovations and discipline advances and greatly contributes to addressing challenging and serious societal issues. Since societal issues are considered to be complex and multifaceted, accordingly research aimed at solving them should be interdisciplinary. As a result, such research ought to have a bigger a priori social impact. However, there is a nonlinear link between interdisciplinary research and its impact. Alternatively, it can be represented visually as the letter U reversed. In other words, the extent to which interdisciplinarity fosters the expansion of impact has a limit. The research efficiency, which the authors define as social impact, starts to decline as the number of disciplines in an interdisciplinary study grows excessively. Specifically, it was discovered that interdisciplinarity loses its benefit and its beneficial impact diminishes when teams' disciplinary diversity increases beyond a certain point. Discipline diversity encourages the use of complementary skills and knowledge, but it also somewhat raises cognitive costs and affective biases, which can make teamwork less efficient. This study quantitatively verified that the disciplinary diversity of stakeholders in cooperation has limits, beyond which the adverse impacts may outweigh the good ones that go against the conventional opinion regarding the importance of diversity [7].

There are difficulties in determining the impact of socio-humanitarian research. Determining the impact is more challenging than in the scientific, physical, or technical sciences, despite the fact that this study is by definition for society and people because it generates knowledge about these subjects.

The challenges are linked to the characteristics of the social sciences and humanities. The reflexive and non-cumulative characteristics of the humanities, as opposed to the normative and cumulative framework of the natural sciences, account for the variability in judgments regarding the value of research across different scientific schools [8, 9]. In paper [10], a global group of writers examined the current strategies, instrument and methods for assessing impact in the humanities and social sciences. They concentrated on three categories of impact: political, social, and scientific. A shift in research that challenges the prevailing paradigm and shapes subsequent studies is what they refer to as scientific impact. However, due to the possibility of multiple paradigms coexisting, identifying the prevailing paradigm in the social sciences and humanities is challenging, if not impossible. Therefore, the potential to start new schools and shape future research in the social sciences and humanities is linked to scientific impact in these fields. However, new schools do not have to replace the old ones; they can coexist. It is crucial that they develop research that adopts a different methodology.

Although the defining characteristic of the social sciences and humanities is the aspiration to conduct research for societal benefit, scholars frequently do not pursue outcomes that would impact society [11, 12]; rather, they articulate their mission as preserving cultural heritage and fostering self-awareness. The impact of socio-humanitarian research, therefore, cannot be measured as a "return on investment", according to researchers [8]. The pursuit of standardized normative methods to assess the impact of research will not produce dependable outcomes, since it conflicts with the particularity and internal diversity of the disciplines.

Determining social impact is generally challenging because the idea of "social impact" and the actuality of impact is still contentious and complex. This is a result of the social sphere's fairly wide concept. The social sphere is linked to both very practical issues such as politics, economics, education, culture, research, social protection, and quality of life, as well as to values, ideas, and public perceptions of the ideal future. However, it also has historical roots. Therefore, the multifaceted nature of the social should be considered in the processes for assessing the impact of research.

The questions of how science and politics interact and how research findings impact the political process should be given careful consideration. The researchers emphasize the need to identify ways to initiate dialogue and draw attention to the specifics of the scientific and political spheres, but they also point out that any recommendations will be beneficial as a communication standard rather than as a clear directive for action [13]. The authors provide several recommendations. Scholars must: conduct excellent research; make their findings intelligible and relevant; comprehend political processes; be approachable to politicians, which means they should interact regularly and be flexible; decide whether the interaction is to advance your ideas or just to present information to politicians; establish relationships with them; and continuously consider whether it is worthwhile and whether your advice has an impact on political decisions.

However, a universal paradigm of interaction between scientists and policy makers is unlikely to exist, as political audiences and scientific organizations have diverse cultures, objectives and tasks. While it is important for scientists to devote their time to establishing relationships and utilizing "windows of opportunity" to impact policy, it is important to keep in mind that this time investment either may not yield any results for years or decades, or may not pay off at all [13].

That is, there aren't any established ways that science can affect political processes. Regarding how scientists should impact public opinion or policy, there are no definitive answers. We shouldn't expect that the impact of science on politics will be proportional to the efforts scientists make to communicate evidence-based findings because science and politics have distinct goals, tasks, and values.

Conclusions. The societal impact of science has long been considered to be that of science carrying out social tasks, and theories of industrial and post-industrial development have reflected this understanding. These processes were mostly reflected in economics and socio-philosophy.

There were attempts to "measure" the societal impact of scientific findings in the late 20th century. The idea of "social impact" became crucial for a wide range of research methodologies, not just those that are practical and technology-focused.

The procedure for proving impact raises many contentious issues of methodological, organizational, and economic nature, and has specifics in different disciplinary areas of science.

Establishing the "impact" of research on different aspects of society, such as boosting productivity, security, social welfare, economic competitiveness, environmental friendliness, etc., enables us to make the value of science evident and serves as a component of accountability to sponsors, governments, and civil society.

The process for demonstrating the impact has peculiarities in several scientific disciplines and presents a number of contentious methodological, organizational, and economic concerns.

The complex, possibly non-linear, and inconsistent relationship between research findings and impact, the challenge of creating instruments and procedures for measuring impact, the inability to precisely estimate the time needed to achieve impact, and the possibility of unfavorable outcomes from using scientific findings arise from the use of impact indicator.

It is important to acknowledge that generating an impact is a unique kind of research work that requires time and resources. This indicator should not be absolutized, as scientific findings do not necessarily have an immediate impact. Truly revolutionary, breakthrough results can only have an impact in the future.

Since Ukraine has made it mandatory for research organizations and higher education institutions to demonstrate the societal benefit of their work in order to receive state certification, scientists are currently working independently and manually because the required infrastructure is still lacking.

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2.5. COLLECTIVE ASSESSMENT OF SCIENTIFIC RESULTS AND PROSPECTS FOR SCIENCE AND TECHNOLOGY DEVELOPMENT

O.S. Popovych, Z.O. Popovych

When it is necessary to weigh the significance of a scientific result, researchers tend to prefer peer-review, i.e. expert evaluation. In principle, this is quite logical. However, for example, when deciding on the feasibility of publishing an article, the editorial board of a scientific journal sometimes encounters reviewers who have some particular dislike for that particular author, which effectively negates their competence and pushes them towards a biased review. Therefore, we resort to anonymous reviewing, but even here impartiality is not always guaranteed.

That is why a method was devised, which its witty authors called the Delphi method (in memory of the ancient Greek Delphic oracle), as a way to reach consensus and develop a common opinion of a large number of specialists without their personal communication. They have the opportunity to know and take into account the assessments of others, without knowing who exactly expressed them. Therefore, the influence of all kinds of biases or authorities is completely removed. This method was invented and applied by the RAND Corporation to assess the most promising areas of weapons development, and gained worldwide distribution after the implementation of the English state forecasting and analytical program (*United Kingdom Foresight Programme*) in the 1990s, to which we owe the spread of the term "foresight studies" [1].

Our institute joined such studies at the beginning of this century. In particular, it was entrusted with the organizational and methodological support for the implementation of the State Program for Forecasting Science, Technology and Innovation Development of Ukraine, which was carried out in 2004—2006. According to the resolution of the Cabinet of Ministers of Ukraine on its approval, this initiated "the creation at the state level of a system of continuous and independent forecasting and analytical studies and the introduction of development in Ukraine, the scientific substantiation of state socio-economic policy and modern methods of its implementation." About 700 experts were involved in the implementation of this program, its results were published [2, 3, 4] and used in the preparation of draft laws[1]. But the then government officials considered "the creation of a system of continuous and independent forecasting and analytical studies" (as stipulated by the resolution of the Cabinet of Ministers of Ukraine when approving this program!) to be an unnecessary luxury, and state funding for such studies was terminated.

But in 2021, in accordance with the instruction of the Presidium of the National Academy of Sciences (NAS) of Ukraine, we returned to such studies, without even minimal targeted funding for this. Dobrov Institute was entrusted with the organizational and methodological support of the study and recommended to focus on 9 thematic areas of science development:

• *fundamental research in the latest areas of mathematics and natural sciences;*

• *research and development for the needs of national security and defense, dual-use technologies;*

• *information and communication and digital technologies, artificial intelligence, robotics, cybersecurity;*

• *new substances and materials, nanotechnology and additive technologies;*

• *efficiency, reliability and safety of energy;*

• *healthcare, new medical means and technologies;*

• *conservation and rational use of natural resources under global climate change;*

• *food security, sustainable agricultural development and related technologies, bioeconomy;*

• *human development, socio-humanitarian, economic and social transformations, new social relations and their legal support.*

Based on the recommendations of the divisions of the NAS of Ukraine and national sectoral academies, we formed expert groups for each of these areas (a total of 379 scientists and industry experts, although only 268 people responded to the questionnaires sent to them). But the recommendations obtained as a result of this study still deserved attention. One of them was, for example, "*development and application of swarm intelligence tools in planning operations using groups (swarms) of mobile robotic systems that act as a team*", which was proposed by the expert group of the thematic area "Research and development for the needs of national security and defense, dual-use technologies."

The current situation at the front undeniably confirms how relevant this recommendation was, but we doubt that research and development in this direction received any, even minimal, additional impetus as a result of our recognition of its relevance and priority.

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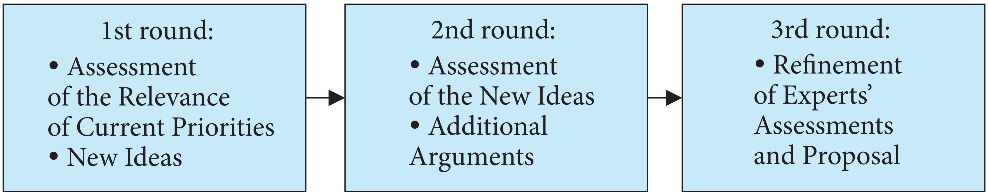

Fig. 1. Sequence of research stages

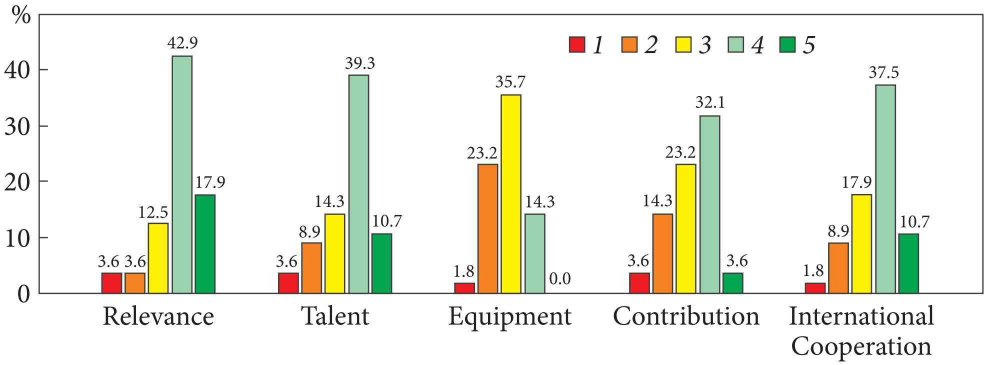

Fig. 2. Analysis of answers to closed questions of the first round of surveys for the direction "Nuclear physics and elementary particle physics. Physics of the universe" from the thematic module "Fundamental research in the latest areas of mathematics and natural sciences"

The fact is that numerous reorganizations and "improvements" of the state administration system in Ukraine have led to a situation where virtually all mechanisms for implementing state priorities were destroyed, as were the real opportunities for science to influence the formation of these priorities. Legislative approval of such priorities has turned into a meaningless fog for the apparatus of Ministry of Education and Science of Ukraine, which it has been stubbornly trying to get rid of lately. Although an article about the results of the 2021 study was published [7], they turned out to be practically unnecessary for anyone.

We are convinced that in the post-war reconstruction, the situation with evidence-based backing of science, technology and innovation policy setting must change. Therefore, given that over the past three years there have been cardinal changes in our state and the situation in domestic R&D, we decided to involve a broader scientific community in reassessing the priority areas obtained as a result of the 2021 study. We were supported in this by the Presidium of the NAS of Ukraine and the Ukrainian branch of the Friedrich Ebert Foundation.

Based on the recommendations of the divisions of the NAS of Ukraine, and also using data on the participants of past studies and, in addition, attracting through a website created specifically for this study some scientists who wished to participate in these studies, we created expert databases for all the nine areas (a total of 960 people).

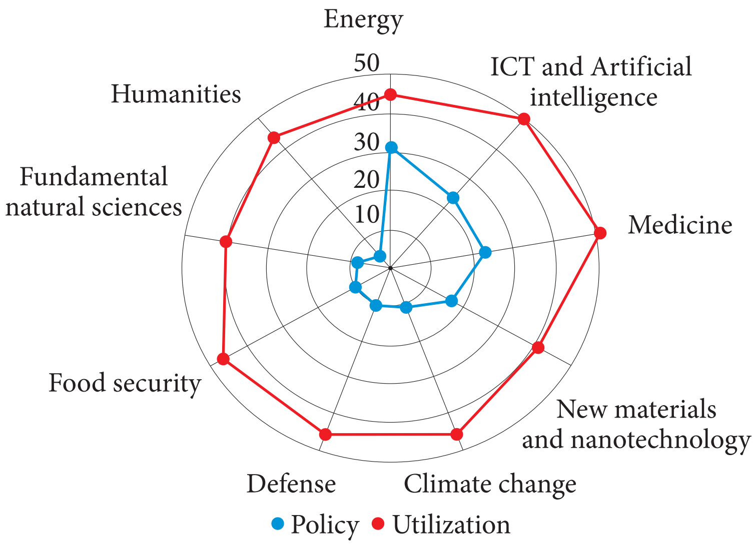

Fig. 3. Comparison of assessments of the presence of an adequate state science & technology and innovation policy and the utilization of science & technology potential by research cluster

A feature of the methodology used in this case [8] was that we did not start "from a clean slate," but started from the results of the forecasting and analytical study of 2021, in which the most promising topics of research and development in nine fairly broad thematic areas proposed to us were named. The main questions that were asked to the experts now:

• Have these priorities retained their relevance today?

• What new scientific and technological prospects and opportunities have emerged as a result of the development of world science?

• What new problems, caused by the full-scale Russian invasion, require attention and concentration of efforts of domestic scientists?

The survey process can be illustrated by the following diagram (Fig. 1).

The course of the study is demonstrated on one of the proposed research areas. Once the questionnaires are filled, the software allows for the assessment of the relevance and feasibility of a research area (based on answers to closed questions) in the form similar to Fig. 2.

As we can see in Fig. 2, 42.9% of experts believe that the direction is relevant for world science, but only 17.9% report that it can now develop in Ukraine. Problems with equipment are also confirmed. A similar analysis was carried out for all directions without exception: for those determined in 2021 and for new proposals. The results are summarized in tables presented in the final report [9].

Given a rather difficult situation in Ukraine with the overall R&D performance and setting and implementing science, technology and innovation policy, we also asked several questions on this matter in the questionnaires. The answers to them are disturbing. Thus, to the question "Do you believe that the state has already basically formed a scientific and technological policy adequate to the current situation?" the vast majority of experts from all thematic areas without exception gave a negative answer.

As seen in the diagram (Fig. 3), over 90% of respondents from all thematic areas answered that the Ukrainian government failed to set up such a policy, and the assessment of the engagement of the available science & technology potential for defense needs fluctuates in the range of 25—50% across thematic areas. Researchers' responses give a clear view of the effectiveness of science & technology policy in a corresponding R&D sector. As we can see, it is maximal in the field of energy, followed by medicine (reaction to covid-19), and extremely low in other areas (it was noticed by less than 20% of experts in new materials and ~10% by natural scientists, agrarians, and climatologists; almost not noticed by social scientists. But the most striking fact is that only 10% of experts who evaluated research for defense purposes believed that the government had set up a science and technology policy in this field. Obviously, it is a continuation of the long-standing (unfortunately!) tradition of underestimating R&D by our authorities, but in the conditions of war, especially one that has very clearly demonstrated the unique role of technological innovations, this is incomprehensible and unacceptable.

And yet, today we have a clearly defined assessment from a rather significant and qualified part of scientists of how the priorities and opportunities for the development of Ukrainian R&D have changed over the past three years, and specific proposals regarding directions that have become particularly relevant. They have been published and available to a broader audience [9]. These results must be taken into account in setting up a science & technology and innovation policy. But it turns to be a tall order. After all, as already noted, efforts of the domestic bureaucracy have succeeded in scrapping all the workable policy schemes from the Ukrainian legislation and the public administration system, with liquidating the government agencies capable of engaging the schemes, created in early decades of independence. Our European partners have also noted a movement in the opposite direction in these matters [2].

This is unacceptable in the current extreme conditions, because the war requires a quick and urgent solution to specific science and technology problems,

[2] The report of the EU Directorate-General for Neighborhood and Enlargement Negotiations notes that while Ukraine is gradually approaching the EU in most indicators, the gap according to the European Innovation Ranking in 2024 has increased and is only 32.5% of the EU average. Ukraine Report 2024. European Commission. URL: https://neighbourhood-enlargement.ec.europa.eu/ukraine-report-2024_en (last accessed: 18.03.2025).

concentration of available capacities and resources. The Ukrainian system for setting and implementation of science and technology policy lacks a body with a sufficient authority and influence, capable to deal with them properly. That is why the idea of the *Supreme Commander-in-Chief's Technology Center* arose, i.e. of an entity able to vigorously intervene in the organization of this work. We would like to wish it success not only in creating new weapons, but also in building up a new system for management of the national science and technology development — the one that will be truly felt by the vast majority of our researchers rather than by 10% of them.

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AFTERWORD

O.A. Mekh

The experience of evaluating the research performance and impact, elaborated on in the presented monograph, shows an imbalance in Ukraine that is not a unique phenomenon but rather a consequence of global trends and transformations. The issues of evaluating Ukrainian R&D are ever stronger refocused from theoretical to practical dimensions, beginning to have destructive effects. Emerging problems are becoming the subject of intense discussions at gatherings of scientists, as well as at scientific and practical conferences and symposia involving other stakeholders in the evaluation process, including representatives of government bodies, public organizations, and research institutions. One example of such discussions was the International Symposium "Evaluating results of scientific research in present-day realities: the evolution of approaches in cognitive, socio-economic and administrative dimensions," held in Kyiv on November 28, 2024, by the National Academy of Sciences of Ukraine under the patronage of UNESCO.

The findings of studies on research evaluation in Ukraine and beyond, as presented in the monograph, lead to the conclusion about an imbalance in favor of metric (quantitative) assessments over qualitative (expert-based) ones, with a significant dominance of formal indicators. The creation of digital and graphical visual indicators and rankings helps better understand specific aspects of an issue or problem. However, their downside is the occasional complete disregard for the essence of scientific results, i.e., the qualitative dimensions of a research problem, its theoretical significance, novelty, alignment with global standards, and socio-economic impact.

Indicators based on expert opinions or assessments, which reveal the qualitative content of research projects, their purpose, logic of inquiry, creative competence, and societal relevance, are increasingly overshadowed by metric indicators, numbers, and graphs. However, a formal metric approach to analysis of the R&D performance, an emphasis on rankings, and the continuous process of refining (and complicating) evaluation algorithms not only fail to reflect the quality of a contribution from researcher or research institution, its novelty, and societal effects but also exacerbate the existing imbalance. This poses a threat to both the entities engaged in research and education Ukraine and the national security.

A purely metric approach to evaluation can have profoundly destructive consequences for Ukrainian R&D system during wartime, as war-related public budget expenditures lead to a reallocation of funds away from civilian sectors. Thus, if funding for domestic R&D is determined solely based on formal indicators, which are easier to obtain than qualitative expert assessments, the very existence of research institutions may be at risk. Moreover, an exclusive focus on rankings significantly increases the likelihood of manipulations with data about the performance of research institutions. Therefore, evaluating the role, creativity and contributions of individual researchers and research teams is a specific process that does not tolerate one-sidedness.

Ukrainian researchers, struggling to meet formal requirements for publication activity, are increasingly collaborating with foreign and international scientific journals with high metric indicators. This creates a risk that a researcher's sole priority purpose will be enhancing his/her scientometric status rather than addressing scientific problems. This could lead to research institutions focusing on internal, corporate use of knowledge and its closed information cycle, which will not contribute to the public perception of Ukrainian research entities as sources of socio-economic development and security.

In the context of European integration, Ukraine is pursuing an open science policy and should, therefore, encourage various measures aimed at the implementation of the National Plan for Open Science, the expansion of scientific communications and societal interactions, and building trust in science. These measures are impossible without addressing the imbalance by revising current approaches to evaluation with emphasis on the qualitative dimensions of scientific results. Hence, the research evaluation system will become harmonious and balanced only if supplemented with qualitative indicators. Such a system should perform several functions:

- stimulating best research practices and enhancing research excellence;
- ensuring global standards, public recognition, and socio-economic impact of research activities;
- ensuring flexibility and adaptability of research teams, structures, and organizations, considering differences in disciplines, competencies, individual abilities, and various phases in the research career;
- meeting all requirements for research activities, arisen from the social, political, environmental, economic, and security challenges facing the country;
- supporting and expanding the autonomy of research institutions and organizations in the country.

Therefore, evaluation of researchers and research institutions, apart from improving the research process and enhancing the quality of results, should foster their positive perception by society. It is also worth emphasizing that the level of theoretical, methodological and institutional support for the evaluation process is crucial for future rehabilitation of the Ukrainian R&D system severely affected by the war. The evaluation system can be deemed balanced once it meets the following requirements:

- prioritizing procedures for evaluation of qualitative dimensions of research activities, with quantitative indicators assigned a secondary (supportive) role; the latter should be used as informational support for experts' work;
- employing a wide range of quantitative indicators, not limited to "funding sources" or "publications in high-impact-factor journals";
- avoiding excessive or inappropriate use of metric indicators to evaluate researcher's outputs, as these may only partially reflect their contribution (e.g., journal prestige or impact factor) or fail to account for the citation context or the duration of research career (e.g., h-index);
- prioritizing achieved scientific results: new scientific knowledge, originality of ideas, and research methods;
- considering the effects of transitioning to open science practices, including data and information exchange, collaboration, and new publication formats such as preprints, scientific reports, and expert assessment reports;
- designating the Presidium of the National Academy of Sciences (NAS) of Ukraine as the body responsible for the official certification procedure in the institutions of the NAS of Ukraine as the supreme scientific self-governing organization.

These evaluation requirements should ensure the survival of the Ukrainian R&D in these challenging times, promote the dissemination of best practices in basic and applied research, foster research culture, guarantee creative freedom, support inclusive development, reward scientific ethics, responsibility, integrity, and the training of the next generation of researchers, particularly talented youth.

Finally, it should be reiterated that in times of significant sociocultural transformations, the issue of uncertainty always arises, necessitating adaptation. The state's adaptation strategy should involve support and stimuli to sectors, even if they do not perform well — this is the cost of navigating a phase of future uncertainty. If objects or sectors, including R&D, are subjected to regulation and evaluation methods designed for "stable" times, their chances of adapting and surviving a challenging phase will diminish or disappear. Ukrainian research institutions will face increasing pressures amid integration into a more competitive global research area. The domestic R&D is unlikely to withstand these changes without government support. Hence, a transitional period with anti-crisis measures, evaluation methods, and incentives is the only path to preserve R&D in this difficult time.

To further improve the research evaluation system in Ukraine, it is advisable to expand cooperation of all stakeholders, including the Ministry of Education and Science of Ukraine, the National Council for the Development of Science and Technology, the NAS of Ukraine, national branch academies of sciences, and international organizations such as UNESCO, the European Commission, and others engaged in addressing science-related issues and utilization of its results.

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