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# Scientometrics: A Tool for Monitoring and Support of Research

*The origins of scientometrics (research metrics) are discussed. The approaches to research evaluation are reviewed, and the tendency to replacing formal quantitative indicators by expert review based on bibliometric indicators is emphasized. The principles of "Leiden Manifesto of Scientometrics" are set out, providing for transparent monitoring and support of research and encouraging constructive dialog between the scientific community and the public. The methodological framework and the peculiarities of implementation of the information and analytical system "Bibliometryka Ukrayinskoyi Nauky" ("Bibliometrics of the Ukrainian Science"), constructed by the Vernadsky National Library of Ukraine, are shown. The proposals on creating advisory councils, responsible for formulating conclusions on the research effectiveness of institutions, are given. The feasibility of building a common platform for expert evaluation of research for the Eastern Partnership Countries by launching similar bibliometric projects in these countries and their further convergence is considered.*

**Keywords:** *research, scientometrics, bibliometric data, monitoring, research performance evaluation, expert evaluation, "Bibliometrics of the Ukrainian Science".*

The term "scientometrics" was put into scientific circulation by V. Nalimov in 1969. In his paper [1] he proposes to apply the term "scientometrics" to qualitative methods for studying research as an information process. Scientometric studies cover the following issues: information model for development of scientific research, growth of information flows, citing, analysis of internal connections in scientific research by language of bibliographic references, evaluation of countries' contribution in the global scientific information flow, tools for statistical analysis of trends in scientific research. Positively evaluating the Nalimov's contribution to scientometrics, we should point to the negative role of his interpretation of this term, because it orients future research on the "numerological" ways.

Ukrainian researchers have long-term experience in theoretical and practical studies devoted to science policy issues. A landmark for their methodological evolution was a book of G. Dobrov, the founder of the Center for Science and Technology Potential and Science history Studies of the NAS of Ukraine, entitled "Science about Sciences: Introduction to the General Knowledge about Science", which laid the framework for "studies about science" in Ukraine. The book incited grater interest to science policy studies in general and was subsequently published in many countries [2]. In this book Dobrov made emphasis on the need for a systematic study of current and future trends of the research system in Ukraine and the world, covering the aspects of history of science and academic schools, conditions and trends of science and technology potential, research infrastructure, science and technology policy, innovation policy, international cooperation etc. Dobrov defines "studies about science" as comprehensive studies and theoretical generalization of social systems' functioning within the research system, to lay the framework for science and technology policy, build up the research potential in a rational way, increase the effectiveness of research by means of social, economic and organizational influence. His definition puts emphasis on the systemic structure of "studies about science" and the need for comprehensive knowledge about the research system. It follows from this definition that scientometrics should be based

on theoretical and methodological results of "studies about science".

Unfortunately, Dobrov's ideas regarding the need to use scientometrics as a tool for support of research have not gained the acknowledgement that they deserved. Few exceptions may be works of Korennoi A. [3], Marshakova I. [4], Haytun S. [5], focused on organization of scientific prognostication, use of bibliometric indicators for research monitoring, identifying the shortcomings of the merely quantitative methods for research performance evaluation. We should emphasize that Marshakova I. and Haytun S. considered the Nalimov's definition of scientometrics "too strict" [6].

From practical point, the largest contribution to scientometric studies was made by J. Garfield who offered a unique idea to use scientific references as a means of information retrieval. His name is associated with establishing the U. S. Institute for Scientific Information and creating the database "Web of Science" with the analytical add-ons. Yet, Garfield kept on calling for cautious use of citation data by arguing that they, like any tool, must be employed in a right way [7].

Disregard for his warning and straightforward focus on Nalimov's "numerology" by led to elaboration of scientific methods for research performance evaluation which failed to take proper account of substantive aspects of research work, being a combination of various kinds of formal parameters [8–10].

The currently dominating point of view is that only professional expert review can provide a comprehensive and objective evaluation of research results, whereas the bibliometric indicators can serve as a supportive tool in taking an expert decision [11–14].

The need for objective evaluation of the research performance and for preventing the lobbying for certain scientometric databases requires consolidated information from different sources.

The purpose of the study is to develop a theoretical framework for creating an integrated common platform for monitoring of research, supporting the expert-based evaluation of research, and for research forecasting.

Before defining the basic concepts for constructing this platform, it is useful to consider the latest developments in the methodology for research evaluation. In a concentrated form, as ten principles, they are set out in the Leiden Manifesto for Scientometrics, adopted at the 19th International Conference on Science and Technology Indicators "Context Counts: Pathways to Master Big and Little Date" (3–5 September 2014, Leiden, The Netherlands) and published in the journal "Nature" in April 2015 [15]. The ten principles are:

1. Quantitative evaluation should support qualitative expert assessment.
2. Measure performance against the research missions of the institution, group or researcher.
3. Protect excellence in local relevant research.
4. Keep data collection and analytical processes open, transparent and simple.
5. Allow those evaluated to verify data and analysis.
6. Account for variation by field in publication and citation practices.
7. Base assessment of individual researches on a qualitative judgment of their portfolio.
8. Avoid misplaced concreteness and false precision.
9. Recognize the systemic effects of assessment and indicators.
10. Scrutinize indicators regularly and update them.

The first principle is fundamental, as it supposes primacy of expert evaluation over "numerological" one: formal indicators should be collected and taken into account when assessing, but only as part of the information required for a professional expert analysis. This principle is closely related to the seventh one, which recommends taking into account the researcher's or team's portfolio (experience, achievements, authority). The third principle is also important, which is about the importance of specific indicators in assessing regional studies that are of national importance and published in other than English language journals (an example of such studies in Ukraine are ones devoted to the environmental monitoring of the

Chernobyl zone). Other important principles are openness of data and procedures of analysis, which is not always provided by commercial bibliometric systems, as well as the ninth principle warning against assessment by a single indicator (criterion), because this approach would substitute the true aim of research objectives for a false one – reaching the maximum of this indicator. If this single criterion is Hirsh Index, then the researcher's objective will be its "boosting" rather than discovering new laws and tendencies.

The analysis of the above principles implies that scientometrics should not focus of support of administrative reforms in research and education systems, but should promote these systems' development, especially in search for advanced research fields; its purpose is, therefore, in supporting decisions of "research" rather than "political" problems.

In keeping with the principles of the Leiden Manifesto of Scientometrics, we have built the system for information analysis "Bibliometrics of the Ukrainian Science" [16]. This system's components are:

- Register of the Ukrainian scientists who have created their bibliometric profiles in Google Scolar;
- Single window access to bibliometric indicators of scientists, groups and journals in the leading science-metric systems (Scopus, Web of Science, Russian Science Citation Index, Ranking Web of Research Centers);
- Analytical processing tools for bibliometric data, to produce summing up information about disciplinary, sectoral and regional structure of the Ukrainian science;
- Source base for expert assessment of research and identification of new trends in the research area;
- National component of the project "Ranking of Scientists" (Cybermetrics Lab).

A specific feature of the system is that it is designed with a view to concepts of convergence of international and national bibliometric projects. These concepts stipulate a basic platform for consolidating bibliometric data from various systems, an integrated system of categories and subcategories (the classification scheme) for representing the research fields and tools for analytical calculations for expert evaluation and identification of research trends.

The main criteria for choosing a platform for consolidating bibliometric data are its accessibility and scope of the indexed scientific papers for obtaining reliable results in statistical terms. These criteria best conform to the bibliometric platform Google Scholar, which handles the entire global scientific documentary flow exept for documents with limited access. Peer-reviewed papers, dissertations, books, abstracts, conference proceedings and other scientific literature from different fields of research are being indexed. The abovementioned positive qualities of Google Scholar have been appreciated by a number of institutions. In particular, the research team Cybermetrics Lab (Spain) has chosen it as a base platform for researchers' rating by their public bibliometric profiles [17]. Considering that Google Scholar is the starting point for information search, the owners of commercial scientometric systems are striving to set up mutually beneficial cooperation with it: information on collaboration with Google Scholar can be found on the official website of the Thomson Reuters Corporation [18]. It can be assumed that the Elsevier Corporation will follow the same path. In this case, use of Google Scholar will allow for access to the data from the abovementioned commercial systems if an access license is available.

The Google Scholar service "Bibliographic references" allows for creating bibliometric profiles that can be viewed as a portfolio of researchers or R&D teams. They contain information on the systematized lists of their works, their citations chart in the respective period of time, the affiliation to organizations and journals. This service is highly demanded: as of September 2015, it was used by more than 10,000 researches from the Ukrainian segment of Internet, including researchers of global merit and beginners with several publications. This not insignificant figure gives an idea of the intellectual potential of Ukraine, reflecting its regional, sectoral and disciplinary dimensions.

An attention should be paid to the uniform system of categories and subcategories (classification schemes, subject headings) for representing thematic fields of researchers. As far as library and information practices are concerned, the greatest application has the Universal Decimal Classification. It, however, focuses on the substantive assessment of a separate document (book, article) and not on a field of researcher's work. This shortcoming does not occur in the classifiers of scientific specialties used for thematic classification of defended dissertations. But they cannot apply for integrated bibliometric projects due to lack of harmonization of classifications at country level.

Appropriate solutions for representation of disciplines are the categories and subcategories offered by the leading scientific and information corporations such as Google Scholar, Elsevier or Thomson Reuters. Each of them offers its own classification system, which is a collection of about 300 categories and sub-categories determined by processing English language documentary flows and harmonized with modern concepts and categorical apparatus of science. Taking into account the choice of base platform Google Scholar for consolidation of bibliometric data, it seems appropriate to use categories and subcategories to represent the disciplinary fields of research [19].

The principal difference of bibliometric systems from bibliographic databases, including electronic catalogs, is the availability of tools for analytical calculations, to support the expert assessment and identify trends in research. In the system Web of Science, such tool is the superstructure InCites, providing for assess and comparisons of research results of organizations and countries, to define their position in the global research system. The superstructure SciVal in the Elsevier Corporation is based on resource database Scopus. It helps organizations assess their potential and identify an advanced development strategy. Based on analysis of co-citation and visualization tools, this superstructure creates a unique graphic map or "Wheel of Science" illustrating efficiency of an organization in all research disciplines. InCites and SciVal are useful for analysis of the research activity at organization, region or country level. The choice depends on the goal: for strategic planning of research in an organization and selection of research fields for support, the SciVal by Elsevier Corporation should be used; and for comparison with other organizations or monitoring the activity of individual researchers, research groups or research branches, InCites by Thomson Reuters Corporation should be used [20] .

Being subject to constant improvements, the abovementioned analytical superstructures have great functionality. In terms of functionality, analytical calculation tools of "Bibliometrics of the Ukrainian Science" are inferior to InCites and SciVal. Nevertheless, they allow for having a general idea about the performance of the Ukrainian research system and its disciplinary, sectoral or regional distribution. Indicators of disciplinary distribution show the prevalence of specialists in economics, accounting for about 25% of the total number of the Ukrainian researchers represented in Google Scholar. If sectoral distribution is taken, the dominant position is with research and teaching staff of the Ministry of Education and Science (60%); in the regional dimension, the largest share is with the researchers from the city of Kiev (35%). Regarding citations (with Hirsch index higher 25), highly cited researchers (65% of the total) are concentrated in the National Academy of Sciences of Ukraine [21].

Improvements in this analytical apparatus have been on, especially ones related with construction and use of linguistic ontology as a means to identifying trends in research. The information base for creating the ontology is bibliometric profiles of the researchers who provide the verified data on publications. Analysis of the frequencies of words in the titles of publications within one subcategory of Google Scholar allows for selecting the most frequently used scientific terms and identifying trends in basic research by comparing terminology systems for different years. At the same time, this allows for carrying out expert forecasting of research and finding original articles that deserve special attention [22].

The database management system MySQL was used as a basic software for

"Bibliometrics of the Ukrainian Science". This system meets the requirements of the so called "cross platform", free distribution, open source code and integration with software languages like java, perl, php or python.

It should be emphasized that quantitative the indicators of the "Bibliometrics of the Ukrainian Science" can not be considered as the criteria for research performance evaluation. They are a reference source for taking expert decisions. Evaluation of several hundred research organizations requires a large number of experts who would be (i) trusted by colleagues and (ii) have high merit as scientific experts in their field. Therefore, the panel of experts should be formed by sending inquiries to academic (science & technology) councils of all the research organizations about nominating experts for each of the research fields of the organization, with providing the necessary scope of professional information about each expert.

Comparative assessment of the performance is advisable within the so-called reference groups of research organizations, formed by similarity of their research fields and types of their results (basic research, technological developments, scientific and technical services, and so on). Advisory council should be formed for each reference group. Overall control over the process and approval (or request on correction) of the results of the advisory council's work should be entrusted to the commission on performance evaluation. In case of low performance figures of an organization or its ultimate disagreement with the assessment, more detailed assessment must be made, including expert review of each unit [23].

The positive experience of testing the methodological framework for "Bibliometrics of the Ukrainian Science" system throughout 2014–2015 has shown its validity and applicability for implementing bibliometric projects focused on the subsequent convergence. They can be specifically used for launching of the project "Bibliometrics of Science of Eastern Countries Partnership".

In its framework, a member state assumes responsibility for creating the English-language database with information on bibliometric profiles of its researchers in Google Scholar System. The database content is to be transferred to the integration center, which will be appointed once the project is launched. This center handles national bibliometric segments and creates the corporative resource freely available for all the project participants. Also, the center provides for free access to the consolidated citation data with analytical tools for obtaining data about the contribution of each country in the scientific communications system, regional and disciplinary distribution of researchers and research groups, their formal and informal links.

The most notable advantage of the proposed project is the possibility of producing an integrated bibliometric database for comparison and expert evaluation of the research activity in the Eastern Partnership Countries. No less important is the fact that the project will help strengthen links between researchers and enhance the positive image of the research system.

## Conclusions

1. The original definition of scientometrics as a set of quantitative methods for analysis and evaluation of research predetermined "numerological" approaches. Development of theoretical framework for scientometrics led to a new understanding of this term. Today, scientometrics is commonly regarded as a tool for monitoring of research systems and support to expert decisions on research.

2. The modern methodology for research evaluation is set out in concentrated form in the ten principles of "The Leiden Manifesto of Scientometrics", targeting it on transparent monitoring of research, with subsequent expert evaluation.

3. The system for information analysis "Bibliometrics of The Ukrainian Science", developed by our team, has become the national component of the project "Rankings of Scientist" (Spain), and complies with the principles of "The Leiden Manifesto of Scientometrics".

4. Common platform for expert evaluation of research in the Eastern Partnership Countries can be built by launching similar bibliometric projects in these countries and their subsequent convergence. The program can be implemented given grant support.

1. Nalimov, V. V. (1969). *Naukometriya. Izycheniye razvitiya nauki kak informatsyonnogo protsessa [Scientometrics. Study of science development as an information process]*. Moscow: Nauka [in Russian].
2. *Dobrov, G. M. (1989). Nauka o nauke. Vvedeniye v obscheye naukovedeniye [Science about Science. Introduction to general studies on science]*. Kiev: Naukova dumka [in Russian].
3. Korennoy, A. A. (1988). Organizatsiya sistemy prognozirovaniya nauchnykh issledovaniy [Organization of the system for forecasting of scientific research]. *Informatika i naukovedeniye [Informatics and Studies of Science]*, 261–262.
4. Marshakova, I. V. (1988). Sistema tsytirovaniya nauchnoy literatury kak sredstvo slezheniya za razvitiyem nauki *[System for citing of scientific literature as a means to monitor science development]*. Moscow: Nauka [in Russian].
5. Khaytun, S. D. (1983). *Naukometriya: sostoyaniye i perspektivy [Scientometrics: performance and prospects]*. Moscow: Nauka [in Russian].
6. Granovsky, Yu. V. *Mozhno li izmeryat nauku? [Can science be measured?]*. Retrieved from http://www.biometrica.tomsk.ru/nalimov/NALIMOV2.htm (25.06.2015) [in Russian].
7. Arefiev, P. G. & Yeremenko, G. O. & Glukhov, V. A. (2012). Rossiyskiy index nauchnogo tsytirovaniya – instrument dlya analiza nauki [Russian index for scientific citation: a tool for R&D analysis]. *Bibliosfera [Bibliosphere]*, 5, 66–71 [in Russian].
8. Moskaleva, O. V. (2013). Ispolzovaniye naukometricheskikh pokazateley dlya otsenki nauchnoy deyatelnosti [Use of scientometric indicators for evaluating research]. *Naukovedcheskiye issledovaniya [Studies of science system]*, 85–109 [in Russian].
9. Akoyev, M. A., Markusova, V. A., Moskalyova, O. V. & Pislyakov, V. V. (2014). *Rukovodstvo po naukometrii: indicatory razvitiya nauki i tekhnologii [Guidelines on scientometrics: science and technology indicators]*. Ekaterinburg: Ural University Publisher [in Russian].
10. Horovy, V. M. (2015). Kriteriyi yakosti naukovykh doslidzhen u kontexti zabezpechennya natsionalnykh interesiv [Criteria of research quality in the context of securing national interests]. *Visnyk Natsionalnoyi akademiyi nauk Ukrayiny [Bulletin of the National Academy of Sciences of Ukraine]*, 6, 74–80 [in Ukrainian].
11. Malitsky, B., Rybachhuk, V., Popovich, A. & Koretsky, A. (2013). Naukometriya: novyye funktsyi i problemy adekvatnosti [Scientometrics: new functions and problems of adequacy]. *Nauka i innovatsyi [Science and innovations]*, 1, 11–17 [in Russian].
12. Mryhlod, O. I., Kenna, R., Holovach, Yu. V. & Bersh, B. (2103). Pro vymiryuvannya naukovoyi efektyvnosti [Measurement of research effectiveness]. *Visnyk Natsionalnoyi akademiyi nauk Ukrayiny [Bulletin of the National Academy of Sciences of Ukraine]*, 10, 76–85 [in Ukrainian].
13. Novikov, A. I., Orlov, A. I. & Chebotaryov, P. Yu. (Eds.) (2013). *Upravleniye bolshymi sistemami [Management of big systems]*. Moscow: Institute of Management Problems of the Russian Academy of Sciences [in Russian].
14. *Leiden Manifesto for Scientometrics*. Retrieved from http://www.igh.ru/about/news/1053/ (25.06.2015) [in Russian].
15. Kostenko, L., Zhabin, O., Kuznetsov, O., Kukharchuk, Ye. & Simonenko, T. (2014). Bibliometrika ukrayinskoyi nauky: informatsiyno-analitychna systema [Bibliometrics of Ukrainian R&D: analytical information system]. *Bibliotechny visnyk [Library bulletin]*, 4, 8–12 [in Ukrainian].
16. *Rankings of Scientists: More countries!* Retrieved from http://webometrics.info/en/node/116 (25.06.2015).
17. *Web of Science*. Retrieved from http://thomsonreuters.com/products_services/science/science_products/a–z/web_of_science/ (25.06.2015).
18. *Google Scholar*. Retrieved from https://scholar.google.com.ua/citations?view_op=top_venues&hl=uk (25.06.2015).
19. Kuharchuk, Ye. O. (2014). Svitovi naukometrychni systemy [Global scientometric systems]. *Bibliotechny visnyk* [Library bulletin], 5, 7–11 [in Ukrainian].
20. *Bibliometryka ukrayinskoyi nauky [[Bibliometrics of Ukrainian R&D]*. Retrieved from http://www.nbuviap.gov.ua/bpnu/index.php?page_sites=formy/ (25.06.2015) [in Ukrainian].
21. Kuznyetsov, O. (2013). Doslidzhennya dynamiky zmin terminiv u bibliotechniy spravi

[Study of the dynamics of change in terminology in librarianship]. *Visnyk Knyzhkovoyi palaty [Bulletin of Book Chamber]*, 4, 31–34 [in Ukrainian].

22. Feygelman, M. *Kak otsenit resultativnost raboty institutov FANO. Chastny vzglyad uchastnika protsessa [Ways to evaluate the productivity of FANO institutes. Individual vision of a participant of the process]*. Retrieved from http://trv-science.ru/2015/06/30/kak-ocenivat-rezultativnost-raboty-institutov-fano/ (25.06.2015) [in Russian].

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## Наукометрія як інструмент моніторингу та підтримки наукової діяльності

*Досліджено витоки наукометрії. Розглянуто підходи до оцінювання результативності наукової діяльності та відмічено тенденцію переходу від формальних кількісних індикаторів до отримання експертного висновку на основі бібліометричних показників. Викладено принципи Лейденського маніфесту наукометрії, дотримання яких забезпечує прозорий моніторинг і підтримку розвитку науки, а також сприяє налагодженню конструктивного діалогу між науковим середовищем та суспільством. Показано концептуальні положення і особливості практичної реалізації інформаційно-аналітичної системи «Бібліометрика української науки», розробленої в Національній бібліотеці України імені В. І. Вернадського. Розглянуто пропозиції щодо формування експертних рад, які ухвалюватимуть висновки про ефективність наукової діяльності установ. Обґрунтовано доцільність побудови загальної платформи для експертного оцінювання наукових досліджень країн Східного партнерства шляхом ініціювання аналогічних бібліометричних проектів у цих країнах та їх подальшої конвергенції.*

**Ключові слова:** *дослідження, наукометрія, бібліометричні дані, моніторинг, оцінювання результативності досліджень, експертне оцінювання, «Бібліометрика української науки».*

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## Наукометрия как инструмент мониторинга и поддержки научной деятельности

*Исследованы истоки наукометрии. Рассмотрены подходы к оцениванию результативности научной деятельности и отмечена тенденция перехода от формальных количественных индикаторов к получению экспертного вывода на основе библиометрических показателей. Изложены принципы Лейденского манифеста наукометрии, соблюдение которых обеспечивает прозрачный мониторинг и поддержку развития науки, а также способствует налаживанию конструктивного диалога между научной средой и обществом. Представлены концептуальные положения и особенности практической реализации информационно-аналитической системы «Библиометрика украинской науки», разработанной в Национальной библиотеке Украины имени В. И. Вернадского. Рассмотрены предложения по формированию экспертных советов, которые будут принимать заключения об эффективности научной деятельности учреждений. Обоснована целесообразность построения общей платформы для экспертного оценивания научных исследований стран Восточного партнерства путем инициирования аналогичных библиометрических проектов в этих странах и их последующей конвергенции.*

**Ключевые слова:** *исследования, наукометрия, библиометрические данные, мониторинг, оценивание результативности исследований, экспертное оценивание, «Библиометрика украинской науки».*