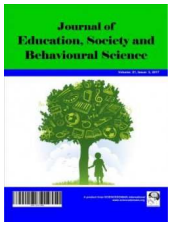

Journal of Education, Society and Behavioural Science

23(3): 1-10, 2017; Article no.JESBS.34946
ISSN: 2456-981X
(Past name: British Journal of Education, Society & Behavioural Science, Past ISSN: 2278-0998)

Modification of Generalized Scientific Indicators Based on the Mathematical Theory of Limits

Popova Olga Borisovna[1*], Romanov Dmitry Alexandrovich[1], Popovskaya Victoria Borisovna[1], Kapustina Alexandrina Aleksandrovna[1] and Shaposhnikov Valery Leonidovich[2]

[1]FGBOU VO "Kuban State Technological University", Krasnodar City, Russia.
[2]Russian University of Cooperation, Mytishchi (Moscow Region), Russia.

Authors' contributions

This work was carried out in collaboration between all authors. Author RDA designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors POB and SVL managed the analyses of the study. Authors KAA and PVB managed the literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JESBS/2017/34946
Editor(s):
(1) Redhwan Ahmed Mohammed Al-Naggar, Professor, Population Health and Preventive Medicine, UniversitiTeknologi MARA, Sungai Buloh, Selangor, Malaysia.
(2) Eduardo Montero García, Professor, Department of Electromechanical Engineering, Polytechnic School, University of Burgos, Spain.
Reviewers:
(1) Lawrence Mapaire, University of South Africa, South Africa.
(2) Alec Sithole, Missouri Western State University, USA.
(3) Beverly A. King Miller, Central New Mexico Community College, USA.
(4) Matt Cronin, George Mason University, USA.
Complete Peer review History: http://www.sciencedomain.org/review-history/22066

Original Research Article

Received 20th June 2017
Accepted 20th November 2017
Published 27th November 2017

ABSTRACT

The objective of this research is to justify new scientometric parameters suitable for the diagnosis of the research activities productivity and sustainable artificial "improvement." It is known that it is generally accepted scientometric indicators that reflect the productivity of research activities of scientists and organizations (team) are the Hirsch index (h-index) and g-index; both indices calculated on the basis of statistical method, scree. However, scientometric indicators, based on citation, give artificial "improvement"; no exception of g-index and h-index. The authors propose modified methods of the indicators calculation based on the application of the mathematical theory of limits; its application makes possible to limit the role of self-citations and citations by co-authors, attempts distortion (unfair boosting) scientometric indicators that reflect the productivity of the

**Corresponding author: E-mail: popova_ob@mail.ru;*

scientist's research activities and the importance of its results to the scientific community. At the same time, the author's method of assessment of the modified g-index and h-index does not deny the importance of reasonable (justified) self-citations and citations by co-authors. The practical significance of research results in the possibility of their use in monitoring systems research activities of scientific institutions (including higher educational institutions), the theoretical significance – the possibility of further scientific. To achieve the goal and solve the tasks set, the following complementary research methods were used: analysis of scientific literature and best practices in management of research activities in scientific organizations - higher education institutions (benchmarking); modeling; methods of Set Theory; automated system-cognitive analysis; methods of qualimetry (theory of latent variables); methods of mathematical statistics (including the scree plot method), methods of the theory of limits. The empirical stage of the research was carried out on the basis of higher educational institutions of the Krasnodar Territory. It is proved that the modified h-index and g-index more adequately reflect the productivity of the scientist's research activities, the significance of its results for the scientific community.

Keywords: Research activities; results; diagnosis; scientometric indicator; modification; mathematical theory of limits.

1. INTRODUCTION

Diagnosing the productivity of the scientists' research activities and the significance of its results for the scientific community is one of the most urgent, but at the same time, the most complex scientometric tasks [1-18]. It is known that the target of research activity is the recognition of its results by the scientific community, and the purpose of using scientometric parameters is to objectively evaluate the productivity of research activities of scientific workers and the significance of its results for the scientific community. The Hirsch index and other scientometric indicators (including the g-index), based on citation, gained popularity due to their objectivity and humanistic potential. Unlike such an index as the average number of citations for a publication, the Hirsch index (h-index), based on the scree plot method (a popular method of mathematical statistics), does not "forbid" a scientist to publish new scientific works (ie publications, not receiving quotations, will not reduce the complex scientometric indicator). But the diagnosis of the productivity of research activity based on the analysis of citation has a number of dangers, one of which is related to the possibility of artificial "improvement" of scientometric indicators, including the h-index and the g-index. Goodhart's Law is known: if any indicator becomes an end in itself, then it ceases to be a good indicator [1-3,8,9,11]. Scientometrics is a kind of measurement in social systems [8,11-17], and the most important factor of their (sociological measurements) systematic errors is the desire to "artificially" improve "the monitoring indicators" at any cost"; do not constitute exceptions and scientometric parameters. As modern experts rightly point out, Hirschmania has become one of the social disasters of the new century [1,7,11].

At present, not only in Russia, but also in the whole world, the number of fraudulent schemes of artificial improvement of scientometric indicators, especially the Hirsch index [1-3,7-9,11], is growing. This leads to a distortion of the evaluation (measurement) of parameters such as the productivity of the research activity of a scientist and the significance of its results for a broad scientific community. Of course, in order to combat this social disaster, it is necessary to use various methods and means in a complex manner. But it is obvious that one of them must necessarily be the use of adequate scientometric indicators that reflect the true, and not fictitious, productivity of the research activity of a scientific worker and the significance of its results for the scientific community.

Thus, sciencemetry as a branch of science ("science of science"), and the practice of managing research activities in scientific institutions (including in higher educational institutions) are badly in need of objective indicators of the productivity of research activities that can not be (or are very difficult to yield) artificial "improvement." The problem of research is the question, what are the objective criteria for the productivity of research activities of scientific workers and the significance of its results for the scientific community, which can not be artificially "improved" (or very weakly amenable to it)? The aim of the study is to justify the new scientometric parameters suitable for diagnosing

the productivity of research activities and resistant to artificial "improvement". The object of this study is the scientific research activity of scientists, the subject of research is the productivity of research activity and the significance of its results for the scientific community. The achievement of this goal was related to the solution of the following research tasks:

1. Develop a model for calculating modified scientometric indicators that adequately reflect the productivity (effectiveness) of the scientist's research activity and resistant (resistant) to artificial improvement technologies.
2. To substantiate the possibility of using author's indicators to monitor research activities of scientists, to evaluate their (indicators) information and validity.

The solution of the above problem, the achievement of the goal and the solution of subordinate tasks are relevant in connection with the growing role of research activity in the modern world (information society) and the need to maintain the idea of higher education institutions as centers of science (the well-known idea of A. Humboldt). One can not ignore the fact that international and national methodologies for higher educational evaluating are dominated by research and its productivity (the Shanghai methodology for evaluating the rating of universities, the Russian method for assessing the effectiveness of universities, etc.). For example, in Russia an annual monitoring of the effectiveness of higher education institutions has been introduced, and the vast majority of monitoring indicators reflect various aspects of research activities and its results. For the authors of the article it is obvious that the problem of an adequate evaluation of the productivity of research activities, as well as the significance of its results for the scientific community, should be considered in the context of problems of a higher order - the problem of competitiveness of scientific and pedagogical workers and the effectiveness of the educational environment [1-18].

2. ANALYSIS OF THE SCIENTIFIC PROBLEMS ELEBORATION

Analysis of the development of the scientific problem. It is known that the Hirsch index of a scientific worker is h, if at least h scientific worker publications have received no less than h citations (references) each. A distinction is made between the Hirsch index and self-citation, and without taking into account self-citations [1,2,7,11-17]; of course, the last parameter more adequately reflects the productivity of the research activity of the scientist.

In addition to the obvious advantages, the Hirsch index has a number of shortcomings. The first disadvantage is the impossibility of taking into account the "superfluous" quality of publications (if the quality of publication is judged by its citation). For example, the Hirsch index of the scientific worker "A" is 8, but the total number of references (citations) to his 8 most quoted publications is not 64 but 180; The same Hirsch index of the scientific worker "B", but the total number of references to his 8 most quoted publications is 74 (that is, close to the lowest possible value for a given Hirsch index). The second disadvantage (inherent in many scientometric indicators, based on quoting) is the possibility of artificial manipulation, i.e. "Improvement", due to unreasonable citations of "lagging" publications. The third defect of the Hirsch index is its fundamental limitation in the number of publications of the scientific worker. A paradoxical situation develops: an employee who has five publications recognized by a broad scientific community (having one hundred quotes for each) is less productive than a scientist, who has ten publications with ten citations each (ie having publications of "medium" arms")!

Note that even such an indicator as the Hirsch index without self-citations is also amenable to artificial improvement, for example, by "agreeing" with co-authors or colleagues about citing publications. But the sense of scientometric indicators is an assessment of the significance of a scientific worker's publications for a broad, rather narrow, scientific community.

The authors of this article (in [11]) have previously proposed a method for combating the first disadvantage: $\hbar = \frac{\sum_{j=1}^{h} H_j}{h}$, where h is the Hirsch index of the scientist, Hj is the number of citations for the j-th publication that determines the Hirsch index. In addition, the first (from the authors indicated) deficiency of the Hirsch index "smoothes" and the g-index, estimated as follows: it is equal to g, if no less than g scientific publications, the total number of references is not less than g2.

Combating the second drawback is a much more complicated problem. Note that the g-index is as easy to manipulate as the h-index (it is possible to manipulate the ђ-index). Another disadvantage of the g-index is that it can be determined by publications that have not received any recognition from the scientific community. For example, a researcher has publications whose citation is 23, 17, 11, 9, 5, 0, 0, 0, 0, 0, respectively. It is obvious that the g-index of such a researcher is 8 (Hirsch index is only 5), although the sixth, seventh and eighth publications have zero citation. The selection of the Hirsch index without taking into account self-citations also does not solve the problem, because A preliminary agreement with co-authors on the unreasonable citing of "lagging" publications is possible.

It is known that with the social disasters associated with the absolutization of the "selected" indicators (applied to scientometric - the Hirsch index), three mutually complementary ways of struggle are possible. The first way is the multiparameterization of diagnostics, and consequently, the monitoring of the research activity of scientists and staff. The second way is strict social control; as applied to research activities - monitoring compliance with the publication ethics (for example, limiting the number of self-citations and citations of the same authors within the same article). The third way is the formation of adequate monitoring indicators that are not amenable (or difficult to achieve) to artificial "improvement"; the fourth way is the optimal combination of the first three.

Certainly, when assessing the recognition (relevance) of the results of research activities of a scientific worker, it is possible to apply such indicator as the Herfindahl index (it is currently used for scientific journals), to assess the degree of uneven citation of a scientific worker by the social environment. The Herfindahl Index is a "harmful" indicator, i.e. an increase in its numerical value reflects a worsening of the situation. It is obvious that if the analyzed (diagnosed) researcher is quoted by a very limited circle of persons, then he will have a high Herfindahl index. But the authors of this article are sure that the low Herfindahl index does not mean a high level of recognition of publications (research results) of a scientist, since The low value of the Herfendahl index can be combined with a low number of citations for the works of a scientist (especially, the low index of Hirsch). In addition, the Herfindahl index has a limiting value, and the number of unreasonable citations is not; on the basis of the mathematical theory of limits, it is not difficult to prove that,

$$\lim_{C\to\infty}\left(\frac{C}{G}\right)=\infty$$

where C is the number of citations on the works of a scientific worker, G is the Herfindahl index (by quoting authors). Consequently, the division of the citation of scientific publications into the Herfindahl index is not an effective way to combat the artificial "improvement" of scientometric indicators.

Thus, the analysis of traditional scientometric parameters showed the presence of two serious drawbacks. The first disadvantage is the possibility of artificial "improvement." The second drawback is "binding" to the number of publications. Another drawback is the impossibility of determining the degree of integrity (systematic) research activities of the scientist and its results, but this is beyond the scope of this problem (evaluation of the productivity of research activities and the true significance of its results for the scientific community). On the basis of the foregoing, the authors conclude that it is necessary to identify and justify new objective criteria for the productivity of research activities of scientists who are resistant to artificial "improvement".

3. METHODOLOGY AND RESEARCH ORGANIZATION

Methodology and organization of research. To achieve the goal and solve the tasks set, the following complementary research methods were used: analysis of scientific literature and best practices in management of research activities in scientific organizations - higher education institutions (benchmarking); cognitive, structural-functional and mathematical modeling; methods of graph theory, sets and relations; automated system-cognitive analysis; methods of qualimetry (theory of latent variables); methods of mathematical statistics (including the method of rocky scree), methods of the theory of limits.

It is necessary to emphasize the role of mathematical methods in our study, first of all - the scree plot method and the method of the theory of limits. The significance of research

results of a scientist or a team is considered as an integral indicator (latent variable), for which it is possible to select particular criteria (indicator variables). Methods “Set Theory” will make it possible to create cognitive models of the research activity of scientists, their impact on the scientific community (scientific megalecond) in general. The most popular in our study were the methods of the theory of limits, used to calculate the author's index of the citation of the scientific publication; The methodology for calculating such an index allows to stop attempts to artificially "improve" the quality of publications by unjustified self-citing and quoting by co-authors. The scree plot method (one of the statistical methods) allows estimating the modified g-index and the h-index. The application of methods of qualimetry (the theory of latent variables) consisted in the allocation of several indicators (rather than one) reflecting the productivity of the research activity of the scientific worker.

Methodological bases of the research: a systematic approach (considers research activity as a complex system process and an integral part of the functioning of higher education institutions), a metasystem approach (considers a set of quotations for scientific publications as a system that includes relatively autonomous components), probabilistic-statistical (considers the recognition of research results activity of a scientific worker as a stochastic process) and a qualimetric approach (proclaims the necessity of multicriteria diagnostics of the productivity of research activities of a scientific worker).

Due to the use of the national science-metric system (the Russian index of scientific citation, the technological platform - web site eLIBRARY.ru), primary actual data on the publication activity of scientific and pedagogical workers of higher educational institutions of the Krasnodar Territory (n = 420) were obtained. In the course of the research, the publication activity of scientific and pedagogical workers of the following higher educational institutions was analyzed: the Kuban State University, the Kuban State Technological University, the Kuban State Agrarian University, the Kuban State Medical University and the Kuban State University of Physical Culture, Sports and Tourism. The primary information that can be obtained in the public domain about researchers in Russian Science Citation Index (RSCI): a list of publications, a list of citations (references) for each publication, indicating the name and authors of citing publications, the place of their work, the date of publication of the citing publication. In other words, the primary information contained in the public domain is sufficient for the empirical stage of the study. The automated system-cognitive analysis made it possible to reveal the validity and differentiating power of the authors' performance indicators of the scientists' research activity (modified h-index and g-index).

4. THE STUDY RESULTS

From the point of view of the authors, the modified Hirsch index, which is calculated as follows, is objective and not subject to an artificial "improvement" in the criterion of the productivity of research activity: it is equal to C, if not less than C publications of the scientist have a citation index no less than C each. The authors of this article propose the following model for calculating the citation index of a specific publication of a particular scientific worker: $C = n_1 + \sum_{j=1}^{n_2} 0{,}75^{j-1} + \sum_{j=1}^{n_3} 0{,}5^{j-1}$. Here: n_1 is the number of "truly external" citations for the publication, n_3 is the number of self-quotations for publication by any member of the team of authors, n_2 is the number of citations for publication by any of the co-authors (according to the science-based database) of any member of the author's collective. On the basis of the theorem on the sum of an infinitely decreasing geometric progression, it is not difficult to prove that the limiting values of the second and third terms are 4 and 2, respectively. The traditional model for estimating the publication's quotability is the following: $C' = n_1 + n_2 + n_3$. In other words, the traditional model of citation publication assessment does not limit the role of self-citations and citations by co-authors, which leads to a distortion of the measurement of the significance of the scientific worker's publications for the scientific community.

The suggested publication publication index limiting the role of self-citations and citations by co-authors was formed on the basis of the author's approach (described in [9]), according to which complex monitoring indicators are calculated on the basis of the theory of limits, in order to deprive the sense of an infinite increase in input monitoring information that can be increased Artificially (it is artificially possible to increase the number of self-quotations and citations by co-authors). At the same time, the

evaluation of the modified Hirsch index does not "nullify" the role of well-founded self-citations and citations by co-authors.

Unlike the modified Hirsch index, the "hard" Hirsch index looks like this: it is equal to n, if at least n publications of the scientist have received no less than n "truly external quotations" each.

As can be seen, the above scientometric indicators (modified and "hard" Hirsch indices) are difficult enough to "improve" through fraudulent schemes. It should also be remembered that the target of research activity is the recognition of its results (i.e. publications) by the scientific community, and the authors' self-citation and quoting by co-authors reflect the recognition (although not always deserved) of publications by a scientific worker from the narrow (rather than broad) Social environment.

The social responsibility of a scientist is a problem that is relevant at all times [1-18]. Therefore, the authors also propose such indicators of the research worker's productivity as a number of publications (a scientific worker) of high and high quality. A high-quality publication will be considered if its citation index (in accordance with the author's methodology) is not lower than 8, a publication of the highest quality - if the citation index is not lower than 10. The suggested threshold values (minimum gradation values) are explained by the authors that the publication of high quality needs for, at least three years to get a true external quotes, the highest quality - at least for five years. Evaluation of the above indicators allows to answer the question: does the research worker have the "core" of the best publications, highly recognized by the scientific community? This is the social responsibility of the scientific worker to the scientific community in order not to "inflate" the number of low quality publications, but to strive for high-quality research results recognized by the scientific community.

The question arises: is it advisable to apply the same indicator to a scientist as to scientific journals-the half-life of his articles (the median age of the cited articles in the current year)? From the point of view of the authors, it is inexpedient, since such an indicator can also be manipulated, unreasonably quoting "old" publications.

The fourth indicator is the modified g-index. Imagine the algorithm for its calculation. The publications of the researcher being diagnosed are sorted in descending order of the author's citation index C. Then we exclude from the list publications that are not cited except for self-citations (ie we leave in the list publications that have either truly external citations or quotations from the co-authors of the diagnosed scientific worker, but not co-authors of this publication). This action is explained by the authors of this article in that self-citations do not mean the publication of a diagnosed worker for the scientific community, but only continuity in his research activity. The modified g-index is equal to G if at least G publications (in the truncated list) have a cumulative index of not less than G^2 . The total citation index $G^{/} = \sum_{i=1}^{G} C_i$, where Ci is the citation (according to the methodology of the authors of this article) of the i-th publication.

Here is an example. Suppose 27 publications of a hypothetical research worker are characterized by a certain citation (Table 1). There is a notation: NS - does not matter. It is obvious that the modified g-index can not determine publications No. 2, 3, 4, 8, 13, 16, 19, 21, 26, 27, i.e. 10 of 27. The modified Hirsch index of this employee is 7 (if you sort 17 publications, then the seventh has a citation index of 7.83), and the modified g-index is 8, so the citations of the first eight publications (sorted in descending order of citation) are 71, 53, and the citation number of the first nine publications is less than 81. In addition, this employee has 3 publications of high quality and one publication of the highest quality (citation index 11.6). It is obvious that the "hard" Hirsch index of such a researcher is 3, the traditional Hirsch index, with self-citations taken into account, is 17, without taking into account self-citations is equal to 10.

The above procedure can be implemented by a more rational sequence of actions. Initially, from the general list of scientific publications excludes works that have no citations (except for self-citations), and then, for the remaining publications, citation indexes are calculated, and subsequently sorted in descending order and the modified g-index is determined.

Any measurement, including a sociological one, is characterized by sinfulness [13-15]. In addition to unsubstantiated citations, there are also possible errors factors (scientometric measurements) of oppositely directed influence,

first of all - the unidentified nature of the publications cited by the scientometric system. The main reason is the incorrectness of registration of official links; at the same time, if you specify the international DOI number, the quoted publication will be identified (recognized) by the science-metric system, no matter how inaccurately it is indicated [16,17].

Table 1. Quoting publications of a hypothetical scientific worker

№	n_1	n_2	n_3	C
1.	2	4	10	6,73
2.	0	0	25	H3
3.	0	0	32	H3
4.	0	0	11	H3
5.	1	6	15	6,28
6.	3	8	11	8,6
7.	1	4	4	5,6
8.	0	0	17	H3
9.	1	6	15	6,28
10.	3	8	11	8,6
11.	1	4	4	5,6
12.	5	8	12	11,6
13.	0	0	23	H3
14.	2	11	14	7,83
15.	1	12	18	6,87
16.	0	0	22	H3
17.	2	11	14	7,83
18.	1	12	18	6,87
19.	0	0	14	H3
20.	5	8	12	11,6
21.	0	0	12	H3
22.	1	6	8	6,28
23.	0	8	14	5,6
24.	2	8	17	8,6
25.	0	10	15	5,77
26.	0	0	7	H3
27.	0	0	9	H3

The analysis of the teachers publication activity in higher educational institutions of the Krasnodar Territory is showed the existence of a weak connection between the traditional, authorial and "hard" Hirsch indices. The surveyed scientific employee and pedagogical workers are such that their Hirsch indices (taking into account self-citations) range from 5 to 33; The correlation galaxy between the author's and traditional parameters (the set of correlation coefficients) is reflected in Table 2. Designations: P1 is the Hirsch index of the scientist with self-citations taken into account, P2 is the Hirsch index without self-citations, P3 is the traditional g-index, P4 is the modified g-index , P5 - the total number publications of high and high quality in a scientific worker, P6 - the modified Hirsch index, P7 - the "hard" Hirsch index.

From the analysis of the correlation galaxy it follows unequivocally that the relationship between the traditional and author's (modified and "hard") Hirsch indices is very weak. This is due to the fact that among the scientists surveyed, the leading factors affecting the complex indicator (the traditional Hirsch index) are self-citation and quoting by co-authors, i.e. the nearest social environment. In other words, the modified and "hard" Hirsch indices are completely different than the traditional ones. The strongest is the relationship between the traditional Hirsch indices (with and without self-citations), as well as between the "hard" Hirsch index and the total number of high and high-quality publications from the research worker. The authors attribute the high importance of citations to the co-authors of scientific workers (often co-authors cite each other's publications), the second fact is that highly qualified scientists capable of attaining high values of the "hard" Hirsch index are capable of publishing a significant number of high-quality publications recognized by a wide scientific community (and not only the nearest social environment, ie co-authors).

Table 2. Correlation range of scientometric indicators

№	P1	P2	P3	P4	P5	P6	P7
P1	–	0,72	0,68	0,62	0,53	0,45	0,24
P2	–	–	0,64	0,69	0,40	0,47	0,42
P3	–	–	–	0,62	0,37	0,41	0,20
P4	–	–	–	–	0,67	0,44	0,48
P5	–	–	–	–	–	0,58	0,78
P6	–	–	–	–	–	–	0,65
P7	–	–	–	–	–	–	–

Table 3. The share of scientists with given ranges of values scientometric indicators

Indicator no.	Range of Indicator Values						
	[5; 9]	[9; 13]	[13; 17]	[17; 21]	[21; 25]	[25; 29]	[29; 33]
P1	32,6	23,5	21	10,3	6,7	4	1,9
P6	53	30	11	4,7	0,95	0	0
P7	49	26	9,7	3,3	0	0	0

The application of the theory of limits in evaluating the productivity of research activities of scientific workers makes it possible to assess the significance of its results for the scientific community with a lesser degree of distortion. The share (in percents) of scientific and pedagogical workers with these or those values of three indicators showed in Table 2 - the Hirsch index, taking into account self-citations, the "hard" and the modified Hirsch index. The fact that the total share of scientific workers with a "harsh" Hirsch index is less than 100% is due to the fact that it is below 5 for a number of scientists; the same is true for the modified Hirsch index.

There is also a legitimate question: is the sample of scientific and pedagogical employees of higher educational institutions representative (remind that it is "only" about 420 teachers of universities in the Krasnodar Territory)? From the point of view of the authors of this article, the range of the "support" science-metric indicator is wide - the Hirsch index, taking into account self-citations. In other words, the data obtained is sufficient to conclude that it is necessary to apply the mathematical theory of limits to assess the productivity of scientific workers.

Discussing the results of this study, we note that the authors solved this metrological (scientometric) problem, as an assessment of the true (and not fictitious) productivity of the scientists' research activities and the significance of its results for the scientific community.

Within the framework of the article, the authors also consider it advisable to put forward practical recommendations, the use of which will increase the effectiveness of research activities of scientists (including teachers of higher education institutions). First, it is necessary to create information portals (on the basis of scientific organizations' websites), in which public information on top-quality publications (as well as the publications themselves in pdf format, as a sample!), as well as information on the most productive (qualified) scientific workers. The expediency of creating such portals is in providing scientific workers with target points of professional growth and samples of research results. In addition, the availability of internal information resources will allow scientific and pedagogical staff of universities to use the results of research activities of their colleagues in the content of training. Secondly, the variable part of the salary of a scientific worker (including the teacher of a higher educational institution), taking into account the value of "human capital", should be proportional to the value

$$r = \prod_{j=1}^{m} \left(1 + f_j\left(h_j\right)\right).$$

Here: m is the number of different scientometric systems in which the scientist has a nonzero Hirsch index, hj is his modified Hirsch index in the j-th science-metric system, f is the step function (is affiliated to the scientometric system). For example, Web of Science and Scopus are not the only Nauometric systems. When determining step functions, it must be keep in mind that the degree of difficulty in achieving the same Hirsch index in different scientometric systems may be different (sometimes incommensurable) degree of difficulty. For example, to achieve even a Hirsch index of 1 in the science-based system of the Web of Science is much more difficult than 10 in the national science-metric system. It is obvious that the probability of artificial achievement of the nonzero Hirsch index (especially, modified) in a large number of scientometric systems is extremely small.

5. CONCLUSION

The modified h-index and g-index are scientometric criteria, on the basis of which it is possible to identify really highly effective (and, consequently, highly qualified) researchers. These indicators, which are extremely difficult to artificially improve, are equally applicable to both individual scientists and research teams. It is hardly possible to artificially increase the number of "truly external" quotations for a large number of scientific publications. The indicators proposed by the authors reflect the scientists's social

activity, i.e. their influence on the scientific community (and, consequently, their integration into the scientific megacenter).

The authors of this article realize that indicators based on citations can not reflect all aspects of the research worker's productivity and the significance of its results. Suffice it to say that no indicators based on citations do not reflect the methodological or practical significance of the research activities results; under methodical significance, the authors understand the use of research results in the content of training [12]. Nevertheless, indicators based on citations are relevant for several decades already; Hirsch index (h-index) received special recognition. However, "life does not stand still," therefore, it is necessary to justify adequate scientometric indicators that are weakly amenable to artificial "improvement," therefore, allowing to estimate the true (and not fictitious) productivity of research activities of scientists.

Analysis and generalization of research results of the study made it possible to draw conclusions:

1. The need to identify new scientometric indicators that adequately reflect the research activities productivity of researchers and resistant (resistant) to manipulation is due to the urgency of combating the artificial "improvement" of scientometric indicators, the growing research activity role in the modern world and universities as science centers.

2. The calculation of author's science-metric indicators - the modified g-index and the h-index - is based on the consistent application of the limits theory and the method of rocky scree. The difference between the author's estimating method the h-index and the g-index from the traditional (well-known) is that the citation of each publication is calculated on the basis of the limits theory, with the aim of limiting the self-citations and links role by co-authors. At the same time, the author's methodology for calculating the publication's citation does not nullify the role of justified (justified) self-citing and quoting by co-authors.

3. Actual data analysis on the research activities results of teachers in higher educational institutions of the Krasnodar Territory revealed a low level of correlation between the modified Hirsch index and the traditional index, which indicates the following: the traditional Hirsch index (even without self-citations) does not adequately reflect the research activities productivity of the scientist, the scientific community's results.

The authors' team prospects study is the creation of models and criteria for assessing the integrity of the scientific worker's research activities (the systemic nature of its results).

ACKNOWLEDGEMENTS

The work was carried out with the financial assistance provided by the Russian Foundation for Humanities within the research projects no. 16-03-00382 within the theme “monitoring the research activity of educational institutions in the conditions of information society”.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Gavrilova EV, Ushakov DV, Yurevich AV. Translyatsiya nauchnogo opyta i lichnostnoyeznanie [Translation of scientific experience and tacit knowledge]. Sociological Studies. 2015;9:28-35. (In Russian)
2. Geidarov P Sh. Ballovaya sistema otsenki nauchnykh trudov i elektronnyy nauchnyy seminar [The scoring system evaluation of academic works and electronic academic seminar]. Sociological Studies. 2015;4: 162–167. (In Russian)
3. Dudina VI. Sotsiologicheskoe znaniye v kontekste razvitiya informatsionnykh tekhnologiy [Sociological knowledge in the context of information technologies development]. Sociological Studies. 2015;6:13-22. (In Russian)
4. Kovshov DK, Kovshova ES. Postroenie sotsialno-psikhologicheskoy karty kollektiva podannym sociometricheskogo issledovaniya [Creating a social-psychological map of a team according to the data of sociometric research]. Sociological Studies. 2015;10:195–209. (In Russian)
5. Lazarev VS, Eliseeva IA. Issledovanie pedagogicheskogo kollektiva kak subyekta innovatsionnoy deyatelnosti [Research of pedagogical team as a subject of innovation activity]. Voprosy Psikhologii. 2015;1:87-97. (In Russian)

6. Lebedeva IP. Myagkie modeli kak forma matematizatsii sotsiologicheskogo znaniya [Soft models as a form of mathematizing sociological knowledge]. Sociological Studies. 2015;1:79-84. (In Russian)
7. Lutsenko EV. Hirschamaniya pri otsenke rezultatov nauchnoy deyatelnosti, eyo negativnye posledstviya i popytka ikh preodoleniya s primeneniyem mnogokriterialnogo podkhoda i teorii informatsii [Hirsch-mania when evaluating the results of scientific activity, its negative effects and an attempt to seize them with the use of a multi-criteria Approach and information theory]. Polythematic Online Scientific Journal of Kuban State Agrarian University. 2015;108(04):1-29. (In Russian)
8. Tolstova Yu N, Voronina ND. O neobkhodimosti rasshireniya ponyatyiya sotsiologicheskogo izmereniya [On the necessity of broadening the notion of sociological measurement]. Sociological Studies. 2015;7:67-77 (In Russian)
9. Fedorova NP, Tyupen'kova G. Ye, Kiseleva Ye S, Romanov DA, Nikulina ON. Sovremennyye sposoby formirovaniya monitoringovykh pokazateley [Modern ways of the monitoring indicators formation]. Nauchnyye trudy Kubanskogo gosudarstvennogo tekhnologicheskogo universiteta. 2015;11:266-292. (In Russian)
10. Hoyo JJG, Madariaga CJ. The debate on the concept of value: Interpretations from the perspective of economics and social anthropology. Mediterranean Journal of Social Sciences. 2016;7(2):11-20.
11. Popova OB, Popov BK, Karandei V Yu, Romanov DA, Kobzeva SA, Evseeva MA. New methods and evaluation criteria of research efficiency. Mediterranean Journal of Social Sciences. 2015a;6(6):212–217.
12. Eck NV, Waltman L. Generalizing the h- and g-indices. Journal of Informetrics. 2008;2(4):263–267.
13. Egghe L. Mathematical theory of the h- and g-indices. Journal of Informetrics. 2008;2(4):263–271.
14. Franceschini F, Maisano D, Perotti A, Proto A. Analysis of the ch-index: An indicator to evaluate the diffusion of scientific research output by citers. Scientometrics. 2010;85:203–217.
15. Guns R, Rousseau R. Real and rational variants of the h-index and the g-index. Journal of Infometrics. 2009;3(11):64–71.
16. Hirsch JE. An index to quantity an individual's scientific research output. Proceedings of the National Academy of Sciences of the USA. 2005;102(46): 16569–16572.
17. Jonash RS, Sommerlatte T. The innovation premium: How next generation companies are achieving peak performance and profitability. Cambridge: Massachusetts; 1994.
18. Popova O, Romanov D, Drozdov A, Mironova M. The geographical latitude index of the relevance of research results activity as scientometric index. International Journal of Engineering and Applied Sciences. 2017;4(6):21-25. Available:https://www.ijeas.org/download_data/IJEAS0406009.pdf

Peer-review history:
The peer review history for this paper can be accessed here:
http://sciencedomain.org/review-history/22066