The need, the possibilities and the methods of measuring the effectivity of scientific research

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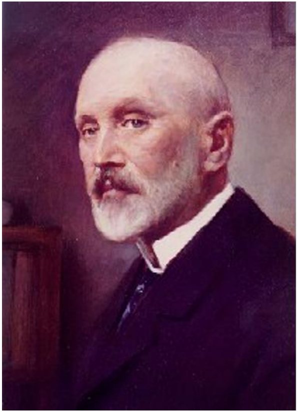
May 4, 2018.

The true science

The thoughts of baron Loránd Eötvös (1848–1919) about science

It is only the true science which is of world importance. Therefore if we want to be true scientists and, as it should be, good Hungarians, then the flag of science should be raised so high that it could be seen beyond our borders, and could receive proper respect.



The name of the game

— The legitimate need of employers (service providers in the public service) is to have at least some approximate information on the work of their employees. Many of the employees also want their results to be quantifiable and comparable, as they can achieve better positions and better payouts with better results.
— Measuring the performance of scientists causes many controversy and often results in controversial procedures.
— One of the manifestations of scientific work is the publication of new results. The best-known science metric measurement methods attempt to quantify the volume, quality and echo of publications.

The growth of science

The reasons of the information explosion

— the increase of money pumped into science,
— the increase of the number of researchers (90% of researchers who have ever lived is still active today),
— the increase in the number of publications (one scientist publishes 0.5-1 article each year),
— the scientific support is increasingly covered by the funds received from the applications, from scientific grants,
— competition and fight between scientists,
— in the assessment of scholars (job applications, academic titles, degrees, assignments, payouts) a major role is played by the publication activity ”publish or perish!”
— the institution (research institute, university) expects to deliver the research results for the money, support received,
— in the institutional career and in the competition for scientific support, a significant role is played by the publications,
— the sponsor will see that he has made his money worthy of a place if his name is mentioned at the end of a number of prominent journal articles.

The scientific activity

The process of scientific activity

— Input: The material input, the labor, the value of the experimental equipment, the amount of applied chemicals, the computer time used, etc.
— Output: the results, the new scientific knowledge, the product.
— All factors for input and output have quality and quantity characteristics, e.g.:
— — the language skills,
— — place and language of publication,
— — the investment, equipment depreciation, etc.
— The tools of scientific research:
— — fresh, up-to-date knowledge of old and new scientific information in the world,
— — opportunity for cooperation and debate,
— — instruments, equipment.

The scientific activity

The communication process of scientific activity

— research,
— congresses, correspondence, preprint,
— writing a scientific article,
— submit the article to a journal editorial board,
— review, evaluation of this article,
— modification of the article, re-submission of the final article,
— appearance, dissemination of the article,
— recognition of the results: quotation, criticism, debate.

The characteristics of the communication process

— activities in the scientific community: research, dissemination, evaluation, recognition, evaluation by research associates and experts, who are also competitors,
— the critical atmosphere is typical, only authenticity is evaluated,
— the intellectual product becomes a property only if it is published,
— only the publication of a scientist will legitimately be recognized as his own discovery.

The tools of scientific communication

Formal channels

— monographs,
— scientific journals,
— reprints.

The first scientific journal

1665: Philosophical Transactions. Publisher: Henry Oldenburg, the Secretary of the Royal Society.

Informal channels

— lectures of scientific meetings (about 65% in written form),
— reports,
— theses, dissertations,
— preprints,
— conference materials.

The origin of scientometry

Hypothesis

The literature of individual disciplines can be the subject to the same regular research as any physical or biological phenomenon, and it is suitable to describe the state of science, as well as the characteristics of scientific research.

The reasons for scientometry

— the amount of scientific product is growing,
— science becomes a production branch,
— scientific research is institutionalized,
— state budget support is necessary,
— the number of scientific researchers is increasing, they are also working on state and industrial projects,
— scientific achievement is expected,
— the design of the research becomes necessary, the science policy emerges.

Who measures, what and why do we measure?

Participants in scientific research

— the state (taxpayers);
— national and international research funding organizations;
— national and international scientific organizations;
— publishers of scientific books and periodicals;
— university colleges, institutes, departments, laboratories;
— industrial and public research institutes;
— scientists.

We try to measure

— how is the taxpayer's money is utilized;
— how is the source of funding is utilized;
— what is the scientific achievement of the university (faculty, institute, department, laboratory) or research institute;
— what is the performance of the individual researcher, the research team's.

What is scientometry?

Scientometry

— Subject: all measurable aspect of the scientific activity (mainly scientific literature);
— Tools: Quantitative (mainly statistical) tools;
— Purpose: Understanding and, if possible, improving the mechanisms of scientific activity.

Main areas of scientometry

— Structural scientometry: Structural mapping of scientific communities, set of documents, concepts;
— Dynamical scientometry: Studying the spatial and temporal behavior of scientific information;
— Evaluative scientometry: Evaluation of the participants in scientific research (countries, institutions, journals, individuals).

What is scientometry?

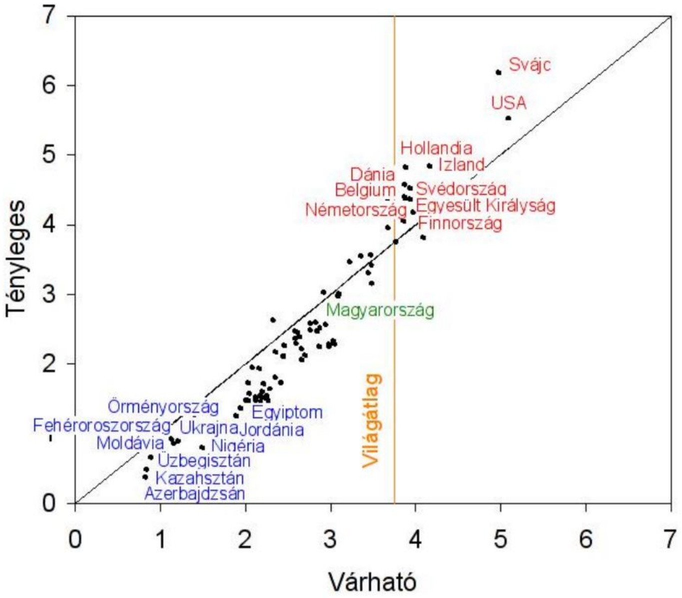
Indicators of scientometry

— Structural: Erdős-number, Collaboration distance, etc.;
— Dynamical: doubling time, citation time, etc.;
— Evaluative: citation number, impact factor, Hirsch index, etc.

Audience of scientometry

— scientists;
— researchers of scientometry;
— decision makers of science.

Where is scientometry used



Ranking of universities

— Academic Ranking of World Universities:
http://www.shanghairanking.com/ARWU2011.html
— Webometrics:
http://www.webometrics.info
— QS World University Rankings:
http://www.topuniversities.com/university-rankings
— The Times Higher Education World University Rankings:
http://www.timeshighereducation.co.uk/world-university-rankings
— Leiden Rankings:
http://www.leidenranking.com/ranking.aspx
— U-Multirank:
http://www.u-multirank.eu/
— CHE University Ranking:
http://www.daad.de/deutschland/hochschulen/hochschulranking

The Sanghai List

The Shanghai Jiao Tong University published for the first time in 2004 the Scientific Ranking of World Universities which soon came to the brink of heated debate. The ranking is based on
— the Nobel and Fields Prize winners (10%),
— the number of Nobel and Fields researchers at the university (20%),
— the number of ”heavily quoted researchers” in the Essential Science Indicators database (20%),
— the number of articles published in the Nature and Science journals (20%),
— the number of publications indexed in the Science Citation Index, Social Sciences Citation Index, and the Arts and Humanities Citation Index databases (20%),
— and the size of the university (10%).

Number of publications

– Scientific performance can be estimated by the number of publications. Because the work demands and role of works of different kinds are different, this is often done by categorizing them into categories.
— Such categories include books, book chapters, articles in foreign language journals, non-revised articles, maps, digital media, educational articles, web articles, etc.

Citation of publications

— The significance of a publication can also be estimated by counting other publications referring to the source work. Likewise, the total number of citations received by a scientific paper may indicate the significance of a researcher's work.
— Self-citation (that is, when referring to another work of the author in his own work) usually is not considered important. If the authors of an article are XY and ZZ, then a citation is referred to as a dependent citation of XY when their jointly written articles are quoted by ZZ in another article published independently of XY.
— Usually only the number of independent citations is analyzed, in which case there is no common person within the authors of the referenced work and the authors of the referenced work.

Citation of publications

— The number of citations can only be interpreted for reference works that are formally published. The number of references in non-published works, such as manuscripts and theses, is irrelevant in this respect.
— Reference lists of the world's most prestigious international journals are processed, for example, by the ISI Web of Science or the Scopus Database.
— An open-access, and therefore increasingly popular, but highly questionable system, launched under the name of Google Scholar. Using its database, the quotation of different researchers can be examined within the scope of the particular indexing service.
— Many researchers also have an own list citations of their papers, which can give you different results than mentioned above.

Impact factor (Garfield Index), MCQ

— An important indicator for journals is the journal quotation index.
— The impact factor is the average quotation of the articles published in 2 consecutive years of a reviewed journal in proportion to the number of articles in the next 3rd year.
— The IF value is calculated based on the databases of Thomson Institute for Scientific Information (ISI).
— The impact factor of journals changes year after year. In a specific case, the value for the year of publication of the article is, in the absence thereof, the most recent value.

— The MCQ (Math Citation Quotient) is the average citation in 5 consecutive years of a journal in proportion to the number of articles in the next 6th year.
— MCQ is calculated based on MathSciNet databases.

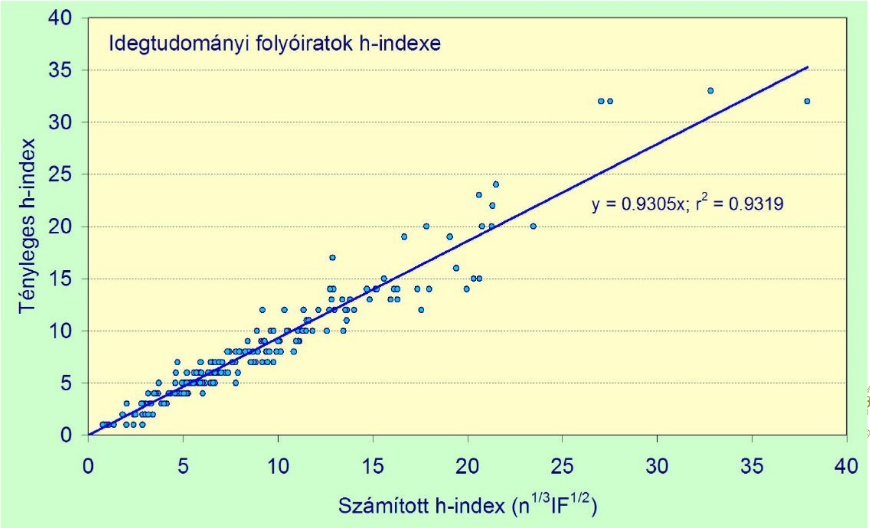
Impact factor (Garfield Index)

The authors generally try to publish their articles in the highest possible impact factor journal, because they can hope for more references on the one hand and, on the other hand, professional journals are usually more prestigious. This is based on the fact that the cumulative impact factor values are commonly used for authors' work or their work as a whole, though this is contrary to the original purpose of introducing this metric.

Hirsch Index

—- Definition "The Hirsch index is h if the researcher has exactly h articles that have received at least h citations (i.e., the other articles received less than h citations)." Therefore, a high h-indexed researcher has published a lot of articles.
— In research practice, the values 6-7 of the h index are relatively easy to achieve, but the further increase of the index from here is difficult. The value 20 for the h index is a remarkable achievement internationally.
— The h index, the number of publications (n) and the average quotation (x), has a surprisingly simple connection: $h \approx n^{1/3}x^{1/2}$. This also shows that although the h index is based on a surprisingly original statistical idea, essentially does not offer a new, independent evaluation criterion.

The *h* index of journals in neuro science



The highest *h* index journals

Rang (h)	Folyóiratcím	h-index	n	IF	Rang (IF)
1	NATURE	85	1828	30.979	8
2	SCIENCE	79	1829	29.162	11
3	NEW ENGL J MED	70	753	34.833	5
4	CELL	57	693	26.626	17
5	LANCET	50	1091	18.316	28
6	P NATL ACAD SCI US	48	5490	10.272	81
7	JAMA-J AM MED ASSOC	46	754	21.455	22
8	NAT MED	44	307	30.550	9
9	CIRCULATION	42	2040	11.164	72
10	J BIOL CHEM	42	12895	6.482	179
11	NAT GENET	41	389	26.494	18
12	NAT IMMUNOL	40	266	28.180	12
13	NAT REV MOL CELL BIO	39	147	35.041	4
14	NAT CELL BIOL	37	358	20.268	24
15	GENE DEV	37	549	17.013	34

Rang (h)	Folyóiratcím	h-index	n	IF	Rang (IF)
16	MOL CELL	37	480	16.835	35
17	J EXP MED	37	616	15.302	39
18	J CLIN ONCOL	37	1065	10.864	73
19	J CLIN INVEST	36	703	14.307	44
20	BLOOD	36	2320	10.120	83
21	CANCER RES	35	2450	8.649	105
22	J IMMUNOL	35	3477	6.702	167
23	ASTROPHYS J	35	4815	6.604	169
24	CHEM REV	34	280	21.036	23
25	J AM CHEM SOC	34	5007	6.516	174
26	ANNU REV IMMUNOL	33	50	52.280	1
27	NEURON	33	667	14.109	46
28	EMBO J	33	1387	10.456	80
29	ANGEW CHEM INT ED	33	1952	8.427	108
30	NUCLEIC ACIDS RES	33	1519	6.575	171

Co-authors

— Most works are no longer written by a single man, but by a smaller or larger group of authors. The order of authorship often expresses the degree of individual contribution but is often unsuitable for this. The first author's position is more prevalent than the middle of the list. The last authorship often refers to a "senior" situation, he is the senior authority of the profession who has started and supported the younger people in the work.
— There is no general rule for computing the rank and value of publications by considering the number of co-authors. Often the co-author's performance is the full value of the joint work. Strange situations may arise if, for example, all employees in a department account for 100% of the jointly published work, and then aggregating the individual performance of the staff to compute the departmental performance, this publication will be multiplied by its value.
— It is difficult to interpret the co-authorship if a publication has hundreds or perhaps thousands of co-authors.

Problems with the metrics of scientometry

– In fact, metrics can only estimate the international value of work. But a significant part of the scientific work is a so-called regionally important one. ”Hungaricum”, for example, the protection of the Hungarian landscape, the cultivation of Hungarian language is unduly undervalued in such measurement attempts.

— The numerical value of available results in different disciplines is very different, and the performance is therefore not comparable. For example, in the medical sciences and in the natural sciences, the rules are clearer; a significant result can be more easily described by citations.
— In social sciences - for example, in legal science - the outcome of a research is only interesting in the particular country.
— In medicine, the papers have typically five-six co-authors and are few pages long. In legal science, the papers have one author and are 15 page long with lengthy bibliography.

Problems with the metrics of scientometry

There are special-specific performances, for example in the case of a plant breeder, the number of plant varieties he has created, accepted and cultivated. There are also secret, confidential, internal expert work for business, government or military reasons, which by their very nature can not be published. Therefore, these achievements can not be compared to achievements in other areas.

The failure to publish results sometimes does not reflect the shyness of research but the mistakes of editors and opponents. For example, when Edward Jenner discovered one of the most devastating diseases of humanity, vaccination against smallpox, he wanted to publish his study on the most prestigious forum of his age. In the rejection letter received from the Royal Society of London, it was: ”The Member of the Company should be cautious and should not risk its appreciation by submitting something to the learned body, which is so different from the accepted knowledge, and it is so incredible.”

Reasons to use the metrics of scientometry

— The metrics allow researchers to show their employer that their work is competitive in domestic and international comparisons.
— Heads of institutions can show policy makers that their institution works well and produces a competitive product.
— Political decision-makers can finally persuade voters that the money spent on science is not a waste of money.
— Although using a single metric could be misleading and biased, but taking multiple different measurements into consideration will give an approximate estimate of real performance.

Reasons to use the metrics of scientometry

— Regional research is usually of a practical nature, according to scholars of science metrics that these should be paid by economic actors. Then, their cultivators will no longer be offended by the fact that the science metrics are mainly based on basic research.
— According to a further argument to science metrics, most of today's researchers do not work on radically new discoveries as Albert Einstein once did. It is unclear that if non-scientific decision-makers do not distribute available money, positions and other resources on the basis of the above principles, then what other principles should they use.

Predator journals

Open-access journals that publish articles in a questionable (un-reviewed, for money, unedited) a way are called predator journals. Their ever-expanding Jeffrey Beall lists can be found at: https://scholarlyoa.com/

Publishers	
Year	Number of publishers
2011	18
2012	23
2013	225
2014	477
2015	693
2016	923

Standalone journals	
Year	Number of journals
2013	126
2014	303
2015	507
2016	882

Hijacked journals

Wikipedia: A hijacked journal is a legitimate academic journal for which a bogus website has been created by a malicious third party for the purpose of fraudulently offering academics the opportunity to rapidly publish their research online for a fee.

In 2012, cyber criminals began hijacking print-only journals by registering a domain name and creating a fake website under the title of the hijacked journals. The first journal to be hijacked was the Swiss journal Archives des Sciences. In 2012 and 2013, more than 20 academic journals were hijacked. In some cases, forgers find their victim in conference proceedings, extracting authors' emails from papers and sending them fake calls for papers.

In 2016, there were 101 hijacked journals discovered.