Scientific profiling instead of bibliometrics: Key performance indicators of the future

Author(s):
Ball, Rafael

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A slice of history

Bibliometrics originally developed from the notion of supporting librarians in their task of selecting optimum literature and optimising holdings management. Not only was this the basic idea of the first bibliometric analyses, it was also the approach adopted by Eugene Garfield, the American chemist and founder of the first bibliometric index, the Science Citation Index (SCI), in the 1950s.

Cole and Eales gave us the first bibliometric analysis. In 1917 the authors studied which books on human anatomy had been published between 1550 and 1860 [2]. As this analysis purely measured the output on a particular topic, however, it was not yet a citation analysis.

The first bibliometric analysis to study citations was conducted by Gross and Gross in 1927 [3]. The authors analysed citations made in footnotes in the field of chemistry, which enabled them to compile a ranking of the key chemical journals of the time based on how frequently they were cited. On the one hand, the chemistry community used this information to assess the important publication organs, which is in keeping with the fundamental concept of journal rankings and the impact factor that is so important today. On the other hand, Gross and Gross were librarians and intended to help libraries in the procurement of journals with their study. In their analysis, they detected an irregular distribution of citations among the various journals and thus provided the basis for Bradford’s law, which was developed in 1934 and according to which key scientific publications are concentrated on a handful of core journals.

Again, these analyses pursued the sole purpose of obtaining information on science and its processes rather than compiling quantitative rankings, for instance. Russian science philosopher Gennady Dobrov defined this kind of research in his book Nazka o Nauke (“The Science of Science”) in 1966 [4].

Nothing changed in this bibliometrics objective until after the Second World War. It was not until the 1950s that the aforementioned Eugene Garfield systemised the quantitative measurement of scientific output by founding his Institute of Scientific Information (ISI), thereby paving the way for today’s citation indexes.

This was the beginning of the age of the classic indicator canon in bibliometrics. The original aim of supporting libraries in managing their holdings was soon forgotten and the Science Citation Index initially developed into a research tool for content-based literature searches, then an instrument for the quantitative measurement of scientific output. This process took many decades. Thanks to the Science Citation Index, what DeSolla Price explained in his book Little Science, Big Science was now possible, namely to apply the tools of empirical science to the sciences themselves. “Why not apply the tools of empirical science to science itself? Why not measure, compile broad hypotheses and draw conclusions? [5]

Metrics in Research

Rafael Ball
ETH Zürich, ETH-Bibliothek

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“Everyone is graded. Lovers by lovers under a veil of silence; traders by vociferous customer complaints; the media by quotas; doctors by patient flows; the elected by voter reactions.”
Michel Serres [1]

Bibliometrics and the advent of performance-oriented funding

At first, politics had little interest in using the quantitative results on bibliometric analyses to assess performance or even allocate funding in science and research. However, this eventually changed in the wake of the so-called “Sputnik crisis”, which revealed virtually overnight that the USSR had beaten the industrial nations of the West in the race into space based on scientific results. Politics began to become interested in managing the supply of scientific information and also exploited the quantitative results of bibliometric analyses so that citation-based procedures especially established themselves as the dominant instrument for performance assessment and research evaluation in the exact sciences in the 1980s.

In the process, the use of these indicators developed right down to micro-level for the assessment of individual scientists. Today, the majority of bibliometricists oppose this use on individual people due to the resulting inaccuracies at this aggregation level.

In the classic indicator canon of bibliometrics, which was valid for several decades, the measurement of output (number of scientific results) and its perception (essentially the number of citations ascertained) are at the forefront. These two parameters can then be used to produce rankings which provide a comparison between people, institutions or countries. Moreover, thematic focuses can be generated with the aid of bibliometric citations analyses.
Nonetheless, due to the indirectness of the assessment, these indicators only allow an approximation of the actual performance. Nor does the perception of a publication measured via the number of citations permit a direct conclusion regarding the quality of the scientific results. The actual problem of classic indicators lies in this extremely indirect approximation of the quality of scientific results.

However, this method is well established in the exact sciences and recognised in the scientific community. After all, due to the mass emergence of scientific publications in the last thirty years, decision-makers bank on quantitative support in science management. Nobody can rely on qualitative parameters of a person-based review these days.

This was also more than adequate in the expert communities and barely called into question in the inner circles of the respective disciplines.

The advent of the internet and the future of key performance indicators

The question of the significance of the indirectness of measuring performance indicators was only cast in a new light with the advent of the internet and the mass availability of digital data. At least four conditions have changed somewhat radically:

1. The mass availability of digital data on the internet enables many quantitative parameters to be evaluated automatically and provided in the form of pattern recognition.
2. The internet has created new public spheres that receive scientific results. Not only does a discipline’s inner circle perceive the publications for longer, but also in different aggregation forms, and broad sections of the public can participate in the results from science and research via digital media. This widens the definition of the perception and the significance of the scientific publications and their authors.
3. In the internet age, scientific findings can be made available extremely swiftly and indirectly. The classic route of publishing in (printed) journals and books is supplemented with or substituted by the different paths in electronic publishing.
4. New communities are also emerging for scientists on a vast range of levels, which are all served and meet and perceive the findings with a varying depth and breadth.

For classic bibliometrics and its indirect indicators, usage statistics (metrics) that gauge the direct use of scientific results in the form of downloads and so-called alternative metrics (altmetrics), which indicates and renders accessible the perception of scientific results and those of the authors, such as via social media in the form of links, storage and recommendations, are now combined. The topic of indirectness (classic bibliometric indicators) is therefore not just nullified; it is also supplemented with direct indicators and might be replaced entirely with the direct visibility of the perception of the perception and use of scientific publications in future.

Moreover, the data source and media form of the scientific publications evaluated have changed considerably: for altmetric or usage measurements, not only do results become important in the written form, but also all forms of scientific “expression”: research data, source texts, source codes, presentations, conferences, self-publications, weblogs, blog entries etc.

For the alternative measurement of scientific output, there are four distinctive forms of use:

1. “Viewed”: activities that gauge the access to scientific articles.
2. “Saved”: the uploading of an article onto a bibliographical programme, for instance.
3. “Discussed”: a used article discussed via a wide variety of social media channels and supplemented by others.
4. “Recommended”: exclusively an activity that recommends a paper for re-use.

This classification of usage results uses different altmetric systems and products, e.g. “article-level metrics [6] by the Public Library of Science (PLOS) or “Impactstory” [7] and more.

The development of bibliometrics clearly reveals that the variety and breadth of the indicators have increased over the decades and that completely new parameters have emerged in the wake of the variety and diversity of the media, which enable the performance, significance and quality of scientific results and their authors to be gauged.

In future, scientists and institutions will be given a whole series of scores, which not only yield a more complete picture of the scientific performance, but also the perception, behaviour, demeanour, appearance and (subjective) credibility. Whether we find this a good thing or not, it is in keeping with the kind and possibilities of evaluation in the digital web age of the twenty-first century.

The next development reveals a tendency towards comprehensive data acquisition and its evaluation. Under the umbrella term “analytics”, it is possible to collect and analyse increasingly large and diverse amounts of data on the web. With big data, new nexuses are being uncovered that nobody had even conceived or called for before.

“As a consequence, an increasing amount of data on every single one of us is available – including from areas of our private lives. The image of the transparent customer and transparent citizen is certainly no longer a vision of the future; it has become a reality [8].

And the image of the transparent scientist, too.

A score like the one that has long existed for the evaluation of scientific efficiency, especially in allocating credits, can then be transferred to science.

The new h-index, which is supposed to determine the significance of a scientist’s publications as a simple indicator, is obsolete and can be replaced by a digital “scientist score”: a value that considers and combines a scientist’s complete data available online. This kind of profiling is another trend, to which bibliometrics will greatly add. If vast amounts of (per
sonal and institutional) information on scientists, which can be compiled and evaluated via a search algorithm, is available, before long this data will yield indications as to the output and performance of these individuals.

A series of analytical tools already exist on the market, such as PLUM Analytics [9], Figshare [10], InCites [11], or SciVal [12], which adopt an integrated management approach and offer performance, financial, personal and publication data for decision-makers in science and research.

Data from classical bibliometrics will then only be a small part of a comprehensive data evaluation of people and institutions.

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