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Finding a Way Through the Scientific Literature: Indexes and Measures

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INTRODUCTION

Since 1665, when Henry Oldenberg published the world's first scientific journal, the *Philosophical Transactions of the Royal Society*, there has been inexorable growth in the number of scientific journals and number of articles published. Indeed, by the middle of the 19th century the volume of published information was overwhelming scientists:

> About the year 1857 Johannes Müller broke down mentally trying to keep abreast of the literature on physiology. (2)

With the availability of such large quantities of information, it became necessary to find ways through the literature to the most relevant and important documents. Over the last 60 years advances in computer technology have allowed information scientists to construct comprehensive bibliographic databases. The information in these databases has been used to calculate bibliometric measures that help one make broad judgments about aspects of the literature (such as prestige, or impact). These tools have enabled scientists to identify and stay up-to-date with the most important developments in their fields. In this article, we describe the major bibliographic databases for scientific publications and give an overview of some of the most high-profile bibliometric measures, what they mean, and how they can be applied.

INDEXING IN BIBLIOGRAPHIC DATABASES

Thomson Reuters is a large media/information company that provides a suite of bibliographic products under the Web of Knowledge brand, accessible via subscription. These products include the Science Citation Index, Web of Science, and Journal Citation Reports.

The Science Citation Index was created by Eugene Garfield (3) and was originally a product of ISI (Institute of Scientific Information). The Science Citation Index has grown over the years since its initial conception, and in its expanded form currently indexes more than 8200 journal titles. The Science Citation Index also provides data for the Web of Science, which contains article-level information, and Journal Citation Reports, which contains journal-level analysis—including the journal Impact Factor—of the various journals included in the Science Citation Index. Getting a journal into the Science Citation Index (and thus into Web of Science and the Journal Citation Reports, gaining an Impact Factor) involves an application to *Thomson Reuters*, who evaluate the journal based on a number of factors, including peer review, timeliness, citability/impact, and geographical outlook.

PubMed and MEDLINE are freely available bibliometric databases provided by the United States National Library of Medicine.

PubMed is an online database of biomedical journal records and abstracts. Its largest component is MEDLINE, with approximately 5500 titles currently indexed with National Library of Medicine's controlled vocabulary, the Medical Subject Headings (MeSH link to http://www.nlm.nih.gov/pubs/factsheets/mesh.html). MEDLINE is a very selective abstracting and indexing service with a stringent review process: applications for journal indexing in MEDLINE are considered by the Literature Selection Technical Review Committee (LSTRC), which comprises members representing different biomedical specialties. The main criteria for the review are scope and coverage, quality and importance of content, quality of editorial work, production quality, audience, content types, English abstracts, and geographical coverage.

In addition to MEDLINE records, PubMed also contains in-process articles, links to full text content in the online archive

Key words
- Bibliometrics
- Impact
- Indexing
- Prestige
- Usage

Abbreviations and Acronyms
SJR: Scimago Journal Rank
SNIP: Source normalized impact per paper

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PubMedCentral, records of author manuscripts funded by NIH and other funding bodies, and records for a subset of books available from the NCBI BookShelf.

SciVerse Scopus is an abstract and citation database of peer-reviewed literature, available via subscription from the academic publisher and information provider Elsevier. The Scopus database includes approximately 41 million records covering 16,500 peer-reviewed journals from 5000 publishers. Scopus has strong international coverage, with more than half of the records originating from Europe, Latin America, and the Asia Pacific region. The database also includes "Articles in Press"—articles made available in Scopus prior to their official publication date for more than 3,000 journals from publishers including Cambridge University Press, Elsevier, Springer/Kluwer, Karger Medical and Scientific Publishers, and Nature Publishing Group.

Indexing in Scopus is determined by a Content Selection and Advisory Board comprising researchers and librarians who review new journals for inclusion. This helps to ensure relevant titles are not omitted. All titles that conform to academic quality norms, specifically peer review, and are published in a timely manner are considered. Scopus covers titles from all geographical regions, including non-English titles, as long as English abstracts can be provided.

BIBLIOMETRICS

Databases such as the Science Citation Index can be used to calculate document and citation-based measures collectively called *bibliometrics*. These measures have been applied to articles, authors, institutions, and, most commonly, to journals. There are metrics that measure different aspects of performance, including impact, output, and prestige.

Raw Citation Counts

The simplest measure of an article's or a journal's impact is the number of citations it receives. If another article cites a document, one can argue that the document must contain something of value that inspires or adds weight to further work. Following this line of reasoning, the number of citations to a document or journal can be taken as a measure of its impact.

Citation counts can be confounded by a number of factors, such as the time span over which citations have accrued, so one cannot make a valid comparison between documents of different ages. Citing patterns also differ between research fields, so one cannot use citation counts to compare articles or journals across different subject areas. Finally, comparisons between journals can be confounded by the size differences between journals; larger journals that publish more articles tend to accrue more citations over a given period (all other factors being equal), so using raw citation counts to compare either articles or journals is not feasible in the majority of cases.

Impact Factor

The Impact Factor is a simple metric available through Thomson Reuters Journal Citation Reports. It is based on data from the Science Citation Index and related data sources. Devised by Eugene Garfield (3), it is the most famous citation-based measure of journal performance. The Impact Factor is a journal-level metric defined as the number of citations in a given year made to all content that a journal has published in the previous 2 years, divided by the total number of citable items published in the journal in the previous 2 years—in effect citations are counted over a standard time window and controlled for differences in journal size. An important feature of the calculation is that it counts all citations to a journal in the numerator component of the calculation, but in the denominator it only counts documents that are deemed to be of scholarly worth; typically this includes articles and reviews, but may also include other content that meets set criteria (5).

The Impact Factor should only be used to compare journals that publish material on the same subject, because of the differences in citation behavior in different subject areas. It is also unsuitable for assessing individual documents. The Impact Factor is a journal level metric, and because the majority of citations to a journal are made to a minority of the articles (typically 50% of total citations go to less than 20% of articles, and about 50% of articles are responsible for 90% of the citations) (6), the Impact Factor says very little about most of the articles in a given journal.

Lastly, because the calculation of the Impact Factor includes a judgment about whether documents should be counted as scholarly items, and counts citations made from one document to another published in the same journal (self-citations), the Impact Factor is potentially susceptible to manipulation.

There are a number of alternative metrics that address some of the issues with the Impact Factor. Because no one metric can be perfect, alternative metrics enable people to assess a journal from different perspectives.

Impact Metrics

In certain research fields, a large fraction of citations are to documents published more than 2 years before the citation is given. In these fields, the 2-year publication window used in the Impact Factor calculation misses much of the citation activity and thus does not fairly reflect the impact of a journal. The 5-year Impact Factor addresses this by measuring cites in a given year to documents published in the preceding 5 years. As the citations are averaged over a larger number of documents than the Impact Factor, it is also more resistant to distortion resulting from single documents receiving an unusually large number of citations. It is worth noting, however, that changing the publication time window from 2 to 5 years does not tend to change the impact of a journal relative to other journals in the same subject area, because temporal patterns in citation activity tend to be similar across all journals in the same subject area. The 5-year Impact Factor is available through Thomson Reuters Journal Citation Reports.

The source normalized impact per paper (SNIP), created by Henk Moed of the University of Leiden in the Netherlands, is, like the Impact Factor, a measure of the average citation impact of a paper in a journal. The SNIP differs from the Impact Factor in that it includes a correction for variation in citation behavior and database coverage across research fields, which allows one to directly compare any journal to any other, and removes the need to assign journals to subject categories. The SNIP also uses a 3-year publication window so that a greater proportion of total cites made to a journal are

included in the calculation, only counts peer-reviewed documents, and in a crucial difference to the Impact Factor, only counts citations made to peer-reviewed documents. The SNIP is based on data from Scopus, and is freely available from www.journalindicators.com and through the Scopus database directly.

The H-index, devised by the physicist Jorge Hirsch in 2005 (4), is an impact metric that takes a different approach. Rather than assessing citations over a set time period, with a calculation that controls for number of documents, the H-index was conceived as a means of assessing the output of an author, incorporating information on the number of papers they have published and the impact of these papers. The H-index is defined as follows: *A scientist has index* h *if* h *of [his/her]* N_p *papers have at least h citations each, and the other* (N_p − h) *papers have at most* h *citations each* (4).

Although originally intended for authors, the H-index can be calculated for any set of documents, for example, the publication output of a country, an institution, or for that matter the output of a journal. The H-index offers a different perspective to other impact metrics, and it can be used to assess the whole content of a journal, which gives a more historical perspective, and also reflects the age, size, and publication rate of a journal.

Prestige Metrics

The Scimago Journal Rank (SJR) is a metric based on data from Scopus that was developed by Felix de Moya at the University of Granada, Spain. It differs from the Impact Factor in that it counts citations in a given year to documents in a 3-year publication window and it weights citations: not every citation is counted equally but is assigned a greater or lesser value based on the SJR of the journal giving the citation. Measures based on this principle are often referred to as "prestige" metrics: they attempt to measure a journal's reputation within the community by looking at where citations are originating. Google PageRank uses a similar principle to rank web pages according to links between pages. The SJR values are available free at www.scimagojr.com and are also included in the Scopus database.

The Eigenfactor score, based on data from Thomson Reuters Journal Citation Reports and developed by Carl and Ted Bergstrom of the University of Washington, is a prestige metric similar to the SJR. It differs from the SJR in some specifics of the calculation, the use of a 5-year publication window, and because it does not include citations between two documents published in the same journal (a behavior called journal-level self-citation). Eigenfactor scores are freely available at www.eigenfactor.org and are also included in Thomson Reuters Journal Citation Reports.

Usage Data

A major limitation of citation-based metrics is that they tend to be backward looking; there is typically a lag between the publication of a document and the first time it is cited, which is why most metrics focus on documents published between 1 and 5 years ago.

With the near ubiquity of online access to journals, download or usage data may provide a more immediate means of assessing the performance of a journal. Researchers are developing robust ways of using usage data to assess journals. We are likely to see a number of metrics that are analogues of the various citation metrics, with two advantages: usage metrics have the potential to be instantaneous, showing which journals are receiving attention based on current content, and they can capture the impact of documents on sectors of the readership who are invisible to citation metrics. These will be nonpublishing readers, such as medical practitioners, who value the material being published by a journal for staying up-to-date in their field, but who are not active in research.

CONCLUSION

Bibliographic indexing and bibliographic databases are powerful tools that enable the organization of, and navigation through, the huge quantity of published scientific research. There are a number of different databases, each with different strengths, and they are becoming increasingly powerful and easy to use, freeing up time for research that would have otherwise been spent searching the literature.

Complementing bibliographic databases are bibliometrics—measures of the impact and prestige of published material, that allow one to further streamline the use of scientific literature. A number of alternative metrics are available and there is growing recognition of the need to use more than one metric to evaluate a journal's performance (1). We must also recognize that citation-based metrics are backwards looking and view citations positively—they assume that if you cite a document this is generally because it contains useful information, although in reality citations can be negative; for example, an article that disputes the results or theories in another document will still cite the document.

Looking to the future, usage data will provide a complementary means of evaluating journals that will cover a broader section of the readership and give a more current view of the attention a journal is receiving.

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