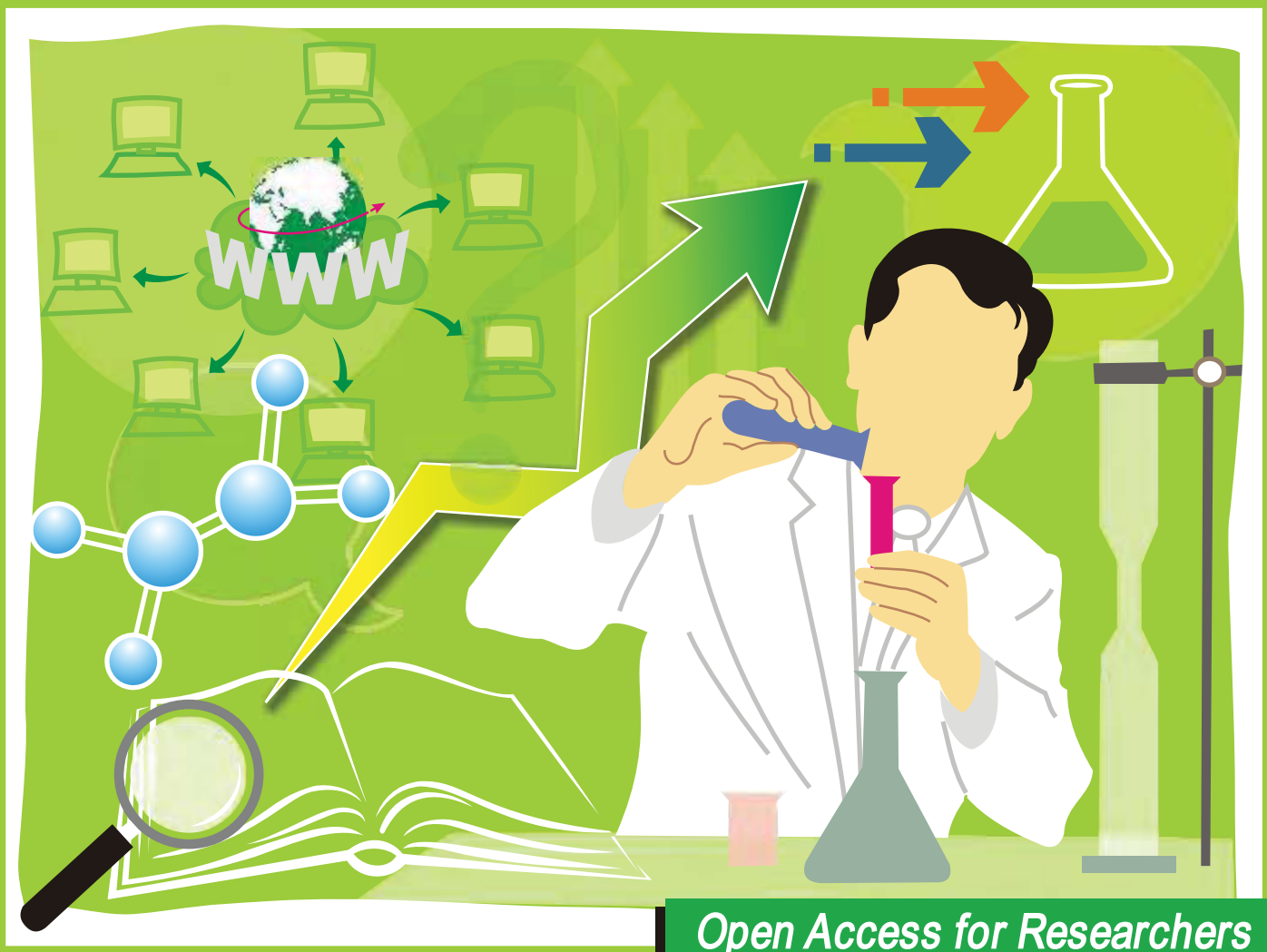
United Nations
Educational, Scientific and
Cultural Organization

4

Research
Evaluation Metrics



Open Access for Researchers

United Nations
Educational, Scientific and
Cultural Organization

Research Evaluation Metrics

Module

4

Research Evaluation Metrics

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MODULE INTRODUCTION

At present**,** research is going on all over the world practically in all subjects and generating millions of research articles and other documents. In some cases, the research works are generating very good results, in most cases mediocre, and in some cases negative results. Basing research results, awards, fellowships, promotion, selection for a job, etc are decided. For all these, evaluation of research output becomes sine qua non.

Centuries ago when the number of researchers were less, peers used to evaluate research. With the passage of time, the number of researchers increased, research areas proliferated, research output multiplied. The trend continued and after World War II the research workers and their outputs started growing exponentially. Today even on a moderate estimate there are around or more than one million researchers and they produce more than two million research papers and other documents per year.

In such a mind-boggling situation, research evaluation is continuously proving to be a tough job. For any award and fellowship there may be scores or hundreds of nominees. From among these, how to select the best candidate has turned out to be a big question. Peer reviews in many cases are proving to be subjective. As a result decisions are getting biased.

In 1963 *Science Citation Index (SCI)* appeared on the scene covering the literature of 1961. A few years hence, Eugene Garfield, the founder of *SCI*, prepared a list of 50 most cited scientists basing first author citation of 1967 *SCI*. The paper titled 'Can Nobel Prize Winners be Predicted?' was presented in 1968 (Garfield & Malin, 1968). In the very next year i.e. 1969, two scientists figuring in the list, e.g. Derek H R Barton and Murray Gell-Mann received the coveted Prize. This vindicated the usefulness of citation analysis. Every year several scientists belonging to the field of Physics, Chemistry, Physiology & Medicine receive the Nobel Prize. If out of a list of 50, two get the award it is no mean achievement for a prediction.

This prediction opened the floodgate of citation analysis as it was free from subjectivity. Even for peers, citation analysis became a useful tool. However, citation analysis was not free from faults. Even Garfield remarked – 'Using citation analysis for evaluation papers is a tricky business. It is fraught with opportunities for error' (Garfiled, 1983).

For research evaluation, some other indicators were needed. Citation analysis along with peer review ensured better judgment in innumerable cases. Something more was needed to make the judgment foolproof to a great extent. The advent of World Wide Web (WWW) provided the opportunity. Quite a number of indicators have come up based on the data available in WWW.

This module dwells on a number of methods (including old and new) available for research evaluation. The module comprises the following four units:

- Unit 1. Introduction to Research Evaluation Metrics and Related Indicators.
- Unit 2. Innovations in Measuring Science and Scholarship: Analytical Tools and Indicators in Evaluation Scholarship Communications.
- Unit 3. Article and Author Level Measurements, and
- Unit 4. Online Citation and Reference Management Tools.

Brief overviews of the units are presented below.

Unit 1 encompassed and discussed citation analysis, use of citation-based indicators for research evaluation, common bibliometric indicators, classical bibliometric laws, author level indicators using authors' public profiles, article level metrics using altmetric tools. It is to be noted that author level indicators and article level metrics are new tools for research evaluation. Author level indicators encompasses h index, citations count, i10 index, g index, articles with citation, average citations per article, Eigenfactor® score, impact points, and RG score. Article level metrics or altmetrics are based on Twitter, Facebook, Mendeley, CiteULike, and Delicious which have been discussed. All technical terms used in the Unit have been defined.

Unit 2 deals with analytical tools and indicators used in evaluating scholarly communications. The tools covered are The Web of Science, *Scopus*, *Indian Citation Index* (*ICI*), CiteSeerX, Google Scholar and Google Scholar Citations. Among these all the tools except *Indian Citation Index* (*ICI*) are international in scope. *ICI* is not very much known outside India. It is a powerful tool as far Indian scholarly literature is concerned. As Indian journals publish a sizable amount of foreign literature, the tool will be useful for foreign countries as well. The analytical products with journal performance metrics *Journal Citation Reports* (*JCR*®) has also been described. In the chapter titled New Platforms for Evaluating Scholarly Communications three websites i.e. SCImago Journal & Country Rank (SJR) [ScimagoJR.com], eigenFACTOR.org, JournalMetrics.com and one software called Publish or Perish (POP) Software have been discussed.

Article and author level measurements have been discussed in **Unit 3**. Author and researcher identifiers are absolutely essential for searching databases in the WWW because a name like D Singh can harbour a number of names such as Dan Singh, Dhan Singh, Dhyan Singh, Darbara Singh, Daulat Singh, Durlabh Singh and more. The ResearcherID.com, launched by Thomson Reuters, is a web-based global registry of authors and researchers that individualises each and every name. Open Researcher and Contributor ID (ORCID) is also a registry that uniquely identifies an author or researcher. Both have been discussed in this Unit. Article Level Metrics (Altmetrics) has been treated in this Unit with the discussion as to how altmetrics can be measured with Altmetric.com and ImpactStory.org. Altmetrics for Online Journals has also been touched. There are a number of academic social networks of which ResearchGate.net, Academia.edu, GetCited.org, etc. have been discussed. Regional journal networks with bibliometric indicators are also in existence. Two networks of this type such as SciELO – Scientific Electronic Library Online, and Redalyc have been dealt with.

The last unit (**Unit 4**) is on online citation and reference management tools. The tools discussed are Mendeley, CiteULike, Zotero, Google Scholar Library, and EndNote Basic. The features of all the management tools have been discussed with figures, tables, and text boxes.

Written by B K Sen

UNIT 1 INTRODUCTION TO RESEARCH EVALUATION METRICS AND RELATED INDICATORS

Structure

1.0 INTRODUCTION

In an open access world, much importance has been given in using open source tools, open access resources and open solutions to engage authors and researchers in collaborative research, peer-to-peer sharing of scholarly information and collaborative evaluation of scholars' works.

On the other hand, exponential growth of scientific literature also has led to rapid disappearance of produced literature before it actually gets noticed by the scientific communities. No single database can capture this over-grown scientific literature. Several data mining tools are probably required to keep abreast with quantum of produced literature. The social webs, available to the researchers' communities in addition to any other groups of citizens, help the researchers in disseminating their produced or contributed knowledge to global communities. The more you are active in social media, the more you have chances to get noticed by fellow researchers and possible research collaborators. Many personalized web-based services are now increasingly made available targeting global researchers' communities, helping them to enhance their social media presence and visibility.

Thus, research evaluation of a researcher or a research institution or a research group looks into detailed analysis of many aspects of this entity. Figure 1 depicts four important dimensions of research evaluation. These aspects are extremely interrelated and interdependent. Weakness in one aspect will lead to lowering value to other aspect. Research evaluation should be carried out to determine strengths and weaknesses in productivity, visibility, reputation, and impact of scientific researchers or institutions.

In this Module, various tools and techniques are discussed in details to help the researchers in strengthening their efforts in enhancing scientific productivity, visibility, reputation, and impact of their research works.

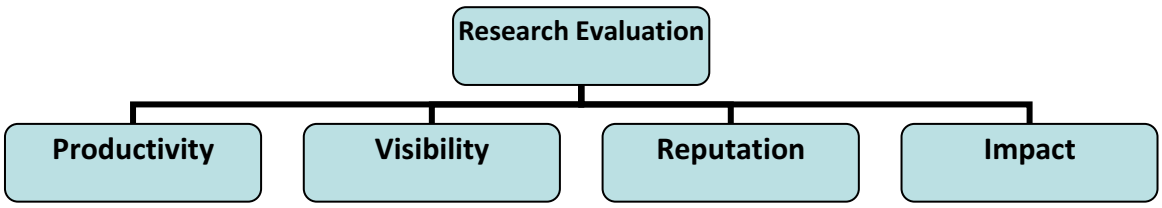

Figure 1: Dimensions of Research Evaluation

1.1 LEARNING OUTCOMES

At the end of this unit, you are expected to be able to

- Describe basic tools used for measurement of scientific productivity and evaluation of research;
- Explain the features of different research evaluation metrics;
- Understand citation analysis, and importance of citations in academic research; and
- Discuss transition from citation-based indicators to author level and article level metrics for research evaluation.

1.2 USE OF CITATION-BASED INDICATORS FOR RESEARCH EVALUATION

After World War II, the measurement or evaluation of research emerged as a key policymaking tool to justify investments in scientific research across the world. This time the world also saw the emergence of cross-border research collaborations, and bilateral, multilateral as well as South-South, North-South, North-North scientific cooperation. International as well as national research collaborations need to assess impact of scientific literature produced by their prospective research collaborators. Measurement of scholarly communications got a new impetus when Eugene Garfield[1] established the Institute for Scientific Information (ISI) in the United States in 1960. Garfield started the first ever citation indexing service for papers published in academic journals. The *Science Citation Index (SCI)* was officially launched in 1964. As defined in the *Glossary of Thomson Scientific Terminology*, "a Citation Index is a bibliographic tool in print or electronic format that lists all referenced or cited source items published in a given time span. … What distinguishes it from other indexes is that it includes all the cited references (footnotes or bibliographies) published with each article it covers". Subsequently, the ISI published *Social Sciences Citation Index (SSCI)* from 1972 and *Arts & Humanities Citation Index (AHCI)* from 1978.

[1] http://en.wikipedia.org/wiki/Eugene_Garfield

Based on wealth of resources available in SCI database, the ISI introduced another tool for ranking academic journals analysing citations they received and impact they percolated into scientific communities. The annual *SCI Journal Citation Reports* was officially launched in 1975. Here, ISI introduced two basic indicators, namely Impact Factor and Immediacy Index. As defined in the *Glossary of Thomson Scientific Terminology*, Impact Factor is "the number of current citations to articles published in a specific journal in a two year period divided by the total number of articles published in the same journal in the corresponding two year period", whereas Immediacy Index is defined as "the average number of times that an article published in a specific year within a specific journal is cited over the course of that same year". Nonetheless, the Impact Factor is actually Journal Impact Factor (JIF), not exactly measuring contributions of individual scientists. JIF is a collective indicator for a journal, not its authors. Similarly, Immediacy Index is "an indicator of the speed with which citations to a specific journal appear in the published literature. Such information is useful in determining which journals are publishing in emerging areas of research".

From its beginning, the SCI database included details of affiliation of all authors of a journal article. This facilitates analysing research collaborations while publishing journal articles, not only for the sake of paper writing but also in laboratory experimentations. ISI silently observed globalization of scientific research, as recorded in SCI database.

The citation products and analytical tools of ISI facilitated formation of a scientific discipline called Scientometrics and related areas such as Bibliometrics, Informetrics, Webometrics, Patentometrics, and Librametrics. Bibliometrics started in early 20th century also received a tremendous boost. A journal titled *Scientometrics* was launched in 1978, followed by other journals such as *Research Evaluation* (f. 1991), *Cybermetrics: International Journal of Scientometrics, Informetrics and Bibliometrics* (f. 1997), *Journal of Informetrics* (f. 2007), *Collnet Journal of Scientometrics and Information Management* (f. 2007), *Journal of Scientometric Research* (f. 2012), besides a few other multidisciplinary journals covering scientometrics and related subject areas.

In the first era of scientometric studies, citation analysis was the predominant method for analysing scientific productivity of individual scientists or research institutions or countries. Research performance of an individual was measured in terms of citations an author's works received, journal's rank or journal impact factor wherein an author's works appeared ~~in~~, and collaboration matrix of collaborating authors. An institution or a country was similarly measured.

In an era of electronic publishing of academic journals (e-journals) as well as online social networking, things have changed very dynamically. Many dimensions of scientist's contributions, influence and impact of research are looked into, as scientific communities are now matured enough to go beyond the conventional bibliometric indicators such as citations count, journal impact factor, immediacy index, etc. Influence of an individual within scientific

communities can be measured in various ways. Recently in 2012, the San Francisco Declaration on Research Assessment (DORA[2]) elaborated some provisions of research evaluation for individual researchers, transition from counting citations based on journals impact factor to counting influence an individual scientist made. A number of research funding agencies have already supported this declaration and they are going to use alternative metrics (or altmetrics) more conclusively.

In the following Sections we shall learn basics of conventional research measurement tools and their applications in evaluation of scientific research.

1.2.1 Citation Analysis

Harrod's Librarians' Glossary defines citation as "a reference to a text or part of a text identifying the document in which it may be found". Citations are usually found in the list of references mostly with full bibliographic details and generally placed at the end of an article or chapter or as footnotes.

Authors cite other authors for different reasons, such as, (a) giving credit (i.e. identifying antecedents and original publications in which a fact, idea, concept or principle was first published); (b) previous work (i.e. identifying general documents related to the topic; presenting previous results; announcing future work; commenting, correcting or criticizing previous work; identifying methodology, equipment, etc.); (c) authority (i.e. substantiating claims and persuading readers; authenticating data and other results, or identifying the results by others supporting the author's work); and (d) social factors (i.e. citing prestigious researchers; citing work by the author's graduate students, fellows and co-workers to increase their visibility; 'perfunctory' citations) (Campanario, 2003).

Citation analysis is a very important method in measuring impact of scientific publications, and more particularly citation analysis helps in identifying role of highly cited papers in expanding universe of knowledge, formation of new scientific disciplines and strengthening scientific communities.

Self Citation

In scientific communication, authors not only cite others' works but also cite their own works earlier authored by themselves. This phenomenon is known as self citation. Author self-citation occurs when an author cites his earlier published works in his forthcoming paper. Whereas, journal self-citation occurs while an author of a journal paper cites other articles from the same journal. In the articles published in the journal A, if there are references to the same journal, then they are all journal self citations.

Both author self citations and journal self citations are valid in scientific discourses, with a threshold limit. Beyond a point it may raise undesirable attention of paper reviewers, information analysts and others from the research evaluation perspectives.

[2] http://am.ascb.org/dora/files/sfdeclarationfinal.pdf

Cited Half-Life and Citing Half-Life

All references cited by an author in an article are not of the same year. If you scan a paper from a journal of humanities or social sciences, you may find some references published even decades ago. The cited half life of an article is the median age of the items cited in that article. Half (i.e., 50%) of the citations to the article are to items published within the cited half-life. Similarly, the cited half-life of a journal is the median age of its items cited in that journal. Half (i.e., 50%) of the citations to the journal are to items published within the cited half-life. It should be noted that the half life is always calculated from the latest year backwards.

Similarly, the citing half-life of a journal is the median age of articles cited by the journal in a calendar year. For example, in the 2012 *Journal Citation Reports (JCR*), the journal *Annual Review of Psychology* has a citing half-life of 9.0. That means 50% of the items cited in *Annual Review of Psychology* in 2012 were published between 2004 and 2012 (both years inclusive).

There are many terms commonly used in citation analysis and related techniques. Some of citation-related terms, popularly used for measurement of science and evaluation of scientific research, are listed in Table 1.

Table 1: Citation Related Terms

Term	Short Definition
Author Self-citation	Author self-citation occurs when an author cites his own work published earlier or going to be published in future.
Bibliographic coupling	It is a measure that uses citation analysis to establish a similarity relationship between documents. It links two papers that cite the same article, so that if papers A and B both cite paper C, they may be said to be related, even though they don't directly cite each other. The more papers they both cite, the stronger their relationship is.
Citation Network	It is a one-way or two-way network analysing relationship between citing and cited references or authors.
Citations Count	It is a simple method of counting total citations received by an earlier published article, with data obtained from a citation database.
Cited Half Life	It is the number of years, going back from the current year, that account for 50% of the total citations received by the cited journal in the current year.
Citing Half-Life	It is the number of journal publication years , going back from the current year that account for 50% of the total citations given by the citing journal in the current year.
Co-citation coupling	It is a method used to establish a subject similarity between two documents. If papers A and B are both cited by paper C, they may be said to be related to one another, even though they don't directly cite each other. The more papers cite A and B, the stronger their relationship is.
Co-citation network	It is a network analysing instances of co-citation coupling.
Journal self citation	It is an instance in which an article published in a journal has cited a previously published article in that same journal.
Self citation	It can an instance in which an article published in a journal has cited a previously published article in that same journal, or it can be an instance in which an author cites his own work published earlier or forthcoming. Self-citation can be of two kinds: journal self-citation or author self-citation.

1.2.2 Concepts of Bibliometrics, Scientometrics Webometrics, etc.

A number of terms are commonly used in defining different approaches of research evaluation and measurement of scientific productivity. Many of the terms are ~~cor~~related as each one addresses a typical aspect of scholarly communications. Table 2 shows an indicative list of terms frequently used as research evaluation metrics. Each term defines a set of methods for a particular type of resources or applications. Some of the terms are used interchangeably to broadening or narrowing scope of research evaluation.

Table 2: Frequently Used Terms Used as Research Evaluation Metrics

Term	Short Definition
Bibliometrics	Bibliometrics is a set of methods to quantitatively analyse academic literature and scholarly communications.
Informetrics	Informetrics is the study of quantitative aspects of information. This includes the production, dissemination, and use of all forms of information, regardless of its form or origin.
Scientometrics	Scientometrics is the study of quantitative features and characteristics of science, scientific research and scholarly communications.
Webometrics	Webometrics is the study of quantitative features, characteristics, structure and usage patterns of the world wide web, its hyperlinks and internet resources.
Cybermetrics	Cybermetrics is an alternative term for Webometrics.
Librametrics	Librametrics is a set of methods to quantitatively analyse availability of documents in libraries, their usage and impact of library services to its user community.
Patentometrics	Patentometrics is a set of methods to quantitatively analyse patent databases, patent citations and their usage patterns.
Altmetrics	Altmetrics is new metrics proposed as an alternative to the widely used journal impact factor and personal citation indices like the h-index. The term altmetrics was proposed in 2010, as a generalization of article level metrics, and has its roots in the twitter #altmetrics hashtag.
Article Level Metrics (ALM)	Article level metrics is an alternative term for Altmetrics.

Applications of Scientometrics and Bibliometrics in Research Evaluation

In the last sixty years, evaluation of public funded research has been carried out globally on a regular basis for performance measurement of different actors of scientific research. Most of the citation databases and citation analysis tools available in today's world have functionalities to instantly generate reports and scientometric profile of a scientist, an institution, a collaborative research group, a country, or a journal. Some of the popular applications of scientometrics and bibliometrics listed below can use report generator tools available with citation-based products and services discussed in Unit 2 of this Module.

- **For Institution/ Collaborative Research Group**: Mapping of collaborations, top collaborating institutions, top collaborating countries,

collaborating with public vs. private institutions, highly cited papers, highly cited authors, top contributing scientists, top publishing journals, scientists with top h-index, top subject categories or research domains, percentage of cited vs. uncited papers, percentage of self-citations, publishing in open access vs. subscription-based journals, comparative study of two or more institutions in a region/ country.

- **For a scientist**: Mapping of collaborations, collaborating institutions, collaborating countries, co-authors, highly cited papers, top publishing journals, percentage of cited vs. uncited papers, percentage of self-citations, author-level indicators such as h-index, i10-index, etc.
- **For a country**: Top contributing institutions, top contributing cities, top contributing states, top research funding agencies, top affiliating apex bodies, mapping of collaborations, top collaborating countries, top collaborating institutions, top contributing scientists, top publishing journals, top subject categories or research domains, percentage of cited vs. uncited papers, percentage of self-citations, highly cited papers, highly cited authors, top scientists with h-index, publishing by public vs. private institutions, publishing in open access vs. subscription-based journals, comparative study of two or more countries in a region or globally.
- **For a journal**: highly cited papers, highly cited authors, percentage of cited vs. uncited papers, percentage of self-citations, top research domains, cited half-life vs. citing half-life, top contributing institutions, top contributing cities, top contributing countries, most downloaded papers, most shared papers, and highly ranked journals based on citation-based indicators.

1.2.3 Common Bibliometric Indicators

There are a number of bibliometric indicators used for research evaluation and performance measurement of journals, institutions, countries and collaborative research groups. These bibliometric indicators are mostly citation-based indicators, traditionally drawn from the citation databases such as *Science Citation Index (SCI), Social Science Citation Index (SSCI) and Journal Citation Reports (JCR)*. Later, from the beginning of the twenty-first century, web-based citation databases such as Scopus and Web of Science, and citation search engines such as Google Scholar, Microsoft Academic Search and CiteSeer^{X} are frequently used for deriving citation-based indicators. Figure 2 depicts various citation-based indicators, mostly derived from citation databases and citation search engines. Some of the indicators help in analysing co-authors, collaborative institutions and collaborative countries commonly found from affiliation search in any citation database. These indicators are discussed in details with suitable examples in Unit 2 of this Module.

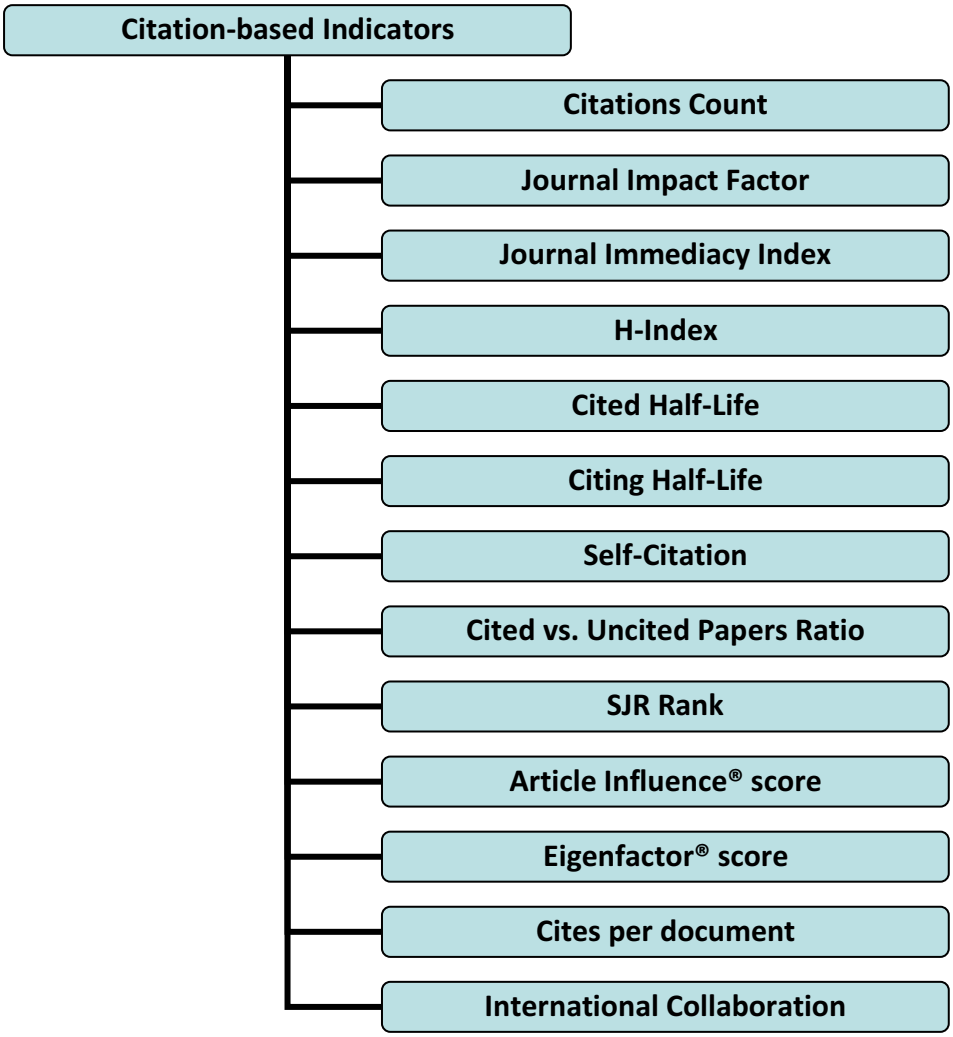

Figure 2: Most Useful Citation-based Indicators, derived from Citation Databases

1.2.4 Classical Bibliometric Laws

Three classical bibliometric laws are widely accepted by the bibliometricians and information scientists in establishing theoretical framework and understanding growth of universe of knowledge or formation of emerging subject areas, as recorded in citation databases. Figure 3 depicts these three classical bibliometric laws. These laws are discussed in details with suitable examples in literature listed in Further Readings at the end of this Unit.

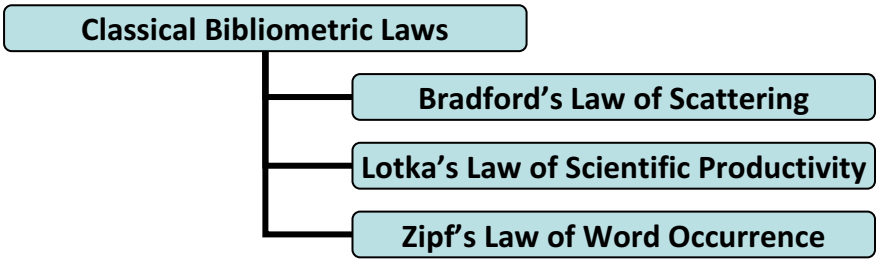

Figure 3: Classical Bibliometric Laws

Bradford's Law of Scattering: Samuel C. Bradford in 1934 found that a few core journals harbour 1/3 of the articles on a given subject, a moderate number of less-than-core journals harbour a further 1/3 of the articles on the subject, and a large number peripheral journals harbour the remaining 1/3 of the articles. He proposed the formula $1:n:n^2$ to describe the phenomenon. However, this distribution is not statistically accurate and it may vary subject-to-subject. But it is still commonly used as a general rule of thumb.

Lotka's Law of Scientific Productivity: Alfred J. Lotka in 1926 in his paper "the Frequency Distribution of Scientific Productivity" found that " … the number (of authors) making n contributions is about $1/n^2$ of those making one; and the proportion of all contributors, that make a single contribution, is about 60 percent". This means that out of all the authors in a given field, 60 percent will produce just one publication, and 15 percent will produce two publications, 7 percent of authors will produce three publications, and so on. According to Lotka's Law of scientific productivity, only six percent of the authors in a field will produce more than 10 articles. However, this distribution is not statistically accurate and it may vary subject to subject. But it is still commonly used as a general rule of thumb.

Zipf's Law of Word Occurrence: Harvard linguist George Kingsley Zipf suggested an equation popularly known as Zipf's law that is often used to predict the frequency of words within a relatively lengthy text. Zipf found that the rank of the word multiplied by the frequency of the word equals a constant. Zipf's law, again, is not statistically accurate, but it is very useful for indexers and indexing databases even during the internet era.

Applications of these bibliometric laws are very often found in the early period of scientometric literature and bibliometric studies. However, their applications in web 2.0 or social media-enabled scholarly communications have not been tested adequately, as scientometric research has now moved into different domains and in different directions.

1.3 TRANSITION FROM CITATION-BASED INDICATORS TO AUTHOR-LEVEL METRICS AND ARTICLE-LEVEL METRICS FOR RESEARCH EVALUATION

Emergence of new web-based services as well as new service providers facilitates the new-age researchers with new tools of social networking and collaborative research. Web 2.0 or social media-based products became a boom for researchers across the world reducing dependence on subscription-based services, and increasing dependence on open access or open source-based services. Many commercial academic database companies are now venturing into offering free web services to the researchers. On the other hand, non-profit ventures as well as web services supported by philanthropic foundations are on the rise. They also offer free web services to the researchers. While authors or researchers have access to many value-added

personalized web services, authors-level metrics are on the rise to help researchers to determine their potentials as well as asserting potentials of research collaborators. Now, the innovative value-added personalized web services are helping in transition from citation-based indicators to author-level metrics and article-level metrics for research evaluation. We shall learn more about author-level metrics and article-level metrics in Unit 3 of this Module.

1.3.1 Author Level Indicators Using Authors' Public Profiles

The personalized web-based researchers' profiles help in deriving many performance indicators of researchers, their collaborators and institutions. Innovative new indicators are now extensively focusing on author's works rather than journal's performance, visibility or prestige. Some commonly available author-level indicators are shown in Figure 4. Table 3 shows most useful author level indicators, derived from online researchers' profiles offered by innovative academic social networks and new age web service providers for researchers communities. We learn more about author level metrics in Unit 3 of this Module.

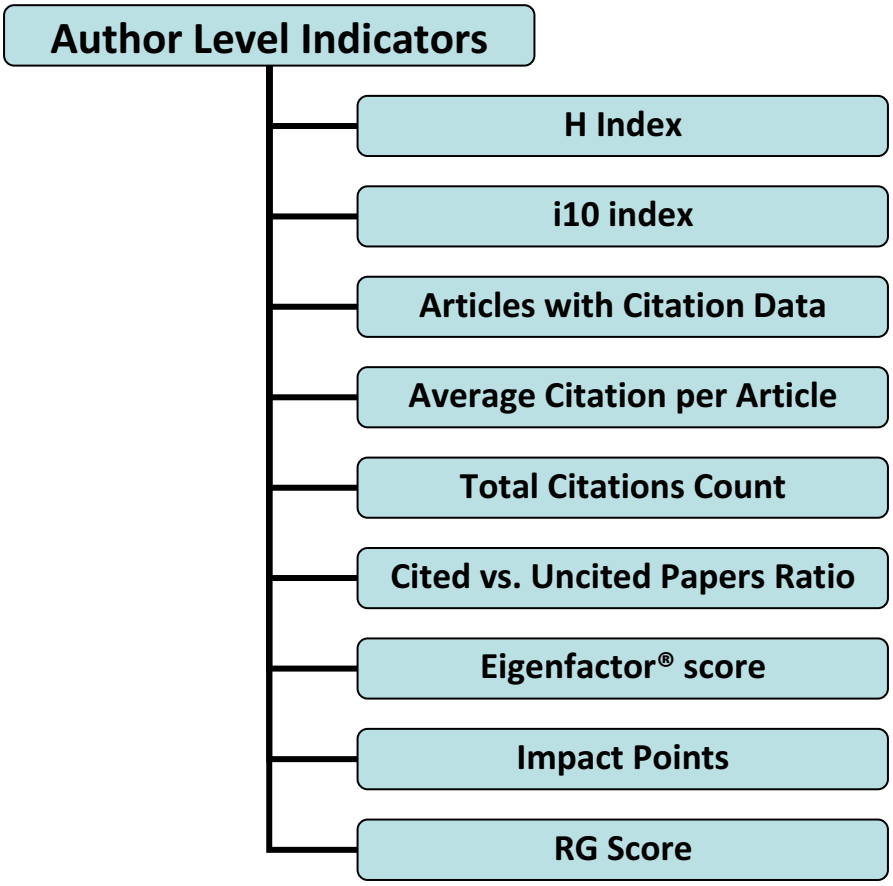

Figure 4: Useful Author Level Indicators, derived from Online Researchers' Profiles

Table 3: Useful Author-Level Indicators, derived from Online Researchers' Profiles

Name of the Indicator	Data Source	Researchers' Profiles/ Tools Used
H Index	Google Scholar, Web of Science, Scopus	Google Scholar Citations, ResearcherID
Citations Count	Google Scholar, Web of Science, Scopus	Google Scholar Citations, ResearchGate
i10 Index	Google Scholar	Google Scholar Citations
g Index	Google Scholar	PoP Software
Articles with citation	Web of Science	ResearcherID
Average citations per article	Web of Science, Google Scholar	ResearcherID, PoP Software
Eigenfactor® score	Web of Science	Social Science Research Network (SSRN)
Impact Points	ResearchGate	ResearchGate
RG Score	ResearchGate	ResearchGate

1.3.2 Article Level Metrics Using Altmetric Tools

Although, many scholarly journals are indexed in world's renowned citation databases such as *Web of Science* or *Scopus*, not every paper published by these journals is lucky enough to get cited by other scholarly papers in successive years. Attracting citations for a published paper is not easy, if not impossible. The online journals and open access journals have liberty to track its online usage through statistics of downloads and HTML views. Thus, they have means to track an alternative measure of article usage.

Innovative new age online journal publishers got interested in deriving article metrics for every published article in their portals. They make these download and usage statistics public in the respective page of article to indicate popularity or acceptance of said article. Some journals started tracking of articles' 'share' in popular social media and social bookmarking websites such as Twitter, Facebook, Mendeley, CiteULike, and Delicious, to mark the articles' popularity or acceptance. This led to the development of article level metrics or altmetrics as an indicator of scholarly communications.

A leading online journal publisher – PLOS[3] (Public Library of Science) had shown its interests in article level metrics in 2009 and started showing this metrics in every article. A statement titled "Altmetrics: A Manifesto"[4] was published in 2010 for streamlining development around the article level metrics. We shall learn more about author level metrics in Unit 3 of this Module.

[3] http://www.plos.org/
[4] http://altmetrics.org/manifesto/

1.4 LET US SUM UP

In this Unit, you have learned about different methods and techniques used in evaluating research, measurement of science scientific communities and scientific communications. Some of them are commonly described as research evaluation metrics. Historically, main tools used for research evaluation are citation analysis and citation indexes. Emergence of interactive social network and social media marks arrival of personalized web-based indicators for measuring social impact and outreach of every piece of scholarly work, and its producers – authors and institutions.

When an author shares his 'just published' research paper in social media, personalized researcher's profile and online forums, it comes with much higher possibilities of getting read or noticed by co-researchers working in the same or allied research areas.

Thus, author level metrics and article level metrics are built upon counting social 'share', 'saved', 'discussed' and 'cited' data sources available through different social webs. You will learn more about citation-based analytical tools and indicators for evaluating scholarly communications in Unit 2, article and author level measurements in Unit 3 and how to use online reference managers in Unit 4 of this Module.

1.5 CHECK YOUR PROGRESS

1) Identify five key citation-based indicators for journals.

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2) Identify five key author-level indicators for evaluating author's productivity.

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3) Identify names of three common bibliometric laws.

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4) Where can you find H-Index of an author?

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5) Where can you find g-Index of an author?

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6) Choose the correct answer of the following:

a) Which Citation Index was introduced first?
   i) Science Citation Index
   ii) Social Science Citation Index
   iii) Arts & Humanities Citation Index
   iv) Data Citation Index

b) Where can you find Impact Points of an author?
   i) ResearchGate
   ii) ResearcherID
   iii) SSRN
   iv) Scopus

c) Which company did introduce *Science Citation Index*?
   i) Thomson Reuters
   ii) Institute for Scientific Information
   iii) Elsevier
   v) Springer

d) Which journal publishers did introduce article level metrics?
   i) JoVE
   ii) eLIFE
   iii) PLOS
   v) Biomed Central

e) Where can you find i10-Index of an author?
   i) Google Scholar
   ii) ResearchGate
   iii) Scopus
   vi) Google Scholar Citations

ONLINE VIDEO TUTORIALS

There are a number of video tutorials available on topics discussed in this Unit. Some of the tutorials were developed by the organizations responsible for the respective products or services, while some others were developed by reputed scientists and libraries. Now, you learn more about how these products can be used for measurement of articles and contributors.

- *Academic Visibility and the Webometric Future* **Video**[5]
- *Alternate Routes: Journal Metrics Revisited* **Video**[6]
- *Citation Analysis and Bibliographies* **Video**[7]
- *Citation Indexing* **Video**[8]
- *Eugene Garfield on H-indexes and Impact Factors* **Video**[9]
- *Eugene Garfield on Impact Factors* **Video**[10]
- *H-Index: A Measure of a Scientist's Impact* **Video**[11]
- *Impact Factor and other Bibliometric Indicators* **Video**[12]

[5] http://www.youtube.com/watch?v=IRLo_VyBMIo
[6] http://www.youtube.com/watch?v=B7WRbybStps
[7] http://www.youtube.com/watch?v=UK8gEe7y_mk
[8] http://www.youtube.com/watch?v=uYTZouNlxWo
[9] http://www.webofstories.com/play/eugene.garfield/71
[10] http://www.webofstories.com/play/eugene.garfield/38
[11] http://www.youtube.com/watch?v=P47yAH8yz9U
[12] http://www.youtube.com/watch?v=Pmw9KKpuqFU

ANSWERS TO CHECK YOUR PROGRESS

UNIT 1

6-(a) i,
6-(b) i,
6-(c) ii,
6-(d) iii,
6-(2) iv.

UNIT 2

6-(a) ii,
6-(b) i,
6-(c) i,
6-(d) iii,
6-(ej) ii.

UNIT 3

(1) iv,
(2) iii,
(3) ii,
(4) ii,
(5) iv.

UNIT 4

(1) i,
(2) iii,
(3) ii,
(4) i,
(5) iii.

GLOSSARY OF TERMS

Term	Definition
Altmetrics	Altmetrics is a new metrics proposed as an alternative to the widely used journal impact factor and personal citation indices such as h-index. The term altmetrics was proposed in 2010, as a generalization of article level metrics, and has its roots in the twitter #altmetrics hashtag.
Article Influence Score (AI)	It determines the average influence of a journal's articles over the first five years after publication. It is calculated by dividing a journal's Eigenfactor score by the number of articles in the journal, normalized as a fraction of all articles in all publications. The mean AI is 1.00. A score greater than 1.00 indicates that each article in the journal has above-average influence. A score less than 1.00 indicates that each article in the

[58] http://vimeo.com/49328590

	journal has below-average influence. (Source: Thomsonreuters.com)
arXiv	It is an e-print service in the fields of physics, mathematics, computer science, quantitative biology, quantitative finance and statistics.
Author Self-citation	Author self-citation occurs when an author cites his own work published earlier or going to be published in future.
Bibliographic coupling	It is a measure that uses citation analysis to establish a similarity relationship between documents. It links two papers that cite the same article, so that if papers A and B both cite paper C, they may be said to be related, even though they don't directly cite each other. The more papers they both cite, the stronger their relationship is.
Book Citation Index	It allows users to search seamlessly across books, journals and conference proceedings to find the information most relevant to their work within one platform. It details the citations received by a book. (Source: Thomsonreuters.com)
Bookmarklet	It is a small software application stored as a bookmark in a web browser, which typically allows a user to interact with the currently loaded web page in some way.
Chinese Science Citation Database	It contains important research and citation data from China, including research trends, top authors, institutions, journals, and more. (Source: Thomsonreuters.com)
Citation	It is a reference to a text or part of a text identifying the document in which it may be found.
Citation Index	It is a bibliographic tool in print or electronic format that lists all referenced or cited source items published in a given time span.
Citation Network	It is a one-way or two-way network analysing relationship between citing and cited references or authors.
Citations Count	It is a simple method of counting total citations received by an earlier published article, with data obtained from a citation database.
Cited Half Life	It is the number of years, going back from the current year, that account for 50% of the total citations received by the cited journal in the current year.
Cited Half-Life (of a journal)	It is the number of years, going back from the current year, that account for 50% of the total citations received by the cited journal in the current year. ISI developed this calculation to provide an indicator as to the long-term value of source items in a single journal publication. It may be noted that the cited half life of

	the literature of a speciality is different from the cited half life of a journal. (Source: Thomsonreuters.com)
Cites per Document (2 years)	Average citations per document in a 2 year period. It is computed considering the number of citations received by a journal in the current year to the documents published in the two previous years, i.e., citations received in year X to documents published in years X-1 and X-2. (Source: Scimagojr.com)
CiteULike	It is a free service to help you to store, organise and share the scholarly papers you are reading.
CiteULike	It is a free service to help you to store, organise and share the scholarly papers you are reading.
Citing Half-Life	It is the number of journal publication years , going back from the current year that account for 50% of the total citations given by the citing journal in the current year.
Citing Half-Life of a Journal	The number of journal publication years, going back from the current year, that account for 50% of the total citations given by the citing journal in the current year. ISI developed this calculation to provide an indicator of the subtle changes in scope of a publication over the course of time. (Source: Thomsonreuters.com)
Co-citation coupling	It is a method used to establish a subject similarity between two documents. If papers A and B are both cited by paper C, they may be said to be related to one another, even though they don't directly cite each other. The more papers cite A and B, the stronger their relationship is.
Co-citation network	It is a network analysing instances of co-citation coupling.
Conference Proceedings Citation Index	It helps researchers access the published literature from the most significant conferences, symposia, seminars, and more. (Source: Thomsonreuters.com)
Crossref	It is an official Digital Object Identifier (DOI) Registration Agency of the International DOI Foundation.
Data Citation Index (DCI)	It provides digital research that is discoverable, citable and linked to primary research literature. You can discover datasets from multiple repositories in one place. (Source: Thomsonreuters.com)
Delicious	It is an online social bookmarking service. Its website address is Delicious.com.
Desktop application	It is an application software that runs stand alone in a desktop or laptop computer.
Dryad	It is an international repository of data underlying peer-reviewed articles in the basic and applied biology. Its website address is http://datadryad.org.
Eigenfactor Score	Its calculation is based on the number of times articles

(EF)	from the journal published in the past five years have been cited in the *JCR* year, but it also considers which journals have contributed these citations so that highly cited journals will influence the network more than lesser cited journals. References from one article in a journal to another article from the same journal are removed, so that Eigenfactor scores are not influenced by journal self-citation. (Source: Thomsonreuters.com)
Free software	It is a computer software that is available free of charge, however, its source code may or may not be made available.
g-index	An index to quantify an individual's scientific research output, proposed by Leo Egghe. (Source: Harzing.com/pop.htm)
Github	It is a social, online repository for open source software.
h5-index	h5-index is the h-index for articles published in the last 5 complete years. It is the largest number h such that h articles published in 2008-2012 have at least h citations each. (Source: Scholar.google.com)
h5-median	h5-median for a publication is the median number of citations for the articles that make up its h5-index. (Source: Scholar.google.com)
hc-index	Contemporary h-index or hc-index adds an age-related weighting to each cited article, giving (by default; this depends on the parametrization) less weight to older articles. (Source: Harzing.com/pophelp/metrics.htm)
h-index	h-index, proposed by J.E. Hirsch, is the largest number h such that h publications have at least h citations. The second column has the "recent" version of this metric which is the largest number h such that h publications have at least h new citations in the last 5 years. (Source: Scholar.google.com)
i10-index	i10-index is the number of publications with at least 10 citations. The second column has the "recent" version of this metric which is the number of publications that have received at least 10 new citations in the last 5 years. (Source: Scholar.google.com)
Immediacy Index (JII)	The average number of times that an article published in a specific year within a specific journal is cited over the course of that same year. This index, published in the *Journal Citation Reports*, is one developed by ISI as an indicator of the speed with which citations to a specific journal appear in the published literature. Such information is useful in determining which journals are publishing in emerging areas of research. (Source: Thomsonreuters.com)
International	Document ratio (in percent) whose affiliation includes

Collaboration (%)	more than one country address. (Source: Scimagojr.com)
Journal Citation Reports (*JCR*)	*JCR* offers a systematic, objective means to critically evaluate the world's leading journals, with quantifiable, statistical information based on citation data. (Source: Thomsonreuters.com)
Journal Immediacy Index	It is the average number of times articles published in a journal in a specific year are cited within the same year.
Journal Impact Factor (JIF)	The number of current citations to articles published in a specific journal in a two year period divided by the total number of articles published in the same journal in the corresponding two year period. ISI stresses that a journal's impact factor is a meaningful indicator only when considered in the context of similar journals covering a single field of investigation or subject discipline. (Source: Thomsonreuters.com)
Journal self-citation	It is an instance in which an article published in a journal has cited a previously published article in that same journal.
Mendeley	It is a research management tool for desktop and web.
Open source software	It is computer software with its source code made available and licensed with the permissions or rights to study, change and distribute the software to anyone and for any purpose.
Plug-in	It is a software component that adds a specific feature to an existing software application.
PubMed	It comprises more than 21 million citations of biomedical literature.
RG Score	The RG Score is a metric that measures scientific reputation based on how all of your research is received by your peers.
RIS File	The RIS file format is a tagged format for expressing bibliographic citations. RIS File is a plain text file that can contain multiple references. RIS files can be exported from reference software such as EndNote and Reference Manager. Each reference is composed of a variable number of fields; and each field is preceded by a six-character label or "tag." Some tags are specific only to certain reference types. Each tag must be in a specific format, and certain other rules apply to all tags.
SciELO Citation Index	It lets researchers around the world discover new insights from research emanating from Latin America, Spain, Portugal, the Caribbean and South Africa while making connections to the broader research landscape for a more complete global picture. (Source: Thomsonreuters.com)

Scienceseeker.org	It refers to science news from science newsmakers. It offers science news aggregation service.
SCImago Journal Rank (SJR)	SJR is a prestige metric based on the idea that 'all citations are not created equal'. (Source: JournalMetrics.com)
Scopus	It is the world's largest abstract and citation database of peer-reviewed literature.
Self-citation	It can an instance in which an article published in a journal has cited a previously published article in that same journal, or it can be an instance in which an author cites his own work published earlier or forthcoming.
SJR (SCImago Journal Rank) indicator	It expresses the average number of weighted citations received in the selected year by the documents published in the selected journal in the three previous years, i.e., weighted citations received in year X to documents published in the journal in years X-1, X-2 and X-3. (Source: Scimagojr.com)
Source Normalized Impact per Paper (SNIP)	SNIP measures contextual citation impact by weighting citations based on the total number of citations in a subject field. (Source: JournalMetrics.com)
Web of Science® (*WoS*)	*WoS* provides quick, powerful access to authoritative content from the highest impact journals worldwide, including Open Access journals, in the sciences, social sciences, arts and humanities. (Source: Thomsonreuters.com)

LIST OF ABBREVIATIONS

A&HCI	Arts & Humanities Citation Index
AI	Article Influence score
ALM	Article Level Metrics
API	Application Programming Interface
CE	Cost Effectiveness score
DOI	Digital Object Identifier
DORA	San Francisco Declaration on Research Assessment
EF	Eigenfactor score
GB	Gigabytes
HC-Index	Contemporary H-Index
H-Index	Hirsch Index
HSS	Humanities and Social Sciences
HTML	Hypertext Markup Language
ICI	Indian Citation Index

ISI	Institute for Scientific Information
JCI	Journal Current Index
JCR	Journal Citation Reports
JIF	Journal Impact Factor
JII	Journal Immediacy Index
MB	Megabytes
OA	Open Access
ORCID	Open Researcher and Contributor ID
PDF	Portable Document Format
PLOS	Public Library of Science
PLOS ALM	PLOS Article Level Metrics.
PMC	PubMed Central
RII	Journal Research Impact Indicator
RIS	Research Information Systems, Inc.
SCI	Science Citation Index
SciELO	Scientific Electronic Library Online
SJR	SCImago Journal Rank
SNIP	Source Normalized Impact per Paper
SSCI	Social Science Citation Index
SSRN	Social Science Research Network
STM	Science, Technology and Medicine
WoK	Web of Knowledge
WoS	Web of Science
XML	Extensible Markup Language

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