Department of Library and Information Science
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Name of the Programme: M.Lib.I .Sc
Course - 4.5: Elective – V
(B) INFORMETRICS AND SCIENTOMETRICS
Course Code:P21MLS20A

Unit-IV: Citation Theory and Analysis; Definition, Theory of citing, different forms of citations, Age of citation – citation counts , Self –citation – Citation Index _ Impact Factor – H Index.

Presented
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Citation

- A **citation** is an **official document or speech which praises a person for something brave** or special that they have done.
- The **referred documents are listed in the references**, which are appended at the end of scientific papers. The **referred documents once cited by the authors are usually called as citations.**

Concept of Citations

- Citations symbolize the ***conceptual*** association of scientific ideas as recognized by publishing research authors.

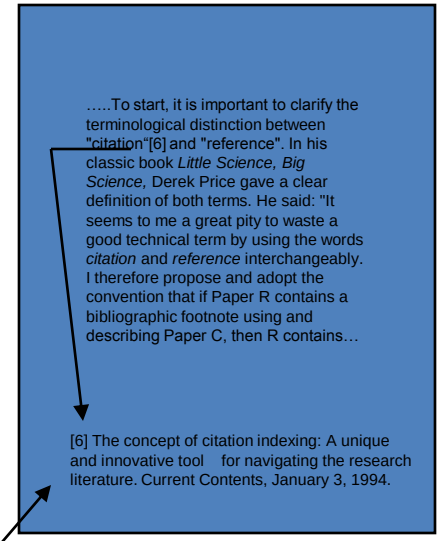
- By the references they cite in their papers, authors make explicit ***linkages*** between their current research and prior work in the archive of scientific literature.

Distinction between "citation" and "reference"

- If Paper R contains a bibliographic footnote using and describing Paper C, then
  - R contains a *reference* to C,
  - C has a *citation* from R.
- The number of references a paper has is measured by the number of items in its bibliography as endnotes, footnotes, etc.,
- The number of citations a paper has is found by looking it up [in a] ***citation index*** and seeing how many others papers mention it."

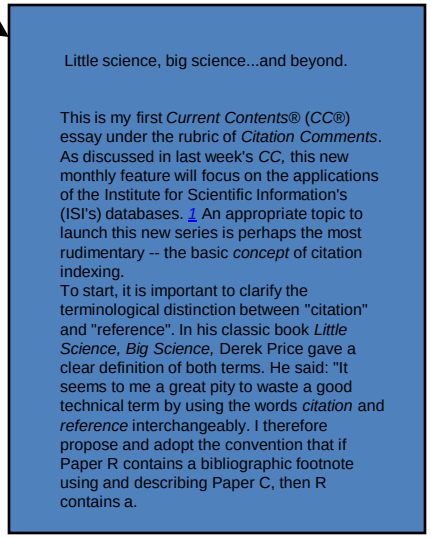
Source: Price D. J. D. Little science, big science...and beyond. New York: Columbia University Press, 1986.

Paper R



R contains a ***reference to*** C,

Paper C



C has a ***citation from*** R.

Citation Analysis

- Citation Analysis is one of the areas of bibliometric research and it has emerged as a useful technique for studying the trends in scientific research.
- In **citation analysis**, one deals **a set of scientific articles and wishes to determine the number of times each of these articles is cited during a certain period of time.**
- **It helps the user and also the librarian of the use pattern of a particular subject.**
- **It is a tool of evaluation, it helps to identify frequently used journals, books, Government publications etc. in a library.**
- An author of scientific publications refers **to earlier and contemporary works that may contain relevance to the claim the author wants to make.**

Definition

- Martyn has defined citation analysis as "the analysis of citations or references or both which form part of the scholarly apparatus of primary communications. The techniques used for putting items of references in some kind of rank or order, whether they are journals or author cited."

Importance of citation

- Giving credit to related work.
- The reference to a standard Methodology or a piece of equipment that has been used, citing rather than describing it in detail.
- Providing broad background to the topic.
- Correcting or criticizing the previous paper.
- Quoting earlier papers that offer collaboration for one's ideas or claims.
- Drawing attention to previous work that is not well known, but ought to be.

Cont..,

- Identifying an earlier publication from which the author obtained the original idea for his or her work.
- Alerting researchers to their forthcoming work.
- Citing a major figure because it makes your research look more respectable.
- Citing a major figure because you think he or she may be a reference of the paper when you submit it to the journal.
- Citing articles that fit the author's perceptions of the journal's readers and what they are expecting.

Usefulness of Citation Analysis

- Citation analysis is used to study the citation links between scientific papers, technical notes and reviews;
- Citation analysis provides relevant measures of utility and relationships of journals where primary function is to communicate research results.
- Citation analysis helps in identification of key documents and creation of core lists of journals,
- It helps in clustering of documents according to common references and citations;

Limitation of Citation Studies

- They provide only an incomplete and biased record of the working of the information system.
- Data have largely to be collected by hand although citation indexes published by scientific institute can sometimes be used.
- Insufficient research has been conducted into the rational behind citing to enable direct (and confident) application of the data.

Citation Biases

- Incomplete citing occurs due to
- A lack of understanding (papers exceeding the knowledge of an author do not influence his work and are not cited):
  - ✓ this may be the reason that often not the discoverer or originator is cited but a later author;
  - ✓ often a reviewer only described or mentioned the finding in a more understandable way.
- A language barrier
  - (often Non-English articles are rarely cited by native English speakers; or
  - even if they are the editors of English-language journals struggling with space usually eliminates them; and also
  - the language barrier between Anglo-American and French scientists).

Cont..,

- A suppression or neglecting of known relevant articles of competing authors(among them also those competition for grants), or
  - of authors belonging to a suspicious watched group, especially those who did not cite the own papers, or
  - of authors who are prejudiced against the own position.
- A lack of finding relevant articles (the author did not have or did not use proper possibilities of information or
  - he did have, but the neglected article was published in an unknown journal not indexed by widespread bibliographies or databases).

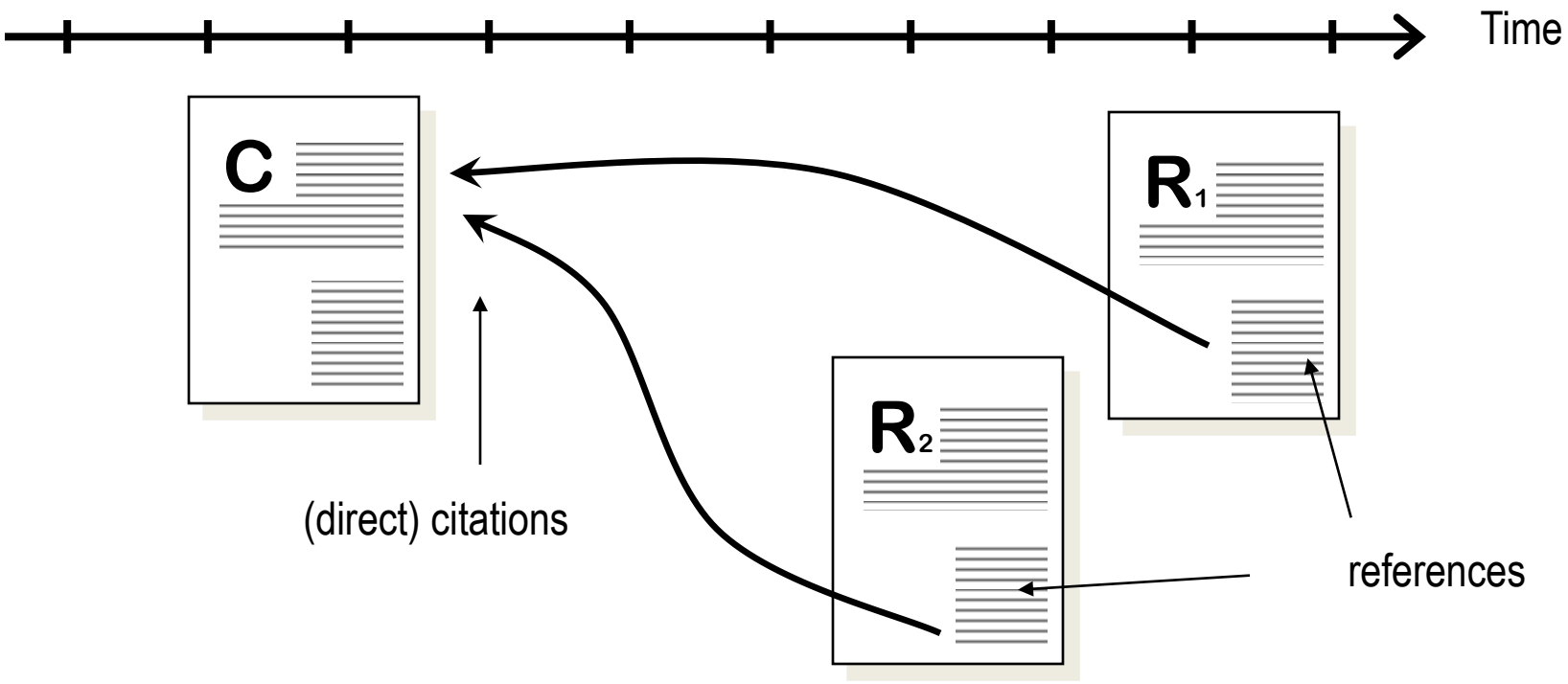
Cont..,

- Secret research for political or economic reasons, e.g. if research results are kept back before a patent is issued.
- Mac Roberts and Mac Roberts (7) conclude that authors fail to cite approximately 70% of the influence.

Citation analysis

- **Reference studies** are based on the ***citing [referring]*** documents, and the goal is typically to investigate the behaviour of the citing [referring] authors (e.g., which journals they refer to and how old the references are)
  - Reference = an entry in the bibliography
- **Citation studies** are based on the ***cited*** documents, and the goal is typically to analyse their use subsequent to publication, e.g., how are they used in other documents, or which ones have received most (or no) citations

Citation analysis - terminology



R_1 and R_2 each have a reference to C - citing [referring]
[the source unit or the issuing unit]

C has 2 citations (from R_1 and R_2) - citing
[the receiving unit or the unit being referred to]

Cf. Price (1970)

Citation Analysis has Three Dimensions

- Co-citation: Two citations are cited together.

- Direct citation: Which establishes the relationship between documents and researchers who uses them and;

- Bibliographic coupling: The relation of two documents by virtue of their joint descent from the third. Citation analysis technique can be applied for various studies like.

Oriented Studies

- **Library and information** – oriented studies, instances of which are visible, in rates of use of library materials and rank order listings of journals.

- **Science-oriented** studies as seen in network: determination through co-citation and clustering.

- **Management-oriented studies**, this can be visualized in evaluation of productivity studies-in terms of citation analysis.

Bibliometric methods

- **Publication analysis** – quantitative investigations of the content of one or more bibliographical fields in a collection (e.g., AU, JN)
- **Citation analysis** – quantitative investigations of the reference lists of the documents in a collection – establishes relationships between *authors* or their work, between *journals*, between *fields*, between *institutions* between *countries*, etc.;
  - **Co-citation analysis** – establishes a subject similarity between two *documents;*
  - **Bibliographic coupling** – links *papers* that cite the same articles;
  - **Co-word analysis** – analysis of the co-occurrence of *keywords*

Evaluation of Scientific Research

Some of the indicators used in the evaluation of scientific research

- Impact Factor;
- Citing articles;
- Citing journal;
- the number and order of authors, etc.

Impact Factor

- ***Impact factor is the number of citations of articles published in the journal during the previous two years, divided by the total number of articles published in the journal for the same time period.***
- Impact factor depends on: the quality of the journal, the language in which it was printed, the territory covered by the distribution system

CITING

- Citing is the way in which the author explains to the readers that certain textual content contained in particular paper is taken from another source. It also gives the reader insight they needed to find the original source, including:
- Information concerning the author;
  - Title of the article;
  - Page numbers from which the material was taken;
  - Time when some content was “downloaded” from some official sites where the content is stored and presented for public use (Open access).

WHY cite?

- Recognition of authorship by quoting is the only proper way to use the work of others and not to commit plagiarism. **There are many reasons that source should be cited:**
  - Citing helps greatly to the one who wants to know more about the author's ideas and where these ideas came;
  - Not all the sources are as good and true. Journals with a high above mentioned indices are relevant to quote;
  - Citing shows how much work has gone into research;
  - Citing helps the reader to distinguish between the author's and ideas of others.
- Very important issues to be considered when quoting content of other authors from scientific publications are:

When to cite;

Very important issues to be considered when quoting content of other authors from scientific publications are:

- When to use quotation marks;
- When to paraphrase;
- When to use an idea already expressed by someone?

Styles of Citation

- CHICAGO;
- MLA (MODERN LANGUAGE ASSOCIATION);
- ACS (AMERICAN CHEMICAL SOCIETY);
- IEEE (INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS);
- NLM (NATIONAL LIBRARY OD MEDICINE);
- VANCOUVER (BIOLOGICAL SCIENCES);
- APA (AMERICAN PSYCHOLOGICAL ASSOCIATION).

Why cite your sources?

- To give your writing credibility. You show that you have gathered ideas from worthwhile places.
- To help the reader. You enable the reader to go and check and read those sources if he/she so wishes.
- To protect yourself from plagiarism. When you cite all your sources, no one can say that you stole or copied ideas from someone else.

Tools

- Citation Databases (Web of Science,Scopus, Google Scholar)
- Compilation of variables from journals in a subject(DOAJ) Journal Citation Reports (JCR)
- Use data
- Publication counts from indexes, or other data bases(PubMed)
- Other indicators databases (national, essential, university, institutional)
- ISI HighlyCited.com .
- Web structures, links

Citation Databases

- Web of Science
- Scopus
- Google Scholar
- Any other Bibliographic databases

Web of Science

Web of Science, previously known as ISI Web of Knowledge, is an online subscription-based scientific citation indexing database.

Publisher	:	Clarivate Analytics
Temporal coverage	:	1900 to present
No. of records	:	90 millions
Web of Science consist of	:	7 online databases

Scopus

- **Temporal Coverage:** From1995 to Present.
- **Coverage:** Health Sciences (32%), Physical Sciences (29%), Social Sciences (24%), Life Sciences (15%).
- It covers nearly **22,000 titles** from over 5,000 publishers, of which **21,500 are peer-reviewed journals.**
- **Updation:** Scopus is the only leading database that is **updated daily** rather than just weekly
- Source: www.elsevier.com/solutions/scopus/content

Scopus: Coverage

- **Over 60 million records** [63% post-1995+ 37% before]
- More than **27 million patent records**
- Over 7.2 million conference papers
- “Articles-in-Press” from over 5,000 journals
- More than 116,000 books with 10,000 added each year thereafter
- **Cited references** in **Scopus go back to 1970** with the project started in March 2014. Scopus has been adding **cited references for pre-1996 content**, going back to 1970. As of December 2015, Scopus has **added over 93 million pre-1996 cited references** to nearly 5 million articles.

Google Scholar

Google Scholar is a freely accessible web search engine that indexes the full text or metadata of scholarly literature across an array of publishing formats and disciplines.

Launched : November 20, 2004

Publisher : Google Inc.

Research Metric Techniques

- Literature Usage Counts
- Publication Counts
- Citation Counts
- Citations Per Publication (CPP)
- Citation Analysis
- Bibliographic Coupling
- Co-citation Analysis
- Co-word Analysis

Literature Usage Counts

Counting of literature usage is very important technique in Bibliometrics because it is important to know whether subscribed or procured documents are used or not.

Publication Counts

- **Paper counts, which measure productivity**, are the most basic bibliometric measure and provide the raw data for all citation analysis.
- Ranking institutions in terms of paper counts helps **to compare the productivity and volume of research output** among various institutions.
- The **number of researchers** at an institution should be taken into account when comparing publication counts across institutions.
- **Characteristics of the papers**, such as **document type**, publication year, and categorization method, should also be considered.

Citation Counts

- **Citation counts** are the number of citations that a particular journal or an article receives during a particular time.
- **Citation count technique** is applied to determine how many citations are being received by
  - **A documents**
  - **An author over a period of time**
  - **An Institution**

Self-citation

Self-citation **occurs in an article when an author references another of their own publications**. This can be a legitimate way to reference earlier findings; but self-citations can sometimes be unduly made in attempt to inflate an individual's citation count.

Citation Counts: Type of Study

- Authorship study
- Type of document Used
- Ranking of Journals
- Self-citation study
- Obsolescence study
- Half-life study

Authorship Study

- Author may write articles **independently or on collaboration basis.** The study will focus on how single author publications get citations in comparison to collaborative works.
  - **Rate of single author citation**
  - **Rate of multi-author citation**
  - **Verification of Lotka's Law**

Ranking of Journals

- Ranking of Journals can be done in three different ways:
  - **Ranking journals by no. of citations;**
  - **Ranking of journals by IF;**
  - **Ranking of Journals by Immediacy Index**

Immediacy Index (I)

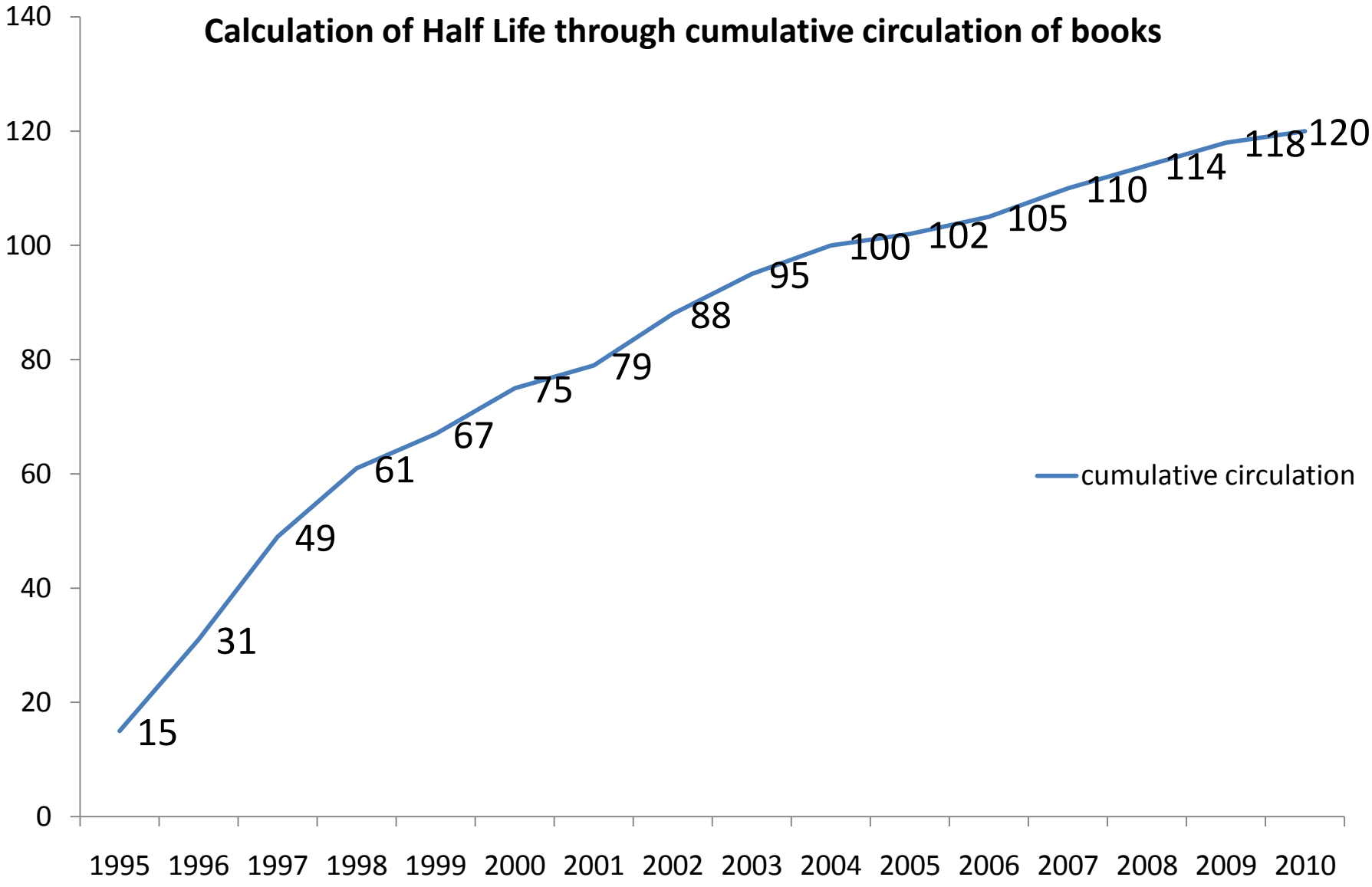
- **Immediacy Index** is a measure of how quickly the average articles in a journal get cited.

$$I = \frac{\text{No. of citations received in 2021}}{\text{No. of documents published in 2021}}$$

Half-Life

- **Half-life** of the literature is the time by which one half of the currently published literature become obsolete.

Example: *A resource acquired by a library in the year 1995. The statistics given above are of the circulation in the* ***period of 16 years****. Total number of issue of this book in period of 16 year is 83 and the median as similar of the above example comes 42, which is achieved in year 2000. Then, 2000 minus 1995 equals five year. So, the* ***half life of the item received in 1995 would be of 5 years.***



Period: 1995-2010 i.e. 16 years; Median Use: 60; Half life= 4 years

Obsolescence

- Obsolescence is the process whereby materials become no longer useful or reliable. Rate of obsolescence varies with the discipline.
- May be applied for Weeding out

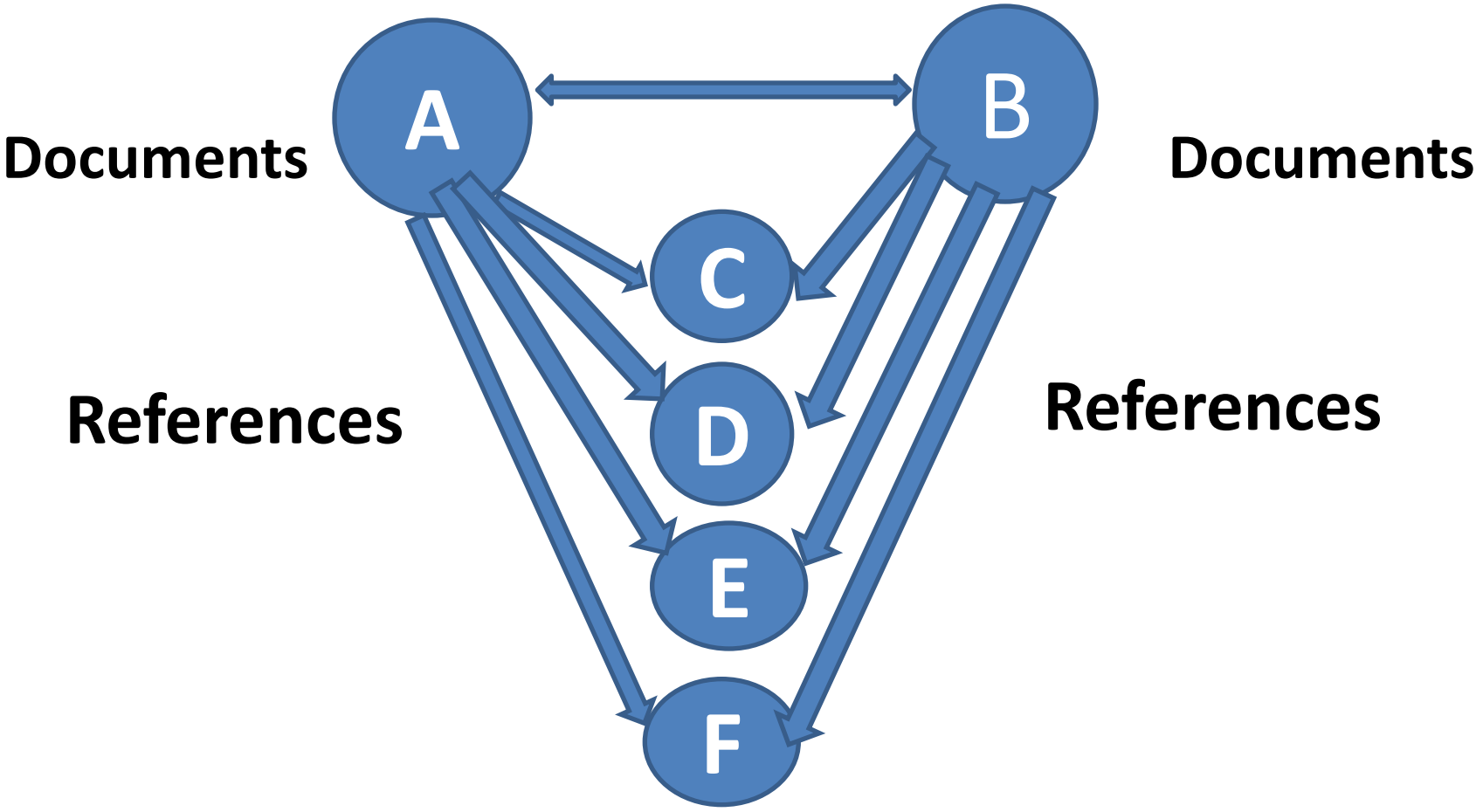
Citations Per Publication (CPP)

- Many researchers e.g. Yi & Jin (2008) used citations per publication (CPP) to evaluate the authors, countries and journals. Mathematically,
- $$CPP = \frac{No.of\ Citations\ received\ by\ an\ author}{Total\ no.of\ publications\ by\ that\ author}$$

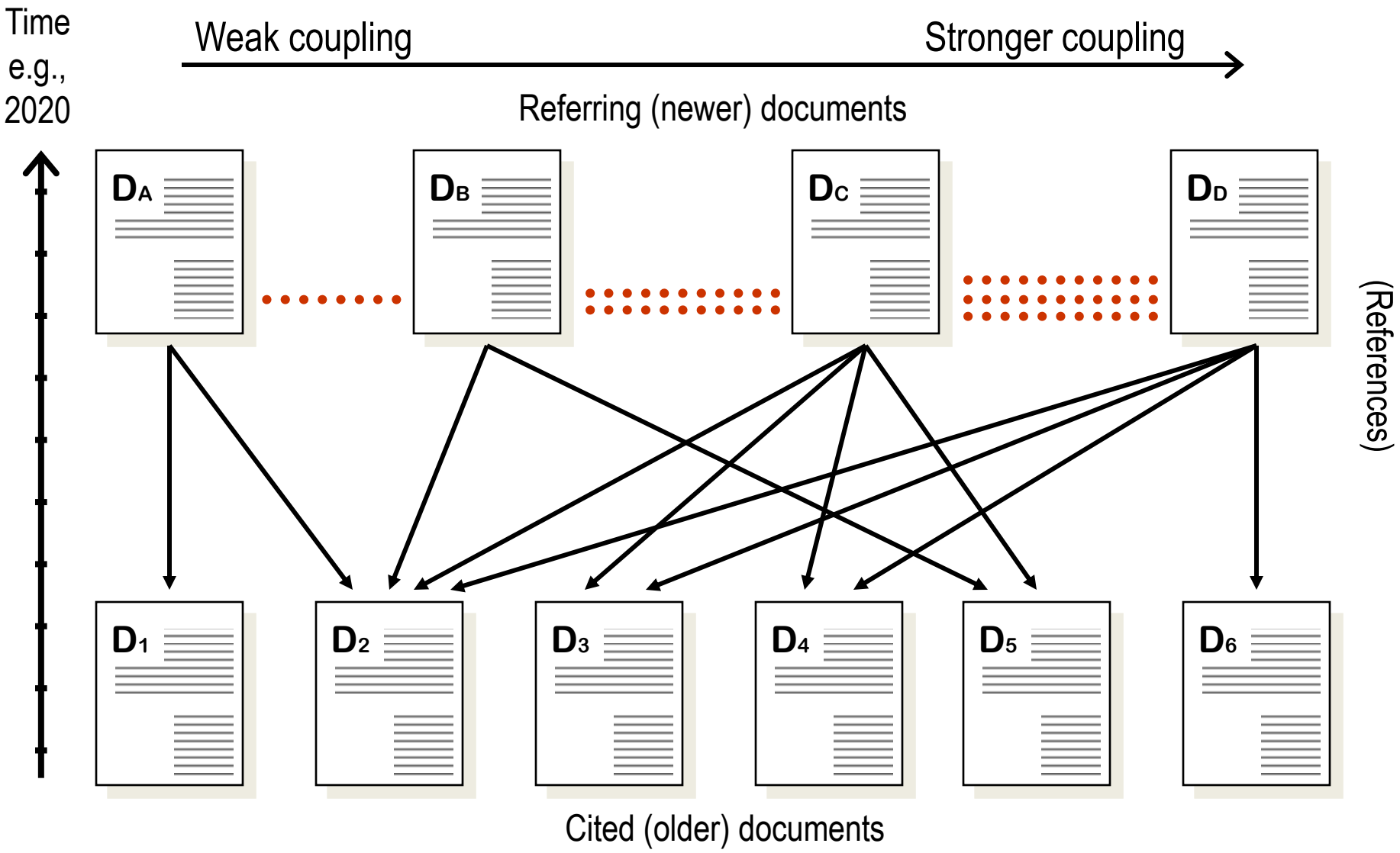
Bibliographic Coupling

- **Kessler** (1963) proposed a technique, known as bibliographic coupling to measure the **similarity between two scientific documents in terms of number of references** they make in common.
- The strength of bibliographic coupling is measured **by no. of references** that are in common.

Bibliographic Coupling



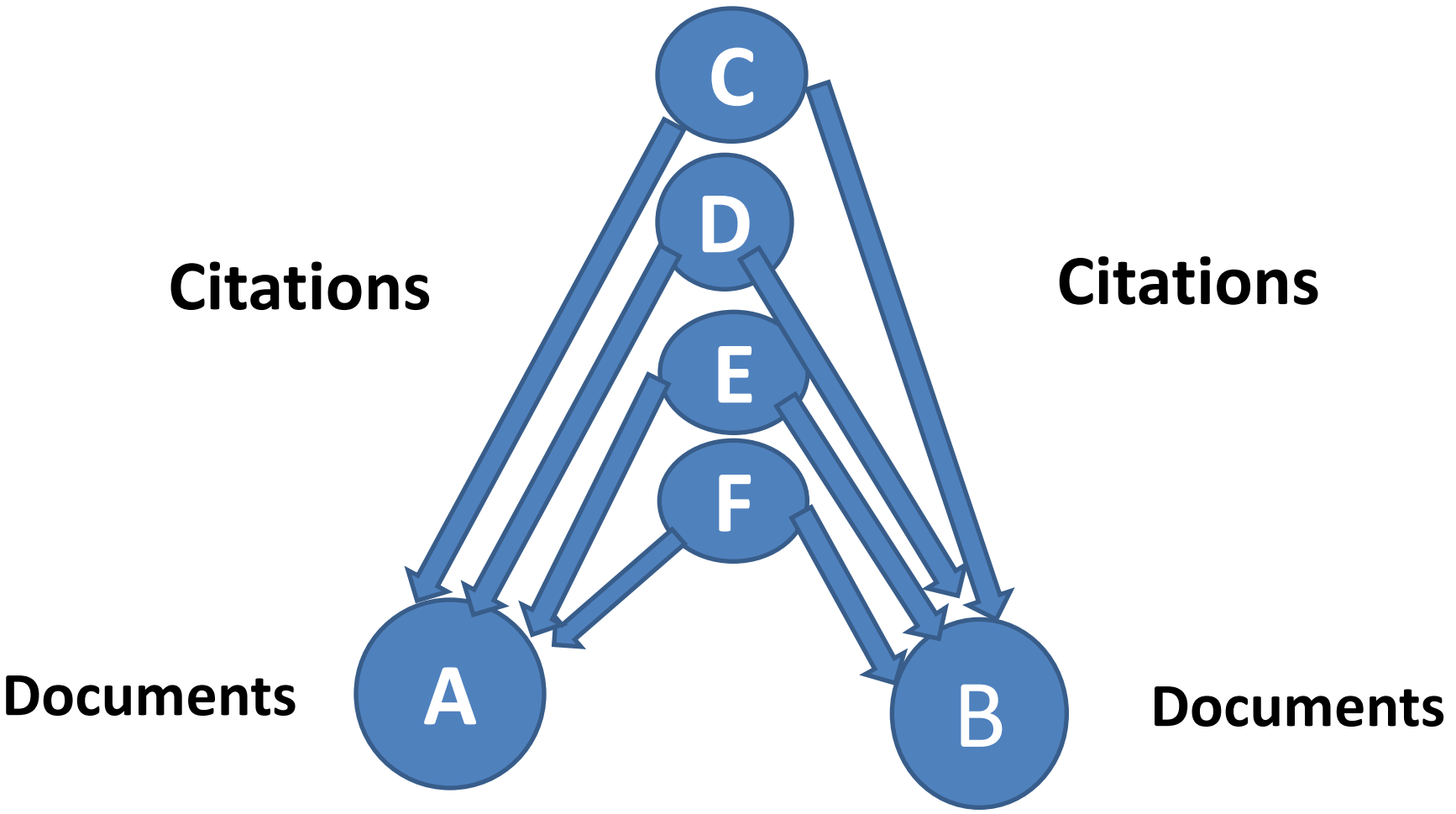
Bibliographic coupling



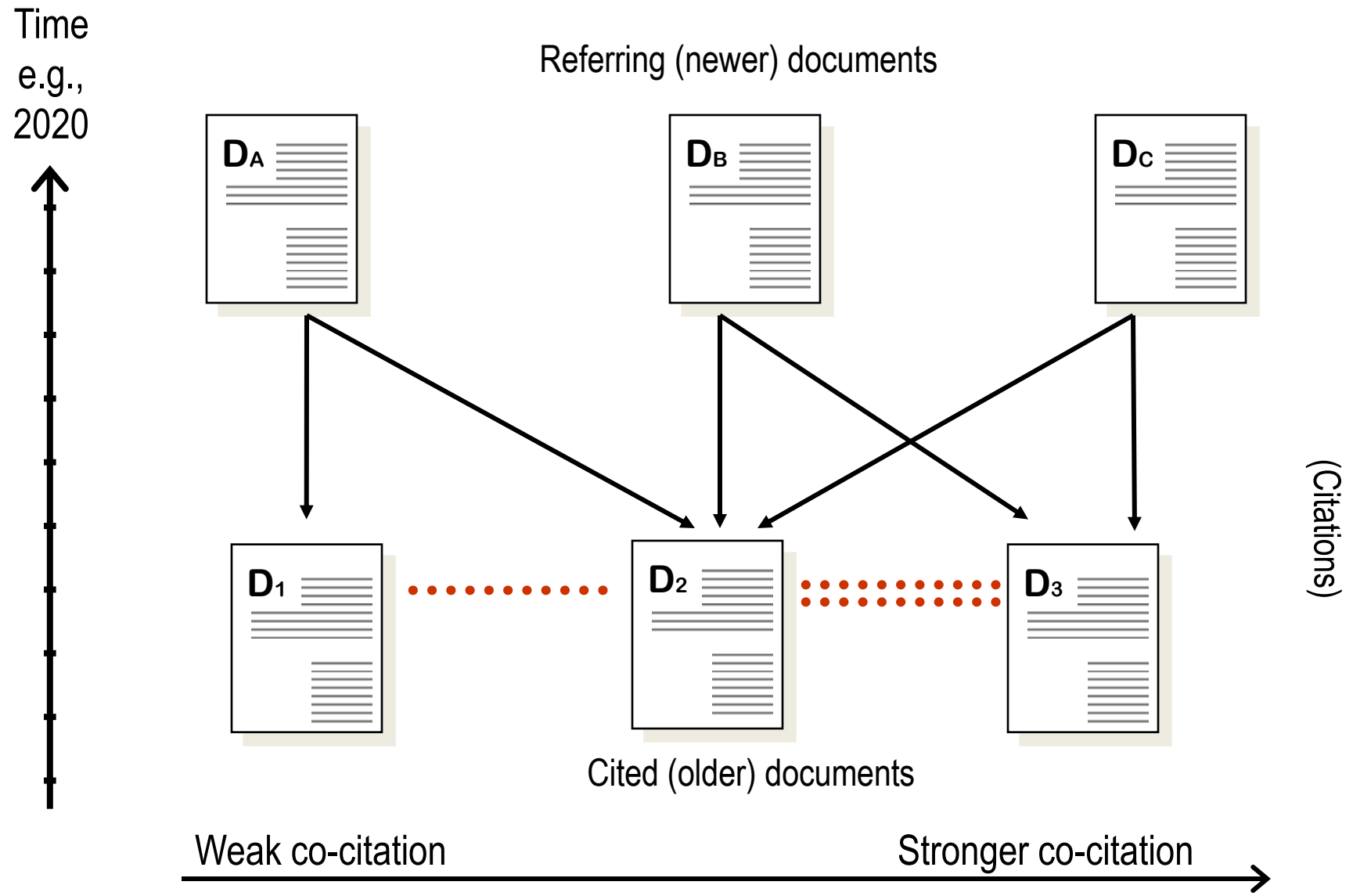
Co-citation Analysis

- **Small (1973)** proposed another technique, co-citation to measure the **similarity between two documents as the number of common documents** that cites both documents.
- **Co-citation analysis** has become the dominant method for the empirical study of the structures of scientific communication.
- The objective of co-citation analysis is **to map the topical relatedness of clusters of authors**, journals or articles.

Co-citation Analysis



Co-citation analysis



Co-citation Analysis

Garfield (1980) proposed the formula to calculate the strength of co-citation, Let say Journal A and B

$$S=\frac{Co-citation\ of\ A+B}{(total\ citation\ of\ A\ and\ B)-(co-citation\ of\ A\ \&\ B)}x100$$

For example, value of co-citation of A & B = 5,

total citation of A & B = 55 then $S=\frac{5}{(55-5)}x100$

i. e $S=\frac{1}{10}x100 = 10\%$

Co-word Analysis

- The **co-word analysis** involves **identification of keywords and their co-occurence** in an attempt to **generate a map index of papers** linked by the **degree of co-occurence** of the keywords.
- **co-word frequencies** are used to construct a co-word structure;

Clustering

- “the process of organizing objects into groups whose members are similar in some way”
- A *cluster* is therefore a collection of objects which are “similar” between them and are “dissimilar” to the objects belonging to other clusters.

Measurement for Publications :

Journal Metrics from

Web of Science

Scopus

Impact Factors (IF)

- The average number of citations received per paper published in that journal during the two preceding years. It measures the quality of academic journals.
- Impact Factor (IF) can be measured as:

IF = A/B

Where

A = total citations received by journal X in the year 2020

B = total number of articles published by journal X in 2018 and 2019

Journal Citation Report(JCR)

- Journal Citation Reports (JCR) provides you with the transparent, publisher-neutral data and statistics you need to make confident decisions in today's evolving scholarly publishing landscape, whether you're submitting your first manuscript or managing a portfolio of thousands of publications.
- Journal Citation Reports (or JCR) is a product of ISI Web of Knowledge and is an authoritative resource for impact factor data. This database provides impact factors and rankings of many journals in the social and life sciences based on millions of citations. It offers numerous sorting options including impact factor, total cites, total articles, and immediacy index. In addition, JCR provides a five-year impact factor and visualized trend data.

Eigenfactor

- Eigenfactor is a rating of total importance of scientific journal. Journals are rated according to the number of incoming citations,
- with citations from **highly ranked journals** weighted to make a larger contribution to the eigenfactor than those from poorly ranked journals. Eigenfactor score is influenced **by the size of the journal.**
- *Eigenfactor scores and Article Influence scores are calculated by eigenfactor.org,*
- *where they can be freely viewed.*

CiteScore metrics

- CiteScore metrics are a suite of indicators calculated from data in Scopus, the world's leading abstract and citation database of peer-reviewed literature.
- Calculating the CiteScore is based on the number of citations to documents (articles, reviews, conference papers, book chapters, and data papers) by a journal over four years, divided by the number of the same document types indexed in Scopus and published in those same four years.

Impact Per Publication (IPP)

- It is a new journal metric called Impact Per Publication (IPP), which has been added to allow researchers and librarians better compare and evaluate journals.
- The IPP measures the ratio of citations in a year (Y) to scholarly papers published in the three previous years (Y- 1, Y- 2, Y – 3) divided by the number of scholarly papers published in those same years (Y- 1, Y- 2, Y – 3) .

$$IPP_{2020} = \frac{\text{Citations in yr. 2020 from papers in yr. 2017, 2018, 2019}}{\text{Papers published in yr. 2017, 2018, 2019}}$$

Source Normalized Impact per Paper (SNIP)

SNIP measures the **impact of a paper within a subject field**. SNIP measures contextual citation impact by weighting citations based on the **total number of citations in a subject field.**

$$\mathbf{SNIP}_{2020} = \frac{\mathbf{IPP}_{2020}}{\textbf{Average no. of citations in year 2020}}$$

Calculation of IPP and SNIP

Let's take a Journal 'X'

YEAR	IPP	SNIP	CITATIONS	PAPERS
2020	3.379	1.477	2394	808
2019			2672	760
2018			2566	746
2017			2722	850

SCImago Journal Rank (SJR)

- **SCImago Journal Rank** (**SJR** indicator) is a measure of scientific influence of scholarly journals that accounts for **both the number of citations** received by a journal and the **importance or prestige of the journals** where such citations come from.

Eigenfactor , SJR & Article Influence

- Eigenfactor **excludes all journal self-citations** while SJR limits **journal self-citations to 33%.**
- Eigenfactor uses a **five year citation window**; SJR uses **a three-year citation window**
- The **Article Influence score** measures the average influence of articles in the journal, and is therefore comparable to the traditional impact factor.

Research Metric Indicators

- h-index
- h5-index
- g-index
- p-index
- i-index
- Energy-Exergy Indicators
- Z-index

h-index

- It is defined as number of articles h (e.g. h=5) that each articles receives at least h citations (h-5). Hirsch (2005) has introduced the concept of h-index.
- The h-index is an author level metrics. The h-index is defined as follows:

  A scientist has index h if h of his/her Np papers have at least h citations each, and the other (Np-h) papers have no more than h citations each.

h-index

- **Characteristics**
  - H-index increases over time;
  - H-index is based on citation counts;
  - Linear relationship between value of h-index and time.
- **Advantages**
  - A single indicator provides the idea of scientific productivity;
  - H-index does not depend on total number of citations;
  - H-index can easily be obtained from WoS and Scopus.
- **Disadvantages**
  - H-index is time dependent;
  - H-index is size independent *[e.g. two scientists h-index value may be same but their performance could not be the same].*

H-index example

Author A

Doc	1	2	3	4	5	6	7	8	9
Cit	55	45	20	10	5	4	3	2	1

Author B

Doc	1	2	3	4
Cit	25	20	9	6

The *h*-index

A scientist has index ***h*** if ***h*** of his or her N_p papers have at least ***h*** citations each and the other (N_p – ***h***) have at least ≤ ***h*** citations each

Doc	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Cit	**49**	**23**	**15**	**14**	**6**	**3**	**1**	**1**	**0**	**0**	**0**

H-index example

Author X has 5 published articles:

Article1, citations 5

Article2, citations 10

Article3, citations 100

Article4, citations 6

Article5, citations 4

The H-index of X is 4: there are 4 papers with at least 4 citations each.

H- Index of Universities in TamilNadu

S. No	Name of the University	Year of established	Life	Number of Publications	Number of Citations	Average Citations	H-index
1	University of Madras	1856	166	9177	1,52,489	16.62	120
2	Annamalai University	1929	93	7557	1,43,345	18.97	120
3	Madurai Kamaraj University	1966	56	4793	80,041	16.7	99
4	Anna University	1978	44	16,271			
5	Bharathidasan University	1982	40	5610	96,156	17.14	107
6	Bharathiar University	1982	40	6679	1,16,791	17.49	119
7	Mother Teresa Women University	1984	38	248	3951	15.93	30
8	Alagappa university	1985	37	3737	63,159	16.9	87
9	Manonmaniam Sundaranar University	1990	32	1777	32,133	18.08	63
10	Periyar University	1997	25	2142	30,561	14.27	67
11	Thiruvalluvar University	2002	20	692	13,546	19.58	53

Web of Science

Clarivate Analytics

After January 6, we will no longer support this version of Web of Science. GO TO NEW VERSION

Select a database: Web of Science Core Collection

Basic Search | Author Search BETA | Cited Reference Search | Advanced Search

"Bharathidasan University" | Organization-Enhanced | Search | Search tips

Select available organizations from the Index
Finds papers from organizations with identified name variants.

+ Add row | Reset

Timespan

Custom year range | 1989 | to | 2021

More settings

Results: 5,610
(from Web of Science Core Collection)

You searched for: ORGANIZATION-ENHANCED: ("Bharathidasan University") ...More

Create an alert

Refine Results

Search within results for...

Filter results by:

Open Access (1,114)

Refine

Publication Years

2021 (529)
2020 (466)
2019 (341)
2018 (331)

Sort by: Date | Times Cited | Usage Count | Relevance | More

1 of 561

Select Page | Export... | Add to Marked List

Analyze Results
Create Citation Report

View Citation Report

1. Cytotoxic cobalt (III) Schiff base complexes: in vitro anti-proliferative, oxidative stress and gene expression studies in human breast and lung cancer cells
By: Gowdhami, Balakrishnan; Manojkumar, Yesaiyan; Vimala, R. T. V.; et al.
BIOMETALS
Early Access: DEC 2021
Full Text from Publisher | View Abstract
Times Cited: 0
(from Web of Science Core Collection)
Usage Count

2. Context-based sentiment analysis on customer reviews using machine learning linear models
By: Chinnalagu, Anandan; Durairaj, Ashok Kumar
PEERJ COMPUTER SCIENCE Volume: 7 Article Number: e813 Published: DEC 17 2021
Free Full Text from Publisher | View Abstract
Times Cited: 0
(from Web of Science Core Collection)
Usage Count

3. Spatial distribution of waves and wave-induced littoral drift along the nearshore regions of the central west coast of India
By: George, Jesbin; Kumar, V. Sanil; Joseph, Duphrin
OCEAN ENGINEERING Volume: 242 Article Number: 110161 Published: DEC 15 2021
Times Cited: 0
(from Web of Science Core Collection)
Usage Count

Citation report for 5,610 results from Web of Science Core Collection between 1989 and 2021 Go

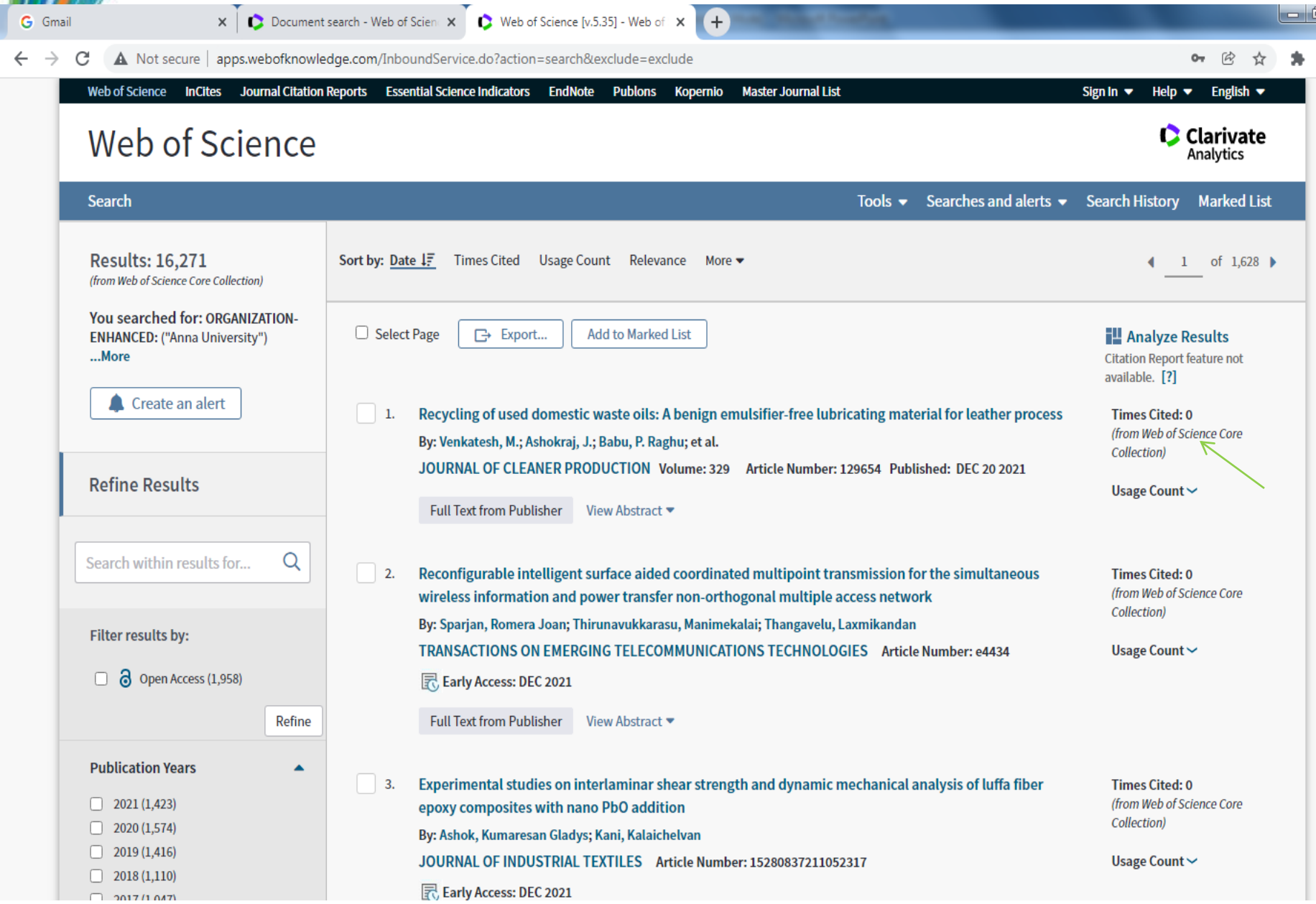
You searched for: ORGANIZATION-ENHANCED: ("Bharathidasan University") ...More

This report reflects citations to source items indexed within Web of Science Core Collection. Perform a Cited Reference Search to include citations to items not indexed within Web of Science Core Collection.

Export Data: Save to Excel File

Total Publications	*h*-index	Sum of Times Cited	Citing articles
5,610 Analyze	107	96,156	68,321 Analyze
2002 – 2021	Average citations per item: 17.14	Without self citations: 84,829	Without self citations: 64,867 Analyze

Citation Report for Anna University



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 2016-2020 have at least h citations each.
- ✓ h5-median for a publication is the median number of citations for the articles that make up its h5-index

Google Scholar h-5-index

Google Scholar

Top publications

Categories ▾ English ▾

	Publication	h5-index	h5-median
1.	Nature	414	607
2.	The New England Journal of Medicine	410	704
3.	Science	391	564
4.	IEEE/CVF Conference on Computer Vision and Pattern Recognition	356	583
5.	The Lancet	345	600
6.	Advanced Materials	294	406
7.	Cell	288	459
8.	Nature Communications	287	389
9.	Chemical Reviews	270	434
10.	International Conference on Learning Representations	253	470
11.	JAMA	253	446
12.	Neural Information Processing Systems	245	422
13.	Proceedings of the National Academy of Sciences	245	337
14.	Journal of the American Chemical Society	245	330
15.	Angewandte Chemie	235	314
16.	Chemical Society Reviews	234	339
17.	Nucleic Acids Research	233	512

The *h*-*b*-index

- The ***h*-*b*-index** developed by Michael Banks of the Max Planck Institute for Solid State Research in Germany, takes the index further by evaluating the impact of compounds used in solid-state physics and scientific topics in general.
- The ***h*-*b*-index** is defined in the same manner as the h-index, but is based on a topic (or compound) search instead of a scientists name.

g-index

- Another popular bibliometric indicator is g-index, developed by Leo Egghe in 2006.
- It is the unique largest number such that top g papers together receive g^2 or more citation.
- It is true that g is greater than or equal to h and i (i.e.$g \geq h > i$).
- Mathematically, g-index may be written as:

$$g2 = \sum_{i \leq g}^{n} ci.$$ (sum of up to g-papers)

p-index

P-index i.e. Performance index is a combination of quality and quantity of research output.

$$\text{P-index} = \sqrt[3]{\frac{C^2}{P}},$$

where c= total citation and p=total number of publications

i-index

In July 2011, Google has developed an academic publication indicator as part of their research. A scientist has index i if i of his or her N papers have at least 10 citations each.

If an author publish 50 papers and is having i-index value =15, which means that his/her 15 out of 50 papers receives at least 10 citations each.

Calculation of h-index, g-index, i-index for Author[no. of publications: 42]

Rank doc.	No. citation	h-index	Rank^2	Cummu. Sum	g-index	i-index
1	22		1	22		i-index =1
2	9		4	31		
3	9		9	40		
4	8		16	48		
5	6		25	54		
6	6	h-index = 6	36	60		
7	4		49	64		
8	4		64	68	g-index=8	
9	2		81	70		
10	2		100	72		

Three Dimension (3-D) Evaluation (Consistency, Energy-Exergy Indicators)

- The 3-D evaluation recently proposed by Prathap is used.
- The quantity (productivity in terms of number of papers published) and quality (specific impact defined as citations per paper) are complemented with a third dimension, called consistency (η).
- This enables a 3-D evaluation of the information production process.
- As observed earlier the Exergy indicator (x) = iC = i^2P a robust second order performance indicator is arguably a better proxy for performance.

Country wise Research Output in Geochemistry according to Exergy Indicator(X)

S.No	Country	Publications (p)	%	TGCS(C)	Impact (i=c/p)	Exergy
1	Peoples R China	3874	25.4	94596	24.41	2309861
2	USA	2894	19	105858	36.57	3872120
3	Canada	1294	8.5	40190	31.05	1248250
4	UK	1114	7.3	38099	34.20	1302993
5	Australia	1043	6.8	35748	34.27	1225234
6	Russia	943	6.2	12104	12.83	155362.5
7	Germany	918	6	28088	30.59	859407.1
8	India	852	5.6	15161	17.79	269783.9
9	France	777	5.1	31452	40.47	1273138
10	Japan	562	3.7	17549	31.22	547984.7
11	Italy	525	3.4	13761	26.21	360695.5
12	Brazil	404	2.7	7233	17.90	129495.8
13	Iran	394	2.6	4824	12.24	59063.39
14	Spain	355	2.3	9625	27.11	260959.5
15	Turkey	355	2.3	6632	18.68	123897
16	Mexico	236	1.5	4985	21.12	105297.6
17	Egypt	235	1.5	3178	13.52	42977.38
18	South Africa	235	1.5	6413	27.28	175006.7
19	Switzerland	235	1.5	6656	28.32	188520.6
20	Austria	211	1.4	5859	27.76	162691.4
21	South Korea	165	1.1	3561	21.58	76852.85
22	Sweden	163	1.1	4243	26.03	110448.2
23	Portugal	158	1	2374	15.02	35670.1
24	New Zealand	142	0.9	4285	30.17	129304.4
25	Norway	133	0.9	2950	22.18	65432.33

Z-index

- Apart from X, an additional indicator $E = {}^{2}_{k}$ where k = 1 to P, also appears as a second-order indicator.
- The simple ratio of X to E can be viewed as the third component of performance, namely, the consistency term $\eta = X/E$.
- Perfect consistency ($\eta = 1$, i.e., when X= E) is a case of absolutely uniform performance; i.e., all papers in the set have the same number of citations, ck = c.
- Thus, for a complete 3-D evaluation of publication activity, the three primary components of quantity P, quality i and consistency η can be used together yielding a Zynergy indicator and a z-index computed $Z = \eta X = \eta E$ and $z = Z^{1/3}$ respectively.

Z-Index of Leading Prolific Authors Publishing in Geochemistry Publications

S.No	Author	Publications	TCS	Impact i = c/p	Consistency η=X/E	Z = (ηX)^1/3	h-Index
1	Santosh M	149	5303	35.591	0.558339	47.23367	39
2	Jiang SY	86	3130	36.395	0.63491	41.66461	33
3	Koeberl C	73	2198	30.110	0.496503	32.0296	25
4	Zhang ZC	72	2703	37.542	0.385637	33.9505	24
5	Li J	66	2063	31.258	0.299355	26.82545	21
6	Xu WL	58	3259	56.190	0.845517	53.69754	31
7	Wang Q	55	1671	30.382	0.337251	25.77395	21
8	Zhang J	55	2737	49.764	0.213486	30.75049	21
9	Chen YJ	52	2291	44.058	0.771341	42.70033	25
10	Zhang L	52	1370	26.346	0.261689	21.13851	18
11	Liu Y	51	1958	38.392	0.20215	24.76908	19
12	Liu XM	50	2607	52.14	0.524764	41.47235	25
13	Mao JW	50	1677	33.54	0.451138	29.38565	19
14	Wang W	50	2586	51.72	0.625797	43.74283	24
15	Sun M	49	3163	64.551	0.668009	51.47482	31
16	Wang F	48	2321	48.354	0.75352	43.8936	26
17	Wang J	48	1755	36.563	0.145484	21.05603	18
18	Zhao ZD	48	1228	25.583	0.543507	25.75057	19
19	Zhang Y	47	1079	22.957	0.288244	19.2561	17
20	Li H	46	886	19.261	0.636165	22.14249	15
21	Li XH	46	3719	80.848	0.332522	46.41284	23
22	Li Y	46	1071	23.283	0.38544	21.26144	16
23	Li C	45	1024	22.756	0.719366	25.59248	19
24	Zhang HF	45	2807	62.378	4.12511	89.72275	23
25	Wang H	44	789	17.932	0.418685	18.09379	17

Webometrics

- Webometrics measures the web related phenomenon. Webometrics includes
  - **Webpage Content analysis**

    Ex. automatic categorization of webpages and texts **;**
  - **Web Link structure analysis;**

    Ex. categorization of hyperlinks and inlinks, self-links and external links
  - **Web usage analysis; and**

    Ex. exploitation of log files for users' searching and browsing behavior)
  - **Web technology analysis.**

    Ex. Performance of Search Engines

Web Impact Factor (WIF)

- Ingversen (1998) introduced the concept of WIF.
- the number of **web** pages in a **web** site receiving links from other **web** sites, divided by the number of **web** pages published in the site that are accessible to the crawler. Mathematically,
- $$WIF = \frac{No.of\ hyperlinks\ in\ a\ site}{Total\ no.of\ webpages\ in\ that\ site}$$

Altmetric Score

The altmetric score provides an idea of **how important an article is by the quantitative value of attention** that it receives.

It is calculated through the **weighted counts of the values of different social media sources** such as newspaper stories, tweets, google+, blogs, comments etc.

Article Level Metrics

Four major hat aggregate and provide article level metrics.

- **PLOS** (http://article-level-metrics.plos.org/). It is a non-profit making publisher, which provides article-level metrics free. It covers only articles.
- **ImpactStory** (http://impactstory.it/). It is a non-profit making article-level metrics providers, which provides article-level metrics freely. It covers not only articles but also code, software, presentations and datasets.
- **Altmetric** (http://altmetrics.org/)**:** It is a non-profit making article-level metrics providers, which provides article-level metrics freely. It covers not only articles but books, code, software and datasets also.
- **Plum Analytics:** It is a non-profit making article-level metrics providers, which provides article-level metrics freely. It covers only articles.

Tool	Purpose	Type
Authormap	It is used for citation mapping and visualization	Web tool
Bibcouple	It is used for visualization of the bibliographic coupling among authors	Software application
Citespace	It is used for visualizing patterns and trends in scientific literature	Map
Fulltext	It is software for co-word mapping of full texts	Software application
HistCite	Bibliographic analysis and visualization software	Software

Thank you

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