



# Opportunities and Limitations of Bibliometrics in Research Evaluation: Planning Reports and Showing Results

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# Summary

- I. Review of bibliometric laws, sources and indicators,**
  - i. Basic Laws and definitions
  - ii. Types of documents and data sources
  - iii. Types of indicators
- II. Types and examples of bibliometric studies**
  - i. Research output
  - ii. Impact factor
  - iii. Citations
  - iv. Other: Interdisciplinarity, collaboration, Technological impact of research; Benchmarking
- III. Data visualization**

# I. REVIEW OF BIBLIOMETRIC LAWS AND INDICATORS



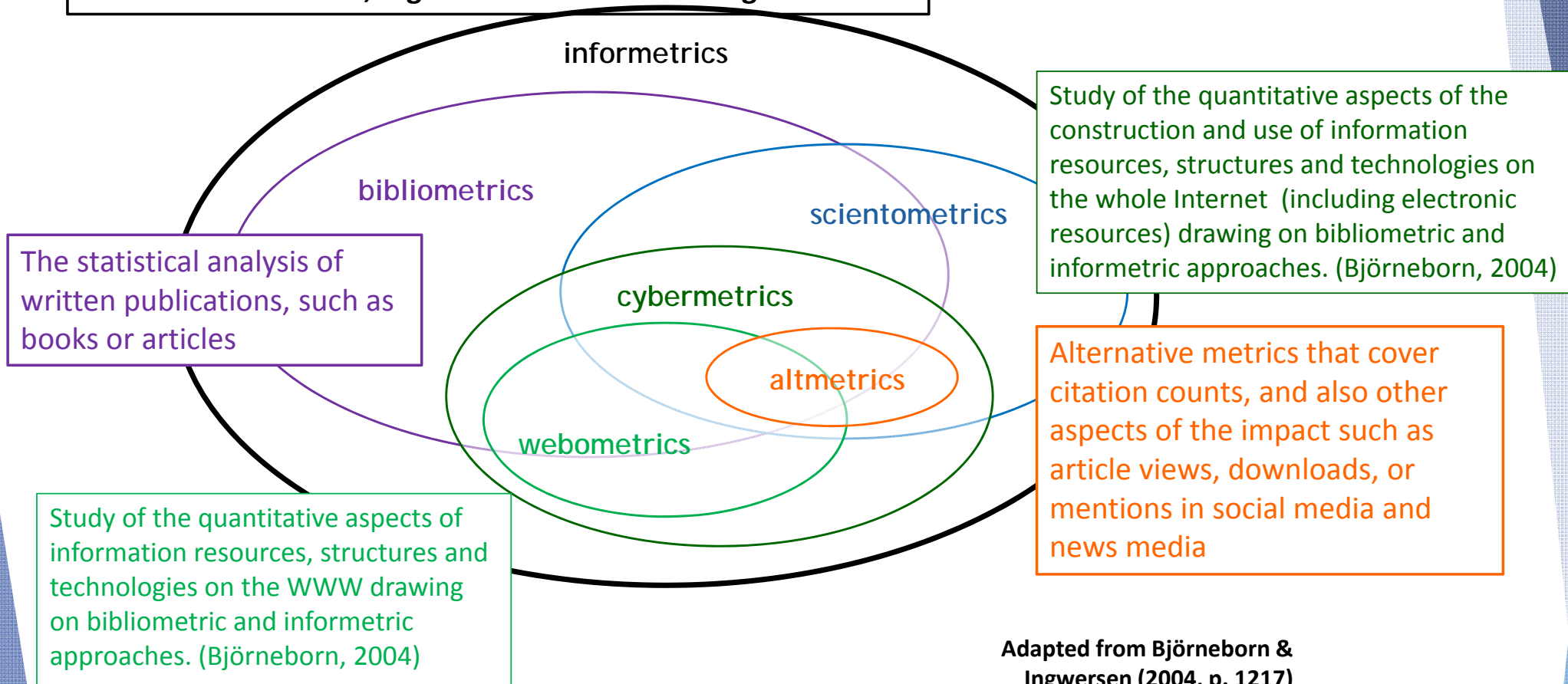
## Classic bibliometrics laws

- **Lotka, 1926**  
Author productivity, examining the publication contributions of authors to a given discipline.
- **Bradford, 1934**  
Journal productivity, examining the concentration of articles in a subject area within a set of scholarly journals.
- **Zipf, 1949**  
Word usage, examining the frequency of occurrence of words within texts.

## Definitions

- **Scientometrics**  
by Nalimov & Mulchenko, 1969:  
“the application of those quantitative methods which are dealing with the analysis of science viewed as an information process”
- **Bibliometrics**  
by Pritchard, 1969:  
“the application of mathematical and statistical methods to books and other media of communication”

**Study of the quantitative aspects of information, includes the production, dissemination, and use of all forms of information, regardless of its form or origin.**



Adapted from Björneborn & Ingwersen (2004, p. 1217)

## Main document types

- Traditionally papers published in periodicals and serials
  - Citable items = *research articles, short communications and notes, letters, reviews, and proceedings papers*
  - Book reviews, editorials, corrections/errata, meeting abstracts and reprints are not considered original research output.

TABLE 1. National publication counts and percentage of publications in each document type for the 26 most active countries and the world total (2007).

Country	All papers	Percentage						
		A	L	R	B	E	M	Rest
USA	392,488	66.5	2.4	5.0	0.6	5.4	19.4	0.7
UK	104,561	65.9	4.6	5.9	1.2	5.5	16.2	0.6
Germany	95,892	72.3	1.7	4.6	0.1	3.2	17.4	0.6
China PR	95,231	92.0	0.6	1.5	0.0	0.7	4.8	0.3
Japan	89,575	78.8	1.5	2.6	0.0	1.2	15.4	0.4
France	63,656	77.6	2.0	4.4	0.1	2.8	12.5	0.6
Canada	57,500	71.7	2.1	4.9	0.5	3.9	16.2	0.6
Italy	55,223	72.7	3.5	4.6	0.1	2.6	16.0	0.5
Spain	41,274	75.9	3.2	4.0	0.1	2.5	13.8	0.5
Australia	35,327	72.4	3.3	5.9	0.6	4.0	13.3	0.5
India	32,842	86.4	3.5	2.6	0.0	2.1	4.7	0.6
South Korea	31,556	83.9	1.2	1.2	0.0	0.8	12.5	0.4
Netherlands	31,148	70.0	3.0	5.4	0.2	3.3	17.7	0.5
Russia	27,330	89.1	0.5	2.8	0.0	0.7	6.5	0.5
Brazil	23,507	79.5	2.0	2.4	0.1	1.4	14.2	0.3
Switzerland	23,165	71.3	1.9	5.5	0.1	3.6	17.1	0.5
Sweden	20,896	77.1	1.5	4.0	0.2	2.4	14.4	0.5
Taiwan	20,038	89.4	1.5	1.2	0.0	1.4	6.1	0.4
Turkey	19,330	79.2	3.8	1.7	0.0	1.7	13.1	0.4
Belgium	17,097	72.1	2.2	5.0	0.1	2.9	17.2	0.5
Poland	16,269	80.0	1.2	2.6	0.0	1.1	14.6	0.4
Israel	12,720	76.8	2.3	4.5	0.1	2.9	12.8	0.5
Austria	12,295	68.9	2.5	4.6	0.0	2.8	20.8	0.5
Greece	11,925	70.2	3.6	4.7	0.0	2.3	18.8	0.4
Denmark	11,750	73.8	1.8	4.4	0.1	2.6	16.7	0.6
Finland	10,055	79.1	1.7	3.9	0.1	1.7	13.2	0.4
World total	1,299,678	68.6	2.8	3.7	0.5	4.8	16.6	2.9

Data source: Thomson Reuters, Web of Science.

A, Article; L, Letter; R, Review; B, Book review; E, Editorial material; M, Meeting abstract.

Source: Zhang et al. JASIST 2011; 62(7), 1403-1411



# Most common data sources

## Scopus

Search	Alerts	My list
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"Service Alert": Chrome 42 and higher and downloading documents from Scopus

Document search | Author search | Affiliation search | Advanced search | Browse Sources | Compare journals

Search for... *Eg., "heart attack" AND stress* Article Title, Abstract, Keywords + ?

+ Add search field

Limit to:

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☐ Added to Scopus in the last 7 days

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ALL

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☒ Physical Sciences (> 7,200 titles.)  
☒ Social Sciences & Humanities (> 5,300 titles.)

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 Expanded (SCI-EXPANDED) –1900-presente  
 Social Sciences Citation Index (SSCI) –1956-presente  
 Social Sciences Citation Index Expanded (SSCI-Expanded) –1975-presente  
 Arts & Humanities Citation Index (A&HCI) –1975-presente  
 Arts & Humanities Citation Index Expanded (A&HCI-Expanded) –1986-2009  
 Social Sciences Citation Index: Science (CPCI-S) –1990-presente  
 Social Sciences Citation Index: Social Science & Humanities (CPCI-SSH) –1990-presente

Web of Science: Índices químicos  
 Chemical Abstracts (CA) –1907-presente  
 Chemical Abstracts Expanded (CA-Expanded) –1986-2009  
 Chemical Abstracts of the Institut National de la Propriété Industrielle de Francia hasta 1840  
 1993-2009

## Google Scholar

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Search Scholar

Overview

Metrics

Coverage

Inclusion

### Google Scholar Metrics

Google Scholar Metrics provide an easy way for authors to quickly gauge the visibility and influence of recent articles in scholarly publications. Scholar Metrics summarize recent citations to many publications, to help authors as they consider where to publish their new research.

To get started, you can browse the top 100 publications in several languages, ordered by their five-year h-index and h-median metrics. To see which articles in a publication were cited the most and who cited them, click on its h-index number to view the articles as well as the citations underlying the metrics.

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To explore specific research areas, select one of the broad areas, click on the "Subcategories" link and then select one of the options. For example: [Databases & Information Systems](#) or [Development Economics](#).

Browsing by research area is, as yet, available only for English publications. You can, of course, search for specific publications in all languages by words in their titles.

Scholar Metrics are currently based on our index as it was in **June 2014**.



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# Other data sources

NCBI Resources How To Sign in to NCBI

PubMed.gov US National Library of Medicine National Institutes of Health

PubMed

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Advanced Help

PubMed

PubMed comprises more than 24 million citations for biomedical literature from MEDLINE, life science journals, and online books. Citations may include links to full-text content from PubMed Central and publisher web sites.

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Beyond economic push-pull: Univ of Kansas Nursing Journal Club covers review of transnational nurse migration.

1.usa.gov/1Ak1Sct

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Life Sciences	68,883
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Date Published

Article

Octreoscan Versus FDG-PET for Neuroendocrine Tumor Staging: A Biological Approach

Clinicians may order Octreoscan or positron emission tomography (PET) scan for staging patients with neuroendocrine tumors (NETs). 111In-Octreoscan (Octreoscan) identifies tumors by radiolabeled targeting of soma...

Malcolm H. Squires III MD, MS, N. Volkan Adsay MD... in *Annals of Surgical Oncology* (2015)

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Article

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Conventional laparoscopy has been applied to colorectal resections for more than 2 decades. However, forming a tumor-specific

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Articles (25877)

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10 count OR

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Health Sciences (17929)

Medicine (General) (17049)

Internal medicine (12439)

Neoplasms, Tumors, Oncology. Including cancer and carcinogens (9180)

Oncology (7407)

Science (3496)

Specialties of internal medicine (2778)

Biology and Life Sciences (2334)

Biology (1907)

Journal license

Publisher

10 count OR

BioMed Central (6563)

Genetics of breast cancer: Applications to the Mexican population

Elad Ziv

Salud Pública de México. 2011;53(5):415-419

Abstract | Full Text

Designed-seamless irradiation technique for extended whole mediastinal proton-beam irradiation for esophageal cancer

Okonogi Nonyuko, Hashimoto Takatoku, Ishida Masaya, Ohno Toshiko, Terunuma Toshiyuki, Okumura Toshiyuki, Sakae Takeji, Sakurai Hideyuki

Radiation Oncology. 2012;7(1):173 DOI 10.1196/1748-717X-7-173

Abstract | Full Text

Fibroblast growth factor receptor 4 Gly388Arg polymorphism in Chinese gastric cancer patients

Yan-Ying Shen, Ya-Chao Lu, Dan-Ping Shan, Yuan-Jie Liu, Xin-Ying Su, Guan-Shan Zhu, Xiao-Lu Yin, Xing-Zhi Ni

World Journal of Gastroenterology. 2013;19(28):4568-4575 DOI 10.3748/wjg.v19.i28.4568

Abstract | Full Text

Development of cabozantinib for the treatment of prostate cancer

Vaishampayan UN

Core Evidence. 2014;2014(default):61-67

Abstract | Full Text

Biomolecular Markers in Cancer of the Tongue

Paolo Fox, Silvano Bosari, Laura Monighini, Carla Codacci-Pisanelli, Jessica Fiore, Dario Ferrari

Journal of Oncology. 2009;2009 DOI 10.1155/2009/412908

Full Text



## Other sources and information

- Social Impact of Research: **Altmetrics** (alternative metrics and tools)

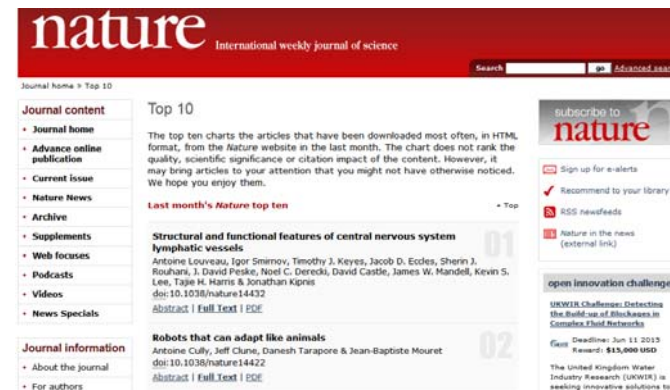
**citeulike**



del.icio.us



- **Documents downloads or views**



- **Patents** and innovation metrics (cooperation and connections between industry and university, use of research outputs in commercial activity, etc.)

## Indicators by level

### Macro-level

- global developments
- national R&D systems
- policies
- cross-sectional fields

### Meso-level

- research and grant programs
- academic fields
- universities, research institutes, funding agencies

### Micro-level

- university institutes/departments
- target/status groups
- research groups
- individuals

## Types of indicators

- Productivity / Activity → number of publications to reflect the research output
- Visibility → count of publications in recognized databases; number of articles in peer reviewed journals; measurement of IF, quartiles or deciles
- Collaboration → number of co-authors or co-affiliations to reflect national and international networking
- Impact → citation rates (several citation indicators)
- Cognitive structures → co-occurrences of words, classifications relations between citations, etc.
- Others → main authorship, percentage of contribution, characterization of publications and disciplines, disciplinary vs cross-disciplinary vs interdisciplinary etc.



Type (generation)	Description	Typical examples
First	Basic indicators; relatively easy to obtain from sources that have been available for decades	Number of publications; number of citations; journal impact metrics
Second	Relative or normalized indicators, correcting for particular biases (e.g. differences in citation practices between subject fields)	Relative or field-normalized citation rates
Third	Based on advanced network analysis using parameters such as network centrality	Influence rates; SCImago Journal Rank; 'prestige' indicators
Fourth	Pre-citation usage counts	PDF downloads; HTML page views
Fifth	Scholarly and lay social network activity	Web and media links / altmetrics including: Twitter counts; Mendeley bookmarks

## The changing face of journal metrics

By Mike Taylor and Judith Kamalski

Posted on 28 November 2012  
<http://www.elsevier.com/connect/the-changing-face-of-journal-metrics#sthash.RKEIgcLh.dpuf>

## II. TYPES AND EXAMPLES OF BIBLIOMETRIC STUDIES

## How can we assess and support research evaluation?

- Monitoring the institutional scientific output
  - Develop an internal workflow and set alerts to register the institution's scientific output
- Developing bibliometric reports and help users with expert bibliometric searches
- Identify new research lines and possibilities for collaboration
- Evaluate external candidates
- Prepare CVs and profiles for appraisals and funding applications
  - Science Experts Network Curriculum Vitae (SciENcv)
  - Unique digital identifiers: Researcher ID, Orcid, Scopus ID
- Assess researchers regarding publication sources and strategies



## Questions or report possibilities

- How much research is taking place?
- In what fields is research being conducted?
- Where is your work having the greatest impact?
- Does the research impact on other research fields?
- Benchmarking comparing research groups or institutions
- Identify front research subjects
- Evaluate the differences of citation tendencies between different fields
- Citation patterns between research groups or journals

## Research output

### ■ Total Count of the Number of Publications

- Journal articles, reviews and other journal publications (letters, news, etc.) , could be in refereed and non refereed journals
- Books and book chapters
- Conference publications (refereed, non-refereed, extracts of paper)
- Patents
- Others

### ■ Other

- Number of publications
- Number of publications in ISI or Scopus
- Number of publications in top journals

## The impact factor

The impact factor (IF) of an academic journal is a **measure reflecting the average number of citations to recent articles published in the journal**. It is frequently used as a proxy for the relative importance of a journal within its field, with journals with higher impact factors deemed to be more important than those with lower ones.

In any given year, the impact factor of a journal is the average number of citations received per paper published in that journal during the two preceding years

**IF**

Received citations in the last year to articles published in the last two years

Number of articles published by the journal in the last two years

It's useful for:

- Measuring the journal's prestige in its scientific community
- Defining which are the most influential journals and decide where to publish
- Defining in which journals are the widely-read articles



## Pros and cons of the impact factor

In November 2007 the [European Association of Science Editors](#) (EASE) issued an official statement recommending "that journal impact factors are used only—and cautiously—for measuring and comparing the influence of entire journals, but not for the assessment of single papers, and certainly not for the assessment of researchers or research programmes"

- The impact factor is not the only indicator of the quality of publications
- For a broader vision we should consider other indicators
- The non-inclusion of a journal in the JCR is not synonymous with poor quality
- Lack of differentiation between different types of documents

Nevertheless:

- ✓ The inclusion of a journal in the JCR is already an indicator that the papers published in it have passed a quality filters and are cited
- ✓ It is a universally recognized way to measure the quality of the research

## Other journals' impact indicators

**Immediacy Index:** Measures the immediate impact, that is, the citations received by a publication during the year which has been published

$$I_{\text{journal in 2014}} = \frac{\text{Number of citations during 2014 to documents published in 2008}}{\text{Number of publications of this journal during 2014}}$$

**Influence Index:** allows to know the influence of a journal within the scientific community

$$I_{\text{inf journal in 2014}} = \frac{\text{Number of citations received by a journal}}{\text{Number of references of the journal}}$$

## Citations

- Total number of citations
- Share of uncited papers
- Normalized citation rate:

Indicates whether a paper is cited above / below average compared to the field it is assigned to.

- Relative citation rate

Indicates whether a paper is cited above / below average compared to the journal it appeared in.



## Normalised citation impact

The relative number of citations to publications from a specific unit, compared to the world average of citations to publications of the same document type, age and subject area.

As an example, 0.9 means that a unit's publications are cited 10% below average and 1.2 that they are cited 20% above average.

**Normalised citation  
impact (1.0 =  
world average)**

The average citation rate of a unit's papers

The world citation average in the subfields in which the unit is active

Corrects for differences in citation practices among fields, publication years and type of document.

## H-index and g-index

- Jorge E. Hirsch introduced a new indicator – called h-index – for the assessment of the research performance of individual scientists.

*“A scientist has index  $h$  if  $h$  of his or her  $N_p$  papers have at least  $h$  citations each and the other  $(N_p - h)$  papers have  $\leq h$  citations each”.*

Proc Natl Acad Sci U S A. 2005; 102(46): 16569-16572

- Leo Egghe introduced an alternative index

*“A set of papers has a g-index  $g$  if  $g$  is the highest rank such that the top  $g$  papers have, together, at least  $g$  citations... “Given a set of articles ranked in decreasing order of the number of citations that they received, the g-index is the (unique) largest number such that the top  $g$  articles received (together) at least  $g^2$  citations.””*

Scientometrics. 2006; 69(1): 131-152

$g$  is (1) the number of highly cited articles, such that each of them has brought (2) on average  $g$  citations. Example: 10 papers, 1 with 400 citations:

$$H\text{-index} = 1$$

$$G\text{-index} = 20 \text{ (400 is } 20^2\text{)}$$

### Advantages:

- The  $g$ -index depends on the full citation count of very highly cited papers, not on the age of the author
- More or less  $h$  is the number of papers of a quality threshold that rises as  $h$  rises;  $g$  allows citations from higher-cited papers to be used to bolster lower-cited papers in meeting this threshold.

**h-index and Variants.**

In: [Soft Computing and Intelligent Information Systems](http://sci2s.ugr.es/hindex) <<http://sci2s.ugr.es/hindex>>



## Some considerations about citations...

- The document type and the 'age' of the paper influences the number of citations received
- Its not possible to distinguish positively or negatively cites an article
- Sometimes articles are cited unread
- In some cases, many citations are self-citations (both author or journal self-citations)
- Inclusion or exclusion of self citations might affect the resulting indicator values
- h-index increases with age, even without further published work
- Citation values depend on the database which they are calculated (greater in Google Scholar than in Web of Science)

## Relative activity and Relative specialization index

- The relative effort a unit of analysis devotes to a specific field measured in publications.

<b>Relative Activity Index</b>	$\frac{\text{The number of publications of the unit (institution, researcher, etc.) in a given field}}{\text{The number of publications of the unit (institution, researcher, etc.) in all fields}}$
--------------------------------	--

- Indicates how active an analysed unit is in a certain field.

<b>Relative Specialization Index</b>	$\frac{\text{Activity index} - 1}{\text{Activity index} + 1}$
--------------------------------------	---



A value of -1 indicates an inactive research field and a value of 1 that all or most of the publications from the unit are in one field.

## Other bibliometric and informetric applications

- Open access affects the IF?
- Countries or areas productivity studies
- Interdisciplinarity studies
- Citation patterns between research groups or journals
- Collaboration studies between groups, institutions or countries
- Evaluate the technological impact of research through patent citation to journal articles



## Questions for consideration regarding the use of metrics in assessing research performance

- What is the **optimal balance** between direct peer reviewing, and the use of quantitative measures based on publication records?
- What **weighting should be applied to** publication number, h factors, journal IF, citation number, primary publication vs review?
- Noting that the order can vary considerably from one field to another, how much credit should be given to **first or last authorship**, middle authorship, or **corresponding authorship**?
- What credit should be given for pre-prints and other electronic publications, **peer reviewed or not**? Should **impact indices** such as downloads, or links be taken into consideration?
- Should the number of **publications that count towards grants or appointments be capped**? For example, should only the best three publications per year be taken into consideration? Should scientists even be **penalized for authorship on more than**, say, 20 publications per year?
- What weighting should be given to **other quantitative measures of research output**, such as patent applications, patents granted or patents licensed?

Publication practices and indices and the role of peer review in research assessment  
(July 2008) ["International Council for Science statement". lcsu.org](http://www.lcsu.org)

## The Leiden Manifesto

10 principles to guide research evaluation:

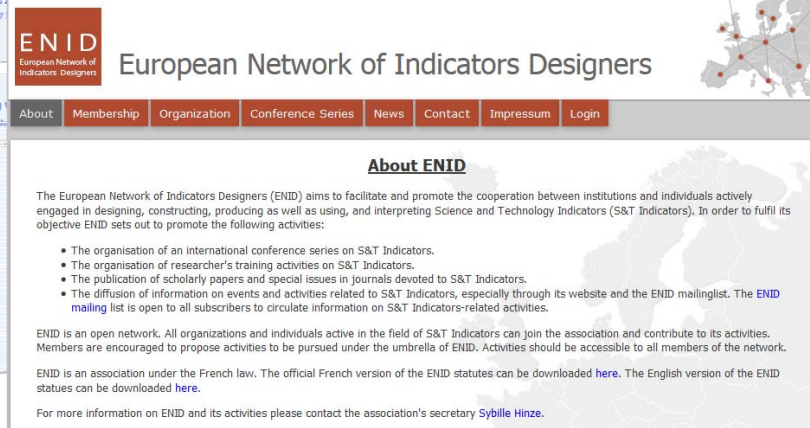
1. Quantitative evaluation should support qualitative, expert assessment
2. Indicators used to evaluate performance should relate clearly to the program goals
3. Protect excellence in locally relevant research
4. Keep data collection and analytical processes open, transparent and simple
5. Allow those evaluated to verify data and analysis.
6. Account for variation by field in publication and citation practices
7. Base assessment of individual researchers on a qualitative judgement of their portfolio.
8. Avoid misplaced concreteness and false precision.
9. Recognize the systemic effect of the assessment and indicators.
10. Scrutinize indicators regularly and update them.







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Knowledge, Research





## III. DATA VISUALIZATION

## VOSviewer

Visualizing scientific landscapes

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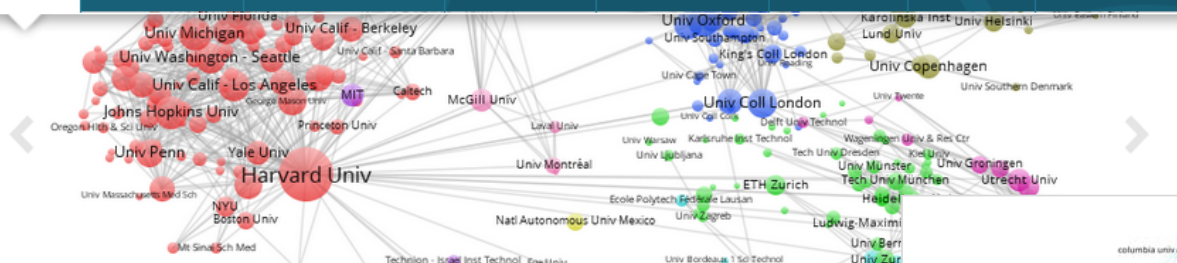
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### Welcome to VOSviewer

VOSviewer is a software tool for constructing and visualizing bibliometric networks. These instance include journals, researchers, or individual publications, and they can be constructed based on co-citation, bibliographic coupling, or co-authorship relations. VOSviewer also offers text mining features that can be used to construct and visualize co-occurrence networks of important terms of scientific literature.

#### VOSviewer version 1.6.4

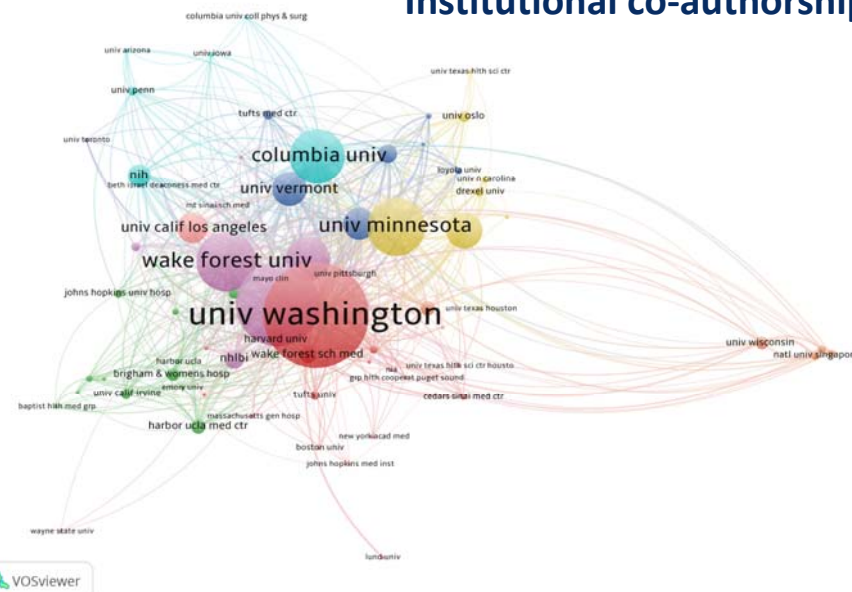
VOSviewer version 1.6.4 was released on April 7, 2016. This version includes





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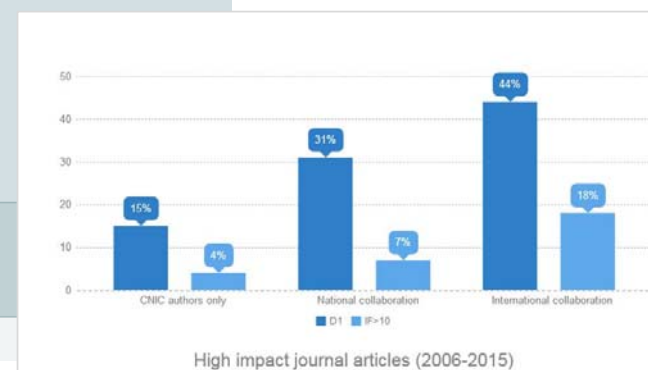
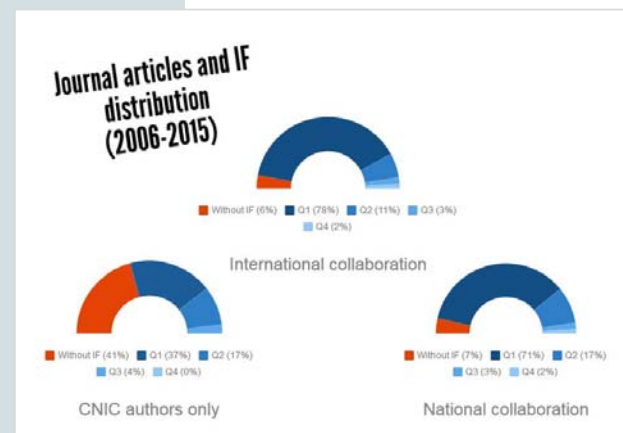


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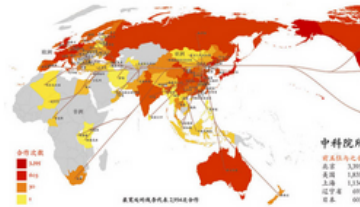


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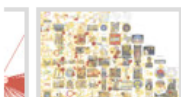

**News**


2016

- Jan 7, The [Sci2 \(Science of Science\) Tool v1.2 beta](#) release provides a range of bug fixes to existing plugins, improvements to plugins and plugin interfaces, and a new 64-bit Windows build.  
[Release Notes](#)



Chinese Academy of Science Co-author N

4 / 4





Have a question?  
Ask an Expert

### Documentation

#### User Manual and Handouts

- Scott Weingart, Hanning Guo, Katy Börner, Kevin W. Boyack, Micah W. Linnemeier, Russell J. Duhon, Patrick A. Phillips, Chintan Tank, and Joseph Biberstine (2010) [Science of Science \(Sci2\) Tool User Manual](#). Cyberinfrastructure for Network Science Center, School of Library and Information Science, Indiana University, Bloomington. [old pdf version](#) - 3.83 MB)
- Sci2 Tool Handout, Alpha 5 Release (Jan 2011)
- [Sci2 Tool Handout](#), Beta 1 Release (Summer 2011, with database support)

#### Classroom Usage

- [S604/S764 Information Networks](#) by Stasa Milojevic, SLIS, IUB
- [S637 Information Visualization](#) by Katy Börner, SLIS, IUB
- [INFO I400 Linked: the science of networks from the social atom to Facebook](#) by Fil Menczer, SOIC, IUB

#### Tutorials


[Katy Börner](#) (2013) Sci2 Workshop at [14th International Society of Scientometrics and Informetrics Conference](#), Vienna, Austria.

David E. Polley and Samantha J. Hale (2013) Sci2 Workshop at [Political Networks in an Interdisciplinary World](#), Political Networks Conference in Bloomington, IN.

[Katy Börner](#) and Monika Herzig (2013) Sci2 Workshop at [4th Annual International Science of Team Science Conference](#), Northwestern University, Evanston, IL.

[Katy Börner](#) (2012) [Sci2 Tool: A Tool for Science of Science Research and Practice Tutorial](#), Portfolio Analysis Symposium, National Institutes of Health, Natcher Auditorium, Bethesda, MD

[Katy Börner](#) and Albert Meroño Peñuela (2012) [Sci2 Tool: A Tool for Science of Science Research and Practice Tutorial](#), OECD, Paris, France.



Watch the movie about CShell-Powered tools on the SciVee: Making Science Visible website by clicking on the image above.

<https://sci2.cns.iu.edu/user/index.php>

# THANK YOU FOR YOUR ATTENTION!

## FOR FURTHER QUESTIONS:

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