How to use bibliometric indices? (if you really must)

Denis Bouyssou
CNRS

Paris 2022
Outline

1. Bibliometrics
2. Model & Results
3. Discussion
Globalization

- knowledge economy
- financial and economic crisis
Academia

Globalization
- knowledge economy
- financial and economic crisis

Globalization and academia
- budget cuts
- arrival of new players (China, India)
- increased mobility of staff & students
- industrialization of academia
Industrialization of academia

Symptoms

- evaluation & funding agencies
- students’ debt crisis
- fraud & plagiarism
- proliferation of indices & rankings: “evaluation fever” (Y. Gingras)
  - bibliometric indices everywhere
Two extreme positions

- bibliometrics is an absolute evil
- bibliometrics brings objectivity and fairness
Two extreme positions
- bibliometrics is an absolute evil
- bibliometrics brings objectivity and fairness

Both positions are plainly wrong!
Bibliometrics defined

- using mathematical and statistical techniques to study communication patterns
Bibliometrics

Bibliometrics defined

- using mathematical and statistical techniques to study communication patterns

The field of Bibliometrics

- active scientific field
  - journals: *Scientometrics*, *Journal of Informetrics*, *Journal of the Association for Information Science and Technology*
  - ISSI: International Society for Scientometrics and Informetrics
Some research questions

- bibliometric laws: Lotka, Bradford
- social network of \{scientists, papers, fields\}
- efficiency of research expenses
- optimal size of an academic institution
- factors influencing transfer of knowledge towards industry
- which journals should libraries subscribe to?
- impact of open access on diffusion on knowledge
- strong and weak research fields of a country
- emerging fields
Journal of Economic Literature 2008 IF (3.65 in 2008 / 5.410 in 2018)
(Using WoS, number of citations given by papers published in 2008 to papers published by JEL in 2006–2007 divided by the number of papers published by JEL in 2006–2007)
Bart knows!

I will not use the IF of journals to evaluate papers anymore
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Evaluative bibliometrics

- publications in journals are the central research output
- citations to publications are important signs of recognition

“bibliometrically limited view of a complex reality” (van Raan, 2005)
Evaluative bibliometrics and bibliometric indices

Evaluative bibliometrics
- Publications in journals are the central research output
- Citations to publications are important signs of recognition
  “Bibliometrically limited view of a complex reality” (van Raan, 2005)

- Count publications & citations
- Summarize these counts by indices
Evaluative bibliometrics and bibliometric indices

Databases

- Web of Science (Clarivate aka Thomson Reuters aka ISI)
- Scopus (Elsevier)
- Google Scholar (Google or PoP)
Quality of data

Denis BOUYSSOU

- plain ASCII
- no \LaTeX{} ligature
- no diacritical signs
- only one word
- no known scientific homonyms

Meltem Öztürk-Escoffier, Zhāng Wěi, Włodzimierz Łukaszewski, Kim Seo-yoon
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Denis BOUYSSOU (checked: 5 September 2022)

<table>
<thead>
<tr>
<th>Database</th>
<th>Papers</th>
<th>Citations</th>
<th>h-index</th>
</tr>
</thead>
<tbody>
<tr>
<td>GS</td>
<td>280</td>
<td>8870</td>
<td>41</td>
</tr>
<tr>
<td>Scopus</td>
<td>83</td>
<td>1667</td>
<td>22</td>
</tr>
<tr>
<td>WoS</td>
<td>77</td>
<td>875</td>
<td>19</td>
</tr>
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Bart knows!

I will not use GS or WoS during evaluation committees
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A few words of warning

Databases

- cleansing is needed and not easy to do!
  - names: diacritical signs, \TeX\ ligatures, transliteration, homonyms
  - correct affiliations are extremely difficult to determine
  - counting: original articles, letters, notes, erratum, editorials
  - spelling errors + incorrect citations
  - lost citations (up to 30%)
- important differences between fields
  - publication intensity
  - citation intensity & behavior
  - longevity of papers (months vs decades)
Citation intensity for the 21 WoS categories (2000)
Map of scientific fields (PNAS, 2008)
Bibliometric nightmares

- how to deal with **multiple authors** (sometimes more than 1,000)
- how to deal with **multiple affiliations**
- how to compare people having different **career length**
- people react and adapt quickly: **perverse effects** are pervasive
- how to understand the **meaning of a citation** (papers on Hydroxychloroquine cure)
Examples of papers with many authors (2011)

<table>
<thead>
<tr>
<th>Year</th>
<th>Paper</th>
<th>Number of authors</th>
</tr>
</thead>
</table>
Bibliometric indices

Hypotheses

- all above problems have been taken care of
- you have a good, verified, and cleaned database
- otherwise, do not use evaluative bibliometrics!
## Bibliometric indices

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### Many possible indices
- Counting of papers
- Counting of citations
- Sum of Impact Factors
- Markovian indices (e.g., PageRank-like)
- $h$-index
Bibliometric indices

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Bibliometric Indices

- what properties?
- how to compare (combine, use) them?
Potential problems with the *h*-index (1/2)

---

**h-index**, J. Hirsch, PNAS, 2005 (6,199 citations on WoS, Sept. 2022)

- The *h*-index of an author is *x* if this author has *x* papers having at least *x* citations each (and her other papers have at most *x* citations each)

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Potential problems with the $h$-index (1/2)

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- The $h$-index of an author is $x$ if this author has $x$ papers having at least $x$ citations each (and her other papers have at most $x$ citations each)

- Author $f$: 4 papers with 4 citations each ($4 \cdot 1_4$)
- Author $g$: 3 papers with 6 citations each ($3 \cdot 1_6$)
- $i_h(f) = 4 > i_h(g) = 3$
### Potential problems with the *h*-index (1/2)


- The *h*-index of an author is $x$ if this author has $x$ papers having at least $x$ citations each (and her other papers have at most $x$ citations each).

<table>
<thead>
<tr>
<th>Author</th>
<th>Papers</th>
<th>Citations per Paper</th>
<th>Total Citations</th>
</tr>
</thead>
<tbody>
<tr>
<td>$f$</td>
<td>4</td>
<td>4</td>
<td>$4 \cdot 1_4$</td>
</tr>
<tr>
<td>$g$</td>
<td>3</td>
<td>6</td>
<td>$3 \cdot 1_6$</td>
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- $i_h(f) = 4 > i_h(g) = 3$

- Both authors publish a new paper with 6 citations ($1_6$).

  - $i_h(f^*) = 4 = i_h(g^*) = 4$ \quad (f^* = f + 1_6 \quad g^* = g + 1_6)$
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</tr>
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<td><em>f</em></td>
<td>4</td>
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<td>4</td>
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<td>6</td>
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</table>

- \( i_h(f) = 4 > i_h(g) = 3 \)

- Both authors publish a new paper with 6 citations (16)
  - \( i_h(f^*) = 4 = i_h(g^*) = 4 \) \( (f^* = f + 16, g^* = g + 16) \)

- Both authors publish a new paper with 6 citations (16)
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**Independence is violated**
Potential problems with the $h$-index (2/2)

Evaluation of authors and departments

- The $h$-index of a department is $x$ if this department has $x$ papers having at least $x$ citations each (and its other papers have at most $x$ citations each).
Potential problems with the $h$-index (2/2)

**Evaluation of authors and departments**

- the $h$-index of a department is $x$ if this department has $x$ papers having at least $x$ citations each (and its other papers have at most $x$ citations each)

**Department $F = (f_1, f_2)$**

- author $f_1 = 4 \cdot 14$
- author $f_2 = 4 \cdot 14$
  - $h$-index of both authors is 4
  - $h$-index of the department is 4
Potential problems with the $h$-index (2/2)

Evaluation of authors and departments
- the $h$-index of a department is $x$ if this department has $x$ papers having at least $x$ citations each (and its other papers have at most $x$ citations each)

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Consistency is violated: the “best” department contains the “worst” authors!
Potential problems with the $h$-index (2/2)

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Outline

1. Bibliometrics
2. Model & Results
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Model of Authors

Authors

- An author is a function $f$ from $\mathbb{N}$ to $\mathbb{N}$
- $f(x)$ is the number of papers by this author having received $x$ citations
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<th>7</th>
<th>8</th>
<th>$\ldots$</th>
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6 papers, 9 citations
Model of Authors

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Objective

- build a binary relation $\succsim$ on $\mathcal{A}$
- $f \succsim g$ if “given their publication/citation record”, scientist $f$ is at least as good as scientist $g$
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**Important Limitation**
- Coauthors are ignored in this talk
Model of Departments

- A department of size $k$ is an element of $\mathcal{A}^k: (f_1, f_2, \ldots, f_k)$
Model of Departments

Departments

- A department of size $k$ is an element of $\mathcal{A}_k$: $(f_1, f_2, \ldots, f_k)$

Objective

- build a binary relation $\succeq$ on $\mathcal{D}$
- $F \succeq G$ if “given their publication/citation record of the scientists in departments $F$ and $G$”, department $F$ is at least as good as department $G$"
Model of Departments

Departments

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Important limitations

- multiple affiliations are ignored
- field normalization is ignored
Axioms

Build $\succeq$ and $\succ$ satisfying

- Consistency
  - seen above

- Transfer
  - if a member of a department publishes a new paper I do not care about who in the department is doing so

- Homogeneity
  - duplicating all authors in a department leaves unchanged the position of the department

- Archimedean
  - any two citation profiles are commensurate
Axioms

Build \( \preceq \) and \( \succeq \) satisfying

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Independence is implied
Consistency

\[ F = (f_1, f_2, \ldots, f_k) \text{ and } G = (g_1, g_2, \ldots, g_k) \]: departments of size \( k \).

If \( f_i \succsim g_i \), for all \( i \) then \( F \succeq G \)

If \( f_i \succsim g_i \), for all \( i \) and if \( f_j \succ g_j \), for some \( j \) then \( F \succ G \)

Transfer

\[ (f_1, \ldots, f_i + 1_x, \ldots, f_k) \triangleq (f_1, \ldots, f_j + 1_x, \ldots, f_k) \]

Homogeneity

\[ (f_1, f_2, \ldots, f_k) \triangleq (f_1, f_1, \ldots, f_1, f_2, f_2, \ldots, f_2, \ldots, f_k, f_k, \ldots, f_k) \]

Archimedeanness

\[ f \succ g \Rightarrow \exists n \in \mathbb{N} \text{ s.t. } f' + (n \cdot f) \succsim g' + (n \cdot g) \]
Scoring rules for scientists

**Definition**

≿ is a scoring rule for scientists (s-scoring rule) if there is a real valued function $u$ on $\mathbb{N}$ such that

$$f \succsim g \iff \sum_{x \in \mathbb{N}} f(x)u(x) \geq \sum_{x \in \mathbb{N}} g(x)u(x)$$

- $u(x)$ gives the worth of one publication with $x$ citations
- many bibliometric indices are scoring rules (but not the $h$-index)
- all scoring rules satisfy independence
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\]

- \( u(x) \) gives the worth of one publication with \( x \) citations
- many bibliometric indices are scoring rules (but not the \( h \)-index)
- all scoring rules satisfy independence

Examples

- \( u(x) = x \): number of citations
- \( u(x) = 1 \): number of publications
- \( u(x) = 1 \) if \( x \geq \alpha \): number of highly cited publications
Rules for departments

Definition

$\succeq$ is an averaging rule for departments (d-averaging rule) if there is a real valued function $v$ on $\mathbb{N}$ such that

$$(f_1, f_2, \ldots, f_k) \succeq (g_1, g_2, \ldots, g_\ell) \iff \frac{1}{k} \sum_{i=1}^{k} \sum_{x \in \mathbb{N}} f_i(x)v(x) \geq \frac{1}{\ell} \sum_{i=1}^{\ell} \sum_{x \in \mathbb{N}} g_i(x)v(x)$$
Sample result

Theorem (B & Marchant, 2011)

The relations $\succeq$ and $\succ$ are linked by Consistency, $\succ$ satisfies Transfer and Homogeneity, $\succeq$ satisfies Archimedeaness

if and only if $\succeq$ is an s-scoring rule and $\succ$ is a d-averaging rule with $u = v$

The function $u$ is unique up to the multiplication by a positive constant
Extensions

- add additional conditions to restrict the shape of $u$
  - $u$ is nondecreasing
  - $u$ is constant
  - $u$ is linear

- characterize indices instead of rankings

Easy!
Extensions

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  - $u$ is nondecreasing
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Easy!

Extensions

- coauthors
- multiple affiliations
- field normalization
- length of career ("age")

Difficult!
Outline

1 Bibliometrics

2 Model & Results

3 Discussion
Bibliometrics

- bibliometrics is not limited to evaluative bibliometrics
- (evaluative) bibliometrics is an interesting field of study
Discussion

Messages

Bibliometrics
- bibliometrics is not limited to evaluative bibliometrics
- (evaluative) bibliometrics is an interesting field of study

Evaluative bibliometrics in practice
- it should be used with much care
- it should not be in the hands of laypersons
- it should not be entrenched in formal rules
- it should always be used as a complement to careful and impartial peer review
  - there is no substitute to reading the papers!
  - there is no substitute to open and public debate!
Warning

- there are quite bad indices
- beware of scientists giving their $h$-index on their Web page or CV!
- beware of comparisons of Universities using bibliometric indices
Discussion

More Messages

Warning
- there are quite bad indices
- beware of scientists giving their $h$-index on their Web page or CV!
- beware of comparisons of Universities using bibliometric indices

(Informal) Proposition on Evaluative Bibliometrics

If
- trained bibliometricians have prepared a clean database
- used to compare people of the “same age” and working in the same field
- using scoring rules

then (and only then)
Evaluative Bibliometrics may be of some help
Are you excellent?

**Excellence**

- **excellence** is another word for **outliers**
  - not everyone can be excellent!
  - what should we do with people that are not excellent?
  - is the mantra of excellence a good motivating tool?
Citation statistics
Statistical Science, 24 (1), 1–14

Bouyssou, D., Marchant, T. (2011)
Ranking scientists and departments in a consistent manner
Journal of the American Society for Information Science and Technology, 62 (9), 1761–1769

Bouyssou, D., Marchant, T. (2014)
An axiomatic approach to bibliometric rankings and indices
Journal of Informetrics, 8 (1), 449–477

Bouyssou, D., Marchant, T. (2016)
Ranking authors using fractional counting of citations: An axiomatic approach
Journal of Informetrics, 10 (1), 183–199
C'EST TOUT POUR AUJOURD'HUI.
Questions?