Recent Developments in the Measurement of Intellectual Influence

Ignacio Palacios-Huerta
LSE

Oscar Volij
Ben Gurion University

EARIE 2013, Évora

Two Types of Ranking Problems

1. “Journal Ranking” Problems

2. “CV” or “Citation Records” Ranking Problems

Two Types of Ranking Problems

1. “Journal Ranking” Problems

    . Palacios-Huerta and Volij (2004)

    . Demange (2012)

2. “CV” or “Citation Records” Ranking Problems

Two Types of Ranking Problems

1. “Journal Ranking” Problems

   . Palacios-Huerta and Volij (2004)

   . Demange (2012)

2. “CV” or “Citation Record” Ranking Problems

   . Chambers and Miller (2013)

   . Perry and Reny (2013)

1. Journal Ranking Problems

JCitationR.pdf - Adobe Reader

File Edit View Window Help

1 / 2 133% Tools Sign Comment

ISI Web of Knowledge℠

Journal Citation Reports®

WELCOME HELP

2009 JCR Social Science Edition

Journal Summary List

Journal Title Changes

Journals from: **subject categories ECONOMICS** VIEW CATEGORY SUMMARY LIST

Sorted by: ArticleInfluence(TM) Score SORT AGAIN

Journals 1 - 20 (of 247) [1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10] **Page 1 of 13**

MARK ALL UPDATE MARKED LIST

Ranking is based on your journal and sort selections.

Mark	Rank	Abbreviated Journal Title *(linked to journal information)*	ISSN	JCR Data						*Eigenfactor™* Metrics	
				Total Cites	Impact Factor	5-Year Impact Factor	Immediacy Index	Articles	Cited Half-life	*Eigenfactor™* Score	*Article Influence™* Score
	1	Q J ECON	0033-5533	13985	5.647	8.171	0.953	43	>10.0	0.04986	11.686
	2	J POLIT ECON	0022-3808	16350	3.841	6.924	0.323	31	>10.0	0.04091	9.928
	3	J ECON LIT	0022-0515	5018	6.919	8.922	1.000	18	>10.0	0.01550	8.274
	4	ECONOMETRICA	0012-9682	20643	4.000	5.321	0.246	61	>10.0	0.04303	7.715
			0022-								

JCR-Web 4.pdf - Adobe Reader

File Edit View Window Help

1 / 1 133% Tools Sign Comment

ISI Web of Knowledge℠

Journal Citation Reports®

WELCOME HELP RETURN TO JOURNAL

2012 JCR Social Science Edition

Cited Journal: AMERICAN ECONOMIC REVIEW

Number of times articles published in 2012 (in journals below) cited articles published in AM ECON REV (in years below). (How to read this table)

Journals 1 - 20 (of 1327) [1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10] **Page 1 of 67**

Impact	Citing Journal	Cited Year											
		All Yrs	2012	2011	2010	2009	2008	2007	2006	2005	2004	2003	Rest
	All Journals	27876	237	561	701	920	1032	1017	1053	1098	1243	1096	18918
2.792	AM ECON REV	738	123	38	31	45	60	52	36	24	25	26	278
	ALL OTHERS (677)	677	0	10	13	15	25	16	19	28	31	30	490
1.065	J ECON BEHAV ORGAN	521	2	13	20	22	28	28	25	32	29	22	300
0.509	ECON LETT	430	2	13	11	14	28	18	17	19	18	15	275
0.437	APPL ECON	362	0	1	0	5	7	10	8	7	12	9	303
1.331	EUR ECON REV	303	2	7	15	10	14	13	15	16	21	11	179
0.557	ECON MODEL	294	0	2	5	6	11	5	6	9	9	7	234
2.086	J INT ECON	253	2	5	17	10	27	9	6	12	22	21	122

- An example of a journal ranking problem:

$$
\begin{array}{c}
\\
JPE \\
AER \\
QJE
\end{array}
\begin{array}{c}
\begin{array}{ccc} JPE & AER & QJE \end{array} \\
\begin{pmatrix}
100 & 100 & 150 \\
50 & 200 & 100 \\
100 & 50 & 150
\end{pmatrix}
\end{array}
$$

# of citations **by** AER **to** JPE

	JPE	*AER*	*QJE*
JPE	100	100	150
AER	50	200	100
QJE	100	50	150

This is the "**cv**" of the *JPE*. All its papers have been collapsed into one row. It shows the number of citations obtained from other journals.

$$
\begin{array}{c c}
 & \begin{array}{ccc} \quad JPE & \quad AER & \quad QJE \end{array} \\
\begin{array}{c} JPE \\ AER \\ QJE \end{array} & \begin{pmatrix} 100 & 100 & 150 \\ 50 & 200 & 100 \\ 100 & 50 & 150 \end{pmatrix}
\end{array}
$$

These are the *QJE*'s "**opinions**" about the journals.

- A journal ranking problem consists of a set of journals and their opinions about them.

$$C = \begin{pmatrix} c_{11} & \cdots & c_{1n} \\ & \ddots & \\ \vdots & c_{ij} & \vdots \\ & & \ddots \\ c_{n1} & \cdots & c_{nn} \end{pmatrix}$$

# of citations **by** journal j **to** journal i

- The objective is to take a journal ranking problem and aggregate the journals' opinions into one "objective" opinion.

$$\begin{pmatrix} c_{11} & \cdots & c_{1j} & \cdots & c_{1n} \\ & \ddots & \vdots & & \\ \vdots & & c_{ij} & & \vdots \\ & & \vdots & \ddots & \\ c_{n1} & \cdots & c_{nj} & & c_{nn} \end{pmatrix} \xrightarrow{\;f\;} \begin{pmatrix} v_1 \\ \vdots \\ v_i \\ \vdots \\ v_n \end{pmatrix}$$

$$v_i \geq 0 \quad \sum_i v_i = 1$$

Examples

Ex.1: The impact factor

$$\begin{pmatrix} c_{11} & \cdots & c_{1j} & \cdots & c_{1n} \\ & \ddots & \vdots & & \\ \vdots & & c_{ij} & & \vdots \\ & & \vdots & \ddots & \\ c_{n1} & \cdots & c_{nj} & & c_{nn} \end{pmatrix} \rightarrow \begin{pmatrix} \sum_j c_{1j} \\ \vdots \\ \sum_j c_{ij} \\ \vdots \\ \sum_j c_{nj} \end{pmatrix} / \sum_{ij} c_{ij}$$

Ex.2: Liebowitz-Palmer method

$$\begin{pmatrix} c_{11} & \cdots & c_{1j} & \cdots & c_{1n} \\ & \ddots & \vdots & & \\ \vdots & & c_{ij} & & \vdots \\ & & \vdots & \ddots & \\ c_{n1} & \cdots & c_{nj} & & c_{nn} \end{pmatrix} \qquad \begin{pmatrix} v_1 \\ \vdots \\ v_i \\ \vdots \\ v_n \end{pmatrix}$$

$$v_i = \lambda \sum_j c_{ij} v_j \quad i = 1, \ldots, n$$

$$\sum_i v_i = 1$$

$$\begin{pmatrix} c_{11} & \cdots & c_{1j} & \cdots & c_{1n} \\ & \ddots & \vdots & & \\ \vdots & & c_{ij} & & \vdots \\ & & \vdots & \ddots & \\ c_{n1} & \cdots & c_{nj} & & c_{nn} \end{pmatrix}$$

$$c_1 \qquad\qquad c_j \qquad\qquad c_n$$

$$c_j = \sum_i c_{ij}$$

Ex.3: Invariant method

(Google's Page Rank, Eigenfactor)

$$\begin{pmatrix} c_{11} & \cdots & c_{1j} & \cdots & c_{1n} \\ & \ddots & \vdots & & \\ \vdots & & c_{ij} & & \vdots \\ & & \vdots & \ddots & \\ c_{n1} & \cdots & c_{nj} & & c_{nn} \end{pmatrix} \rightarrow \begin{pmatrix} v_1 \\ \vdots \\ v_i \\ \vdots \\ v_n \end{pmatrix}$$

$$v_i = \sum_j \frac{c_{ij}}{c_j} v_j \quad i = 1, \ldots, n$$

$$\sum_i v_i = 1$$

Ex.4: The Handicap method

$$\begin{pmatrix} c_{11} & \cdots & c_{1j} & \cdots & c_{1n} \\ & \ddots & \vdots & & \\ \vdots & & c_{ij} & & \vdots \\ & & \vdots & \ddots & \\ c_{n1} & \cdots & c_{nj} & & c_{nn} \end{pmatrix} \longrightarrow \begin{pmatrix} v_1 \\ \vdots \\ v_i \\ \vdots \\ v_n \end{pmatrix}$$

$$v_i = \sum_j \frac{c_{ij}}{q_j} \quad i = 1, \dots, n$$

$$q_j = \sum_i \frac{c_{ij}}{v_i} \quad j = 1, \dots, n$$

$$\sum_i v_i = 1$$

Special Problems

- Normalized problems: Ones that for each column, the sum of its entries equals 1.

$$\begin{pmatrix} c_{11} & \cdots & c_{1j} & \cdots & c_{1n} \\ & \ddots & \vdots & & \\ \vdots & & c_{ij} & & \vdots \\ & & \vdots & \ddots & \\ c_{n1} & \cdots & c_{nj} & & c_{nn} \end{pmatrix}$$

$$\text{-----------------}$$

$$1 \quad \cdots \quad 1 \quad \cdots \quad 1$$

Special Problems

- Row-Balanced problems: Ones that for each row, the sum of its entries are all equal.

$$\begin{pmatrix} c_{11} & \cdots & c_{1j} & \cdots & c_{1n} \\ & \ddots & \vdots & & \\ \vdots & & c_{ij} & & \vdots \\ & & \vdots & \ddots & \\ c_{n1} & \cdots & c_{nj} & & c_{nn} \end{pmatrix} \begin{matrix} \mathrm{c} \\ \mathrm{c} \\ \mathrm{c} \\ \mathrm{c} \\ \mathrm{c} \end{matrix}$$

Axioms

- Invariance to reference intensity. You have 1 vote and your opinion (something relative) does not change, so the scores should not change

$$\begin{pmatrix} c_{11} & \cdots & c_{1j} & \cdots & c_{1n} \\ & \ddots & \vdots & & \\ \vdots & & c_{ij} & & \vdots \\ & & \vdots & \ddots & \\ c_{n1} & \cdots & c_{nj} & & c_{nn} \end{pmatrix}$$

$$\begin{pmatrix} v_1 \\ \vdots \\ v_i \\ \vdots \\ v_n \end{pmatrix}$$

$$\begin{pmatrix} c_{11} & \cdots & \lambda c_{1j} & \cdots & c_{1n} \\ & \ddots & \vdots & & \\ \vdots & & \lambda c_{ij} & & \vdots \\ & & \vdots & \ddots & \\ c_{n1} & \cdots & \lambda c_{nj} & & c_{nn} \end{pmatrix}$$

Axioms

- Uniformity: If a problem is both normalized and row-balanced, then all journals have the same score.

If

$$\begin{pmatrix} c_{11} & \cdots & c_{1j} & \cdots & c_{1n} \\ & \ddots & \vdots & & \\ \vdots & & c_{ij} & & \vdots \\ & & \vdots & \ddots & \\ c_{n1} & \cdots & c_{nj} & & c_{nn} \end{pmatrix} \begin{matrix} \text{c} \\ \text{c} \\ \text{c} \\ \text{c} \\ \text{c} \end{matrix}$$

$$\begin{matrix} 1 & \cdots & 1 & \cdots & 1 \end{matrix}$$

Then

$$\begin{pmatrix} 1/n \\ \vdots \\ 1/n \\ \vdots \\ 1/n \end{pmatrix}$$

Axioms

- Exactness: If a problem is normalized and if all journals have the same score, then the problem must be row-balanced.

If

$$\begin{pmatrix} c_{11} & \cdots & c_{1j} & \cdots & c_{1n} \\ & \ddots & \vdots & & \\ \vdots & & c_{ij} & & \vdots \\ & & \vdots & \ddots & \\ c_{n1} & \cdots & c_{nj} & & c_{nn} \end{pmatrix} \begin{matrix} c \\ \vdots \\ c \\ \vdots \\ c \end{matrix}$$

$$\begin{matrix} 1 & \cdots & 1 & \cdots & 1 \end{matrix}$$

Then

$$\begin{pmatrix} 1/n \\ \vdots \\ 1/n \\ \vdots \\ 1/n \end{pmatrix}$$

Axioms

- **Homogeneity:** If everybody's opinion about a journal changes by a factor of λ, then his score in the aggregate also changes by a factor of λ.

If

$$\begin{pmatrix} c_{11} & \cdots & c_{1j} & \cdots & c_{1n} \\ \vdots & \ddots & \vdots & & \vdots \\ c_{i1} & \cdots & c_{ij} & \cdots & c_{in} \\ \vdots & & \vdots & \ddots & \vdots \\ c_{n1} & \cdots & c_{nj} & & c_{nn} \end{pmatrix} \longrightarrow \begin{pmatrix} v_1 \\ \vdots \\ v_i \\ \vdots \\ v_n \end{pmatrix}$$

then

$$\begin{pmatrix} c_{11} & \cdots & c_{1j} & \cdots & c_{1n} \\ \vdots & \ddots & \vdots & & \vdots \\ \lambda c_{i1} & \cdots & \lambda c_{ij} & \cdots & \lambda c_{in} \\ \vdots & & \vdots & \ddots & \vdots \\ c_{n1} & \cdots & c_{nj} & & c_{nn} \end{pmatrix} \longrightarrow \begin{pmatrix} v_1 \\ \vdots \\ \lambda v_i \\ \vdots \\ v_n \end{pmatrix}$$

Axioms

- Weak homogeneity (or "Import-Export" axiom)
  Stigler, Stigler, Friedland (1990): In *2-journal* problems, when journals have the *same* length of references, the relative impact is determined by their "import-export" ratio:

$$\begin{pmatrix} 1-a & b \\ a & 1-b \end{pmatrix} \rightarrow \begin{pmatrix} b \\ a \end{pmatrix} /(a+b)$$

Journal 1 imports *b* citations from 2, and exports *a* citations to 1.
Journal 2 imports *a* citations from 1, and exports *b* citations to 2.

Axioms

Consistency

If

$$\begin{pmatrix} 30 & 16 & 10 \\ 15 & 35 & 20 \\ 15 & 9 & 30 \end{pmatrix} \rightarrow \begin{pmatrix} v_1 \\ v_2 \\ v_3 \end{pmatrix}$$

then

$$\begin{pmatrix} 30+5 & 16+3 \\ 15+10 & 35+6 \end{pmatrix} \rightarrow \begin{pmatrix} v_1 \\ v_2 \end{pmatrix}$$

Results

- The **Invariant method** is the only one that satisfies *invariance to reference intensity*, *weak homogeneity* and *consistency* (Palacios-Huerta and Volij, 2004).

  It also satisfies *uniformity* and *exactness*.

- The **Handicap method** is the only one that satisfies *invariance to reference intensity, uniformity* and *homogeneity* (Demange 2012).
- The **Handicap method** is the only one that satisfies *invariance to reference intensity, exactness* and *homogeneity* (Demange 2012).

- The Invariant Method does not satisfy homogeneity.
- The Handicap Method does not satisfy weak homogeneity (“import-export”) and does not satisfy consistency.

2- Ranking CVs or citation records or scholars

A **citation record**, a.k.a. **CV**, is a list

$$CV = (c_1, \ldots, c_n)$$

of non-negative numbers, ordered from highest to lowest, where n is the number of publications and, for each $i=1,\ldots,n$, c_i is the number of citations obtained by publication i.

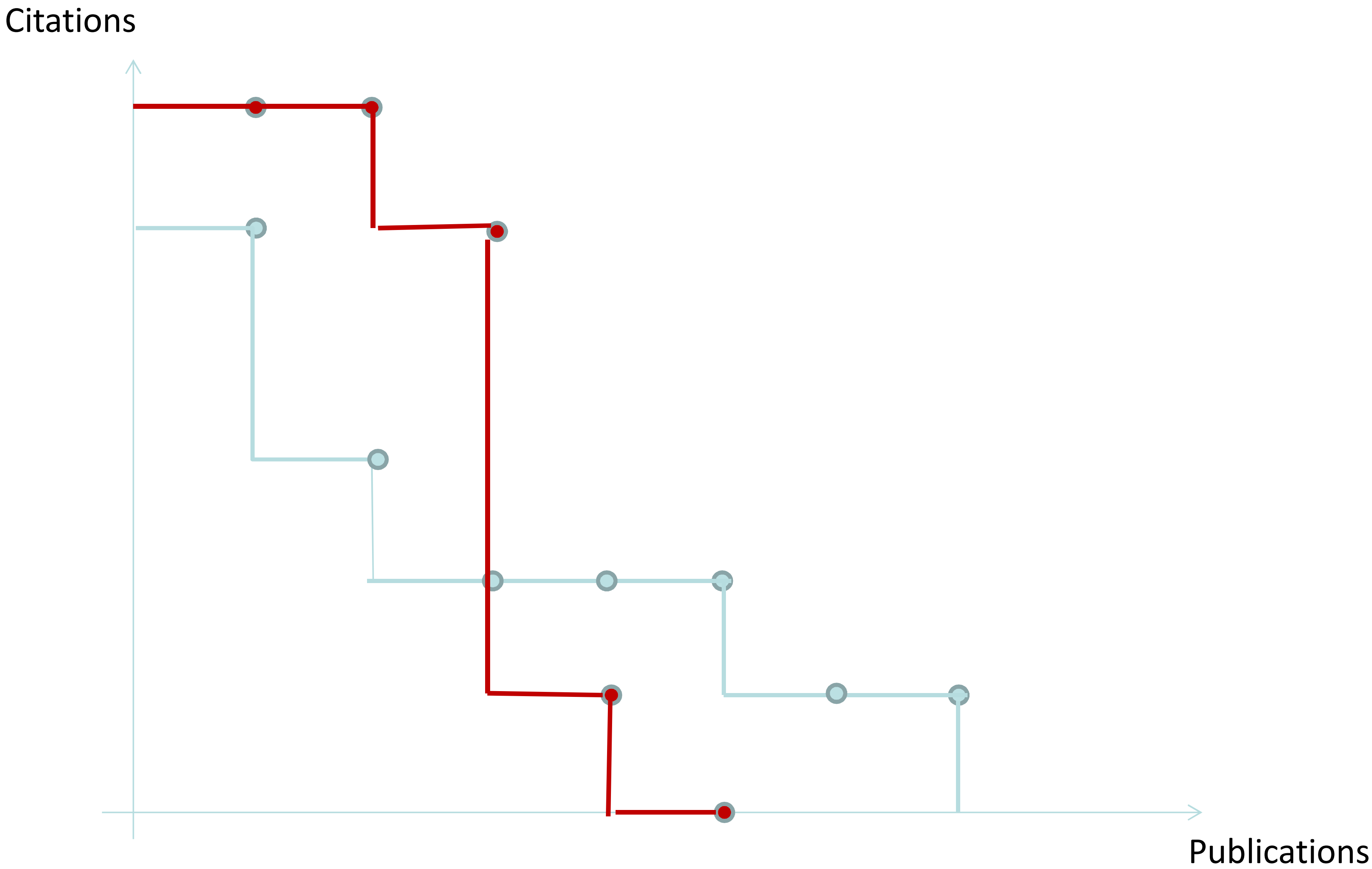
Examples of three CVs with different number of publications:

$$CV1 = (100, 2, 1, 0)$$

$$CV2 = (\sqrt{2}, 1, 1/3)$$

$$CV3 = (50, 49, 48, 30, 20)$$

Graphical representation of a CV



- The objective is to take a CV ranking problem and aggregate the CV's citations into one "objective" number.

$$(c_1,\ldots,c_n) \qquad\qquad I(c_1,\ldots,c_n)$$

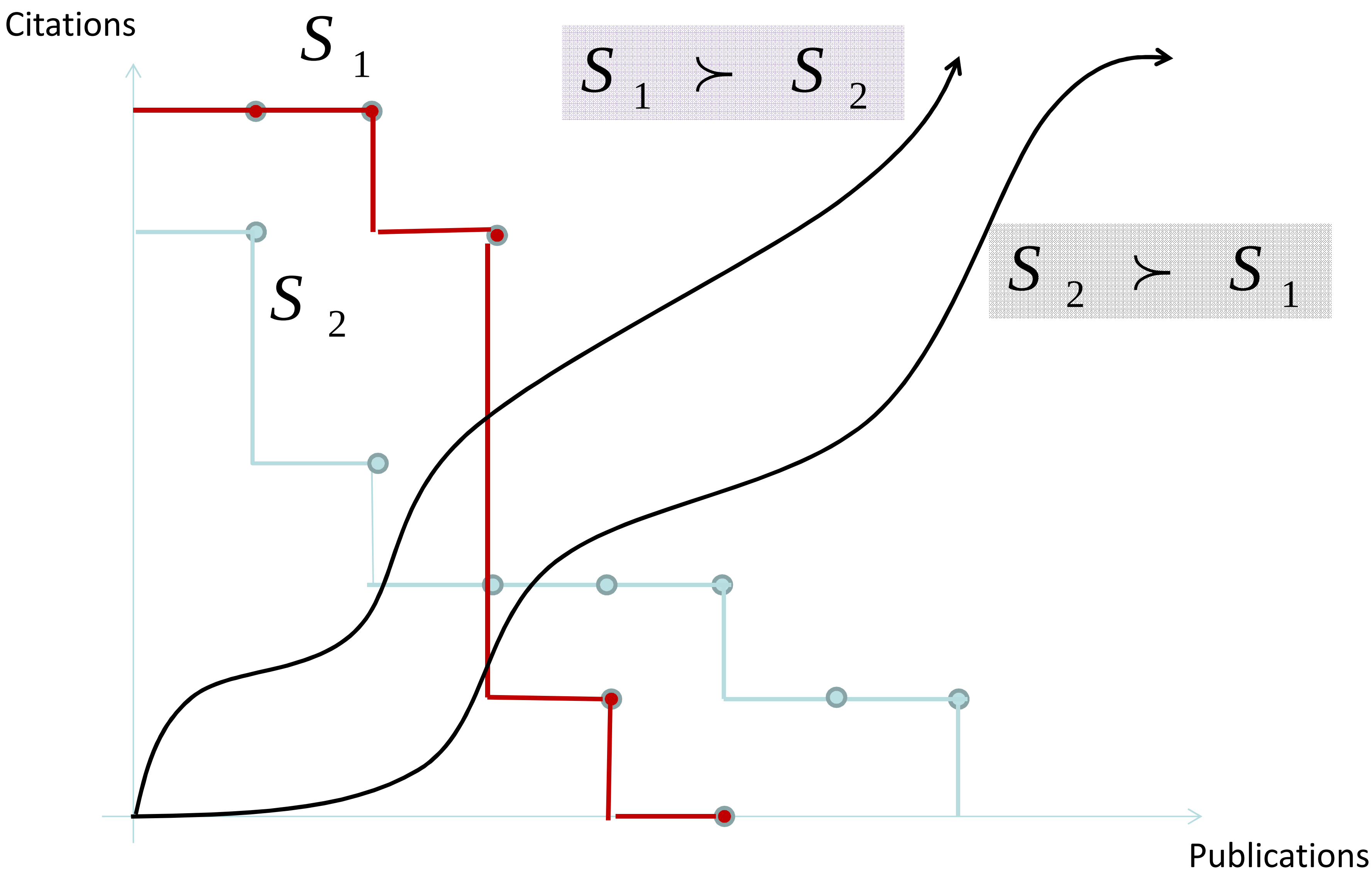
Two families of Indices

- A. Step-Based Indices
- B. Measure-Based Indices

A. Step-based Indices

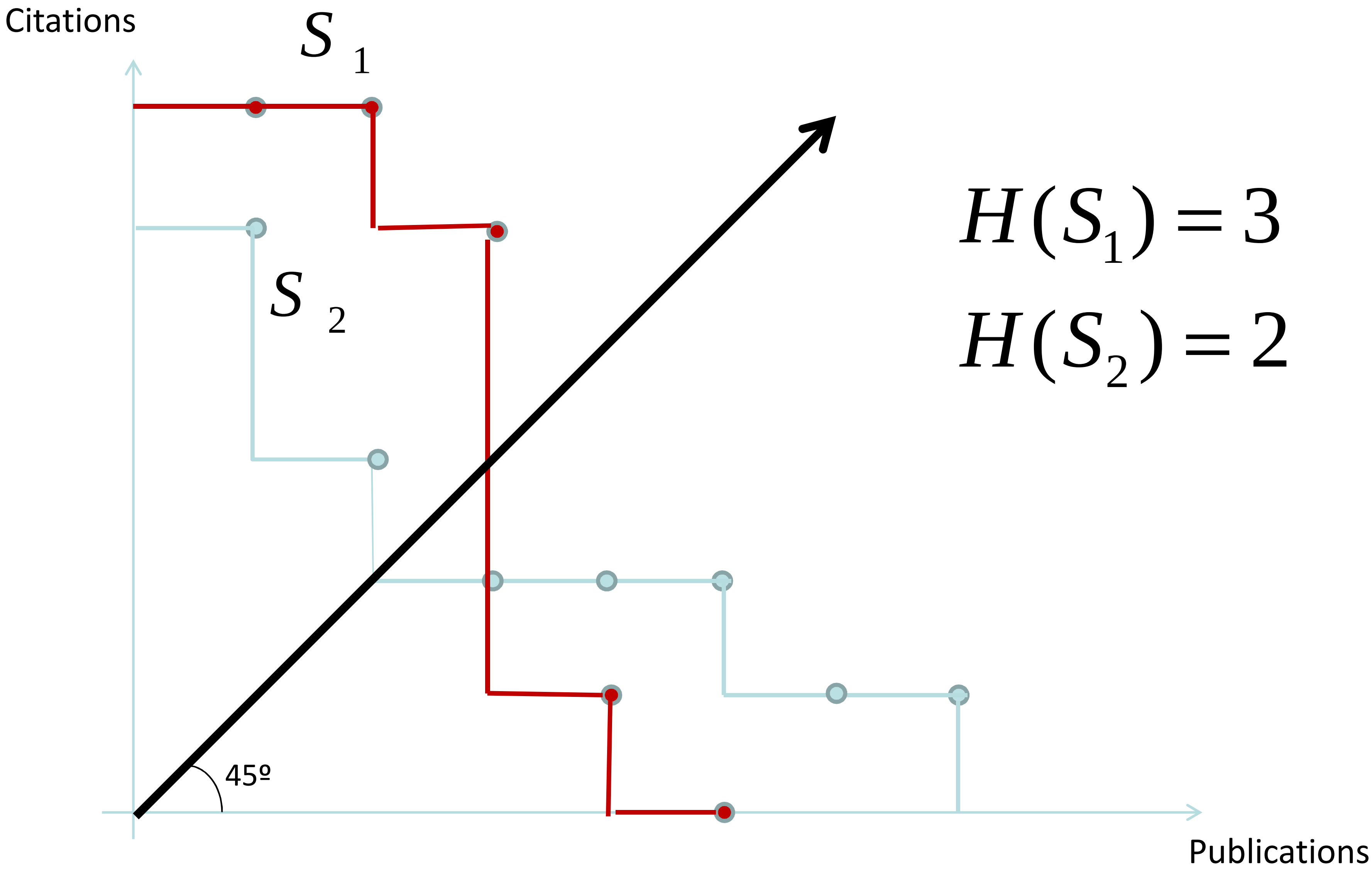
(Chambers and Miller, 2013)

- **Any** **non-decreasing line** **from the origin defines an index** as follows: The index of a CV is the *length of the line* that is “inside” the CV’s frontier.



Citations
S_1
$S_1 \succ S_2$
S_2
$S_2 \succ S_1$
Publications

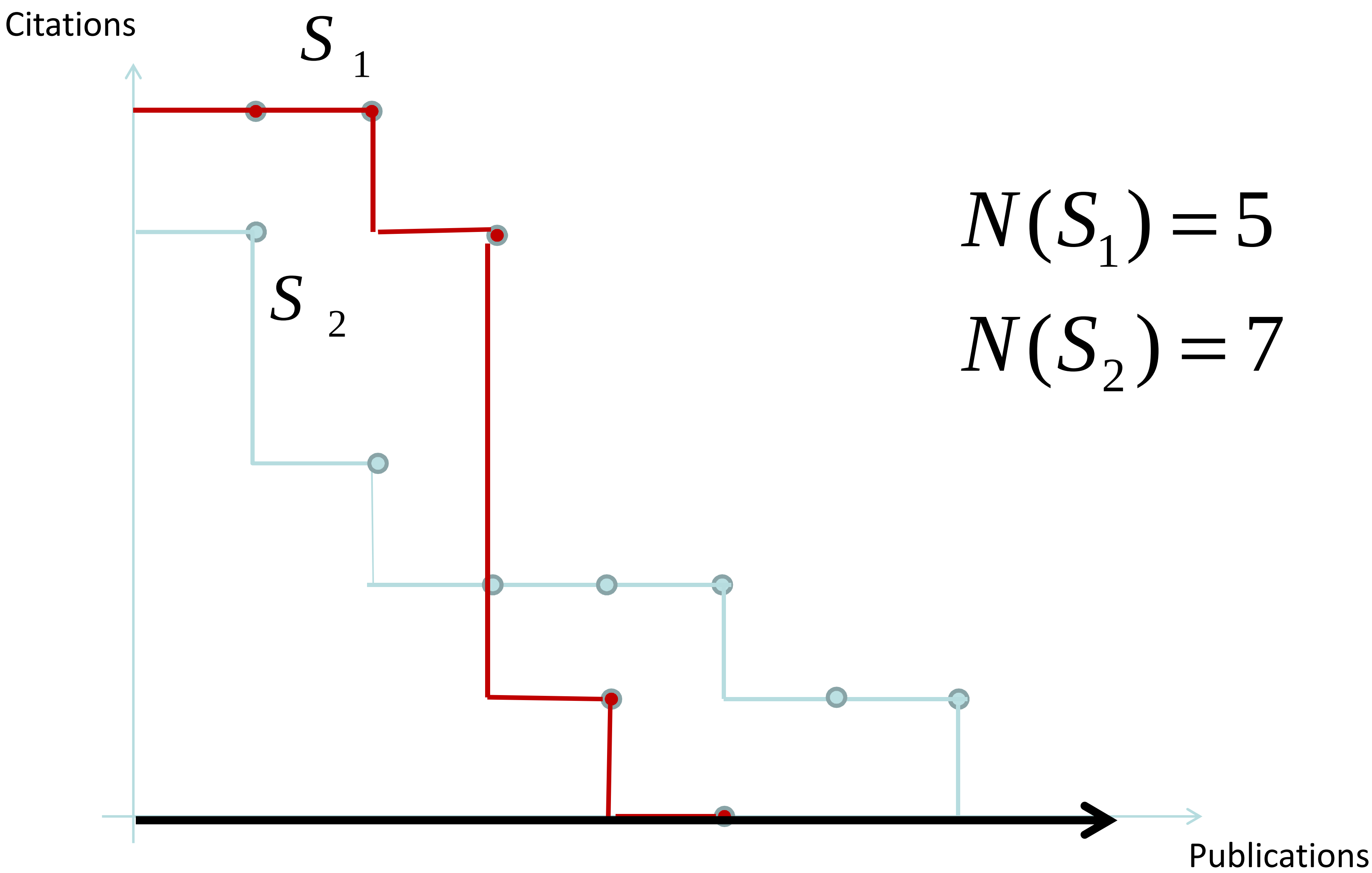
Example: H-index (Hirsch, 2005)



$$H(S_1) = 3$$

$$H(S_2) = 2$$

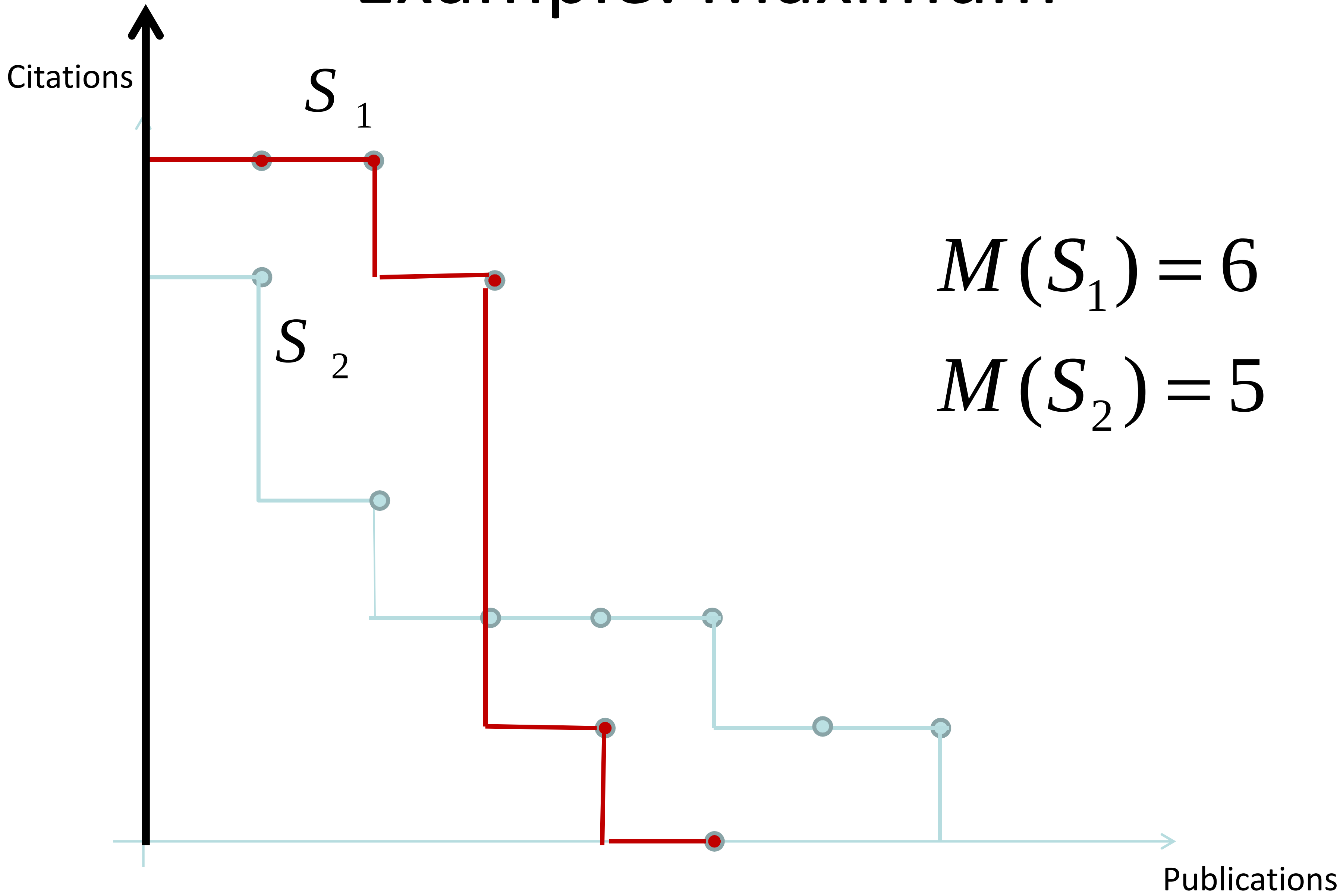
Example: Publication count



$$N(S_1) = 5$$

$$N(S_2) = 7$$

Example: Maximum

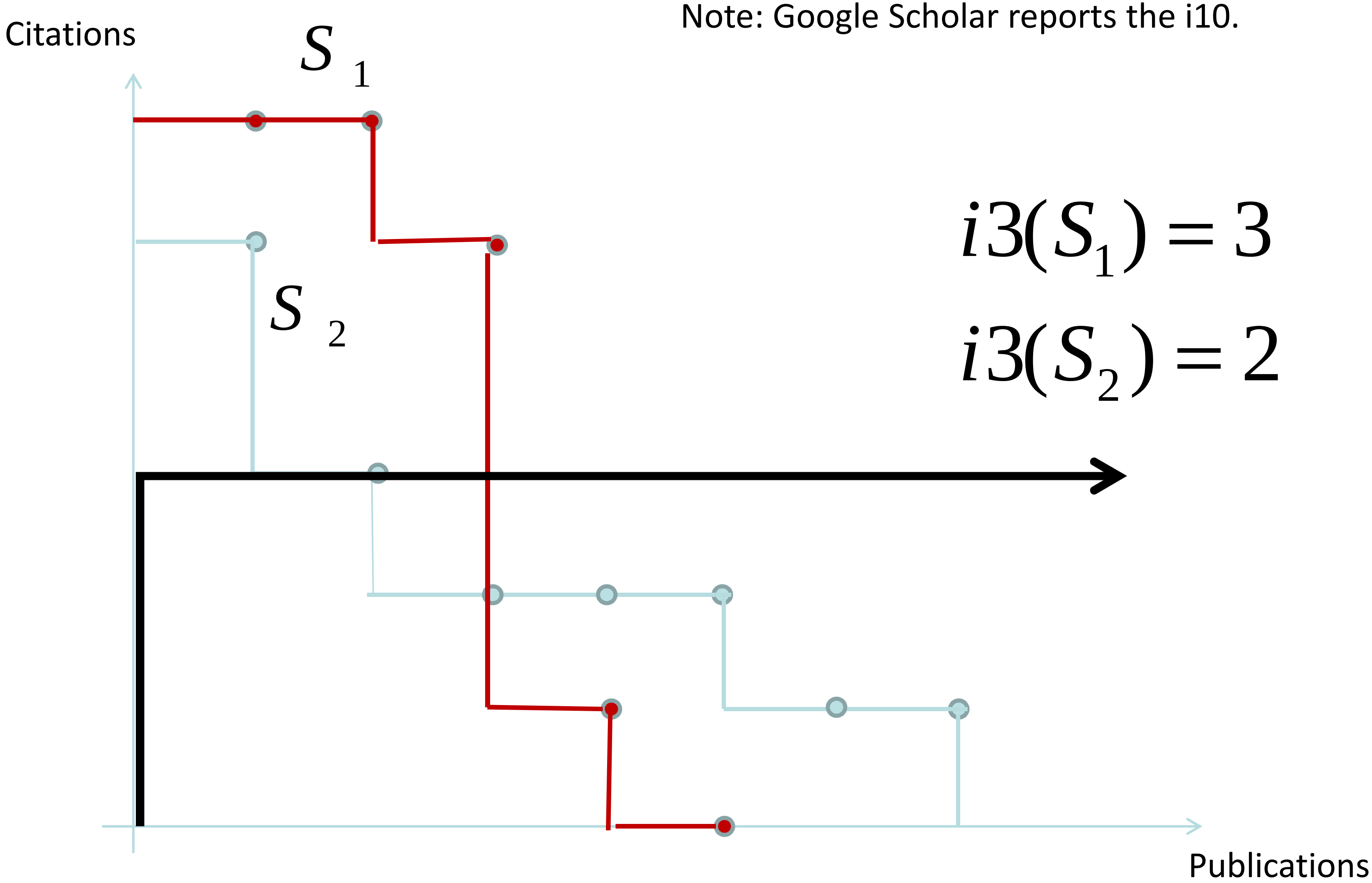


$$M(S_1) = 6$$

$$M(S_2) = 5$$

Example: i3 index (# of papers with at least 3 citations)

Note: Google Scholar reports the i10.

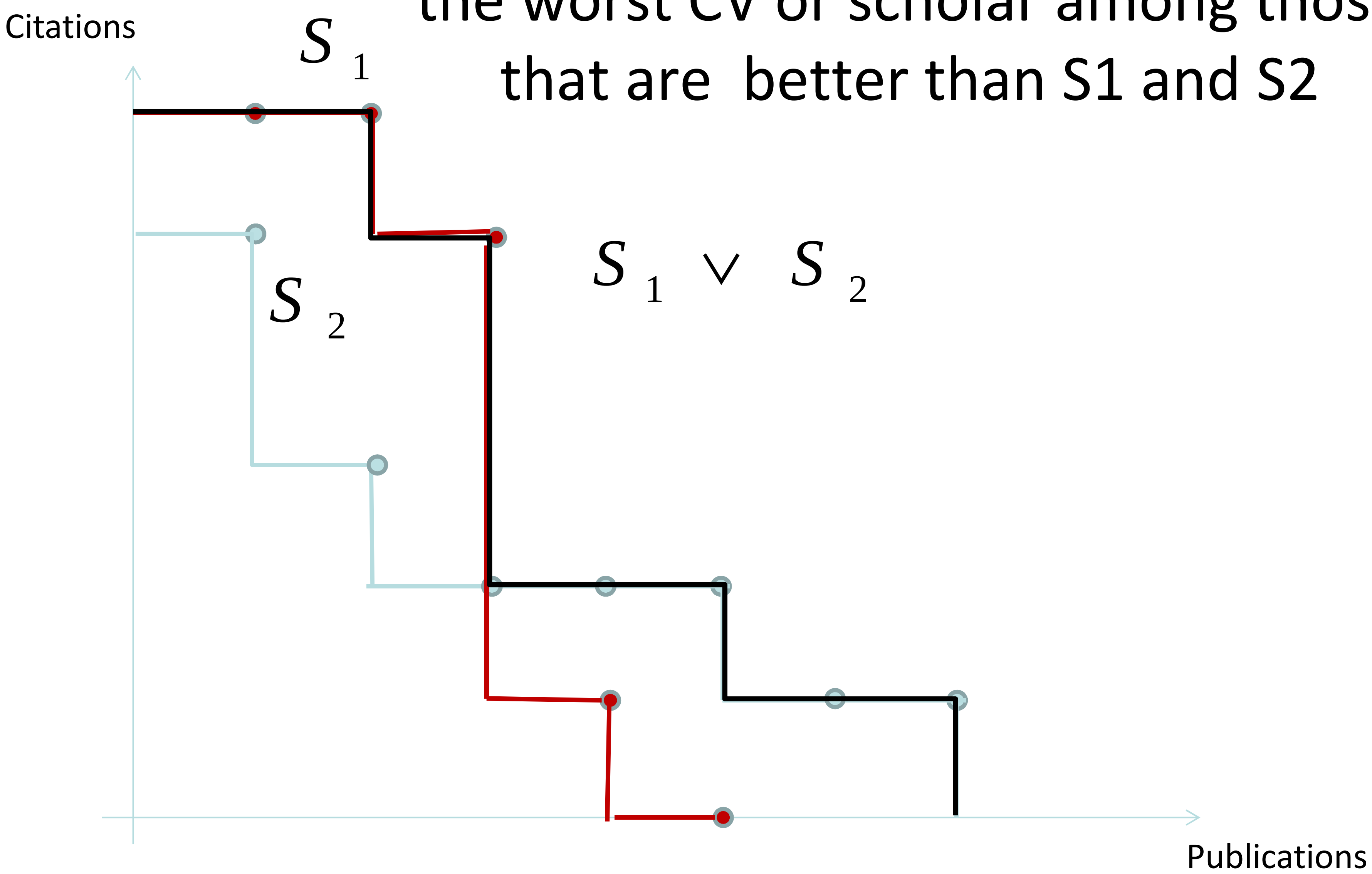


$$i3(S_1) = 3$$

$$i3(S_2) = 2$$

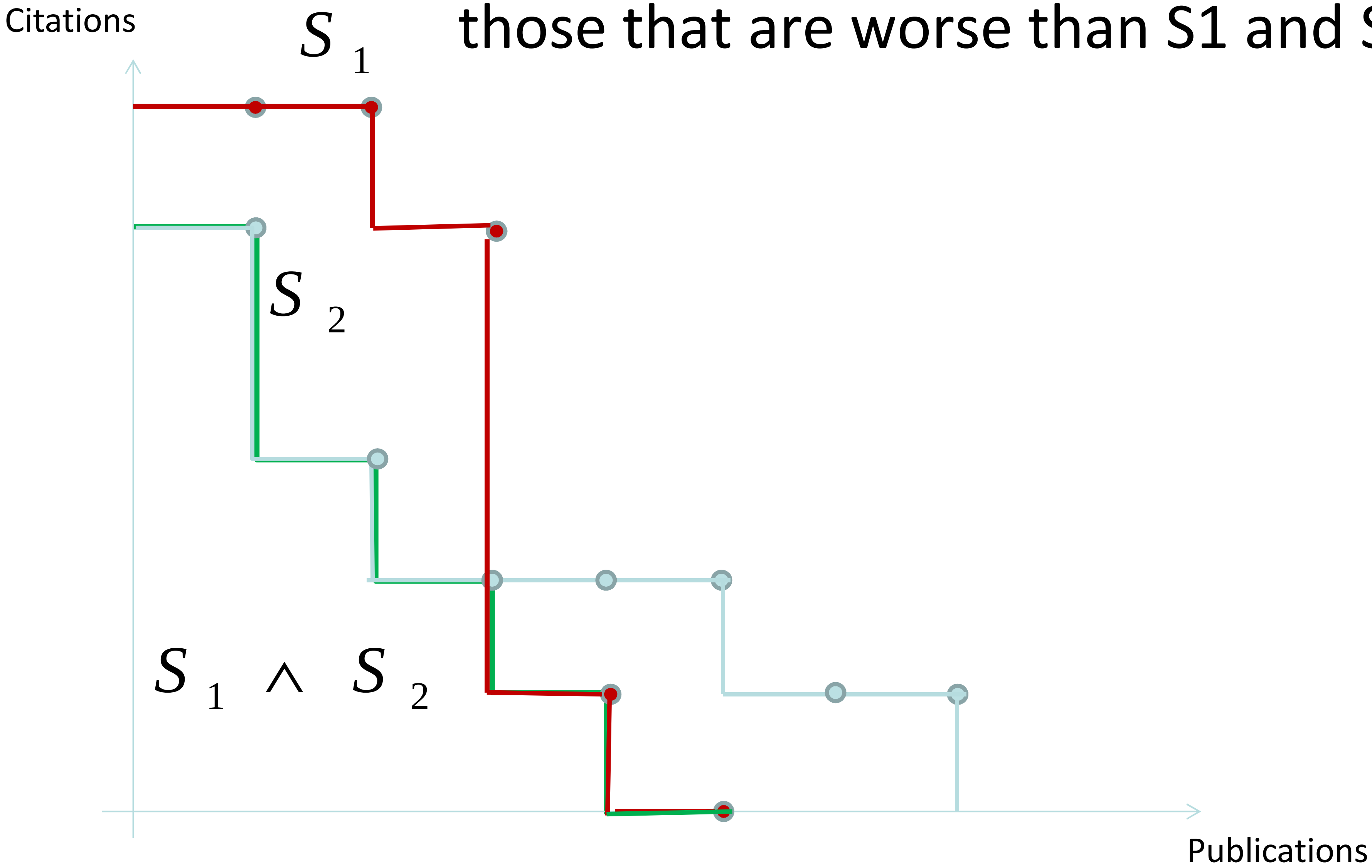
Now consider:

the worst CV or scholar among those that are better than S1 and S2



And:

the best CV or scholar among those that are worse than S1 and S2



Axioms

Consistency with better scholars and

Consistency with worse scholars

$$S_1 \succ S_2 \Rightarrow \begin{cases} S_1 \sim S_1 \vee S_2 \\ S_2 \sim S_1 \wedge S_2 \end{cases}$$

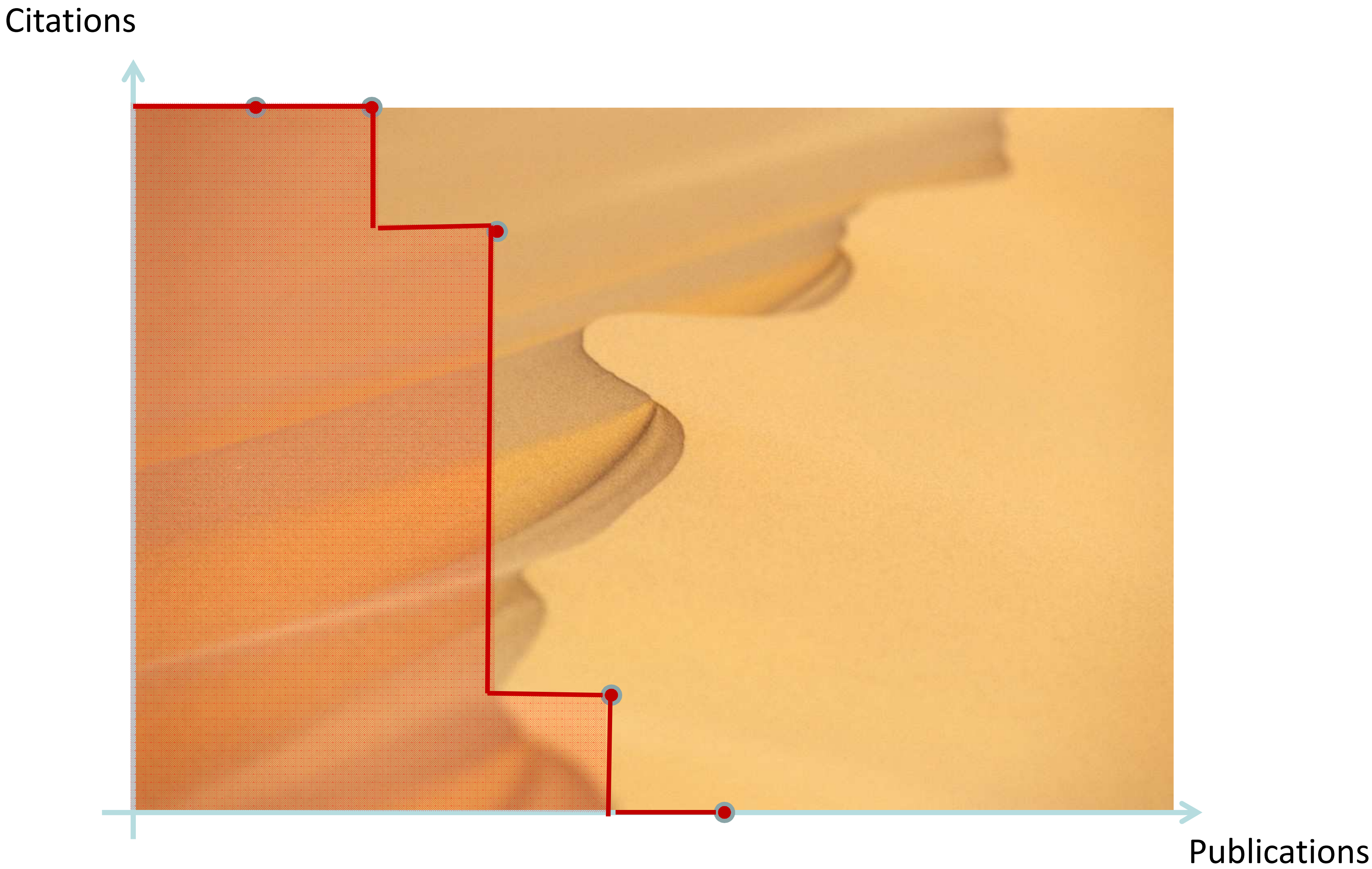
Result (Chambers-Miller, 2013)

- A citation index satisfies Consistency with better scholars and Consistency with worse scholars (and a full range axiom) if and only if it is a *monotonic transformation* of a step-based index.

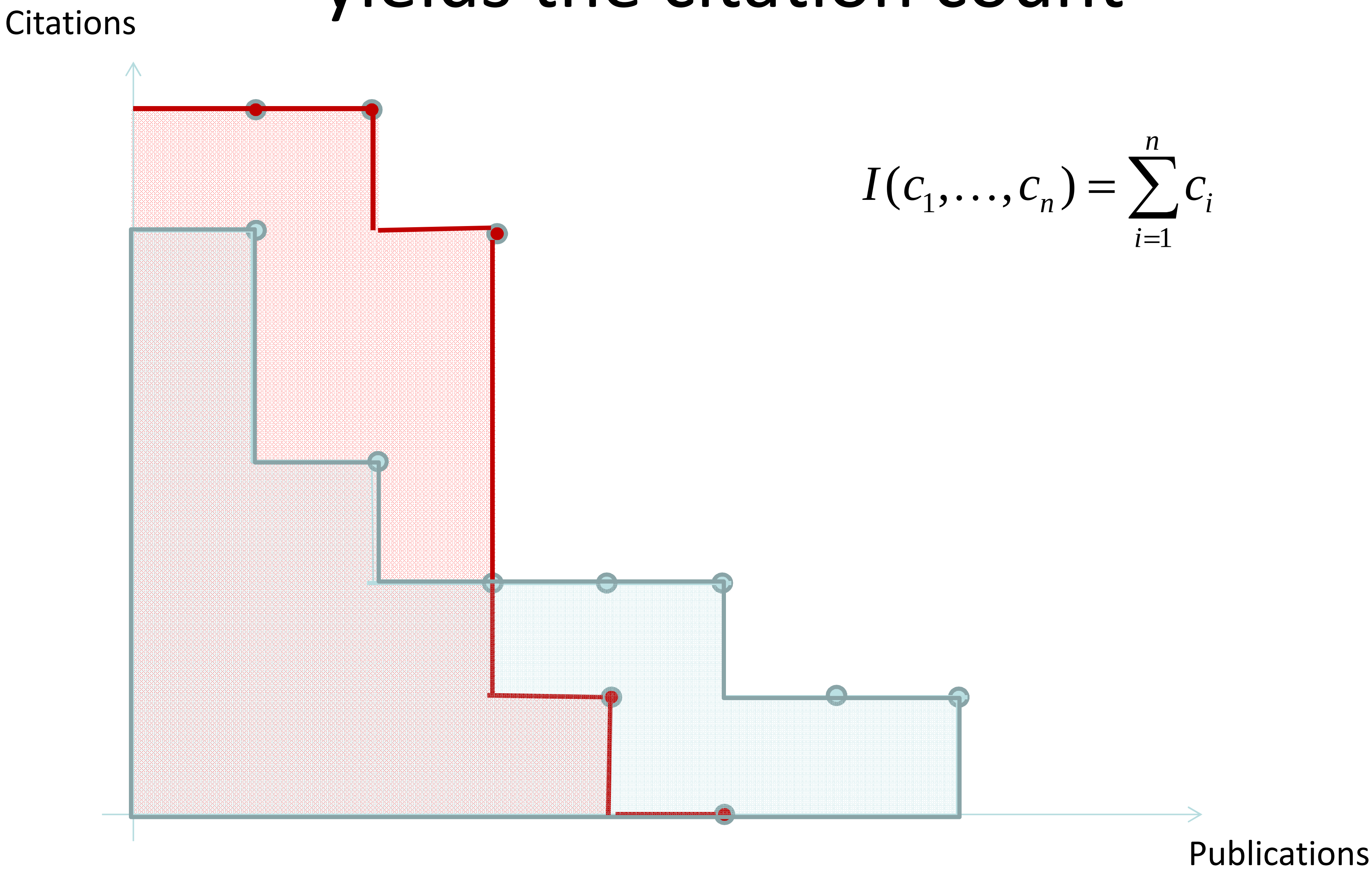
B. Measure-based indices

- **Any measure on the positive orthant defines an index** as follows: the index of the CV is the *measure of the space* under the CV's frontier.

Measure-based indices (“deserts”)



The Lebesgue measure (uniform) yields the citation count



$$I(c_1,\ldots,c_n)=\sum_{i=1}^{n}c_i$$

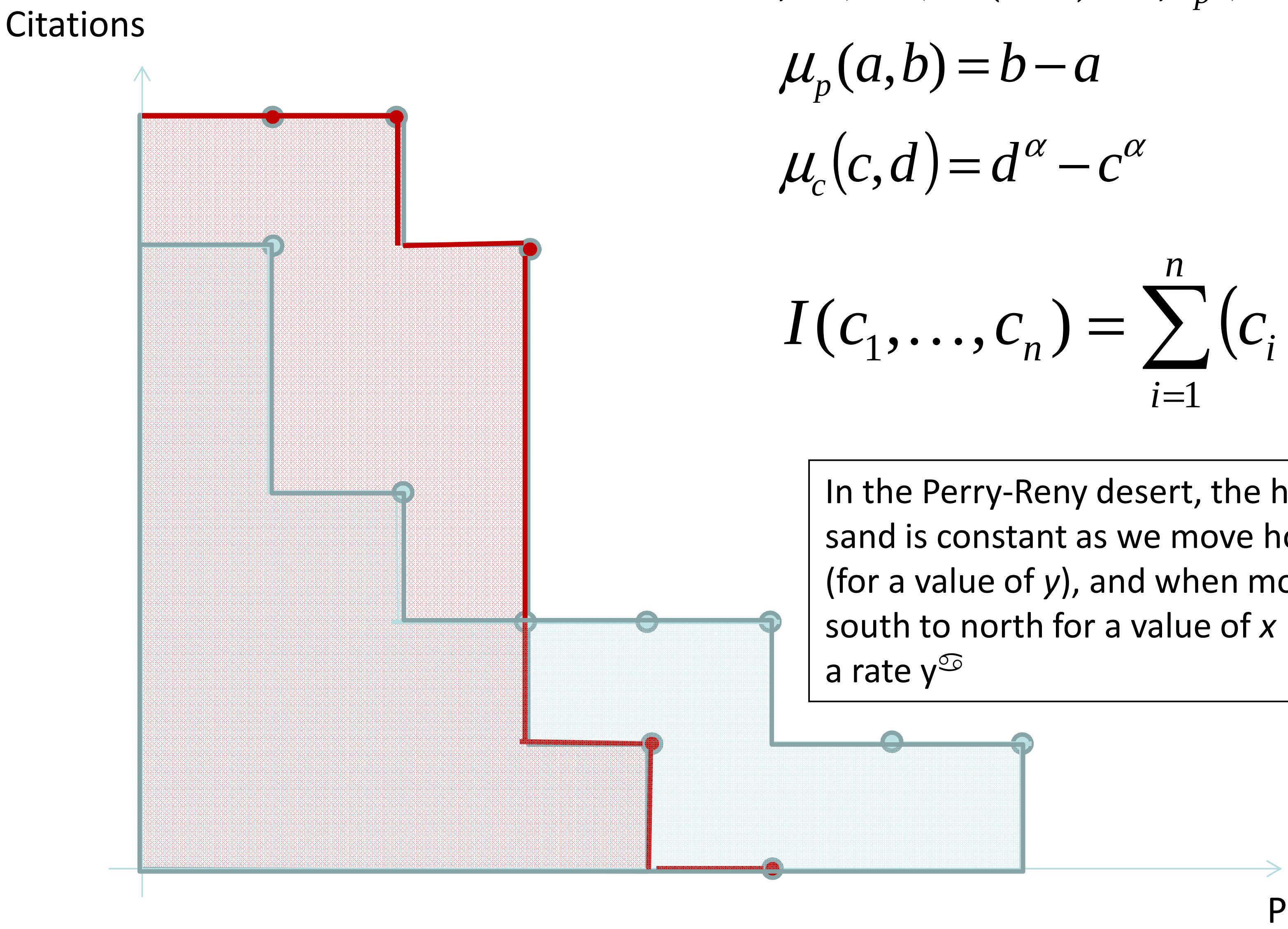
Perry and Reny (2013) use the following product measure:

$$\mu[(a,b)\times(c,d)] = \mu_p(a,b)\cdot\mu_c(c,d)$$

$$\mu_p(a,b) = b - a$$

$$\mu_c(c,d) = d^{\alpha} - c^{\alpha}$$

$$I(c_1,\ldots,c_n) = \sum_{i=1}^{n}(c_i)^{\alpha}$$



In the Perry-Reny desert, the height of the sand is constant as we move horizontally (for a value of *y*), and when moving from south to north for a value of *x* it increases at a rate y^{α}

Axioms

Monotonicity:

$$\left(c_1,\ldots,c_n\right) \geq \left(c'_1,\ldots,c'_n\right)$$

$$\Leftrightarrow$$

$$\left(c_1,\ldots,c_n\right) \succ \left(c'_1,\ldots,c'_n\right)$$

Axioms

Dummy paper:

$$\left(c_1,\ldots,c_n,0\right) \sim \left(c_1,\ldots,c_n\right)$$

Axioms

Independence:

$$\left(c_1,\ldots,c_n\right) \succ \left(c'_1,\ldots,c'_n\right)$$

$$\Leftrightarrow$$

$$\left(c_1,\ldots,c_n\right)\circ(x) \succ \left(c'_1,\ldots,c'_n\right)\circ(x)$$

Axioms

Scale Invariance: for $\lambda > 0$

$$(c_1, \ldots, c_n) \succ (c'_1, \ldots, c'_n)$$

$$\Leftrightarrow$$

$$\lambda(c_1, \ldots, c_n) \succ \lambda(c'_1, \ldots, c'_n)$$

Result (Perry-Reny, 2013)

- An index satisfies Monotonicity, Dummy paper, Independence and Scale invariance if and only if it is a *monotonic transformation* of

$$\sum_{i=1}^{n} (c_i)^{\alpha}$$

Other Developments

- Other theoretical developments (mostly for scientometrics).
- Empirical applications in academic market (Ellison 2012), in the firm (Palacios-Huerta and Prat, 2012).
- Open questions.