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Simple Rational Extension of Hirsch Index

A new scientometric indicator named SH-index is proposed. SH-index is a rational number. Its integer part equals integer part equals usual Hirsch index. The fractional part shows progress of the author in reaching the next unit of Hirsch index. SH-index is simple, interpretable, and inheriting all the advantages of Hirsch index. The new indicator enables to rank the authors with equal Hirsch indices that may be useful in scientific fields with low stream of publications.

Keywords: Scientometrics, Citation Index, Hirsch index rational extension, SH-index.

Introduction

In 2005, to identify the authors who write a lot of good papers J. Hirsch proposed a new indicator (Hirsch, 2005). The simplicity of calculations and robustness to fragmentation of results and to duplicate publications, instantly made Hirsch index a popular scientometric indicator. Hirsch index, or h-index, is a maximal integer number h indicating that the author published h papers, each of them being cited at least h times. These h papers form h-core. To get into h-core the paper is to be cited at least h times.

The authors could be easily clustered into groups with its equal values of Hirsch index. However, integer character of this indicator does not allow ranking authors within a group with the same values of Hirsch index. This ranking is an actual task in the case of low publishing activity where many researchers have the same h index. This state is by reason of: a) non-mainstream scientific area (Garcia-Perez, 2009), (b) some communicating restrictions, for example, linguistic barer for non-English writing researchers, (c) early stages of research career.

The aim of the paper is to develop a new scientometric indicator that, inheriting all the advantages of Hirsch index, will additionally enable ranking the authors with identical Hirsch indices. The new indicator is a rational extension of Hirsch index. Its integer part equals Hirsch index. Its fractional part shows how close the author to the next value of Hirsch index. An advantage of the new index will consist in that it extents Hirsch index while as g-index, A-index, R-index, m-index, e-index, hg-index, ch-index and other popular indices are used in conjunction with Hirsch index. Moreover, time series based on

the new indicator does not have such long plateau as in case of Hirsch index. This suggested that the new indicator will allow better tracing and predicting the progress of an author in improving his Hirsch index within a definite period of time.

Mathematical state of the problem

Let us denote the number of publications of a certain author as *N*. The number of citations of this author is sorted in descending order and presented by the following vector:

$$C = \left(c_1, c_2, ..., c_N\right), \tag{1}$$

where c_i — is the number of citations of the *i*-th publication, $c_1 \geq c_2 \geq ... \geq c_N$, $i = \overline{1, N}$.

From mathematical point of view our aim is to find a functional mapping

$$C \to SH \in \left[h(C), h(C)+1\right], \tag{2}$$

where *SH* denotes SH-index — a new rational modification of Hirsch index;

$h(C) = \max\limits_{\substack{i=1, N \\ i \geq c_i}}(i)$ is Hirsch-index for vector *C*.

On the map (2) the following constrains are imposed:

if Hirsch index *h(C)* is achieved with smallest number of citations, i.e. in the case of $c_1 = h, c_2 = h, ..., c_h = h$, then *Sh(C) = h(C)*;

the greater fractional part of *Sh(C)*, the closer is the author to the increase of his (her) Hirsch index.

New SH-index

The new scientometric SH-index for vector of citations (1) we define as follows:

$$Sh(C) = h(C) + \Delta, \tag{3}$$

where $\Delta = \dfrac{1}{h+1} \cdot \max\limits_{\substack{j=1, h \\ c_j > h}}(j)$ is a fractional part of SH-index indicating the fullness rate of the current h-core with the papers that, by the number of citations, are also included into the next core.

For simplify the calculation we rewrite the fractional part in (3) in the following form:

$$\Delta = \frac{\sum\limits_{j=1, h} r_j}{h+1}, \tag{4}$$

where $r_j = \begin{cases} 1, & if\ c_j > h \\ 0, & otherwise \end{cases}$ is paper membership in the next h-core.

An example of rating authors with same h-index

Citation vectors of three authors are presented in Table 1. All the authors have the same Hirsch index h=4. In order to increase it by 1 unit, 5 papers are required and each of them must be cited at least 5 times. Author A already has 4 such papers, author B — 3, and author C — 0 such papers.

Hence, the estimates of the authors in accordance with the proposed SH-index are as follows:

$$SH(Author\ A) = 4 + \frac{4}{5} = 4.8;$$

$$SH(Author\ B) = 4 + \frac{3}{5} = 4.6;$$

$$SH(Author\ C) = 4 + \frac{0}{5} = 4.$$

Table 1

Vectors of citations

Authors	Number of the paper							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Author A	9	7	5	5	4	2	1	0
Author B	6	5	5	4	1	0	0	0
Author C	4	4	4	4	0	0	0	0

An example of tracing progress of author with constant h-index

Figure 1 shows h-index dynamic and SH-index dynamic for one of the authors of this article. New SH-index clearly shows progress of the author for period 2007–2011 with constant Hirsch index.

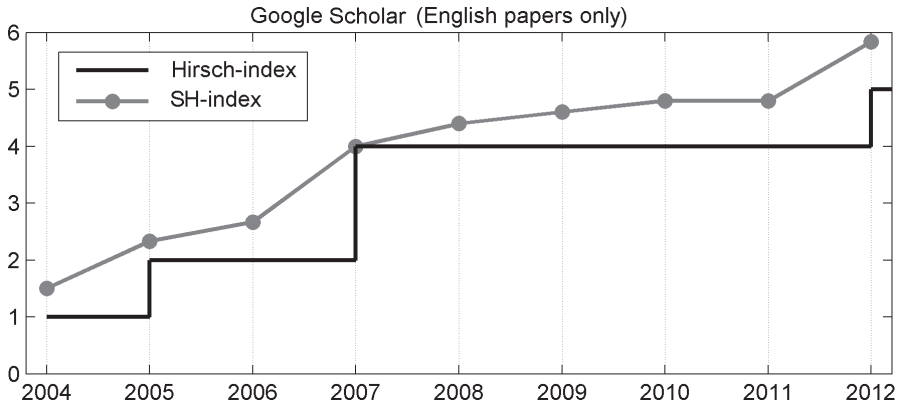

Figure 1. SH-index and h-index of Serhiy Shtovba

Comparison with alternative approaches

The alternatives of the proposed SH-index are the tapered h-index (Anderson et al., 2008) and the rational h-index h_{rat}-index (Guns and Rousseau, 2009). These alternatives are similar, but rational h-index is simpler and more convenient. The rational h-index is defined as follows:

$$h_{rat}(C) = h(C) + 1 - \frac{n}{2h(C)+1}, \quad (5)$$

where $n = (h(C) + 1 - c_{j+1}) + \sum_{j=1,h}(1 - r_j)$ is smallest number of citations for reaching the next value of Hirsch index.

$2h(C)+1$ is theoretically minimal number of citations for reaching the next value of Hirsch index ($h+1$) in the case of the worst initial point when $c_1 = h, c_2 = h, \ldots, c_h = h, c_{h+1} = 0$.

Comparing (3) and (5), we see that integer parts of both indices are identical and correspond to Hirsch index. The fractional parts differ due to the various principles of interpolation between h and $h+1$. In (5) interval $[h, h+1]$ is divided into $2h(C)+1$ equal parts in accordance with the minimal required number of citations. Then, h_{rat}-index is calculated as number of papers from current h-core plus the proportion of implementing the citation plan for the next h-core formation. Hence, in h_{rat} there is a contradiction between the components because one of the summands corresponds to the number of papers and the second is formed according to the number of citations. In the proposed approach this shortcoming is eliminated as both the integer and the fractional parts of SH-index (3) are composed according to the number of papers. In (3) the integer part equals the number of papers from the current h-core and the fractional part equals the fullness paper rate of the next core. In other words, the fractional part of the SH-index could be interpreted as a proportion of implementing the plan on papers in order to obtain the next value of Hirsch index.

Conclusions

A new scientometric indicator — SH-index is proposed. This index is a rational modification of Hirsch index. The integer part of SH-index is equal to Hirsch index. The fractional part of SH-index shows how close the author is to the next value of Hirsch index. The fractional part is calculated as a proportion of the already published papers that are required to reach the next value of Hirsch index. SH-index has low complexity and clear interpretability. Inheriting all the advantages of Hirsch index, the new indicator additionally enables to rank the authors with equal Hirsch indices. Main application field of SH-index is scientific areas with low publication activity. Moreover, time series of Hirsch index often include long plateau, especially when the Hirsch index is high and its property of tenacity begins to manifest. This probably causes low predictability the future h index on base of the time series with integer h index (Garcia-Perez, 2012). The time series do not have such plateau in case of SH-index. This suggested that the new indicator will allow better tracing and predicting the progress of an author in improving his Hirsch index within a definite period of time.

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Предложен новый наукометрический показатель — SH-индекс. SH-индекс представляет собой рациональное число. Его целая часть равна обычному индексу Хирша. Дробная часть показывает, насколько автор приблизился к следующему значению индекса Хирша. SH-индекс — это является простой, интерпретабельный показатель, который сохранил все преимущества индекса Хирша. Новый показатель позволяет ранжировать авторов с одинаковыми индексами Хирша, что может быть востребовано в научных областях с низким потоком публикаций.

***Ключевые слова**:* наукометрия, индекс цитирования, модификация индекса Хирша, SH-индекс.

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Библиографическая идентификация состава и признаков научной школы

В статье рассматриваются возможности идентификации состава и признаков научной школы с использованием комплекса социологических и библиографических методов. Наряду с традиционными социологическими методами предлагается использовать анализ соавторства, взаимного цитирования, диссертаций, благодарностей в научных изданиях.

***Ключевые слова**:* научная школа, идентификация научной школы, библиографические исследования науки, цитирование, соавторство, благодарности в научных публикациях.