



HY-index: A new science-meter index



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ABSTRACT

In academic societies, it is essential to measure the efficiency of the researchers, scientists, institutions, departments, and universities by using a standard method that depends on their publications and citations. This work is devoted to constructing a new index that can measure the quality of the publications of any source mentioned above. The main goal of this new index is to fix the shortcoming of the current indices, such as the well-known h-index. Thus, we assumed a new index that is very sensitive to any change in the total number of publications, the total number of citations, and citations of each publication. The new index is called HY-index, is more sensitive to any change in the publications or the citations. The suggested data of the two authors have been discussed with various situations by using HY-index. This index has been applied to the authors of the recent paper as a real study case by using their data from SCOPUS.

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1. Introduction

Hirsch (2007) is the first who set the first index of the authors, which is called the h-index. Hirsch (2007) intended the h-index to address the main disadvantages of other indicators, such as the total number of articles or a total number of citations. The total number of articles is not fair enough to be an indicator of the quality of the publications. In contrast, the total number of citations could be a good indicator of the quality of those articles. The h-index is intended to measure the quality and quantity of the scientific output simultaneously (Hirsch, 2007; Hirsch and Buela-Casal, 2014). Waltman and Van Eck (2012) found that the h-index cannot be considered a suitable indicator of a scientist's overall scientific impact and discussed what type of indicators can be used as a replacement to the h-index. Kulasegarah and Fenton (2010) set that the h-index is a strong indicator that has many advantages over other bibliometric measures. Also, it gives an evaluative measure for evaluating the research output of scientists. Due to its simplicity of

calculation based on the Web of Knowledge database, the h-index has been well received in the scientific community (Kulasegarah and Fenton, 2010). The h-index depends on the quality of the articles.

Moreover, the h-index depends only on the articles and their citations. In the context of h-index, the increasing of the number of the publication alone does not have a significant effect or direct impact on it, and it introduces only one peak, which is the top of the publications and the publications without citation are out of its calculation. The h-index could be used to author, topic, department, faculty, institute, university, and country (Hirsch, 2007; Hirsch and Buela-Casal, 2014; Jin et al., 2007; Redner, 2010; Sidiropoulos et al., 2007). The number of publications and citations alone are not a coherent criteria family. Brandão (2019) proposed a third criterion for the h-index: The distribution of citations.

Recently, the h-index can be calculated for any publication automatically where any database, which includes the references cited in the publication, will do. For an example of the database using h-index are Chemical Abstracts Services (Columbus, OH, USA), Google Scholar, and Scopus provided by Elsevier (Bornmann et al., 2008; Bornmann and Daniel, 2009).

Mingers et al. (2012) considered the h-index as a measure of a journal's research quality and contribution. The evidence in Minger's paper

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suggests that the h-index would be a better citation-based metric for evaluating the quality and contribution of scholarly journals than other metrics such as the impact factor (IF) or the number of cites per paper (CPP). It also suggests that the data should be taken from Google Scholar rather than the ISI Web of Science (Mingers et al., 2012). Bertoli-Barsotti and Lando (2015) assumed the formula for the h-index, which can be easily computed from three simple indicators: Number of publications, mean of an author's citations, and the number of citations received by the most cited paper. Xu et al. (2015) have developed a journal classification method based on the h-index.

Tyrrell et al. (2017) suggested that to increase a department's h-index, it is essential to foster impactful research from within the faculty ranks of the department. The h-index of academic radiology departments is a meaningful tool that allows for evaluation from within and against other academic centers. Bornmann and Daniel (2005) found that, on average, the h-index for successful applicants for post-doctoral research fellowships was consistently higher than for non-successful applicants, so they asked does the h-index for ranking of scientists really work?

Miguel proposed a two-sided h-index, an extension that computes new h indices progressively up the top and out the tail of the citation curve. This extension represents a citation curve descriptor, one of whose elements is the scalar h (García-Pérez, 2012). Gagolewski and Mesiar (2012) noted that the h-index is a volatile impact function, highly sensitive for applying input elements' scaling.

Many other indices have been constructed, some of them based on the h-index as following (Bornmann et al., 2008):

1- **m-quotient** is defined as follows:

$$m = \frac{h}{y}, \quad (1)$$

where h is, h-index and y are the number of years since publishing the first paper.

2- **g-index** is the highest number g of papers that together received g^2 or more citations (Bornmann et al., 2008).

3- **h(2)-index** is the highest natural number such that h(2) of the author's most cited papers received each at least $[h(2)]^2$ citations.

4- **a-index**

$$a = \frac{1}{h} \sum_{j=1}^h c_i t_j, \quad (2)$$

where $c_i t$ is the citation count.

5- **m-index** is the median number of citations received by papers in the h-index core, i.e., the papers ranking smaller than or equal to h.

6- **r-index:**

$$r = \sqrt{\sum_{j=1}^h c_i t_j}. \quad (3)$$

7- **ar-index:**

$$ar = \sqrt{\sum_{j=1}^h \frac{c_i t_j}{a_j}}, \quad (4)$$

where a_j is the number of years since the publishing of paper j.

8- **h_w-index:**

$$h_w = \sqrt{\sum_{j=1}^{r_0} c_i t_j}, \quad (5)$$

where, r_0 is the largest row index j such that $r_w(j) \leq c_i t_j$.

Mannella and Rossi (2013) have produced evidence that the index $h/\sqrt{A_A}$ (A_A is the academic age), averaged over sufficiently large groups. Moreover, it is a sensible proxy for contemporary h-index. It tends to stay constant in time in the interval between 12 and 24 years of research activity, which is the typical range for researchers to apply for permanent and/or higher positions (Mannella and Rossi, 2013).

2. Disadvantages of h-index

Although all the above indices give good indicators of the quality of the citations and the authors, we believe that they are not fair enough. The essential disadvantage of the h-index is independence from the total citation number, the total publications number, and the highly cited publication.

To clarify the disadvantages of the h-index, we consider the data of two different authors A1 and A2, as in Fig. 1. According to that data, they have the same value of h-index "3"; however, author A2 has a citation number, number of publications, and the highly cited publication more than author A1. Undoubtedly, the case study in Fig. 1 is not the only one, but one can find many other cases in which the comparison between two authors is not apparent by using the h-index.

Thus, this work is dealing with constructing a new index, which can help us to construct the right comparison between any two authors.

A1		A2	
r	Cr	r	Cr
1	11	1	100
2	9	2	95
3	8	3	82
4	2	4	3
5	0	5	2
		6	1
		7	0
5	30	7	283
n	N	n	N

Fig. 1: Publications of two authors A1 and A2 (h-index=3)

3. HY-index

Before we construct a new indicator, we must establish some essential concepts as follows:

1. The total number of publications is an essential indicator of the author's quality.
2. The total number of citations is an essential indicator of the author's quality.
3. The publications with high citations must have a significant effect on the index of the author's quality.
4. Even the publication with zero citations must have an effect on the index of the author's quality.
5. The value of the index must increase when the total number of publications or the total number of citations increases.

Because of the above concepts, we will construct the new index as follows:

Consider that any author has a number of publications n ($n > 0$) And we will arrange those publications in descending order according to their value of citations. We assume the number of citations of each publication is C_r with the order r ($1 \leq r \leq n$).

Hence, the total number of citations of the author is:

$$N = \sum_{r=1}^n C_r, \quad (6)$$

To maximize the effect of the citation number and its order, we calculate the following parameter for each publication:

$$M_r = \frac{C_r}{r}, \quad r = 1, 2, 3, \dots, n. \quad (7)$$

Now, we take the summation of M_r for all the publications as follows:

$$M = \sum_{r=1}^n M_r. \quad (8)$$

Finally, we assume that HY-index to be in the form:

$$\text{HY-index} = \log_2(n \times N \times M)$$

where,

$$(n \times N \times M) \geq 1. \quad (9)$$

Eq. 9 depends on three parameters; the number of publications " n ," the total number of citations " N ," and " M ." We applied the logarithmic with base two to minimizing the value that comes from the product of the three parameters.

When we use Eq. 9 for the case study in Fig. 1, we obtain the following results in Fig. 2.

Fig. 2 displays that the authors A1 and A2 got different values of HY-index with a significant difference, and the results show the sensitivity of the HY-index to all parameters.

To show the sensitivity of the HY-index, we will test the HY-index for the case study in Fig. 1 with some various changes as following:

- Case Study I: We will consider the same two authors, A1 and A2 in Fig. 2 got an extra one citation for the last publication; hence, we get results in Fig. 3.

A1			A2		
r	Cr	Mr	r	Cr	Mr
1	11	11.00	1	100	100.00
2	9	4.50	2	95	47.00
3	8	2.67	3	82	27.00
4	2	0.50	4	3	0.75
5	0	0.00	5	2	0.40
			6	1	0.17
			7	0	0.00
5	30	18.67	7	283	176.15
n	N	M	n	N	M
HY-index	11.4512		HY-index	18.4127	

Fig. 2: Applying HY-index for the case study in Fig. 1

A1			A2		
r	Cr	Mr	r	Cr	Mr
1	11	11.00	1	100	100.00
2	9	4.50	2	95	47.00
3	8	2.67	3	82	27.00
4	2	0.50	4	3	0.75
5	1	0.20	5	2	0.40
			6	1	0.17
			7	1	0.14
5	31	18.87	7	284	176.29
n	N	M	n	N	M
HY-index	11.5139		HY-index	18.4189	

Fig. 3: HY-index for the case study I

Fig. 3 shows that the value of the HY-index of the author A1 has been changed from 11.4512 to 11.5139. The HY-index of the author A2 has been changed from 18.4127 to 18.4189. Those results mean that just only one extra citation for both authors gives different values of HY-index, while the value of the h-index is still the same equal "3" for both authors. Thus, in the context of the HY-index, any change in the number of citations makes a change in its value.

- Case Study II: We will consider the same two authors A1 and A2, as in Fig. 2, got only one new publication without any additional citations, as in Fig. 4.

Fig. 4 represents that the value of the HY-index of the author A1 has been changed from 11.4512 to 11.7142. The HY-index of the author A2 has been changed from 18.4127 to 18.6116.

Moreover, only one new publication with zero citation for both authors leads to changes to the values of the HY-index, while the h-index is still the same value "3" for the two authors. Thus, HY-index is

a more sensitive index for any change in the total number of publications.

A1			A2		
r	Cr	Mr	r	Cr	Mr
1	11	11.00	1	100	100.00
2	9	4.50	2	95	47.00
3	8	2.67	3	82	27.00
4	2	0.50	4	3	0.75
5	0	0.20	5	2	0.40
6	0	0	6	1	0.17
			7	1	0.14
			8	0	0.0
6	30	18.67	8	284	176.29
n	N	M	n	N	M
HY-index	11.7142		HY-index	18.6116	

Fig. 4: HY-index for the case study II

- Case Study III: We will consider the same two authors A1 and A2 in Fig. 2 got upgrading of the highly cited publication, where we added five citations to the publications in the first order for both authors as in Fig. 5.

A1			A2		
r	Cr	Mr	r	Cr	Mr
1	16	16.00	1	105	105.00
2	9	4.50	2	95	47.00
3	8	2.67	3	82	27.00
4	2	0.50	4	3	0.75
5	0	0.20	5	2	0.40
			6	1	0.17
			7	0	0.00
6	35	23.67	7	288	181.15
n	N	M	n	N	M
HY-index	11.7142		HY-index	18.4783	

Fig. 5: HY-index for the case study III

Fig. 5 shows that the value of the HY-index of the author A1 has been changed from 11.4512 to 12.0160. The HY-index of the authors A2 has been changed from 18.4127 to 18.4783. Hence, increasing the value of citation of the highly cited publication leads to a significant effect on the value of the HY-index. Thus, HY-index is very sensitive for any change in the value of the highly cited publication.

- Case Study IV: We will consider the same authors A1 and A2 as in Fig. 2 got five new citations randomly as in Fig. 6.

Fig. 6 represents that the value of the HY-index of the author A1 has been changed from 11.4512 to 11.7839. The HY-index of author A2 has been changed from 18.4127 to 18.4561. Hence, a random increase of the citation number leads to a significant effect on the value of the HY-index. Thus, HY-index is very sensitive for any change in the value of the total number of citations.

- Real Case Study: We will apply the HY-index for the authors of this work, Hamdy M. Youssef and Alaa A. El-Bary, till the year 2020 by using the data from the SCOPUS database.

Starting with Youssef (SCOPUS ID: 8216522500). The total number of publications is 88, the total number of citations is 1933, the highly cited publication number is 223, and the h-index is 25, as shown in Table 1.

A1			A2		
r	Cr	Mr	r	Cr	Mr
1	11	11.00	1	101	101.00
2	10	5.0	2	96	48.00
3	9	3.0	3	83	27.67
4	3	0.75	4	4	1.00
5	2	0.40	5	2	0.40
			6	1	0.17
			7	1	0.00
5	35	20.15	7	288	178.38
n	N	M	n	N	M
HY-index	11.7839		HY-index	18.4561	

Fig. 6: HY-index for the case study IV

Table 1: The HY-index of Youssef (SCOPUS ID: 8216522500)

r	Cr	Mr	r	Cr	Mr
1	223	223.00	45	11	0.24
2	197	98.50	46	11	0.24
3	109	36.33	47	10	0.21
4	83	20.75	48	8	0.17
5	63	12.60	49	7	0.14
6	55	9.17	50	7	0.14
7	54	7.71	51	6	0.12
8	52	6.50	52	6	0.12
9	49	5.44	53	5	0.09
10	48	4.80	54	4	0.07
11	47	4.27	55	4	0.07
12	46	3.83	56	3	0.05
13	45	3.46	57	3	0.05
14	40	2.86	58	3	0.05
15	39	2.60	59	3	0.05
16	37	2.31	60	3	0.05
17	35	2.06	61	3	0.05
18	35	1.94	62	2	0.03
19	33	1.74	63	1	0.02
20	33	1.65	64	1	0.02
21	31	1.48	65	1	0.02
22	29	1.32	66	1	0.02
23	29	1.26	67	1	0.01
24	29	1.21	68	1	0.01
25 h-index	28	1.12	69	1	0.01
26	25	0.96	70	1	0.01
27	25	0.93	71	1	0.01
28	22	0.79	72	1	0.01
29	21	0.72	73	1	0.01
30	21	0.70	74	0	0.00
31	21	0.68	75	0	0.00
32	21	0.66	76	0	0.00
33	20	0.61	77	0	0.00
34	20	0.59	78	0	0.00
35	18	0.51	79	0	0.00
36	18	0.50	80	0	0.00
37	17	0.46	81	0	0.00
38	16	0.42	82	0	0.00
39	16	0.41	83	0	0.00
40	16	0.40	84	0	0.00
41	16	0.39	85	0	0.00
42	16	0.38	86	0	0.00
43	14	0.33	87	0	0.00
44	11	0.25	88	0	0.00
n	N	M			
88	1933.00	470.72			
HY-Index		26.2548			

For the second author, El-Bary (SCOPUS ID: 55929388100), the total number of publications is 90, the total number of citations is 944, the highly

cited publication number is 62, and the h-index is 19, as shown in Table 2.

Table 2: The HY-index of El-Bary (SCOPUS ID: 55929388100)

r	Cr	Mr	r	Cr	Mr
1	62	62.00	46	6	0.13
2	48	24.00	47	5	0.11
3	40	13.33	48	5	0.10
4	37	9.25	49	5	0.10
5	31	6.20	50	5	0.10
6	30	5.00	51	5	0.10
7	30	4.29	52	4	0.08
8	27	3.38	53	4	0.08
9	26	2.89	54	3	0.06
10	25	2.50	55	3	0.05
11	25	2.27	56	3	0.05
12	25	2.08	57	3	0.05
13	25	1.92	58	3	0.05
14	25	1.79	59	3	0.05
15	23	1.53	60	2	0.03
16	23	1.44	61	2	0.03
17	21	1.24	62	2	0.03
18	21	1.17	63	1	0.02
19 h-index	20	1.05	64	1	0.02
20	18	0.90	65	1	0.02
21	18	0.86	66	1	0.02
22	18	0.82	67	1	0.01
23	18	0.78	68	1	0.01
24	17	0.71	69	1	0.01
25	16	0.64	70	1	0.01
26	16	0.62	71	1	0.01
27	15	0.56	72	1	0.01
28	15	0.54	73	1	0.01
29	14	0.48	74	1	0.01
30	13	0.43	75	0	0.00
31	13	0.42	76	0	0.00
32	11	0.34	77	0	0.00
33	11	0.33	78	0	0.00
34	11	0.32	79	0	0.00
35	10	0.29	80	0	0.00
36	10	0.28	81	0	0.00
37	8	0.22	82	0	0.00
38	8	0.21	83	0	0.00
39	7	0.18	84	0	0.00
40	7	0.18	85	0	0.00
41	7	0.17	86	0	0.00
42	6	0.14	87	0	0.00
43	6	0.14	88	0	0.00
44	6		89	0	0.00
45	6	0.13	90	0	0.00
n	N		M		
90	944.00		159.39		
HY-Index		23.6909			

According to Tables 1 and 2, the HY-index of Youssef is 26.2548, and the HY-index of El-Bary is 23.6909. El-Bary has a higher total number of publications than Youssef, while Youssef has a higher number of total citations and value of highly cited publications than El-Bary. Therefore, the HY-index supplied us with the right measure of the author's quality.

4. Conclusion

- HY-index is a new formula that measures the quality of the publications and the authors.
- HY-index is simple to apply for authors, institutions, departments, and universities.
- HY-index depends on the total number of publications, the total number of citations, and the value of a highly cited publication.

HY-index is very sensitive and has been affected by any changes in the above mention parameters. Moreover, it gets rid of the shortcomings of the h-index and the other indices.

Compliance with ethical standards

Conflict of interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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