Vol. XIII & Issue No.11 November - 2020
INDUSTRIAL ENGINEERING JOURNAL

A PROPOSAL FOR MORE RATIONAL INDEX FOR EVALUATING RESEARCH QUALITY THROUGH CITATIONS.

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Abstract

This paper points out severe limitations of h-index being used extensively for evaluating the scientific research performance through citation analysis. It compares some commonly used indices and finds that among the presently used indices, g-index would appear to be a better indicator as it considers the quality of individual papers measured through number of citations, which h-index ignores. However; g-index is rarely being used to evaluate research performance of authors as it is not very easy to compute due to iterative process involved. To overcome this limitation and further enrich g-index; the author has proposed two indices: P-index called Prime index and V-index called 'Value added index' which takes into account the average number of authors / paper published by a particular author. P-index is most easy to compute and gives results which are 2-3% higher than g-index because it includes 100% of citations from an author. The V-index is a novel index of taking into account the average number of authors to normalize the research contribution from an author in multiple authored papers. An illustrative example in given.

INTRODUCTION

Number of citations received by a paper published by an author is increasingly being considered to determine the research productivity of scientists and researchers in any branch of knowledge. A citation is the reference made by an author of the previous published work on the subject matter addressed in that paper. Thus larger the number of citations a paper receives, better is the perceived quality of that paper. Total numbers of citations (TC) are the sum of all the citations received by various papers published in which the author being assessed is an author or a co-author.

A number of indices have emerged to measure the research performance of an author based on citation analysis. Citations are indexed in a number of data bases; some notables are: SCI (Science Citation Index); Web-of-Science; Scopus; Research gate and Google Scholar as well as Harzing's Publish-or-Perish (H-PoP) driven by google scholar. India recently started ICI (India Citation Index) which unfortunately has not become popular compared to foreign cites. We need to make it popular and also work relentlessly to improve the quality of papers published in Indian journals and become 'vocal for local'. It also calls for change of mindset of authors and institutions to promote quality of Indian journals.

ALTERNATIVE INDICES

Various indices have appeared in the literature after Hirsch Index (h-index) proposed in 2005 (3) followed by g-index in 2006 (1). Google Scholar also computes i-10 index in addition to h-index. H-PoP (2) computes a number of performance indicators including h-index and g-index. Scopus only uses h-index. A basic understanding of these indices is briefly outlined as follows because the author has felt a lot of ignorance on the part of many researchers about what these indices are in his interaction with various candidates during faculty selection process.

a) h-index: An author is having an h-index of h if h of his/her research papers have been cited h or more times. This is the most commonly accepted index globally because it is easy to count and was the first among various indices to be proposed. In the author's opinion this is quite unsuitable in measuring the true research performance as highlighted by Vrat (2019). Waltman etal (6) have also pointed out limitations of h-index.

b) i-10 index: Google Scholar also computes i-10 index in addition to h-index which is a shade better than h-index as it includes all those papers which have been cited 10 or more times; but it also suffers from the same drawback as h-index as the actual number of citations in each paper are ignored.

c) g-index: g-index was proposed by Egghe in 2006 (1) and perhaps is the best among the three (h, i-10 and g-index) as it incorporates the actual number of citations of each paper upto g. g-index is that number where the average of top 'g' papers is g. If C is the number of citations of paper arranged in descending order; then g is computed by the following equation:

$$g = \sum_{i=1}^{g} Ci/g$$

or

$$g^2 = \sum_{i=1}^{g} Ci$$

This is a good index but has been least popular in usage because the computation of g-index is an iterative process till the equation defining it is satisfied. Neither Scopus, nor Google Scholar give g-index as a ready reckoner to facilitate its use. Only Harzing's Publish or Perish (H-PoP) driven by Google Scholar (2) provides this index. In performance management systems, it is a well-known fact that a performance indicator is good if it captures most of the performance related data. From that perspective; the least appropriate is h-index as it totally ignores the actual number of citations higher than h. It is a crude count; though easiest to compute. i-10 follows next which is a shade better than h-index. g-index is performance wise the best of these three as it captures individual citations upto g but due to computational difficulty it is the least used index in practice. Many authors are not even aware of its superiority over h-index. Other than (H-PoP), it is not readily available; though (H-PoP) in this author's opinion is a great service to the scientific community – given free of cost except voluntary donations, and it gives a detailed multi-dimensional performance indicators for a more comprehensive evaluation of research performance among competing candidates.

An additional limitation of all the three indices mentioned above is that these are static in nature and give a snapshot of the performance on a given date. (H-PoP) also gives dynamically evolving popularity index by giving a frequency distribution of papers which have been cited 1, 2, 5, 10 and 20 times per year respectively. In earlier version of (H-PoP); a paper cited at least ten times/year was called a starred paper which shows its topicality an or relevance. An additional limitation of all the three indices described above are that these do not distinguish papers on the basis of number of authors in a paper and perhaps ignore the contribution of a researcher having fewer authors in published papers. Ignoring this can distort true contribution and may even encourage increase in the number of authors in the by line. Senanayake etal (2014) proposed a p-index (pagerank-index) (4) which is computed from the underlying citation network of papers and uses page rank algorithm in its computation. The index is a percentile score and is claimed to be better than h-index and "immune to author behavior". It is dynamic and rewards citations of impactful documents by giving higher weightage to citations of documents with higher academic standing to find scientific 'gems' to evaluate the quality of the document and not the journal. They utilized a simulated system to prove its superiority over h-index. However p-index suffers from its inability to help individual scientists to calculate their p-index, being a percentile score. It is not easily accessible to individuals unlike Google Scholars or H-Publish or Perish. Hence its utility for quickly determining the score of an individual scientist is severely limited and it has not been tested on real life data from scientists as yet. p-index also is too cumbersome for quickly finding out the score of an individual scientist or researcher. It also does not test its superiority over g-index which this author perceives to be more useful index than h-index. Hence a need was felt to develop holistic but simple indices by Vrat (2019). (5) This paper makes a plea for adoption of the two indices proposed by Vrat which overcome all the previous limitations described above and yet are perhaps easiest to compute. The author has called them as P-index (Prime Index) and V-index (Value added index) and (P, V) indices together give a far better idea of real contributions made by a researcher as compared to h, i-10 and g-index and overcome computational difficulty of g-index but gives an index marginally better than g-index as it does not ignore even the minutest data (single citation) of a paper. Hence it is recommended to the scientific and research community to use (P, V) indices particularly in place of h-index and i-10 index as g-index is anyway not being used extensively. Hence proposed indices are more complete and are very easy to compute irrespective of database: Scopus, SCI, web of science, Google Scholar, Indian Citation Index etc.

PROPOSED TWIN INDICES

The proposed P-index (Prime index) by Vrat (5) is just the square root of all the papers receiving any citation (even one). Thus it captures total research citations of a scientist and is the easiest to compute:

$$P = \sqrt{\sum_{i=1}^{n} C_i}$$

Where C_i = Number of citations of i^{th} paper arranged in descending order.

n= Total number of papers having non-zero citations. The concept does not change even if papers with zero citations are included as it does not change P value.

V- index (Value added index) (5) is the square root of total number of citations/author. This is obtained by dividing total number of citations by the average number of authors per paper (ā). ā is available on (H-PoP). Even otherwise it can be easily computed once in a year by each author and it is not very sensitive to changes year after year.

$$\bar{a} = \sum_{i=1} N_i/n$$

Where N_i=Number of authors in i^{th} paper, n is the total number of papers published. ā is then used to discount the number of authors to compute V-index and hence is called Value added index by an author in multiple authored research publications.

$$V = \sqrt{\textstyle\sum_{i=1}^{n} ci/\bar{a}} \quad \text{or} \quad \sqrt{TC/\bar{a}}$$

Where $TC = \sum_{i=1}^{n}$ which is readily available data in all data bases.

AN ILLUSTRATIVE EXAMPLE TO COMPARE PROPOSED INDICES WITH PREVIOUSLY DEVELOPED INDICES

To illustrate use of proposed twin indices; an illustrative example is given by using the data from free portal (H-PoP); driven by freely available Google Scholar (2). Table 1 shows the comparison of h-index, g-index with P-index and V-index. Data pertaining to 15 researchers ranging from hyper-active researchers to relatively inactive researchers were randomly chosen. Instead of names, only initials of the academics are given who are from India and other countries.

Table 1. Comparison of various citation indices with the proposed indices for citation analysis

Sr No	Author initials	Total no. of citations	h-index	g-index	Av/ no. of authors/paper	P-index	V-index		
1	PV	7705	38	86	2.31	87.77	57.78	0.020	0.658
2	MS	2079	24	45	3.07	45.59	26.02	0.012	0.570
3	NH	5493	39	73	3.02	74.11	46.36	0.015	0.625
4	SS	814	14	28	2.53	28.5	17.93	0.017	0.629
5	DB	5065	32	69	2.92	71.16	41.64	0.03	0.585
6	MTT	1599	17	39	2.31	39.98	26.30	0.02	0.657
7	RO	37	3	6	2.61	6.08	3.76	0.013	0.621
8	SKG	1139	16	33	2.97	33.74	19.58	0.02	0.580
9	BSS	4710	31	67	2.77	68.62	41.23	0.02	0.600
10	SD	16532	64	123	3.02	128.5	73.98	0.04	0.575
11	JN	14734	60	113	2.58	121.38	75.57	0.06	0.622
12	SB	970	11	30	2.68	31.14	19.02	0.03	0.610
13	VRR	5019	40	56	3.85	70	36	0.2	0.51
14	ASB	945	16	27	2.57	30	19.17	0.10	0.639
15	CNR	109783	154	276	3.39	331.3	180	0.163	0.543

Data source: Harzing – PoP driven by google scholar (2)

Analysis of results obtained in Table 1 are very revealing. Some major observations are:

I. h-index invariably underestimates the true research performance and is the most conservative. Paradoxically this is the most popular index globally.

II. P-index is invariably superior to g-index and is about 2-3% higher than g-index as it captures total citations but is the easiest to compute and thus a major limitation of g-index affecting its use is overcome because no iterative steps are required in computing P or V index.

III. V-index provides a more level playing field by normalizing the citation index discounting for the average number of authors/paper. In our example; varied from 2.31 to 3.85 and hence such discounting is perhaps required. It is envisaged that will generally vary between 2 to 4 which will give V/P ratio to be varying between 70% to 50%. In table 1 it ranges from 65.8% to 51%.

COMPARISON OF INDICES

It is suggested that scientists should use P-index in place of h; i-10 or g-index for its inclusive nature and computational convenience and discourage use of h-index which may not be true indicator. For example in Table 1, researcher at serial number 1 has an h-index of 38 with total citations of 7705 whereas that at serial number 13 has an h-index of 40 with total 5019 citations. g-index of serial number 1 is 86 while that of serial number 13 is only 56. Thus P index is 87.77 in case of serial 1 which reflects that the research performance of author 1 is better than P-index of 70 for serial number 13. If further discounted for average number of authors of 2.31 for 1 against 3.85 for 13; the V-index for serial number 13 becomes 36 as compared to 57.78 for researcher at serial number 1; which is even lower than h-index of that author in serial number 13. Thus h-index can give distorted picture of research performance compared to P and V indices and these are very easy to compute. Leaving exceptions (this could be due to issues of data accuracy) P index is about 2-3% higher than g-index; which is otherwise a good index but due to computational issues involved it is not very commonly used. P and V indices can be used even to resolve ties among authors having the same P index; the one having higher V-index has added higher value through research publications.

If one compares the relative ranks of the researchers obtained using h-index with g-index, only 8 out of 15 scholars have the same rank as in g-index. However using P-index; 12 ranks out of 15 are the same as in g-index and if there are deviations these are only marginal – one rank up or down. However ranks in V-index differ significantly because these are discounted based on the average number of authors/paper. It is suggested that V-index could be used to evaluate scholars if their P-index are essentially comparable. (P, V) indices proposed here are quick ratios for routine comparisons but for more important end-use of these indices; a multi-criteria approach may be more appropriate. It is hoped that a more inclusive and easy to compute (P, V) indices will be adopted for research performance evaluation instead of h-index. It will also remove computational difficulty in the way of using g-index, which is otherwise good.

COMPARISON OF RANKS OBTAINED BY VARIOUS INDICES

Table 2 shows the serial number of authors from Table 1 at different rank positions. We take P-index as a benchmark for rank comparisons to compute Mean Absolute Rank Deviations (MARD) from the reference benchmark of P-index. P-index is chosen because it captures all the citations and hence is the Prime – Index (PI) of research performance. If is the modulus value of the rank deviation of author ranked at place in P-index and its placement in other indices in ranking sequence; then

Mean Absolute Rank Deviation (MARD): $\frac{\sum_{i=1}^{n}|d_i|}{n}$

In this example; n=15

Table 3 compares the MARD values for all the four indices h, g, P and V for the data of illustrative example of Table 1. It can be seen that among h, g and P indices; deviations in ranking (hence ranking errors) is the highest in h-index with MARD of 0.733, whereas for g-index it is 0.266 which indicates that P-index proposed is closer to g-index; which is not being used frequently presumably because of computational difficulty due to iterative nature of computing g-index. P-index makes it almost the easiest index to compute without detailed citation data for each paper if we know the total number of citations. It therefore validates the view point that h-index is not a good way of measuring research performance of scientists but paradoxically it is being used frequently.

Table 2. Ranking Sequence of Scientists for the illustrative example using various indices.

	Serial number of scientist in Table1 having rank varying from 1 to 15. Rank														
Index	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
h	15	10	11	13	3	1	5	9	2	6	8	14	4	12	7
g	15	10	11	1	3	5	9	13	2	6	8	14	4	12	7
P	15	10	11	1	3	5	13	9	2	6	8	12	14	4	7
V	15	11	10	1	3	5	9	13	6	4	2	8	14	12	7

Table 3: MARD Value of indices with P-index as a reference benchmark.

Index type	Total absolute rank deviations	Mean Absolute Rank Deviation (MARD)
h-index	11	0.733
g-index	4	0.266
P-index	0 (Benchmark)	0.00
V-index	14	0.933

MAJOR CONCLUSIONS FROM THE RANK COMPARISONS

It is seen that if g-index is used in place of h-index the ranking errors will be low but computing g-index is relatively more difficult. Hence P-index is more suitable than h and g because it is more comprehensive; easiest to compute and even intuitively appealing and any scientist/researcher can compute it dynamically with ease without access to individual paper citations.

However a comparison of MARD values of P-index and V-index reveals substantial rank deviations because V-index discounts the P-index values based on the average number of authors/paper. Particularly it is seen that those scientists who have a high P-index but have more average number of authors/paper; get over-assessed by P-index and therefore V-index is perhaps a more fair assessment as compared to even P-index as it gives the value addition by the individual scientist in their joint publications. This will be fair to those who are less collaborative authors; who may have lower P-index but have done more value addition in achieving that score.

This paper makes a plea to all scientific institutions, universities and individuals to switch over to (P, V) index in place of more frequently used h-index or i-10 index, which may not reveal true picture of research performance of scientists. It also makes g-index less preferred index.

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