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Rating a Researcher's Cumulative Scholarly Output Based on Their Sequence Numbers in Multi-Authored Publications

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Featured Application: An author-level metric for evaluating a researcher's cumulative scholarly output is presented which can be effectively utilized by abstract and citation databases and search engines.

Abstract: As the academic world yields an ever-increasing research output in terms of journal papers, conference proceedings, and books, the rating of published works and authors becomes imperative. All the big citation databases and search engines are currently using cumulative output indices, such as h-index, i10-index, and g-index, which do not consider the number of co-authors or the researcher's sequence number in the authors list of a publication. In this context, the article presents a novel computational approach for evaluating a researcher's scholarly output by taking into account the total number of co-authors, the sequence number of the researcher in the authors list, and the number of citations received per year by an article. Arithmetic progression is applied to quantify the credit for each co-author of a publication. The respective credits of a researcher are then accumulated for all their publications to obtain the rating. The method yields a truer value of the researcher's impact in terms of their scholarly activities. A global implementation of the metric presented in this work will curb the unethical practice of including the names of non-contributing researchers in the authors list and expecting reciprocity in return.

Keywords: h-index; citations; arithmetic sequence; research; i10-index; impact factor

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1. Introduction

The modern-day advancement and development of the world is indebted partially to the dissemination of research findings through publications. Publication of research articles is the key to successively building on the existing levels of knowledge in a globally distributed research environment. The world is seeing a persistent increase in the total volume of papers published annually. It is reported that the current growth rate of publications in the science domains is 4.1%, leading to a doubling time of 17.3 years [1]. As a research domain is progressively taken to new heights of advancement, it becomes imperative to quantify the contributory shares of the researchers involved. Such is the current competence and efficacy level of the information and communication technology that evaluation of researchers' scholarly impacts is now considered a customary task. Having no issues with the computation prowess, the flaw lies in the methods used to evaluate the impact indices.

The top indices (h-index, i10-index, and g-index) used by the prominent citation databases and search engines include the number of publications and citations but not the number of coauthors per article, the sequence number of the given coauthor in the authors list, or the time elapsed after publication of an article in the evaluation process [2]. Such a deficiency leads to a wrong association of credits with the authors. For example, each of 10 coauthors receive the same credit for jointly coauthoring an article cited 100-times. There is no distinction between the first coauthor and the tenth. Moreover, the sole author of another 100-times cited article receives the same credit. In addition to crediting flawed impacts to the researchers, the anomaly in the evaluation method also encourages an unethical practice of including the names of non-contributing researchers in the authors list [3]. Quite often, such an act is undertaken with an expectation of reciprocity in the future from the non-contributing coauthors. A better quantification approach is thus required to ascribe rightful credits to the coauthors of multi-author publications. A succinct review of the literature in this regard is provided below.

Hirsch-index, commonly known as h-index, is defined as the maximum value of h such that the given author or journal has published at least h papers that have each been cited at least h times [4]. The definition clearly suggests that the number of coauthors of an article has no significance with respect to the index. Likewise, g-index is defined as the largest number such that the top g articles together have received at least g^2 citations [5]. Google Scholar introduced the i10-index in 2011, which indicates the number of articles an author has written that have been cited by at least 10 sources [6]. Schreiber has proposed fractionalized counting of the articles for evaluation of a modified index, h_m, which takes multiple authorship into consideration [7]. The author has claimed the superiority of the method in terms of fractionalizing the number of publications, rather than by fractionalizing the citations, which leads to attainment of a more practicable approach. Although the number of coauthors has been taken care of, the method remains indifferent to the order of coauthors in the authors list. The author, one year later, reported the application of h_m to 26 empirical cases of researchers and claimed superiority over other indices in quantifying the cumulative research output of a researcher while taking multiple authorship into consideration [8]. Likewise, Wan et al. have introduced the "pure h-index" to take coauthors into account [9]. The authors have also presented several possibilities to account for the researcher's sequence number in the authors list, such as total counting, fractional counting, proportional counting, and geometric counting. In comparison to h-index, an author-level index h_I is proposed as the number of papers with at least h_I citations if the author has published alone [10]. The authors have claimed that h_I is less prone to degeneration as its value is less sensitive to different research fields. It is also important to understand that all the commonly used author-level bibliometric indices depend on the length of the researcher's academic career in addition to their field of research [11]. The authors have, therefore, emphasized that the indices should only be used to compare researchers of a similar length of academic career and within the same field of research. Another bibliometric index (c-index) is presented which quantifies the scholarly output of a researcher or a source based on the quantity and quality of the received citations [12]. The authors have described the quality of a citation as the collaboration distance between the citing and the cited authors.

Although there is no standard norm of assigning credits to coauthors in respect of authors sequence, the generally adopted trend is that the coauthors appear in the sequence of a decreasing level of contribution. Such a norm is called a "sequence-determines-credit (SDC)" approach [13]. Thus, the coauthor appearing at the third position is supposed to have contributed more than the coauthor appearing at the fourth position. The other less commonly used norms are "equal-contribution (EC)", "first-last-author-emphasis", and "percent-contribution-indicated" norms. The percent-contribution-indicated norm, also known as "author contribution details", should be prioritized over the SDC approach in order to get a truer picture [14]. Unfortunately, not many journals publish author contribution details, which renders this approach unworkable. Xu et al. have presented a review of different credit assignment schemes proposed by various researchers for quantifying a researcher's output in multiple author publications [15]. Based on the review, the authors have classified the schemes into the following three categories: linear, curve, and other. Heng has proposed the application of harmonic counting for an equity-based distribution of the publication credit among the coauthors [16]. The author has claimed superiority of this method over similar approaches, such as fractional counting, geometric counting, and arithmetic counting. For example, it is claimed, in respect of arithmetic counting, that the credit of the former last coauthor is initially increased by adding more coauthors, thus undermining the effectiveness of the approach. However, the claim will be refuted in this work. A network-based method is also presented for distribution of the publication credit among the coauthors [17]. The method visualizes coauthorship as a directed, weighted network, where coauthors transfer credit shares among one another. The authors have claimed to have empirically validated the approach by fitting it to the data regarding credit shares from various research fields.

A source-level scientometric index, impact factor (IF), is defined as the average number of citations received per year by articles published in an academic journal in the last two years [18,19]. For instance, the IF of a journal reported in the year 2020 is equal to the total number of citations received by it in 2020 divided by the total number of articles published in years 2018 and 2019. Used as a yardstick by institutes and funding bodies for measuring the quality of researchers' scholarly outputs and deciding on research proposals and associated grants, the metric has been criticized for distorting ethical research practices [20,21]. The author-level metric, h-index, and the journal-level metric, IF, are, for obvious reasons, positively correlated. A higher number of citations received by an article would not only increase the h-index of the author/coauthors but also contribute positively toward enhancing the IF of the journal. As far as the association between the journal-level h-index and IF is concerned, however, it has been shown that the level of correlation varies from journal to journal [22].

The brief review of the literature provided above uncovers a significant research gap available. A robust method is required to justly quantify the scholarly impacts of researchers by considering the number of coauthors, the sequence number of the researcher in the authors list, and the time elapsed after the date of publication of their articles. The work presented here employs the concept of arithmetic series to work out a mathematical model for impartial and reasonable calculations of the researchers' scholarly impacts.

2. Method

The development of the researcher rating tool is based on the following three working principles:

1. The credit assigned to a publication is equal to the total number of citations received divided by the number of years elapsed after its publication. If less than a year has elapsed, the article's credit is equal to 2 times the impact factor of the journal in which it has appeared.
2. The summation of the credits allocated to the individual coauthors of the article is strictly equal to the article's credit.
3. Following the sequence-determines-credit (SDC) approach, the individual credits are so allocated that the first coauthor gets the highest share and the difference of the credits of any two consecutive coauthors remains constant throughout the authors list. On the other hand, the equal-contribution (EC) approach awards equal credits to all the coauthors. Both approaches can be managed in the proposed method.

The first working principle is an effort to curb the negative effect of the early stage of a young researcher's career on the metric of their scholarly output. Clearly, a publication garners more and more citations as time passes, giving eminence to older publications. Hence, the factor of time should be incorporated in the quantification process to ensure a level playing field for all the researchers. The IF of the journal is suggested to be used for the articles which are still in the first year of their publication. This is so because these articles do not receive citations to their full potential within that period due to a lot of time being consumed by the citing articles during the write-up, submission, review, revision, and production phases of their publication. Doubling the IF is suggested because the factor's quantification involves the citations received in one year and the papers published in a period of two years. The second principle ensures that the cumulative credit gained by all the coauthors should not be more than the article's credit. As such, the sole author of a single-author publication should get the whole credit. Lastly, the third principle is the only justifiable approach of dividing the credit of the article among its coauthors when the journal has not specified the respective contributory shares. Thus, it is most reasonable that the article's credit should be divided among the coauthors either in a uniformly decreasing manner along the sequence of the authors list or equally.

Mathematical Model

First, an arithmetic progression-based mathematical relationship is developed to find out the credit shares of the coauthors in compliance with the third working principle (SDC and EC). Suppose the number of coauthors and the sequence number of the researcher in question are n and j, respectively. The credit share of any coauthor in the authors list can be determined from the following relationship:

$$a_n = a_1 - (n-1)d;\ n = 1,\ 2,\ \ldots, \tag{1}$$

where a_1 is the credit share of the first coauthor and d is the common difference between the credit shares of any two consecutive coauthors. It is crucial to assign an appropriate value to d to avoid an unrealistically high or low difference between the shares of the first and the last authors. Let:

$$d = \frac{k}{n(n-1)};0\ \leq k \leq 1;\ n = 1,\ 2,\ \ldots, \tag{2}$$

where k is a positive fraction between 0 and 1 which controls the range of credit share between the first and the last coauthors. By substituting the value of d in Equation (1), we get:

$$a_n = a_1 - {}^{k}/_{n};0\ \leq k \leq 1;\ n = 1,\ 2,\ \ldots, \tag{3}$$

The summation S_n of a finite arithmetic series is given by:

$$S_n = \frac{n(a_1 + a_n)}{2};\ 0\ \leq k \leq 1;\ n = 1,\ 2,\ \ldots, \tag{4}$$

Substitute the value of a_n from Equation (3) in Equation (4) and equate the summation to 1. The summation value of 1 represents the whole credit of the article which is to be divided among the coauthors. We get:

$$\begin{gathered} S_n = 1 = \frac{n(a_1 + a_1 - k/n)}{2};\ 0\ \leq k \leq 1;\ n = 1,\ 2,\ \ldots, \\ a_1 = \frac{k+2}{2n};\ 0\ \leq k \leq 1;\ n = 1,\ 2,\ \ldots, \end{gathered} \tag{5}$$

Substitute the value of a_1 in Equation (3). We get:

$$a_n = \frac{2-k}{2n};\ 0\ \leq k \leq 1;\ n = 1,\ 2,\ \ldots, \tag{6}$$

The credit share for the given researcher, located at position j (between 1 and n), can be obtained by using $n = j$ and replacing the values of a_1 and d from Equations (5) and (2), respectively, in Equation (1). We get:

$$a_N = \frac{k+2}{2n} - \frac{(j-1)k}{n(n-1)};\ 0\ \leq k \leq 1;\ n = 1,\ 2,\ \ldots,;j = 1,\ 2,\ \ldots,\ n \tag{7}$$

Equation (7) presents the formula for finding out the fractional credit share of a coauthor located at position j in the authors list of n coauthors.

3. Results

Tables 1 and 2 present the distributions of fractional credit shares from n = 2 to 15 using the values of k equal to 0.2 and 0.4, respectively. All the rows of the tables show uniformly decreasing credit shares while moving rightward from the first author to the last. All the shares in a row finally add up to 1, as shown in the last columns of the tables. Moreover, it can also be observed that the share of the first author decreases as the number of coauthors increases but it always remains more than the other coauthors. It is also worthwhile to note that the coauthor at the mid position of an authors list presented as an odd numbered row (n = 3, 5, 7, . . .) of Table 1 (k = 0.2) holds exactly the same fractional credit share as the one in the same row of Table 2 (k = 0.4). This holds true for the higher values of k, too. Thus, it can be inferred that the uniform spread of the fractional credit shares among a given number of coauthors is centered at the middle of the authors list. These observations speak of the fairness and correctness of the proposed method in dividing a publication's credit among its multiple coauthors.

Table 1. Uniformly decreasing distribution of fractional credit shares of a publication among the coauthors (2–15). k = 0.2.

n	**Sequence Number of the Researcher in Authors List (*j*)**															**Sum**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	
2	0.550	0.450	-	-	-	-	-	-	-	-	-	-	-	-	-	1
3	0.367	0.333	0.300	-	-	-	-	-	-	-	-	-	-	-	-	1
4	0.275	0.258	0.242	0.225	-	-	-	-	-	-	-	-	-	-	-	1
5	0.220	0.210	0.200	0.190	0.180	-	-	-	-	-	-	-	-	-	-	1
6	0.183	0.177	0.170	0.163	0.157	0.150	-	-	-	-	-	-	-	-	-	1
7	0.157	0.152	0.148	0.143	0.138	0.133	0.129	-	-	-	-	-	-	-	-	1
8	0.138	0.134	0.130	0.127	0.123	0.120	0.116	0.113	-	-	-	-	-	-	-	1
9	0.122	0.119	0.117	0.114	0.111	0.108	0.106	0.103	0.100	-	-	-	-	-	-	1
10	0.110	0.108	0.106	0.103	0.101	0.099	0.097	0.094	0.092	0.090	-	-	-	-	-	1
11	0.100	0.098	0.096	0.095	0.093	0.091	0.089	0.087	0.085	0.084	0.082	-	-	-	-	1
12	0.092	0.090	0.089	0.087	0.086	0.084	0.083	0.081	0.080	0.078	0.077	0.075	-	-	-	1
13	0.085	0.083	0.082	0.081	0.079	0.078	0.077	0.076	0.074	0.073	0.072	0.071	0.069	-	-	1
14	0.079	0.077	0.076	0.075	0.074	0.073	0.072	0.071	0.070	0.069	0.068	0.066	0.065	0.064	-	1
15	0.073	0.072	0.071	0.070	0.070	0.069	0.068	0.067	0.066	0.065	0.064	0.063	0.062	0.061	0.060	1

Table 2. Uniformly decreasing distribution of fractional credit shares of a publication among the coauthors (2 to 15). k = 0.4.

n	**Sequence Number of the Researcher in Authors List (*j*)**															**Sum**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	
2	0.6	0.4	-	-	-	-	-	-	-	-	-	-	-	-	-	1
3	0.400	0.333	0.267	-	-	-	-	-	-	-	-	-	-	-	-	1
4	0.300	0.267	0.233	0.200	-	-	-	-	-	-	-	-	-	-	-	1
5	0.240	0.220	0.200	0.180	0.160	-	-	-	-	-	-	-	-	-	-	1
6	0.200	0.187	0.173	0.160	0.147	0.133	-	-	-	-	-	-	-	-	-	1
7	0.171	0.162	0.152	0.143	0.133	0.124	0.114	-	-	-	-	-	-	-	-	1
8	0.150	0.143	0.136	0.129	0.121	0.114	0.107	0.100	-	-	-	-	-	-	-	1
9	0.133	0.128	0.122	0.117	0.111	0.106	0.100	0.094	0.089	-	-	-	-	-	-	1
10	0.120	0.116	0.111	0.107	0.102	0.098	0.093	0.089	0.084	0.080	-	-	-	-	-	1
11	0.109	0.105	0.102	0.098	0.095	0.091	0.087	0.084	0.080	0.076	0.073	-	-	-	-	1
12	0.100	0.097	0.094	0.091	0.088	0.085	0.082	0.079	0.076	0.073	0.070	0.067	-	-	-	1
13	0.092	0.090	0.087	0.085	0.082	0.079	0.077	0.074	0.072	0.069	0.067	0.064	0.062	-	-	1
14	0.086	0.084	0.081	0.079	0.077	0.075	0.073	0.070	0.068	0.066	0.064	0.062	0.059	0.057	-	1
15	0.080	0.078	0.076	0.074	0.072	0.070	0.069	0.067	0.065	0.063	0.061	0.059	0.057	0.055	0.053	1

Table 3 presents the differences and percentage differences between the fractional credit shares of the first and the last authors regarding the cases of two and 15 coauthors per publication, with the value of k varying from 0 to 1.2 at an increment of 0.2. It is observable that an increase in the value of k raises the difference between the shares of the first and the last authors for n = 2 as well as n = 15. Understandably, the absolute values are higher for

$n = 2$, whereas the percentage values are the same for both cases. This is also to be noted that the percentage difference increases at a slower rate against the fixed increments in k.

Table 3. Differences and percentage differences between the credit shares of the first and the last coauthors for $n = 2$ and 15 against the seven values of k.

k	$n = 2$		$n = 15$	
	Difference	**Percentage Difference**	**Difference**	**Percentage Difference**
0	0	0	0	0
0.2	0.1	18%	0.013	18%
0.4	0.2	33%	0.027	33%
0.6	0.3	46%	0.04	46%
0.8	0.4	57%	0.053	57%
1	0.5	67%	0.067	67%
1.2	0.6	75%	0.08	75%

It is quite a subjective matter deciding on the best value of k. $k = 0$ would lead to an equal-contribution (EC) norm, whereas a very high value would yield an unrealistically high difference. A high value of k favors the coauthors listed near the beginning of the authors list whereas a low value favors those near the end. Pragmatically, the range $k = 0.2$–0.6 would be appropriate.

Heng has claimed inferiority in respect of arithmetic progression when compared with harmonic progression, which is based on their observation that the credit share of the former last coauthor is initially increased by adding more coauthors [16]. The data presented in Tables 1 and 2 clearly oppose the claim. Comparing the cells 1–2 (row–column) with 2–2, 2–3 with 3–3, 3–4 with 4–4, and so on, in both tables, clearly shows that the credit share of the former last coauthor is always decreased by adding more coauthors. Such an anomaly only arises when an unrealistically high value of k (≥ 0.8) is used. Furthermore, arithmetic progression fares better than harmonic progression regarding the issue of having an imperceptible difference between the credit shares of the coauthors appearing near the end of the authors list of a publication contributed to by a large number of coauthors.

Extra Credit for Correspondence

The coauthor, which also corresponds with the journal's editorial board and the publisher at the pre- and post-publication stages, deserves extra credit for their efforts. Fixing the share of correspondence in multiauthor publications is a highly subjective matter. It is thus recommended that the corresponding author should be awarded a C% credit share and all the coauthors (including the corresponding author) should share the remaining (100–C)% credit of the paper in the same manner as described in the preceding sections. C is a positive number smaller than 100 whose exact value is a policy matter for a citation database/search engine. Rationally, C should be fixed between 5 and 15. Table 4 presents a reworking of the data presented in Table 1 by considering the last coauthor in each row as the corresponding author. Moreover, the value of C, in the calculations, is fixed as 5.

Table 4. Uniformly decreasing distribution of fractional credit shares of a publication among the coauthors (2–15) with the corresponding author (the one in the last entry—shown as bold—of each row) getting an extra 5% credit (C = 5). k = 0.2.

n	Sequence Number of the Researcher in Authors List (j)															Sum
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
2	0.500	**0.500**	-	-	-	-	-	-	-	-	-	-	-	-	-	1
3	0.342	0.308	**0.350**	-	-	-	-	-	-	-	-	-	-	-	-	1
4	0.258	0.242	0.225	**0.275**	-	-	-	-	-	-	-	-	-	-	-	1
5	0.208	0.198	0.188	0.178	**0.230**	-	-	-	-	-	-	-	-	-	-	1
6	0.173	0.167	0.160	0.153	0.147	**0.200**	-	-	-	-	-	-	-	-	-	1
7	0.149	0.144	0.139	0.135	0.130	0.125	**0.179**	-	-	-	-	-	-	-	-	1
8	0.130	0.127	0.123	0.120	0.116	0.113	0.109	**0.163**	-	-	-	-	-	-	-	1
9	0.116	0.113	0.110	0.108	0.105	0.102	0.099	0.097	**0.150**	-	-	-	-	-	-	1
10	0.104	0.102	0.100	0.098	0.096	0.093	0.091	0.089	0.087	**0.140**	-	-	-	-	-	1
11	0.095	0.093	0.091	0.090	0.088	0.086	0.084	0.082	0.080	0.079	**0.132**	-	-	-	-	1
12	0.087	0.086	0.084	0.083	0.081	0.080	0.078	0.077	0.075	0.073	0.072	**0.125**	-	-	-	1
13	0.080	0.079	0.078	0.077	0.075	0.074	0.073	0.071	0.070	0.069	0.068	0.066	**0.119**	-	-	1
14	0.075	0.074	0.073	0.071	0.070	0.069	0.068	0.067	0.066	0.065	0.064	0.063	0.062	**0.114**	-	1
15	0.070	0.069	0.068	0.067	0.066	0.065	0.064	0.063	0.062	0.061	0.060	0.059	0.058	0.057	**0.110**	1

4. Discussion

A case study focusing on rating the scholarly output of two imaginary researchers is presented in this section. The details are presented in Table 5. In compliance with the first working principle (listed in Section 2), the impact factor of the respective journal is used for working out the article credit if the publication date is later than 01-NOV-2020. Therefore, publications number 6 and 7 of researcher A and 4, 5, and 6 of researcher B will be utilizing impact factors for the evaluation of their credits. All the other articles will utilize the number of citations divided by the number of years elapsed subsequent to their dates of publication.

Table 5. Assumed data regarding the publications of two imaginary researchers. The current date is taken as 01-NOV-2021.

Publication Number	Researcher A					Researcher B				
	n	j	Citations Received	IF (Journal)	Publication Date	n	j	Citations Received	IF (Journal)	Publication Date
1	4	1	31	3.6	01-MAR-2017	2	1	9	2.2	01-OCT-2019
2	2	2	55	10.23	15-MAY-2019	4	2	47	9.4	30-NOV-2019
3	7	7	17	4.2	15-DEC-2019	9	9	11	2.2	01-MAR-2020
4	1	1	10	1.3	15-FEB-2020	3	2	4	1.9	15-DEC-2020
5	12	7	15	3.6	01-OCT-2020	12	3	3	5.3	15-APR-2021
6	3	2	4	2.5	01-FEB-2021	9	6	0	9.4	01-JUL-2021
7	6	1	1	4.2	15-MAY-2021	-	-	-	-	-

Table 6 presents the evaluation of the researchers' fractional credit shares for all the tabulated publications (as presented in Table 5). The evaluation process employs k = 0.3. The researcher's credit (RC) coming from a given publication is the product of the researcher's fractional credit share (a) and the average number of citations received by the article per year (Ct_{avg}) or twice the impact factor (IF) of the publishing journal, if the article is within the first year of its publication. The relationship can be mathematically described as follows:

$$RC = \begin{cases} a.Ct_{avg} & time\ elapsed > 1\ year \\ 2a.IF & time\ elapsed\ \leq 1\ year \end{cases} \quad (8)$$

Table 6. Evaluation of articles' credits, fractional credit shares, and researchers' credits against the details provided in Table 4. k = 0.3.

Researcher	Publication Number	Time Elapsed (Years)	Citations/IF	Article's Credit ($Ct_{avg}/2 \times$ IF)	Researcher's Fractional Credit Share (a)	Researcher's Credit (RC)
A	1	4.67	31	6.63	0.288	1.91
A	2	2.47	55	22.28	0.425	9.47
A	3	1.88	17	9.03	0.121	1.10
A	4	1.71	10	5.84	1	5.84
A	5	1.08	15	13.83	0.082	1.14
A	6	0.75	2.5	5.00	0.333	1.67
A	7	0.47	4.2	8.40	0.192	1.61
B	1	2.09	9	4.31	0.575	2.48
B	2	1.92	47	24.44	0.263	6.41
B	3	1.67	11	6.58	0.094	0.62
B	4	0.88	1.9	3.80	0.333	1.27
B	5	0.55	5.3	10.60	0.091	0.97
B	6	0.34	9.4	18.80	0.107	2.01

The rating of a researcher is the sum of their RCs displayed in the last column of Table 6. The ratings of researchers A and B are thus 22.73 and 13.76, respectively. Publications number 2 for both researchers have yielded the largest contributions because of the large number of citations they have received and an early position of the researchers in the sequence of the authors lists. An increase in the value of k would cause a decrease in the rating of researcher A and an increase in that of B. For instance, setting k = 0.6 yields ratings of 21.3 and 14.29 in respect of researchers A and B, respectively. The reason behind this observation is that researcher A appears in the authors lists of the high citation/IF publications much closer to the ends of the sequences than does researcher B. Thus, a high value of k favors researcher B, whereas researcher A would be happier with a low value.

The superiority of the proposed method can be judged from the credit evaluations of publications number 3 and 5 of researcher A and 3, 5, and 6 of B. Had the measure of quantifying a researcher's credit based on the number of coauthors and the researcher's position not been incorporated, all the coauthors would have individually taken the whole credit of the publication. In this case, every coauthor of the articles 3(A), 5(A), 3(B), 5(B), and 6(B) would have secured 9.03, 13.83, 6.58, 10.6, and 18.8 credits, respectively. Furthermore, an older publication would have stood taller based merely on the cumulative number of citations received throughout the years after its publication. The researcher rating approach presented in this article justly addresses the issue of adjusting the number of coauthors, the sequence number of the researcher in the authors list, and the time elapsed after publication of the article in assigning the due credit.

A limitation to the proposed method lies in the true reflection of the actual contributions made by the coauthors of a multi-authored publication. Pragmatically speaking, the contribution share is rarely distributed in a uniformly decreasing pattern through the sequence of the coauthors as is modeled in this work. Obviously, the true picture of individual contributions can only be visualized if the publication source has provided such information. Some journals do provide such information but mostly in a very qualitative way. The individual contributions are normally divided into various contribution fields, such as conceptualization, investigation, validation, funding, write-up, and more. It becomes very difficult to quantify the individual contributions of the coauthors in percentages from these qualitative fields. Even if some researchers have tried to model the actual contributions to get the shares in numbers, the methods have not gained much popularity. The main reason for such a shortcoming is that the major citation databases and search engines work with simple number-crunching algorithms incorporating modest numerical information regarding publication year, publication source, and number of citations. In such a situation where either the real information on individual contributions is not available or a citation database is unable to convert that qualitative information into individual percentages, the only logical solution is to consider the total number of coauthors of a publication and divide the publication credit among them in a uniformly decreasing manner along the sequence of the authors' list.

5. Conclusions

Most of the author-level scholarly output indices in use today are insensitive to the following three factors: (1) the number of coauthors of a publication; (2) the sequence of the authors list; and (3) the time elapsed after publication of the article. These factors cannot be overlooked if true quantification of a researcher's scholarly output is required. The presented work puts forward an easy and accurate method to cater for the three factors in the quantification process.

A formula, based on arithmetic progression, is worked out to accommodate the first two requirements. The users are required to adjust the value of a factor (k) to get the preferred difference of credit between the consecutive coauthors. Increasing k from zero to a positive value converts the credit assignment mode from equal-credit to sequence-determines-credit. Furthermore, twice the impact factor of the publishing journal is used instead of the number citations for assigning credit to an article published within a year. For others, the article's credit is evaluated as the average number of citations received per year. The presented work is constrained to use the journal's impact factor for the articles within the first year of their publication as they do not receive citations to their full potential within that period due to the large number of time-consuming stages the citing articles are supposed to go through, such as write-up, submission, review, revision, and production after acceptance.

The presented method not only yields a true and fair rating of a researcher's scholarly output, it also discourages the unethical practice of including multiple non-contributing coauthors in the authors list in order to falsely enhance an individuals' ratings and in the expectation that they would reciprocate the favor in their future publications.

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