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A time dimension of paper influence evaluation research: Improvement based on AMMAA algorithm

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ABSTRACT

Aiming at the deficiency of h index and the lack of a comprehensive and effective evaluation index, this paper introduces an ammaa algorithm for paper evaluation and proposes an optimization algorithm integrating time dimension: t-ammaa algorithm, which reflects the influence evaluation of individual scholars through the evaluation of paper influence. We used Web of Science as the data source and focused on the paper published by the authors of Chinese library and information science, to calculate the ammaa value and t-ammaa value of these papers, and then obtained the ammaa value and t-ammaa value of the scholar. The result ranking of the two algorithms and the scholar's H-value ranking are normalized for empirical comparison and analysis. The results show that t-ammaa algorithm considering the cited times, the cited threshold limit, the co-authors' number, and the temporal heterogeneity of the cited papers, is a more reasonable measurement method for evaluating the influence of scholars. It can not only comprehensively evaluate the influence of single author and co-authored paper, but also eliminate the influence brought by time factor.

KEYWORDS

AMMAA algorithm; Temporal heterogeneity; Multi-author paper influence; Author influence; Evaluation index; Altmetrics

1 INTRODUCTION

The scientific research carried out by scholars, and the dissemination of their results plays an important role in scientific progress and social development (Ma et al., 2017). The role of papers in the evaluation of personal academic influence has been increasingly relied on by the universities and research institutes in the evaluation of professional titles and the introduction of talents. In 2018, China's Ministry of Education, together with multiple departments, carried out a special action to clean up ''thesis only'', ''project only'', ''award only'', ''title only'', and ''rank only'' (hereinafter referred to as the "five-only"). In the process of breaking the "five-only", especially when breaking the "thesis only" phenomenon, we should consider the development stage of China's scientific research. "One-stop" is neither realistic nor necessary. The emphasis should be on reversing the unscientific evaluation orientation to make a reasonable evaluation on the academic influence of authors.

At present, the academic evaluation indicators recognized widely, such as citations, h in-

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dex, g index, etc., are all methods used to evaluate the influence of individual researchers. However, with the development of information technology, it is increased normalization of scientific cooperation and knowledge exchange. The form of multi-author cooperation can significantly improve the level of academic research (Polyakov et al., 2017). The progress of scientific research requires cooperation between researchers in multiple fields (Gazni et al., 2012). In science and engineering subjects, such as physics, the number of collaborators can reach hundreds of people, and the number of co-authors is currently increasing. It is becoming more and more normal for articles to be written by more than one author (Shaban, 2007). However, in recent years, the issues of attribution qualifications (Gao et al., 2012) such as "guest author" (Wager et al., 2015), "gift author" (Jack, 2015), and "non-academic collaborator" (Sarna-Wojcicki et al., 2017) have always been following. Related studies have found that the influence of research results may not increase, such as the frequency of citations and downloads with the increase in the number of co-authors (Iribarren-Maestro et al., 2009). Therefore, the journal has also called on each coauthor to make corresponding efforts and contributions (Ilakovac et al., 2007; Tarnow, 2002; Yager, 2007). Based on this, D. Gnana Bharathi (2019) proposed a multi-author aggregation analysis algorithm index - "aggregating metrics for multiple authors' analysis", namely ammaa algorithm in 2019.

2 RELATED RESEARCH

In 2005, Hirsch (2005) proposed the h-index that comprehensively considered the number and quality of scholars' publications and has been recognized and promoted by the academic community. In the same year, the Nature article commented (Ball, 2005) that the charm of the h index lies in that it can highlight those researchers who have made lasting major contributions but have not received honors commensurate with their prestige. Since the h index was put forward, scholars around the world have done a lot of research on it. With the deepening of research, the shortcomings of the h index are gradually discovered: (1) cooperation adulteration, unable to distinguish the contributions of authors; (2) insensitive to the number of papers, only considering papers and frequency of citations in the h index, ignoring the others outside the range; (3) cannot evaluate the influence of authors across fields; (4) impossible to evaluate the influence of scholars in the near future, etc. (Bornmann et al., 2005; Rodrigo, 2007; Zhou, 2009). Up to now, there have been no less than 30 types of h-index correction or expansion (Wildgaard et al., 2014). In 2006, L. Egghe (2006) proposed the g-index from the perspective of the cumulative contribution of the paper citation frequency, and the R index and Hr index are on the same perspective by other scholars (Jin et al., 2007). In 2010, Prathap (2010a) proposed the p index, which optimized the sensitivity and discrimination of the h index. There was also a modification from the perspective of author cooperation, including differential sharing and equal sharing of paper influence. The researches of differential sharing papers' influence include considering the main contributing authors and calculating the weight of collaborators. Among them, the former is when calculating the h index, only the papers with the author as the principal contributor are included, such as the h_{maj} index (Hu et al., 2010); the latter is the honor allocation method based on the ranking of authors and the number of co-authors (Shen & Barabasi, 2014). The researches of equal sharing papers` influence include directly averaging the h index and averaging the number of papers or citations. The former is like the h_I index (Batista et al., 2006), and the latter is like the h_m index and pf index (Prathap, 2010b; Schreiber, 2008). In 2016, Sahoo (2016) proposed the I index addressing the issue of the individual contribution rate of co-authored papers,

which makes the scores of each co-author decrease as the number of paper authors increases, and reduces the impact of "papers with no substantive contributions" to some extent. In 2019, D. Gnana Bharathi proposed a multi-author aggregation analysis algorithm indicator — ammaa algorithm, which realizes the evaluation of scholars' influence by evaluating the influence of papers (Bharathi, 2019).

Based on the above, although the shortcomings of the h index have gotten compensation or improvement, there is still no comprehensive and effective method that can be used in the evaluation of scholars' influence. Therefore, based on the ammaa algorithm proposed by D. Gnana Bharathi, this paper proposes an improved algorithm that incorporates time factors, namely t-ammaa algorithm, and tries to compare and analyze the correlation with the h index through data empirical research, proving this algorithm is more comprehensive, fair and precise in evaluating the influence of scholars.

3 INTRODUCTION TO AMMAA ALGORITHM

3.1 Principle of ammaa algorithm

The ammaa algorithm introduces a threshold limit T, which is a multiplier of co-authorship. For any article, it is not difficult to find from Equation (1)(2)(3) that, if the paper is written by single author, the ammaa value of that is its citations; if the number of authors is more than one, its ammaa value is the square of the total citations divided by the threshold T and the number of authors, and then plus the value of the total citations divided by the number of authors. Thus, for every author, this way will make the impact more than the equal division of total citations by all authors until it reaches the citation limit set by the threshold limit for the coauthors (aT-T). Under this situation, each author can claim to have all of the article's citations, when the ammaa value is equal to the total citations, as shown in Equation (2). The kind of measurement method in which all authors share the citations on average, and the value of their influence will gradually increase by the same share as each additional citation, is similar to that all members of the team can be fully rewarded until the goal is achieved. Before that, each worker has the same performance incentives with each increase in productivity. This not only avoids reducing the enthusiasm of co-authors because of sharing citations equally to weaken the actual author's contribution value, but also does not exaggerate the influence of co-authors without actual contributions. The formula for calculating the ammaa value of any paper is as follows.

For single-author articles:

$$ammaa=c \tag{1}$$

For any other form of multi-author co-authored articles, namely when a > 1:

$$\text{if } c < aT-T,\ ammaa=\frac{(c+(\frac{c^2}{T}))}{a} \tag{2}$$

$$\text{if } c \geq aT-T,\ ammaa=c \tag{3}$$

c= Total citations, a= number of authors, T= threshold limit

This method can also be extended to other evaluations, such as Altmetrics, in which the number of views, sharing and downloads, etc., all can be measured.

When measuring the influence of multi-author papers in the same discipline, the T value is the same, and all co-authors enjoy the full citation threshold (aT-T), which will increase as the number of co-authors increases, as shown in Figure 1a. Before reaching the threshold,

the ammaa value will decrease as the number of co-authors increases, as shown in Figure 1b. As a result, the ammaa algorithm considers both the number of authors and the citations and realizes an innovative fusion that can evaluate both single-author and multi-author papers.

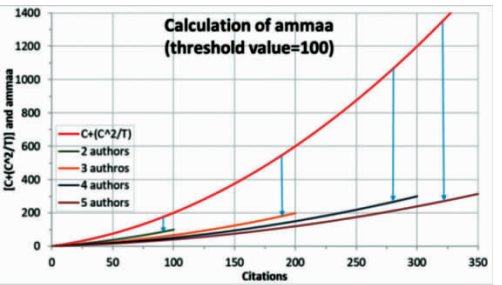

Figure 1a Calculation of ammaa for a different number of coauthors and the way it merges citations as by a single author (here T = 10)

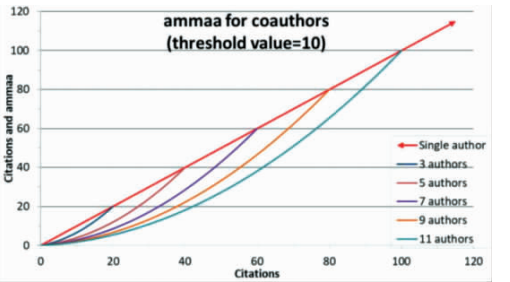

Figure 1b When the T value is fixed (here equal to 100), the greater the number of co-authors, the greater the distance between each author's ammaa value and (c +c2/T)

The value of T can be determined by general consensus or specific to a country, group or organization. T can also be designed to the number of downloads, sharing and views, etc. Traditionally, subjects that have been cited less frequently, such as geology and mathematics, have lower T values. Subjects that have been cited more frequently, such as biotechnology and biochemistry, have higher T values. Any other value of T can also be set on a scientific and reasonable basis. For universal standard, the value of T can be temporarily set to 100. Once T is set, the ammaa value of each co-authored article can be calculated, which is also a measure of the influence of each paper written by every scholar of co-authors. The setting of the T value is determined according to the nature of the subject. Therefore, if there is an interdisciplinary collaboration between authors of low-cited and high-cited subjects, the setting of T can also balance the influence brought by subject differences.

3.2 deficiency of ammaa algorithm

In the process of evaluating the influence of the paper, the problem of inconsistent time axis is often ignored when counting the evaluation index (Yu, 2016), which directly reduce the effectiveness of the evaluation. The ammaa algorithm integrates two factors, including citations and coauthors, but ignores the influence of time on the evaluation effect. The temporal difference of dissemination of academic achievements is reflected by the heterogeneity of the citations of papers. The cited time is the moment of the dissemination, communication and effectiveness of knowledge. The delay between the publication and the citation reflects the knowledge fluidity and its influence (Xie, 2019). If the publication time of two papers is different, but the total citation frequency is the same, then the paper with shorter publication time has more influence. Similarly, if the publication time and total citations have little difference, the academic value between papers with increasing citations and papers with decreasing citations each year is also different (Shu & Zhang, 2017). Therefore, on the basis of ammaa algorithm ignoring the time dimension, this paper integrates the heterogeneity of publication time and cited time to optimize it.

4 PROPOSAL OF T–AMMAA ALGORITHM

In the process of evaluation, weight represents the quantitative allocation of the importance of different aspects of the evaluated object, so that the role of each evaluation factor in the overall evaluation can be treated differently (Paule & Mandel, 1989). This optimization method gives different weights to the ammaa values of the paper each year after publication and calculates the weighted ammaa of the paper. Thus, the t-ammaa value of one paper is the sum of its annual ammaa values with different weights, and the author's t-ammaa value is equal to the sum of the t-ammaa values of all his papers, as follows:

For each paper:

$$t\text{-ammaa} = (1*ammaa_1 + 2*ammaa_2 + 3*ammaa^3 + ... + n*ammaa_n)/ n \quad (4)$$

n = (data collection time - paper publication time)/year, $ammaa_1$, $ammaa_2$....., $ammaa_n$ stand for the ammaa value of the first year, the second year,....., the nth year after publication, respectively. The annual ammaa value is calculated by using the citations(c) of the articles published by authors in that year.

For each authors:

$$t\text{-ammaa} = t\text{-}ammaa_1 + t\text{-}ammaa_2 + t\text{-}ammaa_3 + ... + t\text{-}ammaa_n \quad (5)$$

n = the nth paper of an author. $t\text{-}ammaa_1$, $t\text{-}ammaa_2$, $t\text{-}ammaa_3$, $t\text{-}ammaa_n$ represent the t-ammaa value of this author's first, second, ..., nth paper.

5 EMPIRICAL RESEARCH

5.1 Data source and processing

In this paper, scholars in the field of library and information science in mainland China are selected as the research objects, and the Web of Science Core Collection (hereinafter referred to as WOS) is selected as the experimental data source. Retrieval strategy: SU= (Information Science and Library Science); time span is from 2010 to 2019, and the language type is English; refining limits as follows: Country/region is ("Peoples R China") OR ("China"), literature type is Article. The results show a total of 21279 literature records. In order to ensure the reliability of the data obtained, 12 papers labeled as "withdrawn publications" and records without authors were excluded, leaving 21267 available records finally. Through Python program word segmentation statistics, a total of 60,342 authors are obtained, and the details of all posts and citations of each author. And taking the author's suggestion mentioned above, this research temporarily set T value to be 100. According to Formula (1)(2)(3) and Formula (4)(5), the ammaa and t-ammaa value of each author are calculated and sorted respectively.

5.2 Experimental process

This paper tries to carry out experimental demonstration from the following two perspectives and then makes a comprehensive analysis and discussion.

Firstly, standing the point of view of the number of articles and citations, this paper compares and analyzes the discrimination and correlation between ammaa algorithm, t-ammaa algorithm and h index. In order to ensure the operability of experiment, it is assumed that (1) the average annual citation frequency is more than 40 times, namely, the total citation frequency of articles published in 2010-2019 is not less than 400 times, and (2) on the basis of

(1), the total number of articles published during 2010-2019 is not less than 30 with an average of more than 3 articles per year. Finally, 52 authors who meet the above conditions were screened out, and these 52 authors were checked to exclude the same name and surname. Due to limited space, the publication and citation records of the top 25 authors are extracted (see Table 1).

The h index is currently used internationally. Therefore, this article compares the ammaa algorithm with the author's h value ranking (i.e., ranking 1-ranking 2) to prove the adjustment and discrimination of the ammaa algorithm firstly. Then analyzing and discussing of the ammaa and t-ammaa by comparing value ranking of two (i.e. ranking 2 to ranking 3). The H value of the scholars is retrieved from the WOS, and the retrieval conditions are set in the same way as the data source. In the comparison of the two rankings, a positive number is used to indicate an increase in the author's ranking, while a negative number is the opposite. Due to limited space, some scholars' results are now extracted, as shown in Table 2.

Table 1 Details of total citations and frequency of citations per year of the top 25 posts

Name	Total articles	Individual number	Total citations	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Wang,Wei	77	0	1910	0	13	44	77	106	161	216	237	275	423
Liu,Yang	59	0	2469	2	11	18	30	49	74	107	188	453	745
Zhang,Wei	59	0	1670	3	8	13	36	50	92	104	199	320	432
Li,Jing	59	0	1245	1	24	44	58	100	128	134	158	166	231
Shu,Hua	54	0	1570	2	19	60	97	134	163	198	203	211	255
Wang,Jian	53	0	1568	3	19	27	47	79	147	151	204	220	343
Wang,Yan	53	0	1002	0	4	10	21	34	61	78	98	187	268
Liu,Li	52	0	1162	0	8	12	57	79	82	141	179	157	234
Li,Xia	50	0	2015	1	13	34	58	81	129	185	290	351	480
Wang,Jun	50	0	1655	4	20	57	115	146	170	162	181	211	266
Law,Rob	49	1	2716	3	23	41	85	135	227	295	368	399	625
Zhang,Li	49	0	1157	1	3	32	57	91	82	134	140	172	217
Wang,Jing	48	0	785	0	5	25	39	52	59	66	97	117	161
Chen,Wei	47	0	1534	0	0	4	34	69	80	109	148	276	422
Wang,Li	45	0	935	0	2	43	45	78	85	112	126	140	143
Li,Wei	44	0	816	1	2	13	27	39	63	74	107	151	178
Li,Yan	42	1	820	1	8	35	31	46	54	58	81	114	177
Wang,Lei	42	0	709	0	4	16	26	35	45	54	82	92	161
Tao,Dacheng	41	0	3559	2	24	130	210	286	385	471	512	554	568
Li,Xuelong	41	0	2998	3	26	58	91	185	348	497	488	523	490
Liu,Xiaoping	41	0	2255	1	6	23	50	88	149	238	342	383	497
Zhang,Yu	41	1	1172	0	0	0	18	43	74	118	145	228	260
Yang,Yang	41	0	1014	0	9	9	25	38	49	87	137	170	254
Zhang,Jing	41	0	777	3	9	11	23	37	73	65	117	134	159
Rousseau,R	41	0	754	0	20	36	52	46	74	76	130	112	121

Table 2 Part of the author's ranking and ranking change table

Name	h value	Ranking 1	ammaa value	Ranking 2	t–ammaa value	Ranking3	ranking1–ranking2	ranking2–ranking3
Li,Xuelong	30	1	1657.51	4	526.75	4	–3	0
Tao,Dacheng	29	2	2223.68	1	641.44	3	1	–2
Liu,Yang	20	9	990.74	5	250.48	10	4	–5
Wang,Yi	19	10	752.44	10	204.93	14	0	–4
Li,Yan	19	10	268.19	28	102.03	28	–18	0
Wang,Fang	19	10	135.18	46	63.04	44	–36	2
Zhao,Jing	18	11	121.84	48	58.66	47	–37	1
Zhang,Lei	18	11	1684.34	3	790.55	1	8	2
Zhang,Jian	17	12	179.38	40	71.02	40	–28	0
Zhang,Lin	17	12	879.82	7	295.51	7	5	0
Wang,Yu	16	13	81.77	51	36.49	51	–38	0
Wang,Ying	16	13	117.46	49	50.51	49	–36	0
Li,Li	15	14	102.50	50	45.44	50	–36	0
Zhang,Jie	15	14	588.94	14	190.16	16	0	–2
Liu,Xin	15	14	212.77	32	64.73	43	–18	–11
Wang,Tao	12	16	69.79	52	30.36	52	–36	0

Secondly, at the point of the ammaa value, the paper analyzes and discusses the publications and citations of the top scholars in the ammaa value. Referring to the data above, the first 52 authors were retained, and checked to exclude those with the same name as well. Table 3 is partial data excerpts below.

Table 3 The indicators of the top scholars in ammaa value

Name	ammaa value	Ranking_a	t–ammaa value	Ranking_t	Total article	Individual number	Total citations
Xu,Xin	3000.49	1	1518.59	3	22	0	3325
Thong,JY.L.	2954.82	2	1535.74	1	11	0	3290
Venkatesh,V	2868.69	3	1523.98	2	13	0	3174
Ma,Yi	2339.76	4	718.14	12	4	0	2485
Tao,DaC	2223.68	5	641.44	24	41	0	3559
Xu,Wei	2222.12	6	1313.58	4	20	0	2691
Yang,Ming	2147.19	7	1286.03	5	10	0	2317
Hermjakob,H	2133.85	8	659.31	18	9	0	2628
Perez. RY	2121.47	9	653.99	20	4	0	2412
Vizcaino,JA	2119.24	10	653.14	21	3	0	2390
Csordas,A	2118.01	11	652.85	23	2	0	2378
Ternent,T	2118.01	11	652.85	23	2	0	2378
Wang,R	2081.56	12	652.97	22	18	0	2353
Ji,SW	2076.06	13	1255.60	6	4	0	2099
Yu,K	2075.63	14	1255.10	7	3	0	2098

Name	ammaa value	Ranking_a	t–ammaa value	Ranking_t	Total article	Individual number	Total citations
del–Toro,N	2023.00	15	626.07	25	1	0	2023
Dianes,JA.	2023.00	15	626.07	25	1	0	2023
Law,Rob	2003.92	16	660.25	15	49	1	2716
Gao,Ge	1832.83	17	681.56	13	6	0	1993
Yan,SC	1775.87	18	620.60	26	17	0	2218
Li,C	1728.08	19	663.30	14	4	0	1756
Zhang,ZM	1720.41	20	660.07	16	2	0	1722
Tang,ZF	1720.00	21	659.87	17	1	0	1720
Li,CW	1720.00	21	659.87	17	1	0	1720
Zhang,L	1684.34	22	790.55	10	31	0	2273
Li,XL	1657.51	23	526.75	32	41	0	2998
Liu,GC	1601.61	24	556.15	27	6	0	1709
Zhang,D	1548.42	25	767.95	11	9	0	1872
Lin,ZC	1543.41	26	536.63	28	5	0	1591
Yu,Y	1533.89	27	532.75	29	4	0	1568
Sun,J	1521.52	28	527.18	31	2	0	1524
Tan,XY	1520.81	29	942.45	8	2	0	1538

5.3 Results and analysis

Combining all the data and Table 1 we can see, among the 14739 papers surveyed, 157 are individual work, accounting for only 1.07%. Among the 52 scholars who have published more than 30 articles and been cited more than 400 times, only 7 scholars have published 1 unique paper respectively in 2010-2019. It shows that the form of co-authoring papers has been generally accepted. And scientific cooperation can be used to increase the impact of scientific research results. This result is also consistent with the analysis results of the National Science and Technology Evaluation Center-Clarivate and the research conclusions of domestic and foreign scholars (National Center for Science and Technology Evaluation, 2018; Zhang et al., 2019; Thelwall & Pardeep, 2016).

As shown in Table 3, of all the scholars, 21 have published less than 10 articles, 26 have published articles between 10 and 30, accounting for 50%, and 5 have published more than 30 articles, accounting for less than 10%. Among them, there are three groups of scholars with the same number of articles and the total citations, namely Csordas A and Ternent T, del-Toro N and Dianes JA, Tang ZF and Li CW. After investigating the detailed data, it is found that the first two groups participated in co-authoring a paper that has been cited up to 2023 times. The last group participated in co-authoring a paper cited 1720 times. However, the papers published by these six scholars are only 1 or 2 in the above ten years. If considering the number of publications comprehensively, we exclude the records of scholars with less than 10 publications, as shown Table 4, leaving 22 scholars totally. It is not difficult to find the ammaa algorithm can not only highlight scholars with strong scientific ability, such as more individual authors, but also filter out scholars with higher quality articles. For example, scholar Zhou T ranks 17th in ammaa because he has 10 individual papers, even though his total number of papers is not large.

Table 4 Details of each indicator of the scholars topped 52 in ammaa value and the posts greater than or equal to 10

Name	ammaa value	Ranking_a	t–ammaa value	Ranking_t	h value	Ranking_h	Total articles	Individuals	Total citations
Xu,Xin	3000.49	1	1518.59	3	15	6	22	0	3325
Thong,JY	2954.82	2	1535.74	1	10	9	11	0	3290
Venkatesh,V	2868.69	3	1523.98	2	12	8	13	0	3174
Tao,DC	2223.68	4	641.44	9	26	2	41	0	2485
Xu,W	2222.12	5	1313.58	4	14	7	20	0	3559
Yang,M	2147.19	6	1286.03	5	8	11	10	0	2691
Wang,R	2081.56	7	652.97	8	14	7	18	0	2317
Law,R	2003.92	8	660.25	7	25	3	49	1	2628
Yan,SC	1775.87	9	620.60	10	12	8	17	0	2412
Zhang,L	1684.34	10	790.55	6	18	5	31	0	2390
Li,XL	1657.51	11	526.75	12	30	1	41	0	2378
Zhang,HG	1517.36	12	387.48	16	15	6	15	0	2378
Huang,L	1307.41	13	530.79	11	9	10	10	0	2353
Ge,SS	1303.80	14	424.68	13	10	9	10	0	2099
Xu,D	1139.74	15	357.92	17	12	8	18	0	2098
Cao,JD	1121.82	16	399.73	15	18	5	21	0	2023
Zhou,T	1073.24	17	412.65	14	14	7	22	10	2023
Chen,J	1028.08	18	216.27	22	14	7	25	0	2716
Lu,YB	1001.91	19	277.42	19	14	7	19	0	1993
Liu,Y	990.74	20	250.48	21	20	4	59	0	2218
Xu,Y	969.01	21	265.76	20	9	10	11	0	1756
Sun,J	950.75	22	337.78	18	10	9	14	0	1722

Next, we chose scholars whose ammaa values ranked top 52 and published at least 10 papers, used the same conditions as above to query the h values of each scholar and ranked them (see Table 4), and made the following analysis and discussion together with the first perspective.

5.3.1 The results and discussion about the regulation ability of ammaa and t–ammaa

It can be seen from Table 2 and Table 4 that there is not the same values about ammaa and t-ammaa value in the calculation results of the two algorithms. However, there are scholars with the same H value of 12 groups in Table 2, including 48 scholars, accounting for 92.3%; of 6 groups in Table 4, including 19 scholars, accounting for 86.4%. Normalizing the rankings of H value, ammaa value and t-ammaa value and sorting them according to h value, as shown in Figures 2a and 2b, ammaa and t-ammaa algorithm have the same overall ranking trend, and both of them fluctuate around the h-value ranking, and the range is evident. Then, as shown in Figures 2c and 2d, after adding the time factor, the t-ammaa ranking of 40 authors changed comparing with the ammaa value of the 52 in Table 2, accounting for 76.9%; of 21 scholars changed of the 22 in Table 4, accounting for 95.5%. These results indicate that ammaa and t-ammaa algorithm have better recognition effects than h index, and t-ammaa algorithm is more sensitive to the evaluation of scholars'

influence than ammaa, and its regulating effect is more obvious.

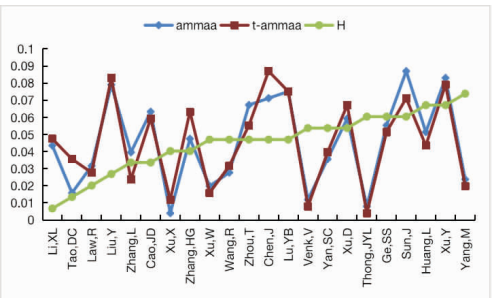

Figure 2a Normalized comparison of the ranking of ammaa, t-ammaa and h index among 52 authors

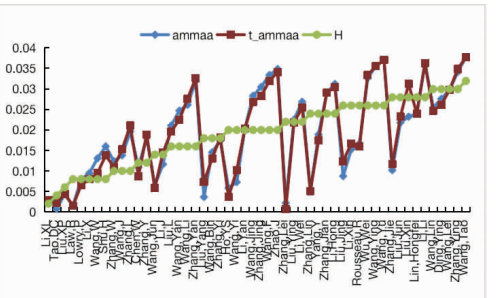

Figure 2b Normalized comparison of the ranking of ammaa, t-ammaa and h index among 22 authors

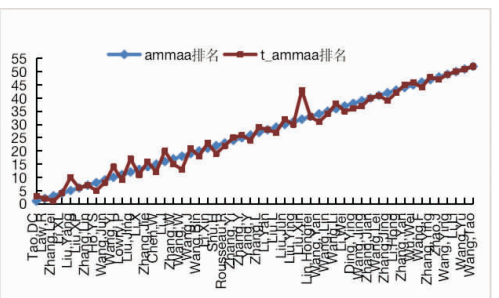

Figure 2c The change of ammaa and t-ammaa ranking among 52 authors

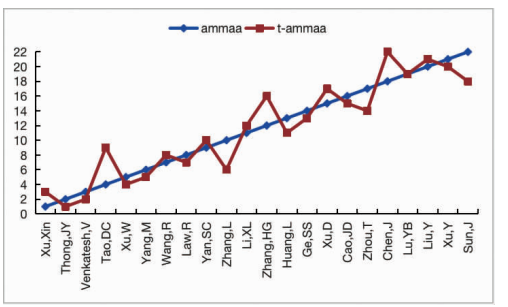

Figure 2d The change of ammaa and t-ammaa ranking among 22 authors

Firstly, the ammaa algorithm and h index are analyzed and compared. From the first perspective, except for the rankings of Wang Yi and Zhang Jie, the rankings of the other scholars have changed under the two evaluation methods. Wang Yu and Zhao Jing changed the most, with changing values of 38, as shown in Table 2. On the other hand, it can be seen from Table 4 that only Wang R has no change in the rankings of the two indexes, while the left 21 scholars have changed all, among which Liu Y has changed the most, with a change value of 16. Analyzing the reasons why Wang Yu's ranking has changed the most, one of them is that the original h-value rankings of scholars are more closely tied; however, the other more primary reason is the number of co-authors. We compared him with Zhang Lin, whose h value is the same but his ranking has not changed, and Zhang Lei, who has moved up the most in the ranking (up 8 rankings). Taking the papers cited frequency greater than 10, it is found that the average number of co-authors of each paper by scholar Wang Yu is 8.62, the highest citation frequency is 41, and the number of co-authors of this paper is 9. Scholars Zhang Lei and Zhang Lin have an average number of co-authors of 6.39 and 6.04 for each paper, respectively. The highest citation frequency is 1,219 and 389, respectively. Moreover, the number of co-authors of the two scholars is 3. Therefore, the ranking of scholar Wang Yu's ammaa value dropped significantly. The above comparative analysis indicates that the ammaa algorithm, which takes into account the number of co-authors, has a significant adjustment effect on the evaluation of co-authored papers and is sensitive to the recognition of highly cited articles.

5.3.2 Comparison of t–ammaa and ammaa

According to Table 2, there are three groups of authors whose ammaa values are almost the same, namely Li Xia (588.96) and Zhang Jie (588.94), Liu Xin (212.77) and Lin Hongfei (212.28), Wang Jing (179.90) and Zhang Jian (179.38). After further observation, the t-ammaa values of these three groups are 236.17 and 190.16, 64.73 and 91.01, and 78.38 and 71.02, respectively, and the difference values are 46.01, 26.28 and 7.36. According to Table 4, the ammaa values of Tao,DC and Xu,W, Ge,SS and Huang,L are 2223.68 and 2222.12, 1303.80 and 1307.4, respectively, and the difference values are 1.56 and 3.6, respectively. After further observation, the t-ammaa values of the two groups are 641.44 and 1313.58, 424.68 and 530.79, respectively, and the difference values are 672.13 and 106.11. It can be seen that, compared with the ammaa algorithm, t-ammaa algorithm has a more significant distinction effect.

As can be seen from Table 2 and Figure 2c, after adding time weight, the most decreased ranking of t-ammaa value is Liu,Xin, which decrease 11 places and rank the 43rd. However, scholar Lin,Hongfei, whose total citations and ammaa values are both lower than Liu,Xin, do not change and still rank 33rd. Observing Table 4 and Figure 2d, scholars Tao DC have the largest decline in the ranking of t-ammaa values (5 ranking), and Zhang, L and Sun, J have risen the most (both up 4 ranking). This is in the case of a smaller number of authors. If larger, the change in ranking may be greater.

Now, we analyze the reasons for the changes in the rankings of Liu,Xin and Lin,Hongfei. According to Table 1, the papers published by the two scholars and the citations each year can be seen as follows: (1) From 2010 to 2019, both scholars published 30 articles, with a total of 829 and 722 citations respectively. (2) The citations of scholar Liu,Xin decreased in 2015 compared with the previous year, and the other years all increased compared with the previous year, while the citations of scholar Lin,Hongfei kept increasing year by year (see Figure 3a). (3) On the whole, the ammaa values of the two scholars are on the rise. Only in 2013 and 2016, the ammaa values of scholar Liu,xin are slightly higher than that of Lin,Hongfei, while in other years, the ammaa values are equal to or far lower than the latter. Taking 2015 as the boundary, scholar Liu,xin's ammaa ranking increased from 8 in 2015 to 22 in 2019, while Lin,hongfei's ammaa ranking increased from 12 to 42, with a larger increase (see Figure 3b). This indicates that the influence of scholars Lin,Hongfei has gradually exceeded that of Liu,Xin from 2015 to 2019. Therefore, when the time weight is introduced, the closer to the statistical time, the more important the factor is. So, the t-ammaa ranking of scholars Liu,Xin is significantly lower than that of Lin,Hongfei.

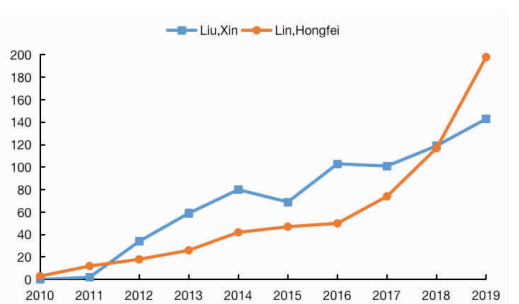

Figure 3a Chart of citation frequency per year of Liu,Xin and Lin,Hongfei

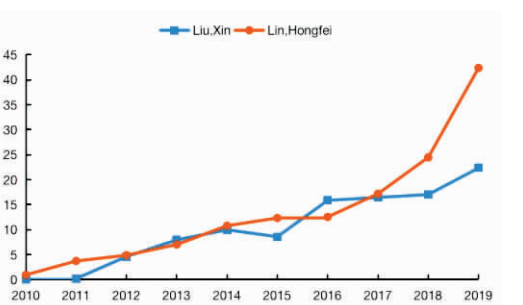

Figure 3b Chart of ammaa value per year of Liu,Xin and Lin,Hongfei

In addition, according to the calculation results of ammaa and t-ammaa, the top three of the two indexes in Table 2 and Figure 2c are both Tao,Dacheng, Law,Rob, Zhang and Lei. In Table 4 and Figure 2d, the top three are Xu,Xin, Thong,JY and Venkatesh,V. The results show that the trends of the two algorithms in describing the influence of academic authors are synchronized, and both have the function of identifying high-influence scholars.

5.3.3 Correlation analysis of each index

If the calculation result of an improved algorithm is too different from that of the original algorithm, it is considered that the improvement of the original algorithm is unreasonable (Xu, 2020). Because of the introduction of time factor, t-ammaa has a certain adjustment effect on the average of scholars's influence, but this moderating effect is only an improvement of ammaa, not a subversive effect. Therefore, the t-ammaa value, ammaa value, h value, total citations and papers of 52 authors and 22 authors in Table 2 were analyzed by Pearson correlation to prove the rationality of the t-ammaa algorithm, respectively. From the first perspective, that is, the papers and total citations is the priority. According to the analysis data (see Table 5), the t-ammaa value of the authors is significantly correlated with ammaa value, h value, total citations, among which the correlation coefficients are 0.956, 0.552 and 0.907 , respectively. H value and total number of citations can be used to evaluate the influence of authors (Hirsch, 2005; Fang & Wang, 2011; Pasterkamp et al., 2007), indicating that ammaa and t-ammaa algorithm, which are significantly positively correlated with h index, are also applicable to the evaluation of authors' influence. And the optimization of the former by the latter is reasonable.

Table 5 Correlation test of each index from the first perspective

		t–ammaa	ammaa	h	total citations	papers
t–ammaa	Corr	1				
	Sig.					
	N	52				
ammaa	Corr	.956**	1			
	Sig.	.000				
	N	52	52			
h	Corr	.552**	.662**	1		
	Sig.	.000	.000			
	N	52	52	52		
total citations	Corr	.907**	.966**	.780**	1	
	Sig.	.000	.000	.000		
	N	52	52	52	52	
papers	Corr	.155	.215	.612**	.411**	1
	Sig.	.273	.125	.000	.000	
	N	52	52	52	52	52

**.a significant correlation at the level of 0.01 (double-tailed)

6 CONCLUSIONS AND RECOMMENDATIONS

By comparing H index, this paper proposes an ammaa optimization method based on time dimension - t-ammaa algorithm. Through the analysis of the papers published by Chinese

scholars in the field of library and information science in the WOS core database, it is found that:

(1) Aiming at the defects of h-index not being able to identify high-impact papers, not sensitivity to the evaluation of co-authored papers, and not being able to involve all the authors' papers, ammaa and t-ammaa algorithm have a significant adjustment effect on the situation where the h value ranking are the same. By setting the threshold variable T and the average sharing the citations, all authors of co-authored papers can increase their influence equally. Not only can it better dig out high-impact and citation-value research literature, but also effectively avoid "guest authors", "gift authors", and "non-academic collaborators" appearing in the signatures of papers, thereby affecting the fairness of the evaluation results, making the author's influence evaluation method more reasonable and objective;

(2) Compared with ammaa algorithm, t-ammaa algorithm takes time into account, and can effectively identify scholars who have maintained high activity in the field for a long time and whose influence has been continuously exerting or rising. Therefore, t-ammaa algorithm comprehensively considers the number of authors' posts, the number of authors, the frequency of citations, the threshold limit T and the heterogeneity of citation time, so it can effectively solve the problems that need to be solved in the author's influence evaluation, such as multi-author signatures, failure to identify high-impact papers, the citations affected by the length of published time, and the influence evaluation of cross-field collaborative scholars;

(3) In the field of humanities and social sciences, co-authoring has become a common phenomenon, and the proportion of single-authored papers is very small. And there is also a phenomenon that a scholar's paper is cited very frequently and the total number of articles is very small, but the ammaa and t-ammaa value rank in the top. Based on the above, it is suggested that in the evaluation process of humanities and social sciences, scholars should be required to produce several papers or independent works in recent years, such as in the last 3 or 5 years, so as to weaken the influence of false collaborators in the evaluation.

From the above research conclusions, it can be seen that the author's academic influence is indirectly revealed through the influence of the paper and not simply evaluated by the impact factor. The cited data of the paper can only be used as an evaluation reference. Especially, in 2021 the Ministry of Human Resources and Social Security and the Ministry of Education issued the "Guiding Opinions on Deepening the Reform of the Teachers' Title System in Colleges and Universities", emphasizing that paper-related indicators such as SCI (Science Citation Index) or SSCI (Social Science Citation Index) should not be used as the direct basis for preconditions and judgments. The actual content of academic papers, especially representative papers with high influence and citation value, must be considered. Through the introduction of time elements, this research can effectively solve the limitation of only relying on the "number" of papers and the number of citations. In the screening of scholars with sustained academic contribution, the number of papers published in the recent one year or three years can be set as an important evaluation method for scholars' continued influence. It solves the problem that some scholars rush to publish papers or concentrate on a certain stage or are in a state of "academic dormancy" for a long time after obtaining a certain title or honor. Finally, for the attribution problem of multiple authors such as "named author", "guest author" or "corresponding author", the average sharing of citations and T value proposed in this article can effectively solve them. And using the optimized algorithm, scholars made a real continuous contribution can be identified

effectively, improving the objectivity of the evaluation of papers or scholars' contribution.

There are also some shortcomings in this study. On the one hand, the sample of this paper involves a single field because only selecting the data published by scholars in the field of library and information science in WOS to conduct an empirical analysis of t-ammaa algorithm. On the other hand, the setting of threshold T in this paper is based on the suggestions of the original author for the general field, while the scientific setting of T value still needs further study.

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Statement of Contributions

All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by Yu Yisheng and Jia Na . The first draft of the manuscript was written by Jia Na and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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