A Measurement Method for Co-author Contribution Ratios Based on Author Contribution Statements: Postprint

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Abstract

[Purpose/Significance] In the era of big science, where scientific research problems are increasingly complex and co-authorship is becoming ever more prevalent, there is an urgent need to evaluate and allocate academic contributions among co-authors of papers, so as to reduce friction among researchers and promote scientific collaboration. [Method/Process] By analyzing the current state of research and practice in author contribution statements, as well as the capabilities and limitations of existing methods for measuring co-author contribution rates, and by integrating author contribution element statements with authors' levels of participation in different contribution elements, this study proposes and constructs a quantitative measurement method for co-author contribution rates that possesses qualitative properties. [Results/Conclusion] This method not only ameliorates the relevant deficiencies of existing co-author contribution rate measurement methods, but also advances bibliometrics from the single-paper unit to the contribution-element unit of paper authors, thereby enhancing the precision and validity of bibliometric evaluation indicators. Case analysis demonstrates that the method can more objectively reflect authors' contribution levels and academic ability status, possessing certain advancement and applicability.

Full Text

Preamble

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A Method for Measuring Co-Author Contribution Rates Based on Author Contribution Statements

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Abstract

[**Purpose/Significance**] In the era of big science, where research problems are increasingly complex and co-authorship is becoming more prevalent, there is an urgent need to evaluate and allocate academic contributions among co-authors of scholarly papers. This would help reduce friction among researchers and promote scientific collaboration. [**Method/Process**] This study analyzes the current state of research and practice regarding author contribution statements, as well as the capabilities and limitations of existing methods for measuring co-author contribution rates. By integrating author contribution element declarations with the degree of participation in different contribution elements, we propose and construct a quantitative measurement method for co-author contribution rates that possesses qualitative characteristics. [**Result/Conclusion**] This method not only improves upon the defects of existing co-author contribution measurement approaches but also advances bibliometrics from the single-paper unit to the author contribution element unit, thereby enhancing the precision and validity of bibliometric evaluation indicators. Case analysis demonstrates that the method can objectively reflect authors' contribution levels and academic capabilities, showing both advancement and applicability.

Classification Number: G203
Keywords: author contribution statement; author contribution element; bibliometrics; academic influence evaluation

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In today's research landscape, the interdisciplinary, comprehensive, and complex nature of scientific problems is becoming increasingly prominent, with continuous cross-fertilization between disciplines. Research collaboration has become the dominant trend in scientific inquiry, with both the scale and scope of cooperation expanding continuously [1]. Correspondingly, co-authored papers—as the primary output of research collaboration—are growing in both absolute numbers and proportion. For instance, 89% of papers in the Web of Science database represent collaborative research outcomes [2]. While single-author papers allow researchers to exclusively claim both contribution and academic credit, the question of how to reasonably measure contributions in multi-author collaborative papers is fundamentally important. This issue affects not only the attribution of academic honor and identification of responsibility but also the fairness and accuracy of evaluations for individuals, institutions, and disciplines, directly impacting research efficiency and the scholarly communication ecosystem. Traditional calculations of co-author contribution rates rely on quan-

titative mathematical transformations that lack attention to actual intellectual contributions [3]. The emergence and development of "author contributions" statements provide new insights for addressing this problem. If authors of every paper follow academic norms and mutually agree to disclose their primary contributions in the text, this would establish a foundation for academic evaluation based on actual contributions. Such a system would help clarify authors' academic credibility and responsibility, enable readers to understand co-authors' research roles and contributions, identify their expertise, and facilitate consultation on relevant issues. Moreover, it would advance bibliometric evaluation metrics—such as citation counts and h-index—from the paper unit to the author contribution element or content unit, enabling more precise academic evaluation of authors and institutions. Therefore, this study focuses on the core proposition of contribution allocation among co-authors and proposes a quantitative measurement method for co-author contribution rates based on author contribution statements, integrating qualitative characteristics.

2 Literature Review

2.1 Current Status of Author Contribution Statement Research and Practice

Society typically establishes legal and customary norms to preserve values and maintain behavioral standards that ensure good order [4]. Authorship represents confirmation of contribution and responsibility and constitutes an essential component of academic norms. The International Committee of Medical Journal Editors (ICMJE) has proposed recommended standards for academic paper authorship [5], establishing four criteria for author identity and qualification: (1) substantial contributions to study conception/design or data acquisition/analysis/interpretation; (2) drafting the work or critically revising important intellectual content; (3) final approval of the published version; and (4) agreement to be accountable for all aspects of the work in ensuring questions related to accuracy or integrity are appropriately investigated. Those not meeting all four criteria should be acknowledged but not listed as authors. China's Copyright Law similarly stipulates: "For works created jointly by two or more authors, the copyright shall be co-owned by the co-authors. Those who did not participate in the creation cannot be co-authors" [6]. Authorship implies both contribution and honor, as well as responsibility—all listed authors are obligated to ensure the scientific validity and authenticity of the research. Excessive author lists dilute the reputation that key researchers should receive, while inappropriate attribution fails to ensure fulfillment of corresponding obligations.

In the late 1990s, international medical journals further proposed author contribution statements based on ICMJE guidelines, promoting their use in select biomedical journals [7-8]. Currently, major international journals such as *Nature*, *Science*, *PNAS*, and *PLOS ONE* have introduced "Author Contributions" sections. These statements represent negotiated disclosures by co-authors, in

textual form, clarifying their respective contributions during the research process. L. Allen et al. argue that disclosing author contributions enhances authors' sense of responsibility and identity, improves readers' understanding of the collaborative process, and helps funding agencies comprehensively evaluate grant applicants [9]. S. Frische contends that listing author contributions increases scientific transparency and plays a crucial role in strengthening academic norms [10].

Author contribution elements constitute the main content of contribution statements, referring to the primary work or intellectual contributions authors make during research, such as conceptualizing research questions or designing studies. V. Larivière et al. analyzed 87,002 author contribution statements, examining relationships between contribution elements and academic seniority/author order, finding that conceptual tasks are typically undertaken by senior authors while technical tasks are often performed by junior researchers [8]. M. O. Baerlocher et al. explored relationships between author order and contribution elements across four medical journals, revealing that first authors showed highest participation across most contribution categories, followed by last authors, second authors, and middle authors—particularly in conception, drafting, and supervision [11]. S. L. Yang et al. examined author participation patterns across contribution elements in three general medical journals [12]. Cui Linwei et al. studied relationships between contribution elements and author order using *Library and Information Service* as a case study [13]. Ding Jingda et al. measured author contribution participation by calculating the ratio of elements participated in to total elements, and measured participation degree in specific elements by calculating the ratio of individual author participation to total co-author participation in that element [14].

Through sustained efforts from academia and publishing, author contribution statements continue to evolve. In 2014, CASRAI (Consortia Advancing Standards in Research Administration) proposed the CRediT (Contributor Roles Taxonomy) standard, classifying author contributions into 14 types: conceptualization, data curation, formal analysis, funding acquisition, investigation, methodology, project administration, resources, software, supervision, validation, visualization, writing—original draft preparation, and writing—review & editing [15]. This standard encourages uniform author contribution descriptions across journals and enables quantitative analysis of contributions. CRediT also applies to individuals acknowledged in papers, allows one participant to contribute to multiple elements, and permits multiple participants in a single element. In 2018, M. K. McNutt et al. recommended adopting CRediT for author contribution statements in *PNAS* [16], a call supported by *Science* [17]. Currently, CRediT has been integrated into electronic submission systems such as Editorial Manager [18].

The development and application of author contribution statements not only clarify co-author contributions and reduce conflicts in research collaboration but also, through standardization, facilitate the establishment of unified indexing

and evaluation systems, guiding academic assessment toward greater depth and precision.

2.2 Capabilities and Limitations of Current Co-Author Contribution Measurement Methods

In the era of big science, where research becomes increasingly "differentiated" and "integrated" and co-authorship proliferates, there is an urgent need for reasonable academic contribution evaluation and credit allocation among co-authors to reduce researcher friction and promote collaboration. Based on domestic and international research, current co-author contribution measurement methods can be categorized into three types: simple measurement methods, order-based measurement methods, and contribution-element-based measurement methods.

2.2.1 Simple Measurement Methods Simple co-author contribution measurement methods are the most direct and convenient, including: (1) **Straight Counting (SC)** [19], which attributes all contribution to the first author (some scholars also consider the corresponding author as co-contributor [20]). This method ignores other co-authors' contributions, resulting in obvious inequity. (2) **Normal Counting (NC)** [21], where each co-author equally shares full paper contribution. This is the method currently used by major citation databases (Web of Science, Scopus, Google Scholar). While acknowledging every co-author, it amplifies some authors' contributions, granting them and their institutions disproportionate academic credit. For example, a highly-cited paper in *The Lancet* involved 45 collaborating institutions; using normal counting for citation allocation in ESI (Essential Science Indicators), institutions with modest research strength entered the top 1% ranking based on this single paper [22]. (3) **Fractional Counting (FC)** [23], which divides paper contribution equally among N authors (each receives 1/N). This fails to distinguish relative contributions, penalizing major authors while inflating others' contributions.

2.2.2 Order-Based Measurement Methods Order-based methods consider both author count and position. Main approaches include: (1) **Harmonic Counting (HC)** [24], where the i-th author's contribution weight in an N-author paper is (1/i)/[1 + (1/2) + … + (1/N)], with a ratio of (i+1)/i between consecutive authors. Research shows HC performs well for researcher evaluation [25]. While contribution decreases with author order, it cannot properly reflect important contributions from corresponding authors in later positions. (2) **Geometric Counting (GC)** [26], where the i-th author's weight is $2^{(N-i)}/(2^N - 1)$. This fixes adjacent authors' contribution ratio at 2:1, failing to reflect actual contribution differences. (3) **Arithmetic Counting (AC)** [27], where the i-th author's contribution $W\_i = 2(N-i+1)/[N(N+1)]$, with $0 \leq W\_i \leq 1$ and $\Sigma W\_i = 1$. Similar to GC, it fixes adjacent author ratios and cannot objectively reflect contribution variations.

2.2.3 Contribution-Element-Based Measurement Methods These methods use qualitative or quantitative contribution descriptions from author statements. Key approaches include: J. V. Verhagen et al.'s QUAD (Quantitative Uniform Authorship Declaration) method [28], which advocates authors state their percentage contributions across conceptual design, data collection, analysis, and writing, enabling contribution-based ordering and rate calculation. M. T. Rahman et al. propose that relative contribution equals the product of participation ratio in each element and element weight [30]. Xu Chen proposes a systematic evaluation process for co-authorship contributions across different scenarios, integrating pre-publication authorship rights and post-publication credit allocation across six research stages [31]. Ding Jingda et al. measure contribution participation by calculating the ratio of elements participated in to total elements, and measure participation degree in specific elements by calculating individual-to-total participation ratios [14].

Comprehensive analysis reveals that simple methods either ignore co-author interests or inflate some authors' contributions. M. Kosmulski noted that all algorithms calculating contributions based solely on author ranking have inherent defects [32]. Order-based methods, while reasonably making contributions decrease with author count and position, cannot reflect actual contributions, especially for alphabetically-ordered or co-first-author papers. Contribution-element-based methods are more reasonable as they use stated contributions. However, current journals lack sufficient quantitative discussion on contribution rates, missing integrated and feasible calculation schemes that incorporate element weights and individual participation degrees. Therefore, this study integrates contribution element weights and participation degrees to construct a matrix-based co-author contribution measurement method using author contribution statements, enabling more reasonable academic evaluation based on actual contributions.

3 Methodology and Application

3.1 Construction of the Co-Author Contribution Rate Measurement Method

Assume a paper with author contribution statements includes n co-authors and m contribution elements (referencing the CRediT taxonomy above). Construct author set A = (a_1, a_2, …, a , …, a) and contribution element set E = (e_1, e_2, …, e , …, e). Let c represent whether author a participated in element e :

c = 0 (author a did not participate in e)
c = 1 (author a participated in e)

The author-contribution element matrix C (composed of 0s and 1s, with single-author papers appearing as single-row matrices) is:

C = [c_{11} … c_1 … c_1

c 1 … c … c

c 1 … c … c]

As papers typically contain multiple contribution elements with varying author participation degrees, the participation degree of the k-th author in the j-th element is t = c /Σ 1 n c [14]. Since different contribution elements carry different weights in a paper, we construct contribution element weight set W = (w_1, w_2, …, w , …, w). Without special weight specifications, elements can be treated equally: w = 1/m (j = 1, 2, …, m). The weighted author-contribution element matrix S is:

S = [$w_1t_{11}c_{11}$ … w t_1 c_1 … w t_1 c_1

w_1t 1c 1 … w t c … w t c

w_1t 1c 1 … w t c … w t c]

Matrix element w t c represents the weighted contribution of author a to element e . The contribution degree (or rate) AC of author a across all m elements is (for single-author papers, AC = 1):

AC = Σ 1 w t c / Σ 1 n Σ 1 w t c

Where Σ 1 n Σ 1 w t c = 1 (sum of all co-authors' contribution rates). AC ranges 0 < AC ≤ 1, with higher values indicating greater contribution. Authors participating in multiple core elements typically have higher AC values.

3.2 Application of the Method

3.2.1 Academic Impact Evaluation Current evaluation methods primarily use paper-level metrics (publication count, citations, h-index). Integrating our contribution rate measurement with these metrics promises more nuanced and precise evaluation.

For citation frequency: If paper k has citation count f and co-author a 's contribution rate is AC , then a 's allocated citations are sf = AC × f . For scholar a with N papers, total allocated citations TF are:

TF = Σ 1 sf = Σ 1 AC × f

This method can be extended to institutions and regions by summing contribution-allocated citations for all affiliated researchers, enabling more precise evaluation and shifting assessment from document-level to author contribution-element level.

3.2.2 Research Expertise Identification The method also facilitates identification of scholars' or institutions' research expertise. For scholar a with N papers, let t represent participation degree in element j for paper k, and c

indicate participation (0/1). The total participation degree across all papers for element j is $\Sigma_1 w t c$, with average participation degree ACV :

$ACV = (\Sigma_1 w t c) / N$

ACV represents capability in element e —higher values indicate greater expertise, providing a measurement method for research specialization.

4 Case Study

4.1 Case Selection

PLOS ONE adopted CRediT standards for author contribution statements in 2016. We examined research papers published between September 1, 2016, and August 31, 2018, selecting the productive HyoGeun Choi and SoYoung Kim research teams as case studies, comprising 21 co-authored papers involving 48 authors (11 authors with >2 publications). Basic information is shown in Table 1 .

4.2 Case Analysis

We measured co-author contribution rates (AC) for 11 authors with >2 publications and compared results with Normal Counting (NC) and Harmonic Counting (HC). C. H. Sekercioglu noted that author ordering may differ from contribution allocation, with multiple authors potentially sharing equal contributions when stated [33]. Since corresponding authors play important roles but typically appear last, HC significantly underestimates their contributions (especially in papers with many authors). We therefore adjusted HC (HCT) by promoting corresponding authors to co-first-author status when they were not first authors.

Using the first paper in our sample as an example: authored by SoYoung Kim, Min-Su Kim, Bumjung Park, Jin-Hwan Kim, and HyoGeun Choi (corresponding author), with contribution statement: "Conceptualization: HGC. Formal analysis: BJP. Funding acquisition: HGC. Methodology: MSK. Writing—original draft: SYK, JHK. Writing—review & editing: SYK, HGC." This includes 6 elements, with authors identified by initials. The author-contribution matrix C is:

C = [0 0 0 1 0 0
0 0 0 0 0 0
0 0 0 0 0 0
0 0 0 0 1 0
1 1 1 0 0 1]

Calculating participation degrees t and assuming equal element weights (w = 1/6), the weighted matrix S is:

S = [0 0 0 1/6 0 0
0 0 0 0 0 0

0 0 0 0 0 0
0 0 0 0 1/12 0
1/6 1/6 1/6 0 0 1/6]

The five authors' contribution rates are: SoYoung Kim: 1/6, Min-Su Kim: 1/6, Bumjung Park: 1/6, Jin-Hwan Kim: 1/12, HyoGeun Choi: 5/12. With paper count = 1 and citations = 8, AC-allocated metrics are: publication counts = 1/6, 1/6, 1/6, 1/12, 5/12; citation counts = 4/3, 4/3, 4/3, 2/3, 10/3.

We calculated AC-allocated publication and citation counts for all 11 authors across all papers, comparing with NC, HC, and HCT perspectives. Results are shown in Table 2 .

Table 2 shows that NC yields significantly higher publication and citation counts than HC, HCT, and AC, indicating NC substantially inflates metrics. HC, HCT, and AC produce more similar results, particularly HCT and AC. Linear regression analysis of publication counts yields: HC vs. AC coefficient = 0.584, P = 0.059 > 0.05 (not significant), $R^2 = 0.267$; HCT vs. AC coefficient = 0.954, P = 0.000 < 0.05 (significant), $R^2 = 0.901$. The strong HCT-AC fit (similar for citations) suggests our AC method aligns well with adjusted harmonic counting, enabling precise, contribution-based allocation. However, AC directly uses negotiated contribution statements, offering greater precision and objectivity. Pending broader adoption of contribution statements, we recommend combining AC with HCT as an effective supplement.

Conclusion

Based on author contribution element declarations and participation degrees, we constructed a quantitative co-author contribution rate measurement method with qualitative characteristics. This approach improves existing methods and, by integrating with bibliometric indicators, enhances evaluation precision and validity. The method is also extendable to institutions and regions. With broader adoption of contribution statements and advances in information processing infrastructure, contribution-element-based measurement will gain importance. A limitation is our equal weighting of all contribution elements; future CRediT standardization of element weights would further improve the method.

References

[1] Kennedy D. Multiple authors, multiple problems[J]. Science, 2003, 301(5634): 733.
[2] Waltman L. An empirical analysis of the use of alphabetical authorship in scientific publishing[J]. Journal of Informetrics, 2012, 6(4): 700-711.
[3] Corrêa JREA, Silva FN, Costa ALF, et al. Patterns of authors' contribution in scientific manuscripts[J]. Journal of Informetrics, 2017, 11(2): 498-510.
[4] Ding Jingda. Research on evaluation theory and method of network academic information resources in humanities and social sciences[M]. Wuhan:

Wuhan University Press, 2017.
[5] ICMJE. Recommendations for the conduct, reporting, editing and publication of scholarly work in medical journals[EB/OL]. [2018-08-13]. http://www.icmje.org/recommendations/.
[6] National Copyright Administration of China. Copyright Law of the People's Republic of China[EB/OL]. [2018-09-16]. http://www.ncac.gov.cn/china-copyright/contents/479.
[7] Hwang SS, Song HH, Baik JH, et al. Researcher contributions and division of labor in knowledge production[J]. Social Studies of Science, 2016, 46(3): 417-435.
[8] Larivière V, Desrochers N, Macaluso B, et al. Contribution lists in research articles with multiple authors published in radiology[J]. Radiology, 2003, 226(1): 16-23.
[9] Allen L, Scott J, Brand A, et al. Publishing: credit where credit is due[J]. Nature, 2014, 508(7496): 312-313.
[10] Frische S. It is time for full disclosure of author contributions[J]. Nature, 2012, 489(7417): 475.
[11] Baerlocher MO, Newton M, Gautam T, et al. The meaning of author order in medical research[J]. Journal of Investigative Medicine, 2007, 55(4): 174-180.
[12] Yang S, Wolfram D, Wang F. The relationship between the author byline and contribution lists: a comparison of three general medical journals[J]. Scientometrics, 2017, 110(3): 1129-1273.
[13] Cui Linwei, Lu Ying. Analysis of author contribution elements based on author order—taking author contribution statements in *Library and Information Service* 2015-2016 as an example[J]. Library and Information Service, 2017, 61(9): 80-86.
[14] Ding Jingda, Wang Xinming. Author contribution statements and their relationship with author order—an empirical study based on three LIS journals[J]. Library and Information Service, 2017, 61(24): 63-70.
[15] CASRAI. CRediT[EB/OL]. [2018-09-13]. http://docs.casrai.org/CRediT.
[16] McNutt MK, Bradford M, Drazen JM, et al. Transparency in authors' contributions and responsibilities to promote integrity in scientific publication[J]. Proceedings of the National Academy of Sciences, 2018, 115(11): 2557-2560.
[17] Berg J. Transparent author credit[J]. Science, 2018, 359(6379): 961.
[18] PLOS. Author contributions[EB/OL]. [2018-09-20]. http://journals.plos.org/plosone/s/authorship.
[19] Rao RIK, Sahoo B. Distributions of multiple authors: a case study of two journals (JASIST and Scientometrics)[J]. Collnet Journal of Scientometrics and Information Management, 2008, 2(1): 27-35.
[20] Hu X, Rousseau R, Chen J. In those fields where multiple authorship is the rule, the h-index should be supplemented by role-based h-indices[J]. Journal of Information Science, 2010, 36(1): 73-85.
[21] Lindsey D. Production and citation measures in the sociology of science: the problem of multiple authorship[J]. Social Studies of Science, 1980, 10(2): 145-162.
[22] Abe O, Abe R, Enomoto K. Effects of chemotherapy and hormonal therapy for early breast cancer on recurrence and 15-year survival: an overview of the

randomised trials[J]. Lancet, 2005, 365(9472): 1687-1717.
[23] Price DD. Multiple authorship[J]. Science, 1981, 212(4498): 986.
[24] Hagen NT. Harmonic publication and citation counting: sharing authorship credit equitably—not equally, geometrically or arithmetically[J]. Scientometrics, 2010, 84(3): 785-793.
[25] Fan Xiangwei, Xiao Xiantao. Research progress and comparative analysis of co-author contribution allocation algorithms[J]. Library and Information Service, 2015, 59(10): 116-123.
[26] Egghe L, Rousseau R, Van Hooydonk G. Methods for accrediting publications to authors or countries: consequences for evaluation studies[J]. Journal of the Association for Information Science and Technology, 2000, 51(2): 145-157.
[27] Abbas AM. Weighted indices for evaluating the quality of research with multiple authorship[J]. Scientometrics, 2011, 88(1): 107-131.
[28] Verhagen JV, Wallace KJ, Collins SC, et al. QUAD system offers fair shares to all authors[J]. Nature, 2003, 426(6967): 602.
[29] Tscharnke T, Hochberg ME, Rand TA, et al. Author sequence and credit for contributions in multi-authored publications[J]. PLOS Biology, 2007, 5(1): 13-14.
[30] Rahman MT, Regenstein JM, Kassim NLA, et al. The need to quantify authors' relative intellectual contributions in a multi-author paper[J]. Journal of Informetrics, 2017, 11(1): 275-281.
[31] Xu Chen. Research on co-authorship contribution degree of single scientific achievements under multiple scenarios[J]. Library and Information Service, 2015, 59(19): 93-99.
[32] Kosmulski M. The order in the lists of authors in multi-author papers revisited[J]. Journal of Informetrics, 2012, 6(4): 639-653.
[33] Sekercioglu CH. Quantifying co-author contributions[J]. Science, 2008, 322(5900): 371.

Author Contributions

Ding Jingda: Conceptualization, research design, paper writing and revision.
Wang Xinming: Data collection and processing, participation in paper writing.

Book Announcement

Information Management Discipline Competitiveness and Structural Reform by Dr. Tao Jun of Northwest University was published by China Social Sciences Press in May 2019 (ISBN: 978-7-5203-4023-6, Price: ¥59.00). This monograph explores potential constraints on LIS discipline competitiveness from perspectives including institutional arrangements, educational environments, professional reputation, integration indicators, and highly-cited paper content structures. The author advocates a shift from practice-oriented professional development to science-oriented development centered on diversified informa-

tion practices, enhancing overall competitiveness through structural reform and disciplinary integration. This innovative, theoretically-grounded work from a frontline educator demonstrates systematic thinking about the discipline's future development.

Note: Figure translations are in progress. See original paper for figures.