Research on Scholarly Impact Identification: A Complete Citation Data Perspective (Postprint)

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Abstract

[Objective/Significance] Currently, widely applied citation evaluation metrics overlook the differences in citation content. This study attempts to incorporate three factors—citation intensity, citation location, and citation sentiment—along with author contribution, to propose a citation-based academic influence evaluation metric. [Method/Process] We present a calculation formula for author contribution, utilize the Analytic Hierarchy Process to determine the weights of citation intensity and citation location, and combine these weighted factors with citation intensity to compute the Author Academic Influence (AAI) metric. [Results/Conclusion] Empirical results demonstrate that the AAI metric comprehensively considers both citation content and author contribution, adds discriminative power to simple citation counts, and provides a new perspective for scholar academic evaluation.

Full Text

Research on Scholar's Academic Influence Identification—From the Perspective of Full Citation Data

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Abstract:
[Purpose/Significance] Current widely-used citation evaluation indicators overlook differences in citation content. This study attempts to incorporate three factors—citation intensity, citation position, and citation sentiment—along with author contribution to propose a citation-based academic influence evaluation index. [Method/Process] We provide a formula for calculating author contribution, utilize the Analytic Hierarchy Process to determine the weights of citation

intensity and citation position, and comprehensively calculate the Author Academic Influence (AAI) index based on citation intensity. [Result/Conclusion] Empirical results demonstrate that the AAI index comprehensively considers citation content and author contribution, increases the discriminative power of simple citation counts, and provides new ideas for scholar academic evaluation.

Keywords: citation content analysis; academic evaluation; analytic hierarchy process; author contribution
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In July 2018, the General Office of the CPC Central Committee and the State Council issued the "Opinions on Deepening the Reform of Project Review, Talent Evaluation, and Institutional Assessment," stating that talent evaluation should "highlight moral character, capability, and performance orientation, overcome the tendencies of over-reliance on papers, titles, education, and awards, implement a representative work evaluation system, and focus on the quality, contribution, and impact of 标志性成果." The document also noted that metrics such as "the number of SCI and core journal publications, citation rankings, and impact factor rankings" should serve only as references for research talent evaluation, with greater emphasis on peer review mechanisms. Traditional citation evaluation indicators increasingly fail to meet academic evaluation needs. Ye Jiyuan proposed that citation analysis is both a quantitative and qualitative evaluation method, as citations themselves have been peer-reviewed, and citation content reflects these peer review results. Citation content analysis can reveal the varying importance of citations in the citing author's mind, thereby demonstrating paper influence. Additionally, whether a paper is completed individually or collaboratively makes a difference, and authors' varying contributions should also be considered.

Therefore, we attempt to conduct multi-angle scholar academic influence evaluation research from the perspective of full citation data combined with author contribution. Specifically, we construct an author academic influence evaluation method from four aspects: citation intensity, citation position, citation sentiment, and author order, using academic papers from *Journal of Library Science in China* over the past five years as experimental data to calculate and analyze author academic influence indicators. The scholar academic influence index we propose evaluates scholar influence through a combination of quantitative and qualitative methods, offering certain application value and providing new ideas for evaluating research outcomes.

2 Related Research

Full citation data can be divided into structural data and semantic data. Structural data includes citation frequency, citation distribution patterns, and citation relationships (mainly co-citation relationships); semantic data primarily refers to citation content information, which can reflect scholars' citation behav-

iors and motivations during paper writing.

2.1 Overview of Academic Influence Evaluation

Early academic evaluation primarily used peer review, a qualitative method where experts in the same discipline or research field evaluate academic journals, researchers, institutions, and their outcomes according to certain standards. While relatively authoritative, this method may be influenced by experts' subjective preferences. Consequently, more objective quantitative statistics were introduced into academic evaluation. Current personal academic influence evaluation indicators based on traditional bibliometrics mainly include total papers, total citations, average citations per paper, number of important papers and their citations, and journal impact factor. Paper volume and citation volume are two basic measures. Average citations per paper can measure scholars' academic influence across different publication quantities but may disadvantage excellent papers. Important paper citation counts can compensate for this defect to some extent, but the definition of "important paper" lacks standardization and is highly subjective. Impact factor refers to the average citation rate of a journal's papers within a certain period. While easy to calculate and widely used for journal quality evaluation, most citations to a journal come from a minority of its published papers, making impact factor a biased indicator for evaluating individual papers or authors.

In 2005, J.E. Hirsch proposed the h-index as a measure of individual high-impact characteristics. The h-index considers both paper quantity and quality but disadvantages young scholars with fewer publications and ignores the dynamic nature of academic evaluation due to its non-decreasing characteristic. F. Radicchi et al. constructed author citation networks and obtained author influence rankings based on PageRank algorithm principles.

These quantitative citation evaluation indicators are computationally efficient but fail to consider author contribution issues. J.K. Wan et al. proposed the h_p index considering paper collaboration numbers and author order. T. Tscharnke et al. provided four suggested methods for calculating multi-author contributions: sequential contribution determination; equal contribution; emphasizing first and last author contributions; percentage allocation. M. Schreiber proposed the h_m index calculated using the inverse of the number of authors per paper. V. Larivière et al. considered the first author as primarily responsible for paper content. He Minwen further optimized the h_w index proposed by Professor L. Bertoli-Barsotti, exploring the correlation between researchers' h'_w index and the number of first-author and second-author papers, demonstrating through examples that incorporating author contribution into author academic evaluation is reasonable.

In 2010, J. Priem et al. proposed altmetrics to evaluate social influence and short-term impact, using multi-platform data statistical analysis as a powerful supplement to traditional evaluation methods. Liu Xiaojuan et al. verified

through examples that altmetrics indicators such as read counts and tag counts can assess literature influence to some extent. Zhao Rongying et al. proposed academic paper influence evaluation indicators based on altmetrics. However, altmetrics remains in development, facing issues such as difficulty distinguishing data credibility and integrating multiple data sources.

2.2 Overview of Citation Content Evaluation Research

Traditional academic evaluation indicators may cause differences in the importance of individual citations within a single paper due to the complexity of citation motivations. Citation position can reflect citation motivation to some extent. H. Voos et al. pioneered citation position-based research, finding that citations in different positions contribute differently to papers. S. Marić et al. experimentally demonstrated that citations in "methods," "results," and "conclusion" sections are more important than those in "introduction." V. Cano explored relationships between citation types, utility, and position, testing citation position's validity as a new bibliometric factor. N. Sombatsompop et al. conducted quantitative evaluations by calculating article impact factor, position impact factor, and journal impact factor.

Moreover, different citations within a single paper are not equal—some are cited multiple times. Generally, the more frequently a citation is mentioned, the more important it is in the citing document. Y. Ding et al. defined the number of mentions in a paper as CountX and whether it was cited as CountOne, finding both methods significantly impact high-citation paper rankings. Liu Shengbo considered citation quality as the ratio of actual citation frequency to reference frequency. Hu Zhigang termed "the number of times a citation is cited or mentioned in the citing document's main text" as citation intensity, revealing citation functions and roles through identifying citation position, intensity, and context. X. Zhu et al.'s hip index weights citations by citation intensity, achieving better results than the h-index.

Additionally, authors assign sentiment when citing papers—positive, negative, or neutral. Unlike objective indicators such as citation position and intensity that reveal citation motivation and behavior, citation sentiment involves subjective judgment, revealing authors' attitudes toward citations. Wei Yangye et al. categorized citation nature as positive, negative, and neutral, evaluating citations through citation intensity and nature analysis. Geng Shuqing et al. proposed a single-paper influence evaluation method based on citation counts and sentiment, using AHP to calculate indicator weights and verifying feasibility through examples.

Therefore, we attempt to measure paper influence based on citation position, intensity, and sentiment, obtaining final author academic influence through weighting by author contribution.

3 Author Academic Influence Evaluation Method

3.1 AAI Indicator

Scholar influence can be divided into academic influence and social influence, where academic influence represents recognition of research achievements by the academic community or peers, and academic papers are major research outcomes. Traditional paper evaluation methods consider academic influence determinable through citation frequency, but Geng Shuqing et al. argued this ignores citation sentiment differences and proposed a paper academic influence index as the sum of three citation sentiment frequencies weighted by their respective weights. We build upon this by adding citation intensity and position.

Thus, a paper p's academic influence PI(p) is the sum of products of citation intensity, citation position, citation sentiment weights, and their corresponding frequencies:

$$PI(p) = \sum W_{position} \cdot W_{sentiment} \cdot N_c \quad (1)$$

where PI(p) is paper p's academic influence value; W_{position} and W_{sentiment} represent citation position and sentiment weights; N_c represents citation intensity in condition c where position and sentiment are fixed.

We consider only academic papers as scholars' academic achievements, where a scholar's academic influence equals the sum of all their papers' influence. Since most papers are collaboratively completed with varying contributions, we allocate paper academic influence values according to scholars' contribution degrees. Therefore, author a's academic influence AAI(a) is the sum of products of academic influence values of papers author a participated in and the author's contribution weight:

$$AAI(a) = \sum_{j=1}^{n} W_{author} \cdot PI_j \quad (2)$$

where AAI(a) is author a's academic influence value; PI represents academic influence values of papers author a participated in; W_{author} represents author contribution weight in that paper.

Citation intensity calculation adopts Hu Zhigang's definition: "the number of times a citation is cited or mentioned in the citing document's main text." We further detail three indicators: citation position, citation sentiment, and author contribution.

(1) Citation Position. S. Marić et al. divided article structure into "introduction," "methods," "results," and "conclusion and discussion" sections. N. Sombatsompop et al. categorized citation positions as "introduction," "experiments and materials," "results and discussion," and "conclusion and others." Hu

Zhigang mentioned the IMRDC structure (introduction, methods, results, discussion, conclusion) in his doctoral dissertation. Zhang Chengzhi et al. divided citation positions into seven parts: "introduction," "related research," "data," "methods," "experiments," "discussion," and "conclusion." Combining actual annotation practices, we find many Chinese documents separate "introduction" and "related work"—the former focusing on research application background and significance, the latter discussing methods and techniques involved. Therefore, we divide citation positions into five secondary indicators: "introduction," "literature review," "data and methods," "experiments and results," and "conclusion and discussion."

(2) Citation Sentiment. Most current research divides citation sentiment into three basic categories: positive, negative, and neutral. Table 1 provides specific descriptions of citation sentiment categories, which we adopt for sentiment classification.

(3) Author Contribution. We consider allocating author contribution weights based on author order, adopting the author contribution rate ranking formula proposed by N.T. Hagen et al. in 2008 to measure author contribution:

$$W_{author}(i) = \quad (3)$$

where W_{author}(i) is author contribution weight in a single paper; i represents author order; N represents the number of paper authors.

3.2 Weight Calculation

We propose secondary indicators for citation position and sentiment requiring further weight calculation. This study uses the Analytic Hierarchy Process (AHP) to determine secondary indicator weights. AHP compares indicators pairwise, quantifying subjective judgments numerically using a 1-9 scale. To ensure scientific and impartial judgments, we invited experts in relevant research fields to complete questionnaires. This study invited 15 full-time teachers and doctoral students from Nanjing institutions. Specific AHP weight calculation steps are:

Step 1: Construct evaluation indicator hierarchies for citation position and sentiment separately.

Step 2: Introduce the research topic to experts, solicit modification suggestions for proposed indicators, and finalize judgment matrices based on expert feedback. According to expert opinions, we merged "conclusion" and "discussion" into one indicator.

Step 3: Distribute questionnaires to experts again, receiving 15 completed responses. Use the sum-product method to calculate each judgment matrix's maximum eigenvalue and eigenvector, conducting consistency tests (CR < 0.1).

If failing consistency tests, feedback is provided to raters for appropriate modifications. If an expert's results differ significantly from others, we inquire about reasons, provide supplementary explanations, and request appropriate modifications.

Step 4: Assign equal weight coefficients to all experts, calculate geometric means of judgment matrix values, select the closest scale as the final judgment matrix result, compute maximum eigenvalues, and conduct consistency tests. Results failing consistency tests are returned to raters for modification.

Following these steps, final comprehensive judgment matrix results for citation position and sentiment are shown in Table 2 and Table 3 , both passing consistency tests (CR < 0.1). We find that from "introduction" to "conclusion and discussion," citation position importance continuously increases—the weight of "data and methods" is nearly double that of "introduction," while "conclusion and discussion" weight is nearly triple. Positive citation importance far exceeds neutral and negative citations, with neutral citation importance being nearly double that of negative citations. Many papers cite in introductions to explain economic/political backgrounds or list related papers without introducing or commenting on their achievements, resulting in lower weights. Conclusion section citations, though fewer, often use others' achievements for discussion and prospects, thus receiving higher weights.

4 Empirical Study and Results Analysis

4.1 Data Source and Processing

Currently, citation content analysis mostly uses English literature, with few Chinese literature studies. Therefore, we selected authoritative library and information science journal *Journal of Library Science in China* (2014-2018) as experimental data to demonstrate scholar influence calculation in the library field. After initial screening, 208 papers remained, from which we extracted 9,336 citation sentences.

First, we annotated citation positions. Academic papers can be divided into empirical and non-empirical research. Empirical research draws conclusions through original data observation, while non-empirical research synthesizes existing achievements through argumentation. Non-empirical papers, such as "Data Management Services in the Transformation of Research Models: Approaches to Achieving Open Access, Open Data, and Open Science," contain no methods or experiments. During annotation, we labeled these as 0, using the mean value 0.2 for subsequent position weight calculations. The annotation method first determines whether a paper is empirical research—if not, directly label as 0; if yes, determine its position based on chapter titles and context. Due to low annotation difficulty and easy distinguishability, one relevant major student completed the entire process.

Second, citation sentiment annotation requires contextual judgment of citation

sentences, completed independently by two relevant major students. Results were integrated, with discrepancies resolved through discussion. Annotation examples are shown in Table 4 .

Annotation result statistics for citation position and sentiment are shown in Table 5 and Table 6 . Among 4,252 position-annotatable citation sentences, literature review citations were most frequent (42.1%), followed by introduction (24.5%), with the remaining three sections having fewer citations. Table 6 shows most citations are neutral, with only minimal positive (5.2%) and negative (0.8%) sentiment. Academic papers are highly professional, with authors using more rigorous language containing less sentiment.

Finally, we counted authors, merging same authors with different expressions or spellings. Due to the narrow data domain, we simply distinguished authors with identical names, resulting in 8,768 authors.

4.2 Results Analysis

Using formulas from 3.1 and weights from 3.2, we calculated AAI indicators. Pearson correlation analysis between AAI indicators and citation intensity yielded r = 0.850, significantly correlated at the 0.01 level. Overall, the AAI indicator remains citation intensity-based. We plotted a scatter diagram comparing citation intensity and AAI indicators, selecting 119 authors with citation intensity > 10, arranged in descending citation intensity order, shown in Figure 1 [Figure 1: see original paper]. The AAI indicator provides clear discrimination among authors with identical citation intensity.

Arranged by descending AAI indicator, Table 7 shows the top 20 authors, providing their involved document counts, citation frequency, citation intensity, AAI indicator, and h-index for comparison. The h-index here is a rough estimate that cannot encompass all databases. Foreign scholars' h-indices directly use Web of Science values, while domestic scholars' foreign publications are relatively few, so CNKI provides more accurate h-indices. Therefore, for domestic scholars we used CNKI, limiting by institution and research field to remove name duplicates, counting paper citations, sorting, and calculating h-indices.

Table 7 shows citation frequency differs from citation intensity, with average citations mentioned approximately 1.5 times per paper. The top-ranked author is Wen Youkui from the Institute of Scientific and Technical Information of China, who published 13 knowledge-element-related papers (see Table 8), with 12 as first author. His citation intensity ranks second at 36 times, but most appear in introduction and literature review sections. Professor Yu Liangzhi from Nankai University's Business School published multiple library science and information service papers as first author, with citation intensity of 42 times, ranking second. Li Wu from Shanghai Jiao Tong University focuses on social reading research, with some positive citations, ranking fourth. K. Church published *Mobile information access: A study of emerging search behavior on the mobile Internet* and *A large scale study of European mobile search behaviour*

as first author. Though citation frequency is not high, citation intensity is high with most mentions in experiments and results, enabling a rank of 12.

Overall, the top 20 scholars have relatively high h-indices, and the AAI indicator can identify scholars with higher h-indices to some extent. The AAI indicator measures both short-term and long-term influence, depending on selected literature time span and scope. The h-index is greatly affected by publication quantity and only increases over time—the longer the research career, the larger the h-index. The AAI indicator calculates using specific time period and domain research papers, being less affected by publication quantity and career length. Both senior scholars proposing classic theories and young scholars proposing emerging research methods can achieve high AAI values. For example, Yan Hui, a relatively young scholar, entered the top 20 according to AAI indicator calculations.

Research shows many citing authors only read 20% of references. The AAI indicator moves beyond citation frequency by introducing citation intensity, position, and sentiment, "selecting" citations that citing authors carefully read, describe, or comment on, assigning them higher weights. Our study uses many indicators but has insufficient data volume, resulting in close AAI indicator values. Some authors achieve higher AAI values due to high citation intensity, important citation positions, and positive sentiment despite being cited by few papers. With larger data volumes, indicators will be more balanced and AAI indicator differences will increase.

5 Summary and Outlook

Building upon citation counts, we incorporate citation intensity, citation position, and citation sentiment, combined with author contribution, to propose the AAI indicator for evaluating author academic influence. We then provide calculation formulas for citation intensity and author contribution, use expert questionnaires and AHP to determine citation position and sentiment weights, and obtain the final AAI indicator calculation formula. Finally, we demonstrate indicator effectiveness through examples and verify the new indicator's rationality and validity. The AAI indicator more comprehensively reflects citation quality and allocates author contribution according to author order, elevating evaluation from paper influence to author academic influence.

This research still has limitations: (1) Due to annotation difficulty, we only used five years of *Journal of Library Science in China* data for demonstration, with insufficient data volume yielding very close AAI indicator values and an overly narrow domain. (2) With small data volume, we simply handled author name issues, but larger data volumes require fast, effective solutions. We used manual annotation, which cannot scale to broader data—future work should attempt machine learning methods for large-scale processing. (3) Author academic influence is only part of scholar influence; patents, software development, and social influence are not considered. How to integrate these multi-dimensional data for

comprehensive scholar influence evaluation requires further research.

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Author Contributions

Li Zheng: Proposed research ideas, designed research framework, collected, cleaned, and analyzed experimental case data, and wrote the paper.
Deng Sanhong: Determined research ideas and revised the paper.
Kong Jia: Participated in case data processing.
Zhang Yiwei: Participated in case data processing.

Research on Scholar's Academic Influence—From the Perspective of Full Citation Data

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Abstract:
[Purpose/Significance] The commonly used citation evaluation index ignores the difference in citation content. This study attempts to add three factors—citation intensity, citation location, and citation sentiment—and combine them with author contribution to propose an evaluation index of academic influence

based on citation. [Method/Process] This paper gives a formula for calculating author contribution, uses the Analytic Hierarchy Process to determine the weight of citation intensity and citation location, and comprehensively calculates the index of author's academic influence with citation intensity. [Result/Conclusion] The example shows that the AAI index comprehensively considers citation content and author contribution, increases the discrimination of simple citation frequency, and provides new ideas for scholar's academic evaluation.

Keywords: citation content analysis; academic evaluation; analytic hierarchy process; author contribution

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