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A New B_W Index for Quantifying Scholars' Research Influence

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Abstract - The growing importance of measuring and evaluating academic performance in academic hiring, promotions, funding allocation, and resource distribution has fueled the demand for better metrics. Traditional ranking indicators, such as publication count and citation-based indices, often fail to capture the interdisciplinary influence and qualitative dimensions of research impact. These shortcomings highlight the need for more comprehensive evaluation metrics. The current study introduces a novel B_W Index, which integrates both quantitative and qualitative aspects of researcher contributions, aiming to provide a more balanced and comprehensive evaluation of scholarly impact. To evaluate the effectiveness of the proposed index, a comparative analysis was conducted on 200 researchers' profiles of Monash University Australia, calculating both the h-index and the proposed B_W Index. The results of the study indicate that researchers with identical H-index exhibit significant variation in B_W Index values ranging from 10 to 55, demonstrating its ability to distinguish research impact beyond citation counts. Furthermore, for researchers with an h-index of 20, the B_W Index ranges from 20 to 82, reflecting an increase in differentiation compared to traditional the H-index. These findings highlight the B_W Index as a more nuanced and equitable measure of academic influence, offering a refined approach to researcher evaluation and addressing the limitations of traditional metrics.

Keywords—Research Evaluation, Expert Finding, Science Policy, H-index, Scientometrics

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1. INTRODUCTION

Measuring and understanding the research impact of individual researchers has become a crucial aspect of comprehensive evaluation [1], [2]. Several evaluation metrics, ranging from publication counts to citation indices to collaborative networks, have been proposed by the research community to make informed decisions on tenure, university rankings, and funding [3]. Traditional bibliometric measures, such as publication counts, citations, co-authorship, the h-index, and its extensions, are inadequate in fully capturing the comprehensive scope of research

impact [4]. Therefore, a more comprehensive evaluative framework, encompassing factors beyond traditional bibliometric indicators, is required to assess the impact of research contributions.

Hirsch [5], in 2005, contended that relying solely on a straightforward tally of bibliometric indicators is insufficient for accurately measuring the scholarly impact of researchers. He introduced a novel ranking metric known as the H-index based on the point that both publication quantity and citation frequency should be included in researcher evaluation. However, the h-index has been widely criticised for its inherent weaknesses in encompassing the multifaceted nature of scientific impact. In response to the constraints of the h-index, researchers have proposed several variations and extensions to overcome its limitations [4].

In a recent study, researcher Ahmed et al. [2] suggest that over seventy multiple parameters have been proposed for the ranking of researchers. Tzitzikas and Dovas in 2024 [6] introduced the HI/co and HI/(coy) indices to address the limitations of the H-Index, particularly its failure to account for co-authorship and research activity over time. In another study, in the same year, researchers Norouzi et al. [7] proposed a set of author-level metrics to enhance the fairness and comprehensiveness of researcher evaluations by addressing key shortcomings of the H-Index, such as its neglect of author credit allocation and field-specific variations. In addition, researcher Rainone et al. [8] proposed the Hm index to overcome the restrictions of the H-index. In several other studies in 2023 [9]-[12], researchers evaluated H-type indices on a dataset of researchers. As of now, the research community predominantly relies on the h-index, alongside its various derivatives and extensions, as a key metric for ranking researchers [13]. In addition, the h-index remains a common factor in evaluation processes for prestigious journals and conferences [14]. The ranking of researchers remains an active and evolving area of research, characterized by a continual influx of novel indices developed to improve evaluation methods. Notably, the seminal H-index paper by Hirsh has garnered substantial attention, being cited by 15,800 researchers within this context.

Although numerous ranking parameters exist, the scientific community has yet to agree on a universal metric for effectively ranking researchers. A protracted debate persists regarding the optimal ranking parameter within the scientific community. We conducted an empirical review of over sixty parameters. During the review, we found that these indices incorporate various factors, such as publication count, citations, and co-authorship for ranking researchers [15], [16]. These indices only count these factors and measure the impact of researchers in quantitative terms. However, an essential aspect that these indices have neglected is the quality of the publication venues in which researchers choose to publish their work [17], [18].

Publication venues assume a pivotal role in disseminating research findings and influencing the academic community. Journals and conferences ranked in higher quartiles are typically associated with greater rigour in the peer-review process and a broader impact across the scholarly community. Researchers who consistently publish in these venues contribute to the advancement of their field more substantially than those publishing in lower-quality venues [19], [20].

In this study, we introduce a novel index called the B_W index that addresses this gap by incorporating the quartile ranking of publication venues. Our proposed index takes a holistic approach that combines two key dimensions: the quantity of publications and the quality of the publication venues. The proposed index overcomes the limitations of the h-index and its various variants which fail to incorporate the quality of publication venues. Unlike the h-index, which relies solely on the quantity of publications and their corresponding citations to rank scholars, our proposed index takes into account the quality of the venues where these publications appear. For the purpose of comparing the results between the novel B_W index and the H-index, we extracted the profiles of computer science researchers affiliated with Monash University.

The rest of the manuscript is organised as follows. The Related Work section explores studies pertaining to researchers' ranking, providing context for the current research. The Methodology section outlines the proposed approach for the novel index. Results and Discussion present a comprehensive analysis of obtained results in comparison to the H-index. Finally, the Conclusion section summarises key findings and discusses potential avenues for future studies

2. LITERATURE REVIEW

The volume of scientific data has extended exponentially, in line with the expansion of scientific activity and productivity. However, this growth has also introduced unprecedented challenges. The quality of a scholar's research work cannot be definitively determined immediately upon its publication. Numerous award winning scholars had to wait for an extended period to get recognition. Furthermore, determinations related to nominations for scientific awards, allocation of scholarships/grants, tenure-track positions, and promotions often hinge on the assessment of these metrics [21], [22]. There are several metrics employed in literature to measure the research impact of a scholar [23], [24] .Therefore, the impact evaluation of a researcher is of great significance. Some of the well-known metrics are count of publications, citation count, H-index and its variants.

For decades, the number of publications was the go-to metric for gauging a researcher's productivity [25]. Subsequently, the research community argued that relying solely on the number of published papers was insufficient for measuring a scholar's overall research impact because many scholars publish their work in low-quality journals to increase their research volume. To address the limitation posed by publication counts, citations are utilised as a method to assess the research impact of a scholar. However, relying solely on citation count can be misleading, as it is susceptible to several limitations and biases. A potential source of bias in citation analysis is self-citation, where researchers artificially inflate their impact by referencing their own work heavily. In 2005, Hirsch introduced an innovative metric known as the H-index, which integrates both publications and citations into a single measure. Owing to its simplicity, the scientific community widely embraced the H-index as a tool for ranking researchers and high-quality journals. However, despite its advantages, the H-index also possesses certain limitations and drawbacks. The citation practices of articles vary across different domains, making it impractical to directly compare the research impact of researchers from diverse domains [4],[26].

Regardless of the contribution, the H-index encourages the inclusion of additional co-authors. The H-index assigns the same weight for a first author as all other authors. In addition, the H-index value never decreases [27]. Because of its limitations, several researchers, including Hirsch himself, have put forth various alternatives to assess the research impact of researchers. Some research studies have considered the original idea of the H-index and complemented it with other assessment metrics, such as the consideration of a huge number of articles, influence of coauthors, publication age and many more [28], [29]. In addition several studies take into account the influence of individual researchers and distribute the citation count among co-authors, resulting in the proposal of several new indices [30]. Some researchers argue that relying on a single index account for only one aspect of scientific assessment. Instead of a single parameter, they propose that a combination of two or more parameters would provide a more comprehensive evaluation of a researcher. Numerous scholars contend that the H-index is susceptible to the "big-hit" problem, wherein the citation count beyond the H-index value holds limited significance in the computation of the H-index [31], [17] .

Several recent studies, published in 2023, [9], [10], [13] argue that the scientific community has proposed over sixty different variants of the H-index to effectively rank scientists. This indicates a dynamic and evolving landscape in the pursuit of refining metrics for assessing scholarly impact and productivity.

Researchers Lathabai and Prabhakaran in 2023 introduced a novel index named the Contextual Index for rating of most prominent researchers [32]. They conducted a comparative study evaluating the performance of this index against the well-known h-index and g-index. Another recent study conducted by HH. Bi in 2023 [33], the scholars evaluated four indices for ranking using a dataset from Google Scholar, focusing on 12 Nobel laureates spanning four scientific fields. The study's findings suggest that the Hi index is a more effective metric than the H-index for assessing the scientific impact of researchers.

In 2022, Khurana and Sharma [34] proposed an index known as hc Index for ranking prominent scholars. They claim that the proposed index performs effectively, especially for lower-ranked researchers, compared to the H-index. Moreover, in 2021, a study conducted by da Silva and Brandão [35] assessed the g-index, R-index, A-index, and ψ-index in contrast to the p-index and z-index. The study aimed to provide valuable insights into the strengths and limitations of h-type indices, with a focus on their suitability for ranking the scholarly impact of researchers across various academic domains.

Ayaz and Masood [36] proposed the k-index as a metric for ranking researchers and conducted experiments on a dataset comprising computer science researchers. Delving into research on various researcher ranking indices, we discovered a common trend: a reliance on counting factors like publications and citations. But this quantitative approach overlooks the qualitative dimension of venue prestige, leaving these indices vulnerable to inaccurate assessments. This gap is particularly striking in their neglect of the impact of where researchers publish their findings.

3. RESEARCH METHODOLOGY

The initial step in our experiments, we focused on acquiring profiles of researchers affiliated with the Monash University computer science department. Following profile extraction, we retrieved comprehensive metadata for each researcher from Google Scholar. This metadata encompassed the number of publications, citations, publication venues, and other pertinent information. To ensure data integrity, we implemented a preprocessing phase to eliminate any irrelevant information or invalid characters. Additionally, we addressed potential name ambiguities within this preprocessing stage. With the refined metadata, we then employed a Python utility to calculate both the H-index and B_W Index for each researcher. Our suggested methodology is visualised in the block diagram of Figure 1.

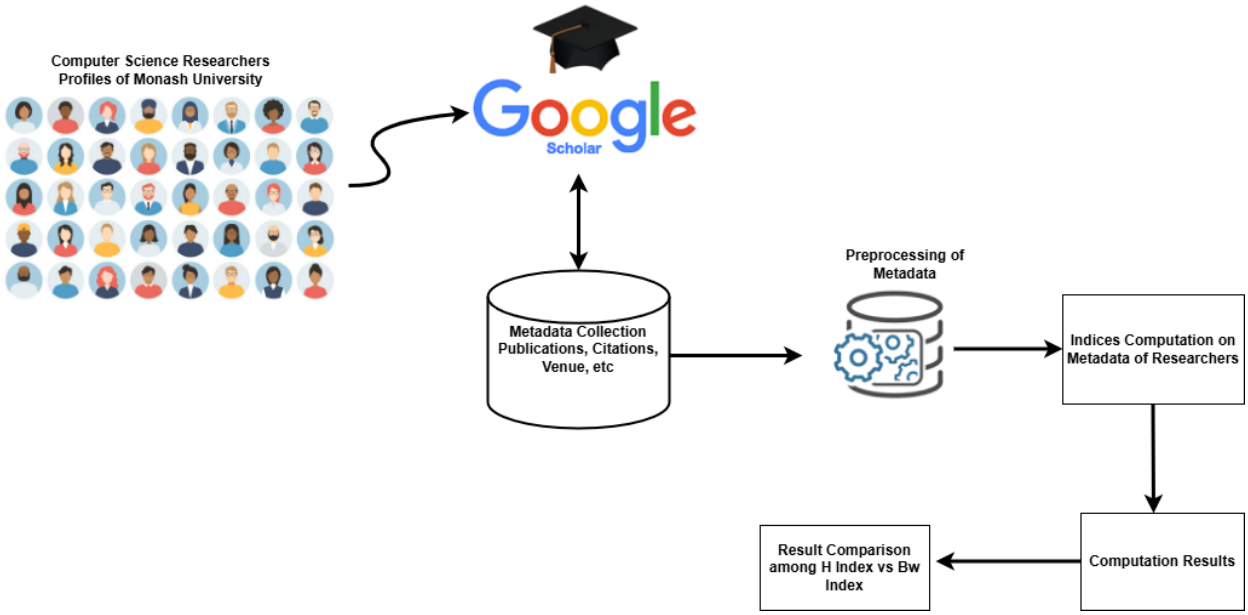


Figure 1. Block Diagram of Proposed Methodology

3.1 Dataset Collection and Preprocessing

To rank researchers using both the h-index and our proposed B_W index, we require researchers' metadata. To obtain this information, we extracted the metadata from the Monash University website. There are nearly 5,572 profiles of researchers spanning various domains, organised into several groups. Several other studies in the literature [34], [37] have employed this dataset to assess the effectiveness and validity of their proposed indices. For this study, we specifically extract the profiles of researchers affiliated with the computer science domain as shown in Figure 2.

We extract the metadata of 200 researchers within the computer science domain from Google Scholar. This encompasses details such as the number of publications, citations, and the venues where these publications are published. After collecting the metadata of researchers, a preprocessing step is initialised. This step ensures the removal of invalid characters like ($, % and so on). Moreover, the process of author disambiguation is implemented to enhance precision and accuracy in distinguishing between multiple authors with similar or identical names.

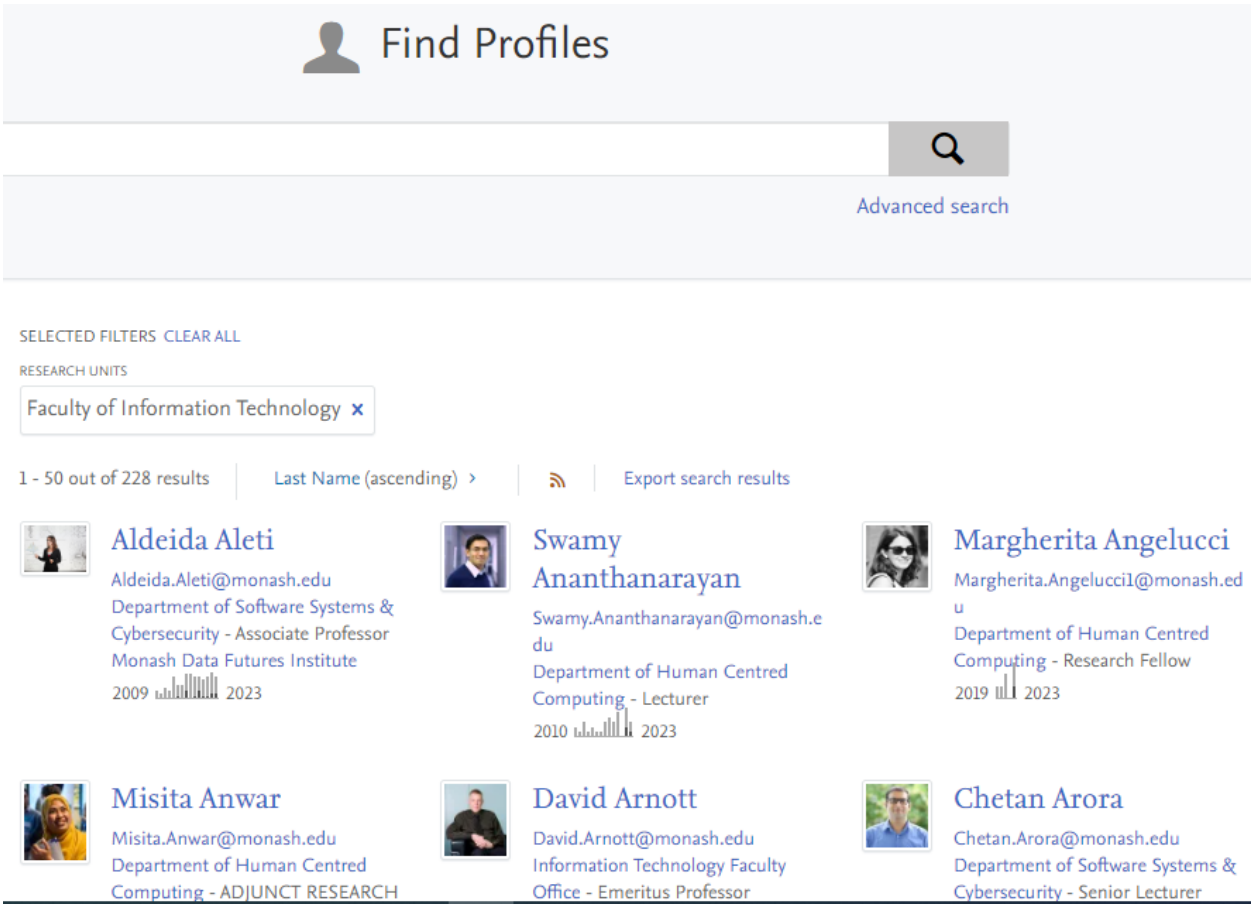


Figure 2. Faculty Profiles of Monash University

3.2 H-index and B_W Index Computation

After data collection and preprocessing of metadata of researchers, the subsequent step involves computing these two parameters based on the gathered information from researchers' profiles. The computational process offers a quantitative assessment of research impact by considering various factors, including publication count, citations, publication venue, and other relevant metrics.

3.3 H-index Computation

The H-index is a metric utilised to quantify the impact and productivity of a scholar's work. It is evaluated as the maximum value "h" such that h articles have at least h number of citations each.

Mathematically the H-index, is represented in Equation (1).

$$h = (no\ of\ articles >= h\ citations) \quad (1)$$

3.4 B_W Index Computation

The proposed Bilal and Wang (B_W-Index) offers a unique ranking of researchers by incorporating the distribution of their publications across various venues, providing a more comprehensive and insightful evaluation. The B_W workflow architecture is shown in Figure 3.

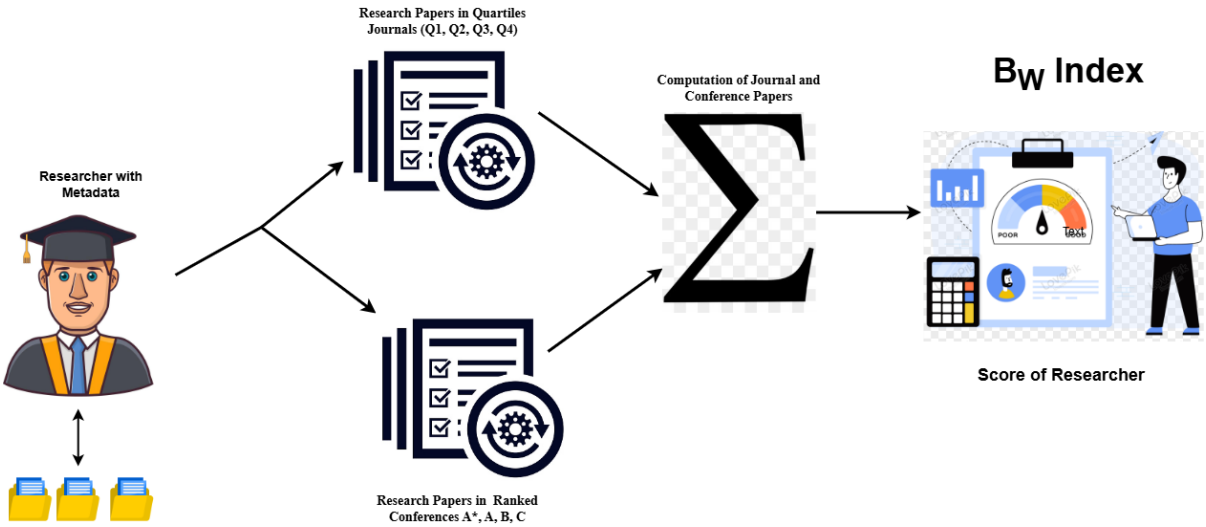


Figure 3. Workflow Architecture of B_W Index

The detailed computation process of the B_W-Index is presented in Algorithm 1. This algorithm systematically defines the steps for evaluating research impact, taking into account multiple factors such as publication count and venue prominence. By following these defined techniques, the B_W index aims to provide a nuanced and robust evaluation of researchers' contributions within the specified domain, offering a more holistic perspective on their scholarly impact.

Algorithm 1: Calculation of B_W Index

Input
List of researcher's publications
Journal Quartiles: Q1 = 1, Q2 = 1/2, Q3 = 1/3, Q4 = 1/4
Conference Rankings: A* = 1, A = 1/2, B = 1/3, C = 1/4
Output
B_W Index
Procedure
1. Initialize
  - journal_count ← 0
  - conference_count ← 0

2. For each publication in the researcher's profile
  - If publication.type = 'journal' then
    - journal_count ← journal_count + journal_weight[publication.quality]
  - Else if publication.type = 'conference' and publication.quality ≥ conference_quality_threshold then
    - conference_count ← conference_count + conference_weight[conference_rankings[publication.quality]]

3. Compute B_W Index
    - B_W Index ← journal_count + conference_count

4. Return B_W Index

Initially, the algorithm assesses the quantity of publications present in both journal quartiles and conference categories. Afterwards, the algorithm calculates the publication count across various quartile-ranked journals and categorised conferences. Following this, the B_W index is calculated based on the metadata of each researcher, resulting in the generation of a ranking score. Mathematically the B_W index of a researcher is computed in Equation (2).

$$Bw\ Index = \sum_{i=1}^{n} \left(Q_i * Quartile\ Weight_{Qi} + C_i * Conference\ Weight_{Ci}\right) \quad (2)$$

Where n represents the total number of research publications of a researcher. Q_i is the quartile of journal publication i. $QuartileWeight_{Qi}$ is the weight associated with the quartile of journal publication i. $ConferenceWeight_{Ci}$ is the weight associated with the conference category of publication i.

The B_W Index considers the quartiles of journals and the conference categories, and it calculates the score based on the weighted sum of these values for all publications. The weights associated with the quartiles of journals and conferences are as follows:

For Journals Publications as computed in Equation (3).

$$W_{Qi} = \left(Q1_{pub} * 1\right) + \left(Q2_{pub} * \frac{1}{2}\right) + \left(Q3_{pub} * \frac{1}{3}\right) + \left(Q4_{pub} * \frac{1}{4}\right) \quad (3)$$

For Conference Publications as computed in Equation (4).

$$W_{Ci} = \left(A^*_{pub} * 1\right) + \left(A_{pub} * \frac{1}{2}\right) + \left(B * \frac{1}{3}\right) + \left(C_{pub} * \frac{1}{4}\right) \quad (4)$$

3.5 Data of Journal Quartiles

For journal quartiles, we extract the recent list (2023) of journals from the Web of Science. This list is released by Thomson Reuters' Journal Citation Reports [38]. The list is commonly used to evaluate the importance or recognition of a journal within its specific field [39], [40]. Bornmann and Williams [41] stated that Journal quartiles can serve as a means to assess the distribution of an entity's (such as an individual, research group, country and institution) publications across journals from various fields. As an example, an interesting option is the % Q1 indicator [42]. This indicator represents the percentage of a researcher's publications that have been published in the most prestigious and influential journal's. Quartile 1 (Q1) indicates that a journal's impact falls within the top 25% of the Journal Impact Factor (JIF) distribution for a specific category. However, Quartile 4 (Q4) indicates that it falls within the lowest 25% of the JIF distribution [43].

3.6 Data of Conferences Categories

Several conference rankings have been compiled by various organisations on an international, national, and community-driven level [44]. These rankings are often considered indicators of a conference's reputation and are used for various purposes, including evaluating the performance of academic institutions and individual scientists, as well as selecting conferences for paper submissions [45]. Goodrum et al. [46] stated that peer-reviewed conferences play a role that is almost as significant as that of prestigious journals. In fact, conferences often have lower acceptance rates and higher citations per paper compared to equivalent journals.

Furthermore, Kangus et al. [44] researcher argued that scholars often prefer to publish their work in prestigious conferences rather than in highly influential journals. One of the explanations given for this trend is the need for faster dissemination cycles driven by the rapid evolution of the field. One of the most structured attempts to establish a conference ranking is provided by the Computing Research and Education Association of Australasia (CORE) [47]. This ranking system classified the conferences into four tiers (A*, A, B, C) [48]. The tiers in this ranking were established based on acceptance rate, where lower acceptance rates correspond to higher tiers. However, specific numerical thresholds were not set against tiers. In addition, the members of CORE are representatives from top universities in the world. We retrieve the latest list (2024) of categorised conferences from the CORE website.

Let's presume an example of how the B_W index computes a researcher's score. The total number of publications of a researcher in each category is 100, as shown in Table 1. The B_W index of a researcher is computed as shown in Equation (5).

Table 1. Researcher Publications Across Different Quartiles and Categories

Journals and Conferences publications	Q1	Q2	Q3	Q4	A*	A	B	C
Number of Publications	20	30	20	5	10	5	10	0

$$B_W\ Index = \sum_{i=1}^{n} \quad (Q_i * QuartileWeight_{Qi} + C_i * ConferenceWeight_{Ci}) \qquad (5)$$

$$B_W\ Index = (20 * 1) + \left(30 * \frac{1}{2}\right) + \left(20 * \frac{1}{3}\right) + \left(5 * \frac{1}{4}\right) + (10 * 1) + \left(5 * \frac{1}{2}\right) + \left(10 * \frac{1}{3}\right) + 0$$

$$B_W\ Index = 58.68$$

4. RESULTS AND DISCUSSIONS

In this section, we analyse the results of our novel B_W index in relation to the widely used H-index. The B_W index employs a more sophisticated method to assess research output, considering the diverse levels of prestige associated with different publication venues. It assigns higher weights to publications appearing in top-tier journals and conferences, reflecting their potential for broader impact. For the evaluation of the proposed B_W Index, we selected a group of 200 computer science researcher's profiles from Monash University.

In Table 2, a subset of researchers is presented along with their respective publication counts, citation numbers, H-index scores, and B_W index values. Our analysis reveals that researchers with varying citation counts and publication numbers can exhibit the same H-index score but differ in their B_W index values.

Figure 5 represents variation in B_W index values among researchers who share identical H-index scores, highlighting the B_W index's ability to discern qualitative distinctions in scholarly output. Through the incorporation of inherent hierarchies within journals and conferences, the B_W index not only recognises the sheer volume of publications but also places significant importance on the quality and impact of these contributions.

Additionally, the H-index may not be the best metric for early career researchers, as it depends on both the quantity of publications and their corresponding citations. Early career scholars often possess fewer publications, and their work might not have had adequate time to garner citations. In contrast, the B_W Index offers a more nuanced evaluation metric, providing a comprehensive approach to capturing the actual research impact. Consequently, it might serve as a more suitable metric for assessing the contributions of researchers in the early stages of their careers.

As academic evaluation shifts towards a more complete understanding of impact, acknowledging the varying influence of publication venues has become crucial. Our findings suggest that the B_W index fills this gap by providing a refined and discerning measure that resonates with the multidimensionality of scholarly contributions, complementing the traditional H-index.

Table 2. Researchers H-*i*ndex and B_W Index Comparison

Researcher Profiles of Computer Science Department, Monash University	H-index	B_W Index
Thomas Chandler No of Publications: 71 Citations:613 https://scholar.google.com/citations?user=5TZ41hgAAAAJ&hl=en&oi=ao	11	10
Shujie Cui No of Publications: 32 Citations: 350 https://scholar.google.com/citations?user=EYVNbx8AAAAJ&hl=en	11	14
John Crossley No of Publications: 264 Citations: 1924 https://scholar.google.com/citations?user=gcE4a0gAAAAJ&hl=en	11	95
Muhammad Aamir Cheema No of Publications:152 Citations: 2435 https://scholar.google.com/citations?hl=en&user=chWbG70AAAAJ	20	82
Zhaolin Chen No of Publications:124 Citations: 2766 https://scholar.google.com/citations?hl=en&user=wM9Y-I0AAAAJ	20	57
Guanliang Chen No of Publications:72 Citations: 2297 https://scholar.google.com/citations?user=NqOqvk0AAAAJ&hl=en&oi=ao	22	30
Mario Boley No of Publications:59 Citations: 1321 https://scholar.google.com/citations?user=0jlBueMAAAAJ&hl=en	16	36
Matthew Butler No of Publications: 66 Citations: 1376 https://scholar.google.com/citations?user=72YvcxsAAAAJ&hl=en	16	25

Note: the researchers have confirmed that the information published has obtained relevant permission

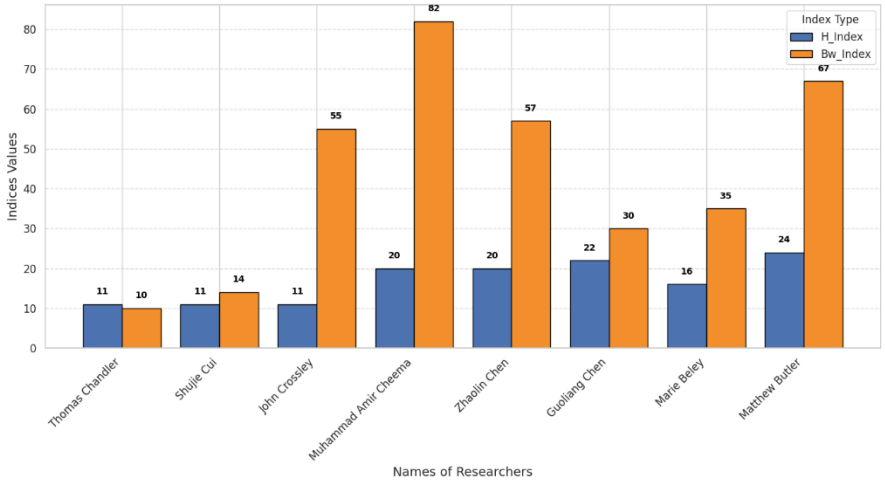


Figure 5. Comparison of H-index and B_W Index of Researchers

These findings are the result of a rigorous and comprehensive analysis, making them valuable not only for human resource departments but also for scientific awarding societies, universities, and research groups. They can be instrumental in making informed decisions related to hiring, promotions, and the approval of research grants for accomplished researchers.

5. CONCLUSION

We introduced the B_W Index as a novel parameter to address the limitations inherent in traditional bibliometric indicators like the H-index, which often fail to capture the full scope of a researcher's impact. With the incorporation of both quantitative and qualitative dimensions, the over proposed Index offers a more nuanced view of academic performance, highlighting distinctions between researchers with similar citation-based metrics. Our analysis of 200 profiles revealed that the proposed index could uncover meaningful differences in academic influence, which traditional indices may overlook. This finding suggests that the B_W Index holds promise as a tool for promoting equity in research evaluations, enabling more accurate and comprehensive assessments for academic hiring, funding allocation, and resource distribution. Future studies could further refine this metric and explore its applications across various academic disciplines, enhancing the fairness and effectiveness of research impact assessments in academia.

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AUTHOR CONTRIBUTIONS

Bilal Ahmed: Responsible for conceptualization, data curation, methodology, validation, and original draft preparation;
Li Wang: Supervised research;
Waqar Hussain: Reviewed and proofread the paper;
Saim Qureshi: Reviewed and proofread the paper.

CONFLICT OF INTERESTS

The authors declare that they have no conflicts of interest.

ETHICS STATEMENT

This research is based on publicly available bibliometric data, which has also been utilised in a previous study cited in the reference section of this manuscript. No personal, confidential, or sensitive information about individuals was used. The research adheres to ethical guidelines, and no direct consent was required as the data were already in the public domain.

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