Impact factor and other citation metrics: The impact on scholarly writing

Pei Kuan Lai[1], Sivalingam Nalliah[2], Cheong Lieng Teng[2], Nicole Lee Ping Chen[3]

ABSTRACT

The impact factor (IF) of a journal, first proposed by Garfield has evolved over the years as an evaluation tool for comparing scholarly journals. Over the past few decades, the utilization of IF has extended beyond the tool for acquisition of journals in libraries and proxy for quality and importance of published journals. Nowadays, IF has been widely used as a surrogate for article quality, assessment of individual researcher's achievement, criteria to secure tenure and job promotion, as well as evaluation tool for the application of research grant or funding. This review addresses the historical perspective of IF and its evolution, the controversial issues leading to the manipulation by journal editors or authors, and followed by some of the interventions to overcome the manipulations and controversies. IF itself has many drawbacks and shortcomings worth addressing as they will lead to bias as a citation index. The scientific community should pay attention to call for a better citation metric which will prove to be an improved yardstick of science. This paper also covers on other citation metrics and their emerging usages as parameter for evaluation of scientific publication quality.

Key words: Impact factor, bibliometry, citation metrics.

INTRODUCTION

Conceived from the seed of an innocent idea for a simple method to compare journals in 1955, Dr Eugene Garfield devised the concept of impact factor (IF)[1]. He firstly referred to the concept of citation index for sciences in his paper Citation Indexes for Science: A New Dimension in Documentation through Association of Ideas published in Science[2]. He was the founder of the Institute for Scientific Information (ISI) in Philadelphia, Pennsylvania which is today part of Clarivate Analytics[3,4].

The IF was first used to select journals for the Science Citation Index (SCI) in 1961. Commencing in 1975, the IF was incorporated into the newly developed Annual Journal Citation Reports (JCR)[5-7] which has since been drawing information from the Web of Science database with close to 150 million records from 33,000 journals from 2014[5].

This paper attempts to depict the IF and its impact, specifically to highlight the uses and misuses of IF, the limitations and drawbacks arising from the utility of IF, the condition of "impactitis" (obsession with IF) and interventions in overcoming it, as well as other emerging citation metrics and their usage in evaluation of relative importance and quality of published articles.

The derivation of impact factor

Fundamentally, IF depicts the average number of citations in a particular journal over a specific period6. It consists of a group of numerical digits and is a measure of frequency with which the articles in a journal have been cited during the previous two years divided by the number of published articles[8-10].

By calculation, the impact numbers are derived from the total number of citations a journal receives in a given year to all articles published in that journal for the preceding two years (numerator) divided by the total number of substantive articles the journal published in those previous two years (denominator)[8-10].

For example, suppose that Journal X has published 30 and 20 source items in the years 2015 and 2016 respectively. These source items have received respectively 40 and 60 citations in 2017[11]. The calculations are summarised as follows:

The impact factor of Journal X for 2017

$$= \frac{\text{Total citations in 2017 to articles published in 2015-2016 for Journal X}}{\text{Number of total citable articles published in 2015-2016 for Journal X}}$$

$$= \frac{40 + 60}{30 + 20}$$

$$= 2$$

[1]Institute for Research, Development, and Innovation, International Medical University, No. 126, Jalan Jalil Perkasa 19, Bukit Jalil, 57000 Kuala Lumpur.
[2]Clinical Campus Seremban, International Medical University, Jalan Dr Muthu, Bukit Rasah, 70300 Seremban, Negeri Sembilan.
[3]School of Medicine, International Medical University, No. 126, Jalan Jalil Perkasa 19, Bukit Jalil, 57000 Kuala Lumpur.
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Corresponding Author:
Ms Lai Pei Kuan, Institute for Research, Development, and Innovation, International Medical University, No. 126, Jalan Jalil Perkasa 19, Bukit Jalil, 57000 Kuala Lumpur.
Tel: 03-27317044 Fax: 03-86567299 Email: LaiPeiKuan@imu.edu.my

As the number of published articles increases in leaps and bounds over the years, IF is now calculated with integers displayed up to three decimal places, e.g. 2.588. This was justified by Garfield as a crucial move to create a unique system[12] to overcome the issue of journals listed with identical IFs[13]. The IF portrays some interesting features. It is a pure number but not a constant and does not have any unit. It is not only year-specific, but also database- and subject-specific.

Utilization of the impact factor

Although IF was originally designed to provide information about the citation performance of a journal[5], IF has gradually evolved for use as a proxy for the relative importance and measure of scientific quality of research in an article[6,13]. Basically, to sum it up, the IF has become an important metrics for authors, researchers, universities, funding agencies, grantsmanship, decision-making bodies, editors, and publishers. Besides, IF is also increasingly used for tenures and promotions of academics as well as for budget and resource planning within universities, research institutions, and colleges.[9,14]

Currently IF is used as a benchmark to select and deselect journals for acquisition in a library based on a ranked IF list[6,12,15,16]. The journals at the top of the ranked list will be included in a library database whilst those at the bottom of the list usually will be deselected considering budget constraints and various other factors[17].

Due to the impact of IF on scholarly writing, it is a common practice for the academics to select high IF journals to publish their treasured works[17]. In a report by Wang[18], most of the researchers opined that they would prefer to publish their papers in SCI journals for various reasons which included: better curriculum vitaes, indicator of their scientific activity, deemed prestigious, and indicator of greater scientific merit[19].

There are concerns when young researchers especially graduate students, post-doctoral fellows and junior faculty clamouring to move up the academic ladder and seeking to be visible in their institutions, choose to publish papers that draw attention to a greater readership in view of the subject of interest rather than where their traditional strength lies[18]. For instance, an engineering faculty may desire to do research and publish in the area of biomedical sciences! This emerging trend leads to low quality of research and publication as the subject of interest is not his area of expertise.

Having said that, some senior tenured researchers were ready to compromise with this practice and still valued their papers being published in non-SCI journals[18]. Publications of even good research material in non-indexed journals were assumed acceptable if they were included in PubMed and searchable[18]. Some researchers who have been relatively established in their academic career would welcome publishing in non-SCI journals but voiced their concern for students who were still struggling to get a job or promotion[18].

In spite of the good reputation that IF has gained since its conceptualisation, there are increasing concerns of its inappropriate use and in ways not originally envisaged by its developer[20,21]. Sadly, many scientists have also acquiesced in such misuse of IF. The misuse warrants closer attention with an increasing number of articles appearing in the media addressing concerns of "manipulation" of the original intention of using metrics to rank scholarly journals[12].

IF is also one of the impetuses behind the "Publish or Perish" culture plaguing the academia today. Many researchers particularly those from the academia are pressured to publish papers in high-impact, peer-reviewed journals in order to meet the institutes' Key Performance Indicators (KPIs). To quote an example, in September 2017, a prestigious university in Malaysia had unethically forced their academicians to cite their colleagues in their research papers to raise the university ranking resulting in the phenomenon "citation stacking"[22,23]. Some institutions such as Sifa University in Turkey have started implementing a reward system to reward the researchers with prizes for publishing in high IF journals[18]. In South Korea, China, and Pakistan, the scientists are rewarded with cash if their papers

get published in high impact journals such as Nature, Science, and Cell[16]. For instance, Zhejiang Chinese Medical University awards papers published in Nature or Science with 100,000 RMB[24].

In many institutions such as Nizam's Institute of Medical Sciences in India, academic performance of a researcher is assessed with publications in indexed journals being the minimum requirement for appointment as faculty as well as for promotion[18]. Meanwhile, governmental research funds and institutions in Moscow, Russia, also used journal IF and ISI citation as a criterion to evaluate the quality of the project and individual researcher outcome[18]. This practice may cause adverse academic consequences. Faculty from fields like Forensic Medicine may be disadvantaged during job promotions for clinicians in one institute in India who have publications appearing in Lancet as opposed to that appearing in reputed journal of Forensic Medicine like *American Journal of Forensic Medicine and Pathology* with impact factor of 39.06 vs 0.883[25].

Researchers who achieve higher IF appear to have a better chance to obtain research grants[18,26,27,28]. In addition to that, a journal's IF has also become a surrogate and proxy for the relative quality of published articles. Using the journal's average citation impact instead of the actual article impact means that the article is graded by the prestige of the journal involved[29]. Opinions vary as to how the quality of each paper should be evaluated. Clearly the quality of each paper should be evaluated by its contents and not by the name of the journal publishing the papers. One should not give credit to a low quality paper because it is published in top journals like IEEE Trans Med Imaging[18].

Limitations of impact factor

IF has its own limitations and drawbacks that are worth addressing[16]. When Garfield first mooted the idea of IF, it never dawned on him that it would become a subject of widespread controversy[1,30]. The usage of IF as a bibliometric indicator has stirred debates amongst the scientific community whether its usage is appropriate.

Since IF is derived from the total citations to the articles of a journal, it cannot serve as a statistical representative of individual journal articles[31,32] and all articles in the same journal are assumed to be of a similar quality. Moreover, the IF does not reflect how well read or discussed a journal is outside the core scientific community and the impact of the paper on health policy[33].

Besides that, IF does not necessarily reflect the true contribution of each researcher in their individual field. Maurea S remarked that Web of Science may be merely an approximate method and it works in such a way that the significance of IF evaluation is not absolutely related with the major or minor role of an author in a research group[18]. Hence, it can only depict the scientific value of a paper, but not the individual value of the single author.

IFs, when used in the ranking of medical and biological research journals, portray strong favouritism towards high-profile disciplines with rapid turnovers such as molecular biology or biochemistry but do injustice to low-profile disciplines such as anatomy and histology[19]. Within medical research itself, basic research in medicine is cited three to five times more than clinical medicine[34]. Biochemistry and molecular biology articles were cited about five times more often than pharmacy articles[35]. Similarly, basic science research tends to be cited more often than applied science as applied science is heavily dependent on basic science[36]. On the contrary, journals in the field of Forensic Medicine have fairly low IF due to smaller size of the field, fewer active researchers, and less pressure to publish[25]. Therefore, it is rather difficult to compare achievements of medical researchers in different disciplines.

Oei[18], who is a radiologist from Erasmus University Medical Center Rotterdam, The Netherlands, related his experience of comparison of IF across disciplines. Journals in radiology usually have a lower IF than those of their clinical counterparts. Therefore, the radiologists will normally end up with lower scores than the clinical specialists when they apply for a cross-disciplinary grant such as The Netherlands Organisation for Scientific

Research (NOW), the Dutch equivalent. In addition, articles published in non-radiological journals will not be counted as it is considered "outside their own discipline"[18].

Language is another factor affecting the IF as journals that are published in English reportedly have higher IFs than those in other languages[19]. Study by Paiva et al.[37] remarked that the likelihood of English articles being published in a high IF journal was 2.85 factors higher (95% CI, 1.24-6.54, p=0.014; CI: confidence interval). As English dominates international research and clinical literature1, domestic papers such as those in Japanese are even excluded in ISI journals[18].

Open access journals tend to be cited more and have higher IFs as well[38]. In a randomised controlled trial conducted by Davis et al., it was reported that as compared to the subscription-based journals, open access journals had 89% more full text downloads and 42% more PDF downloads in the first six months after publication[39], and are twice as likely to be cited 4 to 10 months after publication and almost three times as likely between 10 and 16 months[40,41,42].

Playing the impact factor game

The concept of 'playing' the impact factor game has slowly crept into publications with editors 'massaging' the IFs or artificially raising its value[34] as the 'impact factor game' takes place. In fact, Georg Franck saw it coming that scientists will find ways to game the IF system when their 'success' depends too heavily on citation count[43].

One of the manipulations is self-citation whereby some editors may request the authors to cite other papers published in the previous two years in the same journal to increase its own IF[11,16,32,40]. Nonetheless, self-citation up to a rate of 20% is acceptable by Thomson Reuters but beyond 20% is considered as suspect of abuse[7,44].

Another strategy to increase the value of IF is to publish as many review articles as possible, which sum up the current state of research on a particular topic from different studies[6,32]. Review articles generally have higher or inflated IFs due to its higher possibilities to be cited, having compilations of large numbers of citations, and being used as a substitute for earlier literature[7,18,45,46]. Similarly, articles on methodology or procedures and protocols also get more citations than other papers[47].

Some journals also try to increase the IF by including non-source items in the journal including editorials, correspondence, letters to the editors, perspectives, news items, abstracts, commentaries, interviews, tributes, and even obituaries[13]. Unlike the 'source items' or 'citable items' like original articles, editorials, letters, short communications, reviews, and proceedings, the 'non-source items' are non-substantive source articles and should not be included in the denominator of the IF ratio calculation. Nonetheless, it is worth noting that all citations of these non-source articles are eligible for inclusion in the numerator which ultimately increases the value of IFs[6].

Timing is also another factor that could affect the IF. As the IF has a period of 2-year citation window[45] or simply put, the IF only measures the influence of an article during the first two years after publication[48], many researchers actually target to get their papers published in the early months of the year. Just imagine, a good paper published in January has 11 months longer to be cited compared to the papers published in December of the same year[7,49]. The 2-year period was chosen as it was perceived to reflect peak citation activity for high-impact articles[50]. In addition, journals in rapidly growing research fields, such as systems biology and bioinformatics, tend to publish papers within a short time interval thus achieving higher IF[34].

Furthermore, it is preferable for journals to publish long articles because longer articles tend to have higher citation rate[51]. Besides, journals from research fields which are dynamic and having literature that rapidly becomes obsolete are also favoured[32,46]. This group of journals tend to record higher IF owing to higher publication activity and short publication lags. Short publication time lag also leads to many short term

journal self-citation contributing to higher journal IF[32]. Examples are biochemistry and molecular biology journals.

Some researchers encourage the tactic of "salami slicing", whereby separate yet similar pieces of single dataset are published across multiple papers[52]. Research data and manuscripts are broken into many "least publishable units" so that more articles can be published out of a single study. This method also encourages self-citations which ultimately also increases the IF[7]. On a single project for a research fellowship from the Boehringer Ingelheim Fonds (BIF), the applicants had published from 1 to 16 articles and the results of a regression model showed the multiple publications of research findings led to higher total citation counts[53].

These 'manipulation games' have unwelcome results in the academic world which result in too much emphasis on IF of publications. Journal is designed for citing rather than reading leading to everything readable and entertaining is cut in favour of citable materials[54].

Interventions to overcome obsession with IF

Over time, the scientific community has portrayed the obsession with IF as a medical condition, sometimes referred to as "impactitis" or "IF mania". The consequence of this "medical disease" is that scientists are too focused on high-impact academic works leading to misuse which will adversely affect or even impede scientific progress. Clearly there is a need for some remedial measures.[10]

As English language has become the lingua franca in science and papers published in English language have dominated high-impact journals, the modern academic researchers should rectify this situation so that language would not pose as a barrier for the journals to achiever high IF. The scientific community has been urged to find more ways to include more non-English language journals in the SCI such as translating non-English articles[55]. However, this issue warrants the editors to look into the cost-effectiveness of getting the translations done.

Besides, some editors from the non-English-speaking countries have made the strategic decision to publish bilingual editions of articles in both the native language of their country and English[56]. For instance, editors from journals such as Clinical Medicine in Europe and Latin America have widely adopted this strategy[56]. On top of that, journals such as the Public Library of Science (PLoS) have also adopted the use of open systems allowing authors of non-English-speaking countries to send a version of the articles in their native language as complementary material (supporting material) in addition to the English version[56].

Albeit IF is relatively vital in depicting the importance and impact of a publication, scientists should really stop judging science based on the publication venue[10]. Academic institutions should also reduce emphasizing on journal citation metrics for employment and career advancement. Journal club members should diversify the articles selections by including the low-IF yet interesting articles to facilitate discussions. [10]

Some research institutions have set up journal clubs typically involving review, discussion, and critique of selected scientific papers. It is believed that journal clubs help to train young scientists and provide information to the participants about new developments in science. Most of the time, journal clubs are dominated by articles from high impact journals. The journal club members should diversify the journal club selections by including also the interesting articles from more specialised society journals which might help to improve journal club discussions. [10]

Perhaps the scientific community should be more educated and well-informed about the misuse of the IF by incorporating IF in the curriculum of ethics courses as well as seminars on publication ethics for established scientists, postdoctoral fellows, and research staff. Topics which should be discussed include the rampant misuse of IF, the calculation of IF, the limitations of IF as indexing metrics, the influences of IF in scientists' behaviours, and the manipulation of IF in the gaming system.

Some debates on the impact factor

The scientific community has the majority voice that the benefits of IF outweigh the harms it brings and it is nonetheless still the best available tool currently[18]. Egorov V.I and Choi Y[18] strongly agreed that IF serves as an objective tool and explicit evaluation criterion to evaluate a researcher's achievements. Chung H-W opined that papers published in the absence of IF can conveniently come with hidden truth as compared to papers published with IF which often entails an entire team increasing the transparency to the public[18].

Nevertheless, some suggestions have been given by the researchers on how the IF can be improved[18]. Wang remarked that a more comprehensive approach with some conversion factors and other complementary measurement methods should be developed to allow cross-discipline comparisons[18]. Kuyumcu S advised that some kind of per paper statistical evaluation tool should be used as evaluation method so that every paper can have its own score[18]. On top of that, there has been suggestion to use Google citation as a tool for per paper evaluation[18].

Other bibliometric indicators

Owing to the controversies and limitations of using a single metric alone, many other alternative bibliometric indicators have been proposed[57]. To name a few, the list includes cites per doc. (2 years), CiteScore, citation analysis, H-index, Article Influence Score (AIS), PageRank algorithm, SCImago Journal Rank (SJR), Source Normalized Impact per Paper (SNIP), and Eigenfactor Score.

CiteScore was created by Scopus and launched by Elsevier in 2016[58]. CiteScore is derived from the number of citations received by a journal in one year to documents published in the three previous years, divided by the number of documents indexed in Scopus published in those same three years[58]. In comparison with IF, the calculation of CiteScore is based on Scopus data while IF is based on Web of Science data. CiteScore is based on a 3-year citation window while IF adopts a 2-year citation window. Last but not least, CiteScore incorporates all document types indexed by Scopus including articles, reviews, letters, notes, editorials, conference papers and *etc*. while IF only includes source items which are citable, namely articles and reviews. In addition, CiteScore is well-received amongst the scientific community due to its user-friendliness, comprehensive coverage of more than 22,000 titles on Scopus, transparency of underlying data, as well as its free-access status.

Besides, *H-index*, also known as Hirsch index, was invented by Jorge E. Hirsch who was a physicist at University of California (UCSD) in 2005[45,59,60]. This index corresponds to the number 'h' of articles by an author that have been cited 'h' times[9]. For instance, a researcher with an h-index of 5 would have published 5 papers with each cited by others at least 5 times[60]. Compared to IF, H-index does not take into account of outlier publications which contribute to a skewed picture of a researcher's impact. Also, H-index helps the non-experts to evaluate other researchers in their field due to its transparency nature. It is noteworthy to highlight a limitation of H-index in which the indicator does not discriminate between the impact of principal authors and co-authors[61]. This is because a researcher who has never been a principal author may appear in many papers as co-author and thus, may have a very high H-index.

Apart from CiteScore and H-index, there are many other alternative bibliometric indicators for active consideration. Another indicator, for instance, that can be used to evaluate the impact of a researcher is the Total Citations received for the past 5 or 10 years based on Google Scholar. However, it is not the focus of this paper to discuss each and every one of the indicators.

CONCLUSIONS

The value of IF and its position as the dominant metric cannot be denied despite its drawbacks and shortcomings. Essentially, it is not the IF itself, but

how the researchers and other stakeholders including grant bodies as well as university tenure and promotion committee utilise it judiciously. Users of IF should bear in mind the limitations of IF and do not over-interpret data from their analyses. There are also emerging trends to 'manipulate' its significance and this 'manipulation game' should be stopped. Researchers should consider the vital factors or alternatives as well as the language involved. Lastly, academic promotions should take note of the factors as mentioned and not solely rely on IF alone. The scientific community should focus on the quality and contents of the articles and not on judging an author by the journal's impact factor. Conclusively, impact factor should not be used as a yardstick to define the success of a journal.

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