Mj. Int. J. Sci. Tech. **2008**, *02* (02), i-vi

Maejo International

Journal of Science and Technology

ISSN 1905-7873

Available online at www.mijst.mju.ac.th

Invited Article

Journal impact factors--their use and misuse

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Received: 26 May 2008 / Published: 13 June 13, 2008

Abstract: With increasing importance being attached nowadays to doing research and writing papers for publication, the question of journal selection arises. Apart from the obvious criterion of choosing a journal which corresponds with the subject area of the paper, it has become fashionable to use the ***journal impact factor*** as a criterion for selection. Indeed, it is almost as though the value of the impact factor is becoming more important than the journal itself. But what exactly is this "impact factor" and how useful is it?

Historically, the idea of an impact factor was first mentioned by Eugene Garfield in *Science* magazine in 1955 [1]. That paper is considered to be the primordial reference for the concept of what we know today as the ***Science Citation Index***. Some years later, in the early 1960s, Garfield and Irving Sher created the ***journal impact factor*** to help select journals for

the new Science Citation Index. The impact factor was based on 2 elements: the ***numerator***, which is the number of cites in a given year to articles published in the journal in the previous 2 years, and the ***denominator***, which is the number of articles published in the journal in the same previous 2 years. Thus, a journal's impact factor for 2007 would be:

$$\text{Impact Factor 2007} = \frac{\text{number of cites in 2007 to articles published in 2005} + 2006}{\text{number of articles published in 2005} + 2006}$$

Nowadays, both journals and publishers alike attach great importance to their impact factors. If they are high enough, they use them for promotional purposes. This is a far cry from Garfield's original intention. At the *International Congress on Peer Review and Biomedical Publication* in Chicago, USA, in 2005, Garfield reflected on the past 50 years since his original idea and commented:

"In 1955, it did not occur to me that "impact" would one day become so controversial. Like nuclear energy, the impact factor is a mixed blessing. I expected it to be used constructively while recognizing that in the wrong hands it might be abused."

During its lifetime, the impact factor has gradually evolved into being an indicator that now far outweighs its intended purpose. For example, it now influences research assessments, grant applications, and even staff promotions in ways that Garfield could never have imagined. Even in its main role as an index of journal impact, its value is often overstated. I have heard it said, even by respected academics, that journals with impact factors of less than 1 are not worth considering for publication. But the fact is that there are many high quality journals in the fields of science, technology and engineering with impact factors of less than 1. Our Polymer Research Group, for example, has just had a paper published in the journal *International Polymer Processing* which is generally regarded as being one of the leading journals for the polymer industry worldwide, yet it has a 2006 impact factor of 0.563. This is because some journals, especially industry-related journals, tend to publish a proportionately larger number of articles (the denominator) that are general interest rather than research articles and which tend not to be cited (the numerator). Other journals simply publish in specialist areas that are well read by a particular community but are also not well cited. This skewness of citations amongst journals is well known and is one of the main arguments used by critics of the impact factor.

In addition to the impact factor, there are two other indicators created by the Institute of Scientific Information (ISI) which are used to measure how a journal receives citations to its articles over time. These are the so-called ***immediacy index*** and the ***cited half-life***. The immediacy index is a measure of how quickly items in a journal get cited after publication, while the cited half-life is a measure of how long articles in a journal continue to be cited after publication. However, neither the immediacy index nor the cited half-life is as commonly used as the impact factor. Consequently, this article focuses its attention on the impact factor and the extent to which it is used or misused as the case may be.

One of the least appreciated, or simply misunderstood, features about the impact factor is how variable it is with respect to both sociological and statistical factors [2]. Sociological factors include the subject area of the journal, the type of journal (letters, full papers, reviews), and the average number of authors per paper (which is related to subject area). Statistical factors include the size of the journal and the length (years) of the citation measurement window (usually 2 years but sometimes as long as 5 years). Some examples of how these various factors affect a journal's impact factor and the precautions that should be taken in making comparisons are listed below:

- ***Subject Area*** - Generally, fundamental and pure subject areas have higher average impact factors than specialized or applied ones. Indeed, this variation can be so great that the top journal in one field may have a lower impact factor than the bottom journal in another field. To refer back to the previous example, it is meaningless to compare the 2006 impact factors of *International Polymer Processing* (= 0.563) with, say, the *Journal of Organic Chemistry* (= 3.790) or even the *Journal of Polymer Science, Part A: Polymer Chemistry* (= 3.405). Comparisons of impact factors should only be made for journals in the same subject area.

- ***Multiple Authorship*** - The average number of authors per paper also varies according to subject area, from the social sciences (about 2) to the fundamental life sciences (about 4). Given the tendency of authors to cite their own work, it is therefore not surprising that journals in subject areas with a higher average number of authors per paper have higher average impact factors.

- ***Article and Journal Type*** - Even within the same subject area, there are significant variations in impact factor due to article and journal type. For example, review journals invariably have higher impact factors than other types of journals simply because review articles attract more citations and review journals publish relatively fewer articles.

- ***Journal Size*** - Journal size in terms of the number of articles published per year is a statistical factor that affects the extent to which the journal's impact factor varies from year to year. As would be expected, the smaller the number of articles, the greater the variation. It has been estimated that, year to year, the impact factors of smaller journals (< 35 articles per year) vary on average by more than ± 40%, whereas those of larger journals (> 150 articles per year) vary only by around ± 15% [2]. This does not mean that smaller journals are less consistent in their standards. It simply means that the impact factor of a smaller journal needs to vary more than that of a larger journal to be statistically significant. Thus, small increases in impact factor from one year to the next are often statistically insignificant, despite what journals and publishers may say. As a rule of thumb, it can be considered that journals in the same subject area with impact factors that differ by less than 25% belong together in the same rank.

- ***The Numerator/Denominator Problem*** - Since the impact factor is a ratio, clear and unambiguous definitions for the top (numerator) and bottom (denominator) terms are essential. But what exactly counts as a paper? Do letters to the editor or editorials or "Viewpoint" articles such as this count? ISI classifies papers into various categories such as research articles, reviews, proceedings papers, editorials, letters to the editor, news items, etc. Whereas only those classified as research articles, reviews and proceedings papers are counted in the denominator, citations to all papers (including editorials, letters to the editor and news items) are counted for the numerator. This can lead to an exaggerated impact factor, but more so for some journals than others. For example, letters to the editor in medical journals (which are not "letter papers" in the sense used in physical science journals) often attract lively debate resulting in significant numbers of citations, thus enhancing the numerator without adding to the denominator. This so-called "numerator/denominator problem" is yet another example of why considerable care needs to be taken when using impact factors.

With these observations in mind, we can now return to the title of this article: ***Journal Impact Factors – Their Use and Misuse***. It is fair to say that, over the years, journal impact factors have been the subject of much debate which has given rise to many conflicting opinions. Hoeffel [3] expressed an opinion shared by many that:

"Impact Factor is not a perfect tool to measure the quality of articles or journals but there is nothing better and it has the advantage of already being in existence and is, therefore, a good technique for scientific evaluation. Experience has shown that in each specialty the best journals are those in which it is most difficult to have an article accepted, and these are the journals that have a high impact factor. Most of these journals existed long before the impact factor was devised. The use of impact factor as a measure of quality is widespread because it fits well with the opinion that we have in each field of the best journals in our specialty."

Personally, I would not disagree with this view. The system is clearly not perfect but it is the best that we have. Some observers, including librarians, have argued that the numerator (number of cites) in the impact factor calculation is much more relevant to a journal's "impact" than the denominator (number of articles). Therefore, why not weight them differently or just ignore the denominator completely and consider only the number of cites. They claim that this would also bring review journals more into line with research journals since the high impact factors of review journals are artificially enhanced by the relatively low number of articles that they publish. The detailed arguments for and against impact factors are too numerous to mention here. Suffice it to say that it is not so much their "use" as their "misuse" (some would say "abuse") which is the main cause for criticism.

Returning to the theme of journal selection, it was mentioned at the start of this article that there is a growing trend for aspiring authors to select journals primarily by impact factor rather than journal content. In my opinion, while the impact factor is certainly important, it should not be the prime consideration in journal selection. The prime consideration should be the suitability (in terms of content and style) of the journal itself for the subject matter of the paper. Not only does this enhance the paper's chances of being accepted, it also ensures that it will be read by fellow workers in the same specialist field. Going for a higher impact factor in a less suitable journal only increases the risk of rejection.

In conclusion, journal impact factors are undoubtedly useful if used constructively. Until someone comes up with a better idea, they are here to stay for the foreseeable future, probably with some fine adjustments along the way. Since the idea of an impact factor was first introduced in 1955, it has undergone an amazing transformation from being an obscure bibliometric indicator to being the chief quantitative measure of the quality of a journal. However, when impact factors start being used to assess the quality of research work, the researchers who wrote the paper, and even the institution in which they work, we are entering dangerous territory. Impact factors are certainly useful as indicators of the influence that a particular journal has within in its own subject area, but they are not direct measures of research quality. With this in mind, we should accept the limits of their usefulness and be extremely careful not to venture into areas where they can be misused.

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