Malaysian Journal of Library & Information Science, Vol.4, no.2, December, 1999: 41-46

CHANGES IN IMPACT FACTOR

B.K. Sen
Faculty of Computer Science and Information Technology
University of Malaya
50603 Kuala Lumpur, Malaysia
E-mail:bksen@fsktm.um.edu.my

ABSTRACT

Enumerates some conditions that affect the impact factor of a standard research journal to undergo change. Shows with mathematical proof that the impact factor of a journal will tend to increase or decrease with the increase or decrease in the number of standard research journals covered by a database, or with a substantial change in the composition of content of a journal. The inclusion of more articles of higher citation generation potential will tend to increase its impact factor and lower citation generation potential will tend to bring it down.

Keywords: Impact factor, Citations.

INTRODUCTION

Dr Eugene Garfield, the founder of the Institute of Scientific Information, Philadelphia PA and also of the various citation indexes, conceived the term 'impact factor' way back in 1955 while developing a plan for the launching of a citation index. With the publication of *Journal Citation Reports (JCR)* in 1975 by the aforesaid Institute, the impact factor found profound application. The impact factor is a ratio of citations received by a journal in a particular year on its source items published during a fixed period in the immediate past to the number of aforesaid source items. It is to be noted that the impact factor provided by *JCR* takes into account the source items of the previous two years while computing the impact factor of journals.

Mathematically, the impact factor can be expressed as follows:

$$I_{f(j)} = \frac{C_1 + C_2}{S_1 + S_2} \qquad (1)$$

Where: $I_{f(j)}$ = Impact factor of the journal J for the year Y,

S_1 = The number of source items published in the journal J in the year Y – 1

S_2 = The number of source items published in the journal J in the year Y – 2

C_1 = The number of citations received by S_1 source items in the year Y, and

C_2 = The number of citations received by S_2 source items in the year Y.

With a concrete example, the impact factor can be explained as follows, *Journal of Documentation (J Doc)* published 18 and 13 source items in 1988 and 1989 respectively. The source items received

respectively 10 and 9 citations in the year 1990. Therefore, the I_f of *J Doc* for the year 1990 is:

$$I_{f(J\ Doc)} = \frac{10 + 9}{18 + 13} = 0.613$$

It is to be noted that the impact factor of a journal is database and year specific (Sen, 1999).

DEFINITION OF TERMS

Standard research journal (SRJ) (Symbol – J_x) – A journal that publishes only research articles, maintains timely schedule of publications; is devoted to a particular field of knowledge, say K: well known amongst the research scholars in the world; cited internationally by journals belonging to its own field, allied fields, and alien fields; and its age is not less than three years. Unless otherwise specified, the term research journal means SRJ in this article.

Core journal – A journal that belongs to the first zone of Bradford distribution (Bradford, 1934).

Allied journal – A journal that belongs to the second zone of Bradford distribution.

Alien journal – A journal that belongs to the third zone of Bradford distribution.

Source item – An item published in one of the journals processed for a citation index. Source items include original articles, editorials, letters, reports of meetings, correction notes, reviews, etc. (*SCI,* 1996). Book reviews and news items are not source items. *Synonyms* – citable item, source document, source article.

Source journal – A journal processed for a citation index.

Y – The calendar year for which the impact factor of a journal is calculated.

Citation generation potential (CGP) – The capability of an article to generate citation.

CHANGES IN IMPACT FACTOR

Axioms

(i) The CGP is different for different articles and its value is ≥ 0.

(ii) The number of citations received by an article will vary from year to year and its value will be ≥ 0.

(iii) The number of articles included in a particular journal will also vary from year to year.

Basic Premise

The database D determining the impact factor of journals contains the required data pertaining to selected research journals as well as review journals.

Taking all the factors into account, considered as axioms and premise we shall show mathematically, that the impact factor of a journal in almost all cases will vary from year to year even if the number of journals covered by the database remains the same over the years, provided the average CGP of the articles included in the journals is not equal to 0.

We know from equation 1 that the impact factor of the journal J, for the year Y = $(C_1 + C_2) / (S_1 + S_2)$. Let us derive the impact factor of J_x for the year Y + 1. Now we are to consider the source items published in J_x in Y – 1 year and Y year.

We have, S_1 = The number of source items published in the journal J_x in the year Y – 1, and suppose:

S_3 = The number of source items published in the journal J_x in the year Y,

C_3 = The number of citations received by S_1 source items in the year Y + 1, and

C_4 = The number of citations received by S_3 source items in the year Y + 1

Hence $I_{f(Jx)}$ for the year Y + 1=$(C_3 + C_4) / (S_1 + S_3)$. (2)

For the value of $I_{f(Jx)}$ to be equal for the years Y and Y + 1, $(C_1 + C_2) / (S_1 + S_2)$ will have to be equal to $(C_3 + C_4) / (S_1 + S_3)$. It is possible when the value of $(C_1 + C_2) = (C_3+C_4)$; and $(S_1+S_2) = (S_1 + S_3)$.

According to axioms $S_1 \neq S_2 \neq S_3$ and $C_1 \neq C_2 \neq C_3 \neq C_4$. Hence, the impact factor for the year Y and Y + 1 will be different. The probability of $(C_1 + C_2) = (C_3 + C_4)$; and $(S_1 + S_2) = (S_1 + S_3)$ is not absolutely zero. But, such occurrences will not be many and may be considered as exceptional.

In another case, when $C_1 + C_2 = x (C_3 + C_4)$ and $S_1 + S_2 = x (S_1 + S_3)$, the impact factor of a journal for two consecutive years will be equal. Such a case is also unlikely to be very common.

Changes in Impact Factor with the Change in the Coverage of a Database

Basic Premise

Citations received by J_x in Y year follow Bradford's law (1934).

For making the calculation simpler, let us write the equation 1 as:

$I_{f(Jx)} = C_n / S$ (3)

Where $C_n = C_1 + C_2$ and $S = S_1+S_2$.

The numbering of citing journals accounting for C_n citations is $\alpha + \alpha x + \alpha x^2$, where α, αx, and αx^2 respectively represent the numbers of core, allied and alien journals. The expression $\alpha + \alpha x + \alpha x^2$ represents the subset of the universal set of journals citing J_x in the year Y. Hence, α number of core journals, α x number of allied journals, and αx^2 number of alien journals each account for $C_n/3$ number of citations.

Case 1 – The number of core journals pertaining to the field K is increased by n, keeping the number of allied and alien journals constant. Now, the total number of core journals of field K is α + n. The addition of n core journals to the database contributes roughly n $C_n/3\alpha$ citations to the tally of J_x taking the total to $C_n + nC_n/3\alpha = C_n(1+n/3\alpha)$.

Therefore, $I_{f1}(J_x) = C_n(1+n/3\alpha)/S$ (4)

Case 2 – The number of allied journals pertaining to the field K is increased by n, keeping the number of core and alien journals constant. Now, the total number of journals allied to the field K is αx +n.

The addition of n allied journals to the database contributes roughly $nC_n/3\alpha x$ citations to the tally of J_x taking the total to $C_n + nC_n/3\alpha x$ $C_n(1+n/3\alpha x)$.

Therefore $I_{f2}(J_x) = C_n(1+n/3\alpha x) / S$ (5)

Case 3 – The number of alien journals pertaining to the field K is increased by n, keeping the number of core and allied

journals constant. Now, the total number of journals alien to the field K is $\alpha x^2 + n$.

The addition of n alien journals to the database contributes roughly $nC_n/3\alpha x^2$ citations to the tally of J_x taking the total to $C_n + nC_n/3\alpha x^2 = Cn(1+n/3\alpha x^2)$.

Therefore $I_{f\,3}(J_x) = C_n(1+n/3\alpha x^2) / S$ (6)

Now, we have four impact factors, e.g.

(i) $I_{f(Jx)} = C_n /S$,
(ii) $I_{f1}(J_x) = C_n(1+n/3\alpha) / S$,
(iii) $I_{f2}(J_x) = C_n(1+n/3\alpha x) / S$, and
(iv) $I_{f3}(J_x) = C_n(1+n/3\alpha x^2) / S$.

Multiplying the right hand side of the above equations with S/C_n, we get 1, $(1+n/3\alpha)$, $(1+n/3\alpha x)$, $(1+n/3\alpha x^2)$. Here, the value of α, n and x are all positive and greater than one. The values of α and n are whole numbers. Sometimes, the value of x may be fractional. Hence, $(1+n/3\alpha) > (1+n/3\alpha x) > (1+n/3\alpha x^2) > 1$. Therefore, $1_{f\,1}(J_x) > 1_{f\,2}(J_x) > 1_{f\,3}(J_x) > 1_{f\,1(Jx)}$

The result leads to the conclusion that the impact factor of the journal J_x, will rise with the addition of core, allied and alien journals to the field to which J_x belongs. The rise in the impact factor will be high, medium or low respectively with the addition of core, allied journals provided their respective numbers remain the same.

Conversely, if we reduce n number of journals in each of the three cases mentioned above, then the equations (i) to (iv) will take the following shape;

(v) $I_{f(Jx)} = C_n /S$,
(vi) $I_{f1}(J_x) = C_n(1-n/3\alpha) / S$,
(vii) $I_{f2}(J_x) = C_n(1-n/3\alpha x) / S$, and
(viii) $I_{f3}(J_x) = C_n(1-n/3\alpha x^2) / S$.

Multiplying all the equations with S/C_n, we get 1, $(1-n/3\alpha)$, $(1-n/3\alpha x)$, and $(1-n/3\alpha x^2)$. Considering the value of α, x and n as above, we get $(1-n/3\alpha) < (1-n/3\alpha x) < (1-n/3\alpha x^2) < 1$. Therefore, $1_{f\,1}(J_x) < 1_{f\,2}(J_x) < 1_{f\,3}(J_x) < 1_{f(Jx).}$

The result leads us to the conclusion that the impact factor of the journal J_x, will fall with the deletion of core, allied and alien journals to the field to which J_x belongs. The fall in the impact factor will be high, medium or low respectively with the addition of core, allied and alien journals provided their respective numbers remain the same.

Changes in Impact Factor with the Change in the Composition of Content

Sometimes a research journal may start including some review articles as well or a research journal on physics may start including some papers on mathematics. This type of change in a journal is being referred here as the change in the composition of content.

Basic Premise

The citation generation potential differs from one type of article to another and also from one subject to another. The premise is based on the fact that on an average, the impact factor of a review periodical is found to be higher than that of a research periodical, and the impact factor of a physics periodical is higher than that of a mathematics periodical. This is evident not only from *Journal Citation Report* but also from our years of

experience at the National Centre on Bibliometrics at New Delhi.

Changes in the Types of Articles

Suppose, the journal J, was publishing only research articles till the year Y-3. From the year Y-2 it started including 80% research articles and 20% review articles. We call this journal as J_y. Both research and review articles pertain to the same subject K. In the year Y, the research articles and review articles published in the year Y-2 receive C_1 and C_2 citations per article respectively, and the articles published in the year Y-1 receive C_3 and C_4 citations respectively, where $C_2 > C_1$ and $C_4 > C_3$.

If the journal J, publishes 100 articles in a year, of which 80 are research articles and 20 are review articles, then the impact factor of the journal J_y in the Y year will be:

$$I_{f(Jy)} = \{80(C_1+C_3) + 20(C_2+C_4)\}/200 \quad (7)$$

On the other hand if the journal continues to publish research articles only, then in the year Y the impact factor will be:

$$I_{f(Jx)} = 100(C_1+C_3)/200 \quad (8)$$

Suppose $C_2 = C_1 + a$, and $C_4 = C_3 + b$, where both a and b are positive intergers. Putting the values of C_2 and C_4 in equation 7 we get:

$$I_{f(Jy)}$$
$$= \{80(C_1+C_3) + 20(C_1+a + C_3+ b)\} / 200$$
$$= \{80C_1+80C_3+20C_1+20a+20C_3+20b\}/200$$
$$= \{100C_1+ 100C_3 + 20a +20b\}/200$$
$$= (100C_1+ 100C_3)/200 + (20a +20b)/200$$
$$= I_{f(Jx)} + (20a +20b) / 200 \quad \Theta 100(C_1+C_3)/200 = I_{f(Jx)}$$

Hence $I_{f(Jy)} > I_{f(Jx)}$

From this, it is clear that the impact factor of a research journal will increase if it starts including a substantial number of review articles. Conversely, it can be shown that the impact factor of a review journal will decrease if it starts including a substantial number of research articles. Changes in impact factor may also be observed if a research journal starts including a substantial number of non-research articles, or a semi-research journal starts including more research articles.

Changes in the Subject of Articles

Similarly, it can be shown that if a mathematics journal starts including articles in physics in substantial numbers, the impact factor tend to be higher. Conversely, if a physics journal starts including a substantial number of articles on mathematics, its impact factor tend to be lower.

CONCLUSION

Now, we can draw the following conclusions. The impact factor of a journal tend to increase or decrease (i) with the increase or decrease in the number of standard research journals covered by a database, or (ii) with the substantial change in the composition of content. The inclusion of more articles CGP tend to increase its impact factor and lower CGP tend to bring it down.

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