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# Improved, extended, and total impact factor of a journal *

Florentin Smarandache[1,†]

1. Mathematics and Science Division, University of New Mexico,
705 Gurley Ave., Gallup, NM 87301, USA.
1. E-mail: ✉ smarand@unm.edu

**Abstract** In this short paper we recall the (Garfield) Impact Factor of a journal, we improve and extend it, and eventually present the Total Impact Factor that reflects the most accurate impact factor.

**Key words** Impact factor, Journal impact factor, Garfield impact factor, improved impact factor, extended impact factor, total impact factor.

**2020 Mathematics Subject Classification** 00A05, 00A06, 00A09, 00A64, 00A99.

## 1 Introduction

The Impact Factor (IF) or Journal Impact Factor (JIF), that is used today, was proposed by Eugene Eli Garfield (1925 –2017), an American linguist and businessman, the founder of the Institute of Scientific Information (ISI), Science Citation Index (SCI), and especially Journal Citation Reports (JCR). Among others the Impact Factor is computed since 1975 only for the journals registered in the database of the Journal Citation Reports (see [1]). We call it the Garfield Impact Factor (GIF) to distinguish it from the three new types of impact factors that we propose now, in order to improve, extend, and totalize the impact factors' formulas for a better accuracy of the citations of articles published in a specified journal.

## 2 Garfield impact factor

Let us consider a journal $J$ that started in the year $Y_1$. We want to compute its impact factor in the year $Y_2$, where $Y_1 < Y_2$, and the calculation is done in the year $Y_2 + 1$.
The Garfield IF of the journal $J$ for the year $Y_2$ is defined as follows:

$$IF_{Y_2}^{\text{Garfield}}(J) = \frac{C(Y_2,\ Y_2-1) + C(Y_2,\ Y_2-2)}{P(Y_2-1) + P(Y_2-2)}, \tag{2.1}$$

where $C(Y_2,\ Y_2-1)$ means the number of citations during the year $Y_2$ of the said journal's published articles during the previous year $Y_2-1$; $C(Y_2,\ Y_2-2)$ is similarly the number of citations during the year $Y_2$ of the journal's published articles during the past two years, i.e., $Y_2-2$ and $Y_2-1$. $P(Y_2-1)$ and $P(Y_2-2)$ represent the number of the journal's published articles during the years $Y_2-1$, and $Y_2-2$ respectively. $IF_{Y_2}^{\text{Garfield}}(J)$ is calculated for the next year $Y_2+1$.

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†Corresponding author Florentin Smarandache, E-mail: smarand@unm.edu

## 3 Flaws of the Garfield IF

We list the following flaws of the Garfield impact factor:

**a)** The number of citations of the journal's articles published in the year $Y_2$ and cited in the same year $Y_2$ are missed.

**b)** The journal's published articles taken into consideration are only for the previous two years $Y_2 - 1$ and $Y_2 - 2$, which is superficial.

## 4 The improved impact factor

The case **a)** is always omitted by $IF^{\text{Garfield}}$ that never takes into consideration the citations in the same year in which the articles were published.
An improved and more accurate $IF^{\text{Garfield}}$ is:

$$IF_{Y_2}^{\text{Improved}}(J) = \frac{C(Y_2,\ Y_2) + C(Y_2,\ Y_2 - 1) + C(Y_2,\ Y_2 - 2)}{P(Y_2) + P(Y_2 - 1) + P(Y_2 - 2)}, \tag{4.1}$$

by including the citations during year $Y_2$ of the journal's papers published during the year $Y_2$. This is, of course, computed in the year $Y_2 + 1$.

## 5 The extended impact factor

The case **b)** shows the incompleteness of the Garfield IF which we remove by defining the Extended Impact Factor as follows:

$$IF_{Y_2}^{\text{Extended}}(J) = \frac{\sum_{k=Y_1}^{Y_2} C(Y_2,\ k)}{\sum_{k=Y_1}^{Y_2} P(k)}, \tag{5.1}$$

where $C(Y_2, k)$ is the number of citations during the year $Y_2$ of the journal's published articles during the year $k$; and $P(k)$ is the number of the journal's published articles during the year $k$; of course, $k \in \{Y_1, Y_1 + 1,\ Y_1 + 2, \ldots, Y_2\}$.

### 5.1 Distinctions between the extended impact factor and the Garfield impact factor

The main distinctions with respect to the Garfield Impact Factor are the following:

- $IF^{\text{Extended}}$ shows all the citations during the year $Y_2$ of the journal's all published articles since the starting of the year $Y_1$, while, $IF^{\text{Garfield}}$ shows the citations during the year $Y_2$ of only previous two years' published articles, therefore $IF^{\text{Garfield}}$ is incomplete;
- $IF^{\text{Extended}}$ also includes the citations during the year $Y_2$ of the journal's published articles in the same year $Y_2$, while, $IF^{\text{Garfield}}$ misses it, so $IF^{\text{Garfield}}$ is less accurate.

## 6 The total impact factor

Now we define the best and the most accurate and complete or exact impact factor, i.e, the *Total Impact Factor*, as defined below:

$$IF_{Y_2}^{\text{Total}}(J) = \frac{\sum_{k=Y_1}^{Y_2} C(k,\ [Y_1,\ k])}{\sum_{k=Y_1}^{Y_2} P(k)}, \tag{6.1}$$

where $C(k,\ [Y_1,\ k])$ is the number of citations during the year $k$ of the journal's all the published articles during the years $Y_1, Y_1 + 1, \ldots, k$ altogether, where $Y_1 \leq k \leq Y_2$, and $[Y_1, k] = \{Y_1, Y_1 + 1, \ldots, k\}$; and $P(k)$ is the number of the journal's articles published during the year $k$.

## 7 Accuracy relationship of order

Let us consider the relationship of order " $>_a$ ", that means "better accuracy".
Then we have:

$$IF^{\text{Total}} >_a IF^{\text{Extended}} >_a IF^{\text{Improved}} >_a IF^{\text{Garfield}}.$$

## 8 Numerical example

We present an illustrative example in Table 1.

We read this table on columns, for example:

in the year 2015 the journal $(J)$ has published 20 articles; these articles published in the year 2015 got:

6 citations in the year 2015;

15 citations in the year 2016;

4 citations in the year 2017;

no citations in the year 2018;

and 9 citations in the year 2019;

then, the total number of citations of the articles published in the year 2015 in the journal $J$ is 6+15+4+0+9=34;

and so on;

in the year 2019, the journal $(J)$ published 40 articles, and they got 90 citations in the same year 2019.

Let's use all four impact factor formulas to compute the journal's impact factors for year 2019 (that is computing in the year 2020).

1. Garfield Impact Factor for year 2019:

$$IF_{2019}^{\text{Garfield}}(J) = \frac{C(2019,\ 2018) + C(2019,\ 2017)}{P(2018) + P(2017)} = \frac{16+55}{45+50} = \frac{71}{95} \simeq 0.747.$$

2. Improved Impact Factor for year 2019:

$$IF_{2019}^{\text{Improved}}(J) = \frac{C(2019,\ 2019) + C(2019,\ 2018) + C(2019,\ 2017)}{P(2019) + P(2018) + P(2017)}$$

$$= \frac{90+16+55}{40+45+50} = \frac{161}{135} \simeq 1.193.$$

3. Extended Impact Factor for year 2019:

$$IF_{2019}^{\text{Extended}}(J) = \frac{C(2019,\ 2015) + C(2019,\ 2016) + C(2019,\ 2017) + C(2019,\ 2018) + C(2019,\ 2019)}{P(2015) + P(2016) + P(2017) + P(2018) + P(2019)}$$

$$= \frac{9+11+55+16+90}{20+40+50+45+40} = \frac{181}{195} \simeq 0.928.$$

4. Total Impact Factor for year 2019:

$$IF_{2019}^{\text{Total}}(J) = \frac{34+38+135+28+90}{20+40+50+45+40} = \frac{325}{195} \simeq 1.667.$$

Therefore, according to the accuracy relationship of order $>_a$ we have:

$$1.667 >_a 0.928 >_a 1.1928 >_a 0.747.$$

Whence, the exact (correct, most accurate) impact factor of journal $(J)$ is equal to 1.667.

Table 1: Illustrative table to show the comparative study of the proposed impact factors.

| *Example* | | | | | | *Journal (J)* | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year of Publication | 2015 | | | | | 2016 | | | | 2017 | | | 2018 | | 2019 |
| Number of published articles | 20 | | | | | 40 | | | | 50 | | | 45 | | 40 |
| Year of citations | 2015 | 2016 | 2017 | 2018 | 2019 | 2016 | 2017 | 2018 | 2019 | 2017 | 2018 | 2019 | 2018 | 2019 | 2019 |
| Number of citations per year | 6 | 15 | 4 | 0 | 9 | 19 | 0 | 8 | 11 | 10 | 70 | 55 | 12 | 16 | 90 |
| Total number of citations | 34 | | | | | 38 | | | | 135 | | | 28 | | 90 |

## 9 Conclusion

We have defined for the first time three new types of impact factors of a journal and we designed an accuracy relationship of order. On a numerical example each type of impact factor was computed. Upon each impact factor's formula we clearly have: The Total Impact Factor is more accurate than the Extended Impact Factor, which is more accurate than the Improved Impact Factor, which, in turn is more accurate than the Garfield Impact Factor.

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[1] Editors, *Find impact factor / check impact index of thousands of worldwide journals,* https://www.resurchify.com/impact-factor.php