Journal of
Social and Administrative Sciences
www.kspjournals.org
Volume 3 June 2016 Issue 2

Credit Allocation Based on Journal Impact Factor and Co-authorship Contribution

By Javier E. CONTRERAS-REYES †

Abstract. Some research institutions demand researchers to distribute the incomes they earn from publishing papers to their researchers and/or co-authors. In this study, we deal with the Impact Factor-based ranking journal as a criteria for the correct distribution of these incomes. We also include the Authorship Credit factor for distribution of the incomes among authors, using the geometric progression of Cantor's theory and the Harmonic Credit Index. Depending on the ranking of the journal, the proposed model develops a proper publication credit allocation among all authors. Moreover, our tool can be deployed in the evaluation of an institution for a funding program, as well as calculating the amounts necessary to incentivize research among personnel.
Keywords. Co-author credit; Impact factor; Ranking; Cantor's succession; Harmonic credit.
JEL. A12, C02, C10.

1. Introduction

Research institutions like universities or governmental/military institutes require staff to re-distribute the remunerations they receive from publishing in journals among their researchers/employers (Groshen, 1991). Thus, one wage type earned for published papers serves as payment to co-authors. This problem is difficult to solve, given the prevalent conflicts of interest in many institutions, where distribution of payments is often unjust due to bad practice or ignorance. Therefore, a quantitative method to deal with distribution issues in relation to co-authorship is necessary.

The impact factor (IF) is a citation-based measure for performance related to prestige and proliferation of journals in which research institutions publish their papers (Mattsson et al., 2011). A journal's IF gives the mean number of citations received by papers that have been published in these journals, and is one of the most popular indexes regarding quantitative methods to evaluate research (Bouyssou & Marchant, 2011). Moreover, the number of citations determines the impact of journals on journal rankings (Tsai, 2014). Generally, journals with a high IF contain a lower percentage of uncited articles (Hsu & Huang, 2012).

In this paper, we present a model for the distribution of money benefits to an individual or a group of co-authors who published an International Scientific Indexing (ISI) paper. The model is based on two elements:

i) the ranking of the journal based on Impact Factor (IF) as a criterion for weighing the distribution of these incomes; and
ii) the authorship credit factor for a distribution of the incomes among the authors (Lukovits & Vinkler, 1995), useful for multi-authored scientific publications.

† Departamento de Matemáticas, Universidad Técnica Federico Santa María, Valparaíso, Chile.
☎. +56 032 2151 513
✉. javiersoulforged@gmail.com

Below our authorship factor considers the geometric progression of Cantor's theory (Cantor, 1883), which we then compare with the harmonic credit approach of Hagen (2008). Finally, we illustrate our results using three publications with varying numbers of co-authors, and journals with distinct IF and scholarly fields.

2. Credit distribution model

Let t be the total publication credit allocated for one article ($t > 0$), and let r be the quotient of the journal's rank with respect to the total number of journals ($0 < r \leq 1$). The journal's rank is based on IF and is associated to the journal's area, as by the Web of Science. Let p be a proportion arbitrarily assigned to an institution to define the income base from the total t. Thus, the total publication credit allocated for all authors is obtained by

$$Q_t(p,r) = pt + (1-p)(1-r)t, \qquad 0 \leq p \leq 1. \tag{1}$$

Function (1) depends only p and r; t is known. Evaluating point $(1,0)$ in the second derivative we obtain $\partial^2 Q_t(p,r)/\partial p \partial r = t > 0$, i.e., $Q_t(p,r)$ reaches a relative maximum at $(1,0)$ and is given by the total amount available. Therefore, $Q_t(p,r) \leq t$ for all $0 \leq p \leq 1$ and for any $t > 0$. We can interpret the model (1) with respect to p as:

(i) if $p = 1$, the credit $Q_t(1,r)$ corresponds to available funding. Even if relative maximum t is reached with this value, it does not incentivize publication with respect to the journal quality;

(ii) if $0 < p < 1$, the credit $Q_t(p,r)$ is the sum of a bonus base, pt, with an extra bonus, $(1-p)(1-r)t$, given by the IF of the journal. This is favourable if an institution wishes to incentivize a publication with respect to journal quality;

(iii) if $p = 0$, the credit $Q_t(0,r)$ depends not only on the available funding, but also relates to journal ranking. This is a non–favourable case if an institution wishes to use all available funding to incentivize publication (Figure 1 illustrates the aforementioned cases).

When $r \approx 0$ and $p = 1$, the total amount is maximized when $r = 1$ and $p \approx 0$. For these values, the amount quickly decreases and the value $p = 0.5$ could be acceptable to differentiate the credit base from the credit related to journal ranking. Values of r near (and including) 1 correspond to journals with the lowest impact, and $Q_t(0,r) = 0$, $Q_t(p,r) = pt$ and $Q_t(1,r) = t$. This means that the ranking influences negatively the total publication credit. In a contrary case, values of t near zero relate to the more prestigious journals. Given the values p, r and t, model (1) gives the total credit to be allocated for the co-authors. As such, the institutions generally divided the credit equally among all co-authors (Hagen, 2008).

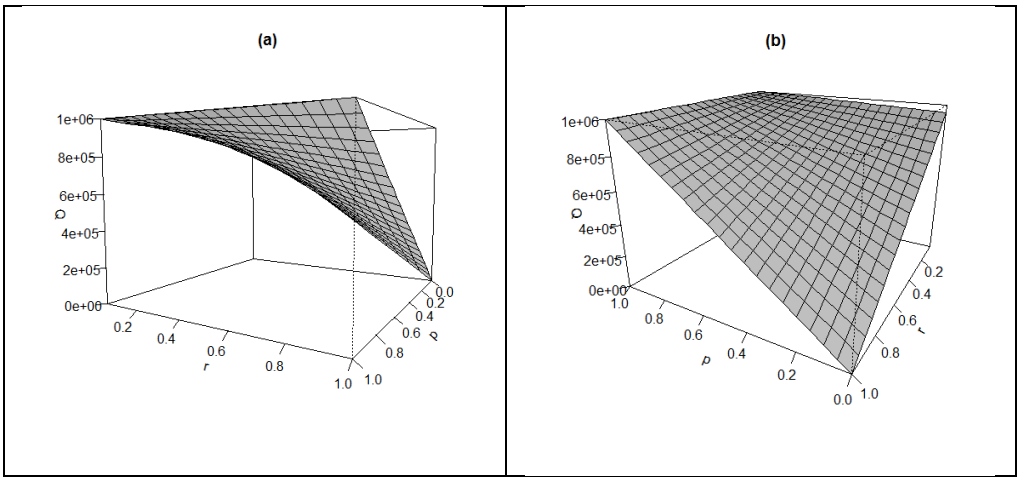

Figure 1. *Total publication credit* $Q \equiv Q_t(p,r)$ *allocated for all authors, with* $t = 10^6$, $0 \le p \le 1$, *and* $0 < r \le 1$.

In the next section, we consider three authorship credit indexes to distribute the credit $Q_t(p,r)$ in fractional form to privilege the main authors of a paper.

3. Authorship credit indexes

The total credit determined by model (1) is related to the publication; but how could it be assigned to the publication's authors? Authorship credit for multi-authored scientific publications is routinely allocated either by issuing full publication credit repeatedly to all co-authors (Hagen, 2008), or by dividing one credit equally among all of them (Karpov, 2014). We consider this latter option. That is, the credit allocated for a specific author is

$$A_t^i(p,r) = P_i Q_t(p,r), \tag{2}$$

where P_i, $0 < P_i < 1$, corresponds to a succession of proportions or weight of the total credit. From (2) it becomes clear that infinite P_i functions exist to share the incomes between N authors. In addition, the condition called *sums of all shares* P_i *is equal to 1* is accomplished (Hagen, 2008). Among all of these functions proposed in the literature (Egghe et al., 2000; Hagen, 2013), we highlight the Harmonic Credit Index in the next subsection.

3.1. Harmonic credit index

Hagen (2008) proposed the Harmonic Credit Index (HCI) H_i for the i th-author as follows:

$$H_i = \frac{1}{i}\left(\sum_{j=1}^{N}\frac{1}{j}\right)^{-1}, \quad i = 1,\ldots,N, \tag{3}$$

where N is the number of authors. The d'Alembert's ratio test for succession (3) shows that $|H_{i+1}/H_i| = 1$ when $i \to \infty$, meaning the test is inconclusive. However, the property (i) of Section 3.1, $H_1 + \ldots + H_N = 1$, ensures the convergence of this succession (Hagen, 2008). HCI ensures that:

(i) the total publication credit is shared among all coauthors;
(ii) the main author gets most credit, and the i th author receives more credit than the $(i+1)$ th author;
(iii) the higher the number of authors, the less credit per author.

In Hagen (2013), HCI is compared with various co-author credit models such as fractional, Liu-Fang, Lukovits-Vinkler, and Trueba-Guerrero. For an empirical dataset including medicine, bibliometric literature, psychology, and chemistry (see more details in Hagen, 2010), HCI performs better than its competitors explaining nearly 97% of the variation versus, for example, 40% of fractional credit index.

The amount assigned to co-authors of (2) can be evaluated using (3), yielding

$$A_t^i(p,r) = H_i Q_t(p,r). \tag{4}$$

Following from these properties of HCI, the total sum of $A_t^i(p,r)$ is equal to the credit $Q_t(p,r)$ assigned to all co-authors. Thus, formula (4) gives the complete HCI.

3.2. Cantor's succession index

A geometric progression can be considered as a co-author credit index. The formula

$$C_i = \frac{2^{i-1}}{3^i}, \qquad i = 1,...,N, \tag{5}$$

with N the number of authors, corresponds to the proportion of the unit interval remaining, or Cantor's set (Cantor, 1883).

The d'Alembert's ratio test shows that $|C_{i+1}/C_i| = 2/3 < 1$ when $i \to \infty$, i.e., the series converges absolutely. Compared with H_i, C_i do not depend on the total number of authors. However, the total sum of the C_i 's is less than 1; it is 1 only for a large number N of authors. These series correspond to the total length removed from Cantor's sets. Figure 2 compares both successions (3) and (5) between $N = 20$ authors. It shows that the first five H_i proportions differ from each author in a decreasing order. The first five C_i, however, are about similar to each author, but in decreasing order. Only for $i = 6$ both successions are about equal and for $i > 6$, H_i tends to be larger than C_i but with similar distribution among these authors. This illustrates that Cantor's succession is also a fractional counting, where one credit is divided non-uniformly among all co-authors (Hagen, 2008; Hagen, 2010). Therefore, this succession also corrects for the inflationary bias produced by multi-authored publications.

As in Section 3.1, co-author amount assignment of (2) can be evaluated using (5) to obtain

$$A_t^i(p,r) = C_i Q_t(p,r). \tag{6}$$

Hereafter, we will refer to formula (6) as Cantor's Succession Index (CSI). We see that the total sum of $A_t^i(p,r)$ is less than the total credit $Q_t(p,r)$. If a large number of co-authors worked on the, the total sum of $A_t^i(p,r)$ tends to be the total

credit $Q_t(p,r)$. However, for a small number of authors, CSI produces an error in the distribution and a considerable bias, leading to ill–distributed credit. For this reason, and to obtain an index with which this important property is accomplished, it is necessary to implement a correction factor for CSI, as presented in the next subsection.

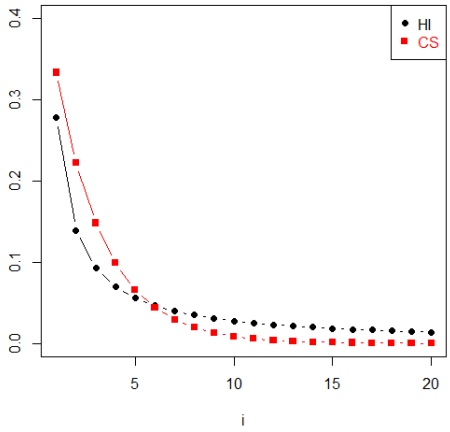

Figure 2. *Harmonic credit (HI) and Cantor's succession (CS) for* $N = 20$ *authors.*

3.3. Adjusted Cantor's succession index

For a finite number of authors N, we have the publication credit

$$\begin{aligned}\varepsilon &= Q_t(p,r) - \sum_{i=1}^{N} A_t^i(p,r) \\ &= Q_t(p,r)(1 - \sum_{i=1}^{N} C_i),\end{aligned} \tag{7}$$

that is always positive and 0 when $N \to \infty$. Using (7), we define a corrected version for $A_t^i(p,r)$ as

$$\overline{A_t^i}(p,r) = A_t^i(p,r) + \frac{\varepsilon}{N}. \tag{8}$$

Hereafter, we refer to formula (8) as the Adjusted Cantor's Succession Index (ACSI).

From (8), it is clear that $\overline{A_t^i}(p,r) = A_t^i(p,r)$ when $N \to \infty$. Considering (7) and (8), we can corroborate that $\sum_{i=1}^{N} \overline{A_t^i}(p,r) = Q_t(p,r)$. Based on ACSI, we obtain a new publication credit allocated for a specific i th author in (2) given by

$$\overline{A_t^i}(p,r) = C_i Q_t(p,r) + \frac{\varepsilon}{N}. \tag{9}$$

ACSI also preserves the property of fractional counting, where one credit is divided non-uniformly and equally among the main co-authors and the rest, respectively.

4. Examples

We illustrate the performance of each co-author credit from ISI publications, considering formulas (4) and (9) and a bonus base proportion of $p=0.5$, in the following examples:

1. The Earth and Planetary Science Letters ISI journal has an impact factor of 4.724 (Web of Science 2013), and ranks 5th out of 80 journals in the field of Geochemistry & Geophysics. Considering research by Lange et al. (2012), for the values $t=2\times10^6$, $r=0.063$ and $N=11$, the publication credit allocation between the N authors is $Q_t(0.5,0.063)=1,937,000$ for HCI and ACSI and $Q_t(0.5,0.063)=1,914,606$ for CSI (see Table 1). The total proportion of C_i is near 1 given the large list of co-authors. This produces CSI near ACSI. However, for the properties mentioned in Section 3.1, HCI distributed the credit to the three main authors in a non-uniform way, whereas ACSI provides more equal credits among them.

Table 1. *Credit co-authorship distribution considering Lange et al. (2012).*

Author (i)	C_i	CSI	ACSI	H_i	HCI
1	0.333	645,666.67	647,702.46	0.331	641,416.78
2	0.222	430,444.44	432,480.23	0.166	320,708.39
3	0.148	286,962.96	288,998.75	0.110	213,805.59
4	0.099	191,308.64	193,344.43	0.083	160,354.19
5	0.066	127,539.10	129,574.89	0.066	128,283.36
6	0.044	85,026.06	87,061.85	0.055	106,902.80
7	0.029	56,684.04	58,719.83	0.047	91,630.97
8	0.020	37,789.36	39,825.15	0.041	80,177.10
9	0.013	25,192.91	27,228.70	0.037	71,268.53
10	0.009	16,795.27	18,831.06	0.033	64,141.68
11	0.006	11,196.85	13,232.64	0.030	58,310.62
Total	0.989	1,914,606.00	1,937,000.00	1	1,937,000.00

2. The Fisheries Research ISI journal has an impact factor of 1.843 (Web of Science 2013), and ranks 12th out of 50 journals in the Fisheries field. Considering research by Contreras-Reyes et al. (2014), for the values $t=1.2\times10^6$, $r=0.063$ and $N=3$, the publication credit allocation between the N authors is $Q_t(0.5,0.24)=1,056,000$ for HCI and ACSI and $Q_t(0.5,0.24)=743,111.1$ for CSI (see Table 2). In contrast to the first example, C_i is far from 1, given the low co-authorship, thus CSI is far from ACSI. In this case, HCI should be more adequate to distribute the total amount between the three authors. However, ACSI preserves the proportion among the authors.

Table 2. *Credit co-authorship distribution considering Contreras-Reyes et al. (2014).*

Author (i)	C_i	CSI	ACSI	H_i	HCI
1	0.333	352,000.0	456,296.3	0.545	576,000
2	0.222	234,666.7	338,963.0	0.273	288,000
3	0.148	156,444.4	260,740.7	0.182	192,000
Total	0.704	743,111.1	1,056,000.0	1	1,056,000

3. Consider now Ausloos (2015). The Physica A ISI journal has an impact factor of 1.722 (Web of Science 2013), and is ranked 25th out of 78 journals in the Physics Multidisciplinary field. For the values $t=1.2\times10^6$, $r=0.321$ and $N=1$,

the publication credit allocation for the author is $Q_t(0.5, 0.321) = 792,308$ for HCI, CSI and ACSI. Given that we have only one author, CSI does not provide a precise criterion. Using the adjusted version, we obtain the same result for HCI.

5. Conclusions

The proposed bonus distribution model gives a publication credit allocation associated to the performance of a journal, given by its IF-based ranking. This approach allows to restrict the credit allocated to each author, and so ranking criteria encourage research activity in an institution and to publish in higher-ranked journals. This tool is also helpful when an institution needs to be evaluated for a funding program as well as to determine where to direct amounts to incentivize research (Egghe et al., 2000).

The proposed model is not restricted to a specific succession index. The most simple index is one that divides the total available amount equally among all co-authors (Hagen, 2008). Cantor's index considers authorship rank instead, and the HCI considers these ranks and the number of co-authors. HCI provides different credits among the main authors, where this number depends on the total number of authors. However, the HCI should be employed for three main reasons:

(i) HCI proportions differ from each author in a decreasing order, allocating the higher amounts of credit to the prime authors, who make larger individual contributions to a paper (Mattsson et al., 2011);

(ii) Adjusted Cantor's Index is still a fractional counting, and only divides non-uniformly the first fraction of the credit among all co-authors; and

(iii) HCI's formula is much more tractable and simpler than ACSI.

Since the selection of proportion p of the proposed model is largely influenced by institution's policies, the model allows for sufficient flexibility to decide how to develop research among co-authors. Actually, several institutions such as universities choose option (i) of Section 2, assuming that an ISI paper deserves recognition only if it has the aforementioned indexation. This looks erroneous, however, because the journal ranking provides a qualification to measure its reputation with respect to an associated field (Bouyssou & Marchant, 2011).

Given that *H*-index is probably not the best indicator/predictor of the journal quality (Hirsch, 2007), the proposed model can easily be adapted to a more effective index to determine ranking r. Additionally, further research using a stochastic *H*-index (Nair & Turlach, 2012) is needed, where the underlying proposed model is dependent on time.

Acknowledgements

This research was partially supported by Grant PIIC 057/2015 from Universidad Técnica Federico Santa María (UTFSM, Valparaíso, Chile). I would like to thank Ghislaine Barría (IFOP, Valparaíso, Chile) for their constructive feedback that has improved this work substantially, as well as the associated editor and two anonymous reviewers for their helpful comments and suggestions.

References

Ausloos, M. (2015). Assessing the true role of coauthors in the h-index measure of an author scientific impact. *Physica A*, 422, 136-142. doi. 10.1016/j.physa.2014.12.004

Bouyssou, D., & Marchant, T. (2011). Bibliometric rankings of journals based on impact factors: An axiomatic approach. *Journal of Informetrics*, 5(1), 75-86. doi. 10.1016/j.joi.2010.09.001

Cantor, G. (1883). Über unendliche, lineare Punktmannigfaltigkeiten V (On infinite, linear point-manifolds (sets)). *Mathematische Annalen*, 21(4), 545-591. doi. 10.1007/BF01446819

Contreras-Reyes, J.E., Arellano-Valle, R.B., & Canales, T.M. (2014). Comparing growth curves with asymmetric heavy-tailed errors: Application to southern blue whiting (Micromesistius australis). *Fisheries Research*, 159, 88-94. doi. 10.1016/j.fishres.2014.05.006

Egghe, L., Rousseau, R., & Van Hooydonk, G. (2000). Methods for accrediting publications to authors or countries: Consequences for evaluation studies. *Journal of American Society of Information Sciences*, 51(2), 145-157. doi. 10.1002/(SICI)1097-4571(2000)51:2<145::AID-ASI6>3.0.CO;2-9

Groshen, E.L. (1991). Five reasons why wages vary among employers. *Industrial Relations: A Journal of Economy and Society*, 30, 350-381. doi. 10.1111/j.1468-232X.1991.tb00793.x

Hagen, N.T. (2008). Harmonic allocation of authorship credit: Source-level correction of bibliometric bias assures accurate publication and citation analysis. PLoS ONE 3, doi. 10.1371/journal.pone.0004021

Hagen, N.T. (2010). Harmonic publication and citation counting: sharing authorship credit equitably not equally, geometrically or arithmetically. *Scientometrics*, 84(3), 785-793. doi. 10.1007/s11192-009-0129-4

Hagen, N.T. (2013). Harmonic coauthor credit: A parsimonious quantification of the byline hierarchy. *Journal of Informetrics*, 7(4), 784-791. doi. 10.1016/j.joi.2013.06.005

Hirsch, J.E. (2007). Does the h index have predictive power? *Proceedings of the National Academy of Sciences*, 104(49), 19193-19198. doi. 10.1073/pnas.0707962104

Hsu, J.W., & Huang, D.W. (2012). A scaling between Impact Factor and uncitedness. *Physica A*, 391(5), 2129-2134. doi. 10.1016/j.physa.2011.11.028

Karpov, A. (2014). Equal weights coauthorship sharing and the Shapley value are equivalent. *Journal of Informetrics*, 8(1), 71-76. doi. 10.1016/j.joi.2013.10.008

Lange, D., Tilmann, F., Barrientos, S.E., Contreras-Reyes, E., Methe, P., Moreno, M., Heit, B., Agurto, H., Bernard, P., Vilotte, J.P., & Beck, S. (2012). Aftershock seismicity of the 27 February 2010 Mw 8.8 Maule earthquake rupture zone. *Earth and Planetary Science Letters*, 317-318, 413-425. doi. 10.1016/j.epsl.2011.11.034

Lukovits, I., & Vinkler, P. (1995). Correct credit distribution: A model for sharing credit among coauthors. *Social Indicators Research*, 36(1), 91-98. doi. 10.1007/BF01079398

Mattsson, P., Sundberg, C.J., & Laget, P. (2011). Is correspondence reflected in the author position? A bibliometric study of the relation between corresponding author and byline position. *Scientometrics*, 87(1), 99-105. doi. 10.1007/s11192-010-0310-9

Nair, G.M., & Turlach, B.A. (2012). The stochastic h-index. *Journal of Informetrics*, 6(1), 80-87. doi. 10.1016/j.joi.2011.09.006

Tsai, C.F. (2014). Citation impact analysis of top ranked computer science journals and their rankings. *Journal of Informetrics*, 8(2), 318-328. doi. 10.1016/j.joi.2014.01.002