Modified Impact Factors

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ABSTRACT

New versions of JCR IF are proposed for comparing them with JCR IF. They focus on the journal self-citation and the number of citing sources. The proposed versions are grouped into: 1) IFs penalized by self-citations, 3) IF encouraged by the number of citing sources and 3) IFs combining the penalized IFs and encouraged IF. This study evaluates the impact of journal self-citations and distribution of citations among sources on JCR IF. The study indicates that self-citationshave little impact on the values of IF and the IF rankings, whether or not journal self-citations areincluded. The proposed indicators have been evaluated for the 30 journals in Computer Science field indexed in JCR 2013. The Spearman's ρ correlation between the JCR IF and IFs penalized by self-citations is in the range of 0.76-0.96 and the Kendall's τ correlation is in the range of 0.57-0.86. The study also indicates that compared to the IFs penalized by self-citations, the IF encouraged (EIF) by the number of citing sources correlated moderate with the JCR IF, the Spearman's ρ correlation is 0.73 and the Kendall's τ correlation is 0.59. Experiment results showed that the JCR IF moderately correlated with the combined IFs, Spearman's ρ correlation is in the range of 0.69-0.72 and Kendall's τ correlation is in the range of 0.55-0.58. We also showed that penalization strategy of self-citation can influence on the result. For example, IF linearly penalized (LPIF) by self-citations highly correlated with the JCR IF (Spearman's ρ correlation is 0.99 and Kendall's τ correlation is 0.93), and IF non-linearly penalized (nLPIF) by self-citations moderately correlated with the JCR IF (Spearman's ρ correlation is 0.76 and Kendall's τ correlation is 0.57). Finally, we concluded that IFs with and without penalization lowly correlated with the number of articles and the number of citing sources.

Key words: Impact factor; self-citation; penalized impact factors; encouraged impact factor; combined impact factors

INTRODUCTION

The quality of a scientific journal is generally measured in impact factors provided by ISI Web of Knowledge Journal Citation Reports (JCR). Impact Factor is the most important indicator to determine the influence of a journal. This indicator represents the average number of citations to a journal over a specific period of time, usually two years.[1,2]

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$$\mathrm{IF}_J^y = \frac{\sum_{i=1}^{N_J^y} C_{IJ}^y}{A_J^{y-1} + A_J^{y-2}}, \quad (1)$$

where IF_J^y is the impact factor of journal J in a year y; N_J^y is the number of journals citing the articles of journal J in the year y; $A_j^{y-1} + A_j^{y-2}$ is the total number of articles published in journal J in the two previous years $y-1$ and $y-2$; C_{IJ}^y is the number of citations received by journal J in the year y from journal I.

In Eq.(1), the numerator is the number of citations in year y to any items published in the journal in previous 2 years; and the denominator is the number of articles published in the same 2 years.[3]

Despite popularity of impact factor there are many adverse effects of ranking the journals by IF.[4] Pointed out several limitations regarding the use of impact factors, e.g. manipulations by authors and editors, disambiguation with peer-review process, distinction between the qualities of journal articles, etc. Ways forboosting the prestige of a journal, in other words, "tricks" of engineering and IF manipulating on purpose of increasing the nominator or decreasing the denominator of Eq.(1) were pointed out.[5]

In calculation of impact factor or not considered either not widely studied following factors:

– Number of citingsources – 10 citations from different journals must be preferred to 10 citations from one journal, because large-scale distribution of citations proves widely adoption of given journal among different researchers;
– Fractions of self-citations – in certain cases, authors are forced to cite articles from the same journal. Although some of self-citations may be legitimate, they can distort the scientific literature and opinion of science policy-makers.[6,7] Found that high self-citing rate of journal may strongly affect the impact factor.

In this paper, penalized impact factors, considering weight fractions of self-citations, encouraged impact factor, considering distribution scale of citing sources and combinationof both penalized and encouraged impact factors are proposed.

MATERIALS AND METHODS

Using citations for evaluation of the performance of scientific journals was initiated[1] and he established the first citation indexes (Science Citation Index) and the company, the Institute for Scientific Information (ISI).[8]

Long time JCR IF was the predominant metric for evaluation of the journals despite considerable criticism. Recently have been proposed new indicators including the Eigen factor, the h-index, SJR and SNIP. It is important to understand how these indicators differ from each other, and the degree of their validity.[8,9] The Eigen factor explicitly excludes journal self-citations unlike most other indicators.[10] Reviews the literature on citation impact indicators. There have also been several reviews of the use of indicators in research evaluation.[11] Since IF only measures the average number of citations per article in a certain time window, it can be argued that it does not reflect the real value of a periodical. The book[2] defines five dimensions, which build a framework for a multidimensional method of journal evaluation.

Unweighted citations also have been noted as main disadvantage of IF, so in IF calculation all citations are counted with equal weight, regardless the prestige of the citing journal.[12] Impact factor takes into account only the quantity of the citations but not their quality. Different modifications of IF, weighted by cited journals' IF were proposed,[13,14,15,16] constructed mathematical model of generalized weighted impact factor.[17] An approach presented in[18] takes into consideration the fact, who quoted the papers analyzed:

$$\mathrm{WIF}_{\mathrm{J}}^{y} = \frac{1}{A_J^{y-1} + A_J^{y-2}} \sum_{j=1}^{A_J^{y-1}+A_J^{y-2}} \omega_j, \tag{2}$$

The only difference is that instead of counting the numbers of citation c_j of a given article j, this formula sums the weighted citations ω_j:

$$\omega_j = \sum_{i=1}^{c_j} W_i, \tag{3}$$

where c_j is the number of independent quotations of the article j; W_i is the weighting factor of the ith author quoting the article j.

In[14] proposed a new way of calculating a journal impact factor, called the CHAL impact factor, an abbreviation for "cited half-life" IF. They proposed the following definition of a journal impact factor.[14,19]

$$\mathrm{MIF}_J^y = \frac{C_J^y / 2}{\sum_{t=0}^{y_m} A_J^{y-t}}, \tag{4}$$

where MIF_J^y denotes the median IF of journal J in the year y; $\sum_{t=0}^{y_m} A_J^{y-t}$ denotes the cumulative number of articles published by journal J during the period $[y - y_m, y]$; y_m is the median cited age; C_J^y is the total number of citations received by journal J in the year y which is calculated as follows:

$$C_J^y = \sum_{i=1}^{N_J^y} C_{IJ}^y \tag{5}$$

Self-citation of a journal may affect its impact factor. Journal self-citations, defined as a citation received from an article published in the same journal. Journal self-citations are an important subject in scientometrics studies which can be are classified into the self-citing rate and the self-cited rate. The self-citing rate relates a journal self-citation to the total number of references it gives. The self-cited rate relates journal self-citations to the number of times it is cited by all journals, including itself.[20,21,22] Investigated the effect of the self-citation rate of a journal on its IF of pediatric journals indexed in the JCR.[23] Spearman's ranked correlation showed that IF was significantly and inversely correlated with self-citation rate.

Classified the research studies that have been conducted in the investigation of journal self-citations into four

categories[20]: 1) The first category explored the basic characteristics of journal self-citation; 2) The second category studied the self-citing and self-cited rates of journals of an individual country; 3) The third category investigated journal self-citation rates for a certain subject; 4) The fourth category investigated the journal self-citation rates and the manipulation of their impact factors. The mathematical expressions of the relation between journal self-citation rate and its impact factor were established in[24] analyzed the possibility that journal editors manipulate the journal impact factors by raising the self-cited rate. Stated that coerced journal self-citation is unethical and if unchecked it will continue to falsify the value of IF.[25] Analyzed journals selected from list of JCR from 1998 to 2007, with large increases or decreases in their IFs from a given year to the following.[26] About 54% of the increases and 42% of the decreases in the journal IFs were associated with changes in the journal self-citations. Was found that, in some journals rate of self-citation is a dominant influence in the total level of citation. In these cases, self-citation has the potential to distort the real influence of the journal in given subject.[27] Demanding of authors by journal editors to cite articles from recent years of the journal had been detected as strategy of IF manipulation.[28,29,30] Noticed that publishing large amounts of editorial material with many self-citations by academic journals is one of the ways for increasing impact factor.[31] Analyzed that publishing relatively many review articles by self-citations and limiting the number of included articles is also one of the ways to increase IF of journals.[32]

Based on data of the JCR of ISI in the subject category "Ecology",[33] found that journals with higher impacts have lower self-citation rates. He also detected that with increasing journal impact the self-citation rates decrease. To avoid further deliberate increases in self-citation rates, Krauss suggested take journal-specific self-citation rates into account for journal rankings. He proposed adjusted impact factorwhichexcludes journal self-citations in calculating impact factor:

$$\mathrm{AIF}_J^y = \frac{C_J^y - sC_J^y}{A_J^{y-1} + A_J^{y-2}}, \qquad (6)$$

where sC_J^y denotes the number of self-citations of journal J in the year y.

In[34] have been analyzed problems associated with the use of journal impact factors and has been remarked that journal self-citation is one of the problems associated with the use of journal impact factors. Cases of coercive self-citation by peer reviewers have been analyzed in.[35]

The absolute value of any particular index is arguably meaningless unless compared with other indices. It is clear different metrics result in divergent rankings. So to provide more objective ranking of journals[36] developed a κ-resampled composite rank incorporating five indices: IF, Immediacy Index, SNIP, SJR and Google 5-year h-index.

One of the most important values for determining the journal impact is distribution of citations among citing sources. Offered fractionally citation counts normalized in terms of the citing sources.[37] Fractional counting of citations defined the significance of differences among small and large sets of citing sources. The audience factor was proposed[38] as a variant of a fractional citation-counting scheme. Audience factor is a weighted impact factor, addressing field-discrepancies by citing-side normalization, in contrast both with post-facto field-normalization and influence measures.[39] For solutions of the problem related by citation frequencies between different sciences has been offered Scopus's Source Normalized Impact per Paper (SNIP).[40] In ranking scientific journals by SNIP following characteristics of journals considered as the main aspects: its properly defined subject field, the frequency at which authors cite other papers in their reference lists, the rapidity of maturing of citation impact, and the extent to which a database used for the assessment covers the field's literature.

Proposed Versions of Impact Factor

In this section, we propose new versions of IF which have beentaken into consideration the journal self-citations and distribution of citations among citing sources.

Penalized Impact Factors

Distortion cases of IF by journal self-citations have been noticed above. For more adequate ranking of scientific journals we proposed the following versions ofimpact factor penalized by self-citations which decrease by increasing self-citations.

Impact factor linearly penalized (PIF)by self-citations. This indicator is defined as follows:

$$\mathrm{LPIF}_J^y = \frac{\alpha \times sC_J^y + \beta \times (C_J^y - sC_J^y)}{A_J^{y-1} + A_J^{y-2}} \qquad (7)$$

where α and β are the rate coefficients of self-citations and non-self-citations which $0 < \alpha \le \beta < 1$ and $\alpha + \beta = 1$.

In this study, to penalize self-citations we set the following relation between α and β, $\beta = 2\alpha$. From the equality $\alpha + \beta = 1$ we obtain that $\alpha = \frac{1}{3}$ and $\beta = \frac{2}{3}$.

From Eqs.(6) and (7) we obtain the following relation between LPIF and AIF:

$$\mathrm{LPIF}_J^y = \alpha \times \frac{sC_J^y}{A_J^{y-1} + A_J^{y-2}} + \beta \times \mathrm{AIF}_J^y. \quad (8)$$

From Eqs.(1), (5) and (6) we obtain the following relation between JCR IF and AIF:

$$\mathrm{IF}_J^y = \frac{sC_J^y}{A_J^{y-1} + A_J^{y-2}} + \mathrm{AIF}_J^y. \quad (9)$$

Impact factor non-linearly penalized (nLPIF) by self-citations. This version of IF is defined as follows:

$$\mathrm{nLPIF}_J^y = \mathrm{IF}_J^y \times \log\left(\frac{C_J^y}{sC_J^y}\right), \quad (10)$$

Pure Impact Factor (PrIF). The PrIF in calculating the impact factor not only excludes the journal self-citations it also excludes the uncited articles:

$$\mathrm{PrIF}_J^y = \frac{C_J^y - sC_J^y}{cA_J^{y-1} + cA_J^{y-2}}, \quad (11)$$

where cA_J^{y-1} and cA_J^{y-2} are the number of articles published in journal J in the years $y-1$ and $y-2$, respectively, that have been cited at least once in the year y.

Encouraged Impact Factor

Impact factorencouraged by the number of citing sourcestakes into considerationan influence sphere of the journal:

$$\mathrm{EIF}_J^y = \frac{N_J^y}{N^y} \times \mathrm{IF}_J^y, \quad (12)$$

Where N^y– is the number of journals registered in JCR in the year y.

Combined Impact Factors

We introduce the followingindicators combining the both penalized and encouragedIFs:

$$\mathrm{AE\_IF}_J^y = \frac{N_J^y}{N^y} \times \frac{C_J^y - sC_J^y}{A_J^{y-1} + A_J^{y-2}}. \quad (13)$$

$$\mathrm{LPE\_IF}_J^y = \frac{N_J^y}{N^y} \times \mathrm{LPIF}_J^y. \quad (14)$$

$$\mathrm{nLPE\_IF}_J^y = \frac{N_J^y}{N^y} \times \log\left(\frac{C_J^y}{sC_J^y}\right) \times \mathrm{IF}_J^y. \quad (15)$$

$$\mathrm{PrE\_IF}_J^y = \frac{N_J^y}{N^y} \times \frac{C_J^y - sC_J^y}{cA_J^{y-1} + cA_J^{y-2}}. \quad (16)$$

When ranking the journals using these indicators, we take into account both the portion of self-citations in all citations and the degree of distribution of the citations among citing sources.

Data collection

For evaluation of the proposed indicators we have selected 30 journals in the Computer Sciencefieldindexed in JCR 2013. Theproposed indicators have been calculated for these journals and compared with their JCR IFs. Table 1 gives a list of the journals analyzed in the study and their bibliometric characteristics, i.e. impact factors, number of citations, self-citations, number of citing sources, number of articles and number of cited articles.

RESULTS

In this section, were calculated impact factors penalized by self-citations, impact factor encouraged by the number of citing sources and combined impact factors of the journals (Table 2).

From the Table 2 we obtain the following ranking lists of journalsgenerated by different indicators (Table 3).

DISCUSSION AND CONCLUSIONS

In order to see how theproposed indicators have influenced to the ranks of journalswe have compiled a table of the ranks difference (Table 4).

In Table 4, the positive numbers indicate that compared to the IF's ranks the journals improved their position in the corresponding indicators, and negative numbers are the opposite. As can be seen in Table 5, the best (IEEE Transactions on Pattern Analysis and Machine Intelligence) and worst (International Journal of Pattern Recognition and Artificial Intelligence) ranked journals (based on JCR IF ranking) retained their positions in all rankings. Some journals (Genetic Programming and

Table 1: Bibliometric characteristics of journals

#	Journal title	Number of citing sources	Number of citations in 2013	Self-citations	Number of articles published in 2011 and 2012	Number of cited articles published in 2011 and 2012
1	ACM Transactions on Applied Perception	57	42	4	40	26
2	ACM Transactions on Information Systems	99	55	3	42	35
3	ACM Transactions on Knowledge Discovery from Data	77	42	1	37	24
4	ACM Transactions on Sensor Networks	105	79	2	54	39
5	ACM Transactions on Software Engineering And Methodology	86	54	2	37	30
6	ACM Transactions on the Web	123	62	5	39	29
7	Applied Numerical Mathematics	140	250	4	241	120
8	Artificial Life	55	93	1	48	31
9	Cognitive Computation	82	98	11	89	59
10	Computer Speech And Language	76	123	6	68	50
11	Expert Systems with Applications	862	6178	1110	3144	2563
12	Fuzzy Optimization and Decision Making	39	46	14	46	31
13	Genetic Programming and Evolvable Machines	44	48	8	45	28
14	IEEE Transactions on Autonomous Mental Development	59	73	15	54	39
15	IEEE Transactions on Computational Intelligence and AI in Games	80	58	11	50	40
16	IEEE Transactions on Dependable and Secure Computing	255	163	2	143	117
17	IEEE Transactions on Pattern Analysis and Machine Intelligence	735	2283	82	401	362
18	Information Sciences	834	3282	727	843	730
19	International Journal of Applied Mathematics and Computer Science	121	189	45	136	99
20	International Journal of Pattern Recognition and Artificial Intelligence	58	83	23	148	73
21	Journal of Ambient Intelligence and Smart Environments	60	80	12	74	40
22	Journal of Informetrics	149	519	93	145	128
23	Journal of Machine Learning Research	372	639	51	224	137
24	Neural Computation	205	383	26	226	156
25	Neural Processing Letters	77	95	7	77	53
26	Pattern Recognition	748	1326	161	513	445
27	Pattern Recognition Letters	518	576	57	542	428
28	Scientometrics	333	1130	146	497	378
29	Swarm Intelligence	38	49	6	27	19
30	World Wide Web (WWW)	81	96	17	59	38

Table 2: Indicators of journals

#	Journal title	JCR IF	AIF	LPIF	nLPIF	PrIF	EIF	AE_IF	LPE_IF	nLPE_IF	PrE_IF
1	ACM Transactions on Applied Perception	1.050	0.950	0.667	1.072	1.462	0.060	0.054	0.038	0.061	0.083
2	ACM Transactions on Information Systems	1.310	1.238	0.849	1.654	1.486	0.130	0.123	0.084	0.164	0.147
3	ACM Transactions on Knowledge Discovery from Data	1.135	1.108	0.748	1.843	1.708	0.087	0.085	0.058	0.142	0.132
4	ACM Transactions on Sensor Networks	1.463	1.426	0.963	2.336	1.974	0.154	0.150	0.101	0.245	0.207
5	ACM Transactions on Software Engineering And Methodology	1.459	1.405	0.955	2.089	1.733	0.126	0.121	0.082	0.180	0.149
6	ACM Transactions on the Web	1.590	1.462	1.017	1.738	1.966	0.196	0.180	0.125	0.214	0.242
7	Applied Numerical Mathematics	1.037	1.021	0.686	1.863	2.050	0.145	0.143	0.096	0.261	0.287
8	Artificial Life	1.938	1.917	1.285	3.814	2.968	0.107	0.105	0.071	0.210	0.163
9	Cognitive Computation	1.101	0.978	0.693	1.046	1.475	0.090	0.080	0.057	0.086	0.121
10	Computer Speech And Language	1.809	1.721	1.176	2.373	2.340	0.137	0.131	0.089	0.180	0.178
11	Expert Systems with Applications	1.965	1.612	1.192	1.465	1.977	1.694	1.390	1.028	1.263	1.704
12	Fuzzy Optimization and Decision Making	1.000	0.696	0.565	0.517	1.032	0.039	0.027	0.022	0.020	0.040
13	Genetic Programming and Evolvable Machines	1.067	0.889	0.652	0.830	1.429	0.047	0.039	0.029	0.037	0.063
14	IEEE Transactions on Autonomous Mental Development	1.352	1.074	0.809	0.929	1.487	0.080	0.063	0.048	0.055	0.088
15	IEEE Transactions on Computational Intelligence and AI in Games	1.160	0.940	0.700	0.838	1.175	0.093	0.075	0.056	0.067	0.094
16	IEEE Transactions on Dependable and Secure Computing	1.140	1.126	0.755	2.178	1.376	0.291	0.287	0.193	0.556	0.351
17	IEEE Transactions on Pattern Analysis and Machine Intelligence	5.693	5.489	3.727	8.225	6.080	4.185	4.034	2.740	6.045	4.469
18	Information Sciences	3.893	3.031	2.308	2.549	3.500	3.247	2.528	1.925	2.125	2.919
19	International Journal of Applied Mathematics and Computer Science	1.390	1.059	0.816	0.866	1.455	0.168	0.128	0.099	0.105	0.176
20	International Journal of Pattern Recognition and Artificial Intelligence	0.561	0.405	0.322	0.313	0.822	0.033	0.024	0.019	0.018	0.048
21	Journal of Ambient Intelligence and Smart Environments	1.081	0.919	0.667	0.891	1.700	0.065	0.055	0.040	0.053	0.102
22	Journal of Informetrics	3.579	2.938	2.172	2.673	3.328	0.533	0.438	0.324	0.398	0.496
23	Journal of Machine Learning Research	2.853	2.625	1.826	3.132	4.292	1.061	0.977	0.679	1.165	1.597
24	Neural Computation	1.695	1.580	1.091	1.980	2.288	0.347	0.324	0.224	0.406	0.469
25	Neural Processing Letters	1.234	1.143	0.792	1.397	1.660	0.095	0.088	0.061	0.108	0.128
26	Pattern Recognition	2.585	2.271	1.619	2.367	2.618	1.933	1.699	1.211	1.770	1.958
27	Pattern Recognition Letters	1.063	0.958	0.673	1.068	1.213	0.550	0.496	0.349	0.553	0.628
28	Scientometrics	2.274	1.980	1.418	2.021	2.603	0.757	0.659	0.472	0.673	0.867
29	Swarm Intelligence	1.815	1.593	1.136	1.655	2.263	0.069	0.061	0.043	0.063	0.086
30	World Wide Web	1.627	1.339	0.989	1.223	2.079	0.132	0.108	0.080	0.099	0.168

Table 3: Ranks of journals

#	Journal title	JCR IF	AIF	LPIF	nLPIF	PrIF	EIF	AE_IF	LPE_IF	nLPE_IF	PrE_IF	# of articles	# of citing sources
1	ACM Transactions on Applied Perception	27	25	26	21	23	27	27	27	25	27	26	26
2	ACM Transactions on Information Systems	18	16	16	17	21	17	16	16	17	19	25	15
3	ACM Transactions on Knowledge Discovery from Data	22	19	21	14	17	23	21	21	18	20	28	20
4	ACM Transactions on Sensor Networks	14	13	14	8	14	13	12	12	12	13	19	14
5	ACM Transactions on Software Engineering And Methodology	15	14	15	10	16	18	17	17	15	18	29	16
6	ACM Transactions on the Web	13	12	12	15	15	11	11	11	13	12	27	12
7	Applied Numerical Mathematics	28	22	24	13	12	14	13	14	11	11	7	11
8	Artificial Life	8	7	7	2	5	19	19	19	14	17	22	27
9	Cognitive Computation	23	23	23	23	22	22	22	22	22	22	14	17
10	Computer Speech And Language	10	8	9	6	8	15	14	15	16	14	17	22
11	Expert Systems with Applications	7	9	8	18	13	4	4	4	4	4	1	1
12	Fuzzy Optimization and Decision Making	29	29	29	29	29	29	29	29	29	30	23	29
13	Genetic Programming and Evolvable Machines	25	28	28	28	25	28	28	28	28	28	24	28
14	IEEE Transactions on Autonomous Mental Development	17	20	18	24	20	24	24	24	26	25	20	24
15	IEEE Transactions on Computational Intelligence and AI in Games	20	26	22	27	28	21	23	23	23	24	21	19
16	IEEE Transactions on Dependable and Secure Computing	21	18	20	9	26	10	10	10	7	10	12	8
17	IEEE Transactions on Pattern Analysis and Machine Intelligence	1	1	1	1	1	1	1	1	1	1	6	4
18	Information Sciences	2	2	2	5	3	2	2	2	2	2	2	2
19	International Journal of Applied Mathematics and Computer Science	16	21	17	26	24	12	15	13	20	15	13	13
20	International Journal of Pattern Recognition and Artificial Intelligence	30	30	30	30	30	30	30	30	30	29	10	25
21	Journal of Ambient Intelligence and Smart Environments	24	27	27	25	18	26	26	26	27	23	16	23
22	Journal of Informetrics	3	3	3	4	4	8	8	8	10	8	11	10
23	Journal of Machine Learning Research	4	4	4	3	2	5	5	5	5	5	9	6
24	Neural Computation	11	11	11	12	9	9	9	9	9	9	8	9
25	Neural Processing Letters	19	17	19	19	19	20	20	20	19	21	15	21
26	Pattern Recognition	5	5	5	7	6	3	3	3	3	3	4	3
27	Pattern Recognition Letters	26	24	25	22	27	7	7	7	8	7	3	5
28	Scientometrics	6	6	6	11	7	6	6	6	6	6	5	7
29	Swarm Intelligence	9	10	10	16	10	25	25	25	24	26	30	30
30	World Wide Web	12	15	13	20	11	16	18	18	21	16	18	18

Table 4: Difference between JCR IF's and other indicators' ranks

#	Journal title	AIF	LPIF	nLPIF	PrIF	EIF	AE_IF	LPE_IF	nLPE_IF	PrE_IF
1	ACM Transactions on Applied Perception	2	1	6	4	0	0	0	2	0
2	ACM Transactions on Information Systems	2	2	1	–3	1	2	2	1	–1
3	ACM Transactions on Knowledge Discovery from Data	3	1	8	5	–1	1	1	4	2
4	ACM Transactions on Sensor Networks	1	0	6	0	1	2	2	2	1
5	ACM Transactions on Software Engineering And Methodology	1	0	5	–1	–3	–2	–2	0	–3
6	ACM Transactions on the Web	1	1	–2	–2	2	2	2	0	1
7	Applied Numerical Mathematics	6	4	15	16	14	15	14	17	17
8	Artificial Life	1	1	6	3	–11	–11	–11	–6	–9
9	Cognitive Computation	0	0	0	1	1	1	1	1	1
10	Computer Speech And Language	2	1	4	2	–5	–4	–5	–6	–4
11	Expert Systems with Applications	–2	–1	–11	–6	3	3	3	3	3
12	Fuzzy Optimization and Decision Making	0	0	0	0	0	0	0	0	–1
13	Genetic Programming and Evolvable Machines	–3	–3	–3	0	–3	–3	–3	–3	–3
14	IEEE Transactions on Autonomous Mental Development	–3	–1	–7	–3	–7	–7	–7	–9	–8
15	IEEE Transactions on Computational Intelligence and AI in Games	–6	–2	–7	–8	–1	–3	–3	–3	–4
16	IEEE Transactions on Dependable and Secure Computing	3	1	12	–5	11	11	11	14	11
17	IEEE Transactions on Pattern Analysis and Machine Intelligence	0	0	0	0	0	0	0	0	0
18	Information Sciences	0	0	–3	–1	0	0	0	0	0
19	International Journal of Applied Mathematics and Computer Science	–5	–1	–10	–8	4	1	3	–4	1
20	International Journal of Pattern Recognition and Artificial Intelligence	0	0	0	0	0	0	0	0	1
21	Journal of Ambient Intelligence and Smart Environments	–3	–3	–1	6	–2	–2	–2	–3	1
22	Journal of Informetrics	0	0	–1	–1	–5	–5	–5	–7	–5
23	Journal of Machine Learning Research	0	0	1	2	–1	–1	–1	–1	–1
24	Neural Computation	0	0	–1	2	2	2	2	2	2
25	Neural Processing Letters	2	0	0	0	–1	–1	–1	0	–2
26	Pattern Recognition	0	0	–2	–1	2	2	2	2	2
27	Pattern Recognition Letters	2	1	4	–1	19	19	19	18	19
28	Scientometrics	0	0	–5	–1	0	0	0	0	0
29	Swarm Intelligence	–1	–1	–7	–1	–16	–16	–16	–15	–17
30	World Wide Web	–3	–1	–8	1	–4	–6	–6	–9	–4

Evolvable Machines, IEEE Transactions on Autonomous Mental Development, IEEE Transactions on Computational Intelligence and AI in Games, Swarm Intelligence, World Wide Web, Journal of Ambient Intelligence and Smart Environments, Journal of Ambient Intelligence and Smart Environments)deteriorated,on the contrary, otherjournals(ACM Transactions on Applied Perception, ACM Transactions on Sensor Networks, ACM Transactions on Knowledge Discovery from Data, ACM Transactions on Sensor Networks,Applied Numerical MathematicsPattern Recognition Letters) improved their positions in the rankings based on new indicators compared to their JCR IF's ranks.

To make a clear picture, we used correlation coefficient between the indicators. Then, we examined whether Spearman or Pearson correlation coefficient is appropriate for constructing the correlation matrix between the indicators. Since Spearman coefficient (ϱ) is independent of the normality of the data distribution and moreover

Table 5: Spearman's coefficients of between indicators

	JJCR IF	AIF	LPIF	nLPIF	PrIF	EIF	AE_IF	LPE_IF	nLPE_IF	PrE_IF	# of articles	# of citing sources
JCR IF	–											
AIF	0.96	–										
LPIF	0.99	0.99	–									
nLPIF	0.76	0.88	0.82	–								
PrIF	0.87	0.92	0.90	0.85	–							
EIF	0.73	0.76	0.76	0.68	0.63	–						
AE_IF	0.72	0.78	0.76	0.72	0.65	0.99	–					
LPE_IF	0.72	0.77	0.76	0.71	0.64	1.00	1.00	–				
nLPE_IF	0.69	0.78	0.74	0.79	0.67	0.96	0.98	0.97	–			
PrE_IF	0.70	0.77	0.75	0.73	0.68	0.99	0.99	0.99	0.97	–		
# of articles	0.32	0.33	0.33	0.25	0.32	0.70	0.69	0.69	0.65	0.72	–	
# of citing sources	0.52	0.57	0.56	0.51	0.44	0.94	0.94	0.94	0.90	0.93	0.76	–

Table 6: Kendall's coefficients of rankings generated by different indicators

	JCR IF	AIF	LPIF	nLPIF	PrIF	EIF	AE_IF	LPE_IF	nLPE_IF	PrE_IF	# of articles	# of citing sources
JCR IF	–											
AIF	0.86	–										
LPIF	0.93	0.93	–									
nLPIF	0.57	0.71	0.64	–								
PrIF	0.73	0.79	0.76	0.70	–							
EIF	0.59	0.61	0.61	0.53	0.49	–						
AE_IF	0.58	0.63	0.61	0.56	0.50	0.96	–					
LPE_IF	0.58	0.63	0.61	0.55	0.49	0.97	0.99	–				
nLPE_IF	0.55	0.64	0.60	0.64	0.54	0.85	0.89	0.88	–			
PrE_IF	0.57	0.61	0.60	0.56	0.54	0.93	0.94	0.94	0.89	–		
# of articles	0.20	0.20	0.20	0.15	0.18	0.52	0.50	0.50	0.45	0.54	–	
# of citing sources	0.38	0.43	0.41	0.39	0.34	0.80	0.80	0.80	0.75	0.80	0.60	–

it can handle ties, in this study has been used Spearman ρ coefficient for the construction of the correlation matrix.[41,9] The correlation matrix (12×12) was formulated and most indicators were found to be significantly correlated (Spearman ρ > 0.8) with each other at a statistical significance level of 0.05, but there were also a few indicators that showed no strong correlation (ρ < 0.5) with the majority of other indicators.

Table 5 shows that, the Spearman's ρ correlation coefficient between JCRIF and AIF (after removing self-citations) reaches a statistical significance level with a high correlation, ρ = 0.96. Table 5 also shows that, not only after removing self-citations and also removing non-cited articles, the Spearman's ρ correlation coefficient between JCR IF and PrIF reaches a statistical significance level with a high correlation, ρ = 0.87. In the correlation between IFs (JCR IF, AIF, LPIF, nLPIF, and PrIF, i.e. after removing or penalizing self-citations and also removing non-cited articles) andnumber of articlesthere is low correlation, in the range of 0.25-0.33. While the indicators JCR IF, AIF, LPIF, nLPIF, and PrIFare moderately correlated with number of citing sources, in the range of 0.44-0.57. As seen, unlike the penalized IFs (AIF, LPIF, nLPIF and PrIF) the encouraged IF (EIF) and combined IFs (AE_IF, LPE_IF, nLPE_IF, PrE_IF) highly correlated with the number of articles and citing sources, in the range of 0.65-0.72 and 0.90-0.94, respectively. High correlation of these indicators with the number of citing sources is obvious. It follows immediately from the definition (12). Another interesting result is that compared to high correlation (ρ = 0.99) between the JCR IF and LPIF, correlation between the JCR IF and nLPIF is low (ρ = 0.76). It follows that penalization strategy of self-citation can influence on the result.

From the perspective of rankings, as seen in Table 5, the overall rankings of journals based on JCRIF and penalized Ifs values produce Spearman's ϱ that reaches a statistical significance level as highly correlated: is in the range of 0.76-0.96. Compared to these results, JCR IF is moderately correlated with the EIF and with combined IFs (AE_IF, LPE_IF, nLPE_IF, PrE_IF), is 0.73 and is in the rangeof 0.69-0.72, respectively.

A similar result was also obtained in the calculation of Kendall correlation. The results of calculation were shown in Table 6.

Similar to Spearman's ϱ correlation coefficient the Kendall's τ correlation coefficient among the indicators JCR IF, AIF, LPIF and PrIF is also high, in the range of 0.73-0.93.

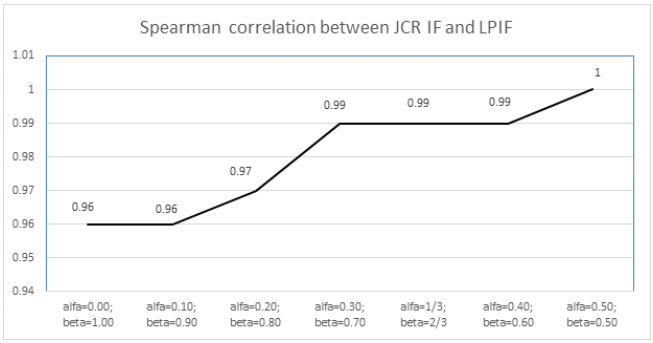

Figure 1: Spearman's ρ coefficient between JCR and LPIF for different values of α and β

Here the exception is nLPIF. Compared to the indicators AIF, LPIF and PrIF, correlation between the JCR and Nlpif can be considered as moderate, τ =0.57.

In this study, we also investigated the influence of the parameters α and β on the correlation between JCR IF and LPIF. As can be seen in Figure 1, journal self-citation does not influence on ranking of journals. Correlation between these indicators is high for different values of the parameters α and β.

According to the findings of this study, journals' IF values and rankings with or without self-citations are all highly correlated. It is hereby recommended that, in comparison with journals' IF values or ranking, self-citations do not need to be eliminated. As scholarly communication behaviors vary in different disciplines, this recommendation may be a useful consideration for Computer Science and can serve as a reference for other disciplines.

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CONFLICT OF INTEREST

We declare that we have no financial and personal relationships with other people or organizations that can inappropriately influence our work, there is no professional or other personal interest of any nature or kind in any product, service and/or company that could be construed as influencing the position presented in, or the review of, the article entitled, "Modified Impact Factors". The study was conducted by the authors, no other people involved in conceiving, performing, and writing this study!

ABBREVIATIONS USED

ISI: Institute for Scientific Information; JCR: Journal Citation Reports; IF – Impact Factor; AIF: Adjusted Impact Factor; WIF – Weighted Impact Factor; EIF: Encouraged Impact Factor; LPIF: Impact Factor Linearly Penalized; nLPIF: Impact Factor non-Linearly Penalized; PrIF: Pure Impact Factor; MIF: Median Impact Factor; SNIP: Source Normalized Impact per Paper SJR: SCImago Journal Rank; AE_IF: Adjusted and Encouraged Impact Factor; LPE_IF: Impact Factor Linearly Penalized and Encouraged; nLPE_IF: Impact Factor non-Linearly Penalized and Encouraged; PrE_IF: Pure and Encouraged Impact Factor.

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