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Interpolated sub-impact factor (SIF) sequences for journal rankings

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ABSTRACT

In a previous publication the journal sub-impact factor denoted as SIF, and derived sub-impact sequences have been introduced. Their calculation included a discrete step. Now we adapt this scheme to include an interpolation procedure. A mathematical proof is given showing that anomalies that may happen in the discrete approach cannot happen anymore in the interpolated approach.

1. Introduction

Journals can be evaluated from different perspectives. This has led to comparisons between various bibliometric indicators and peer review based journal rankings (see e.g. Xu, 2011). It is evident that journal quality is a multi-dimensional concept (Aarssen, Tregenza, Budden, Lortie, & Leimu, 2008; Brumback, 2004; Cahn, 2014; Haustein, 2012; Kurmis & Kurmis, 2006; Rousseau, 2002; Van Fleet, McWilliams, & Siegel, 2000). For instance, an empirical study (Xu, 2011) has shown that the correlation between the ABS (Association of Business Schools) journal ranking and JCR journal rankings is not always consistent. Thus, when introducing a new indicator one should provide a clear statement about its purpose, rather than directly attempting to evaluate overall journal quality. In Xu (2011) and Xu, Liu, and Rousseau (2015) the SIF indicator has been designed and introduced for the specific evaluation of a journal's contribution to knowledge accumulation in one or more subjects, this as an aspect of overall journal quality.

Xu (2011), see also Leydesdorff and Bornmann (2011), states that the outcome of knowledge accumulation includes the two aspects "quantity" and "quality". She, moreover, points out that it is crucial to take the whole citation distribution into consideration. Therefore, the evaluation of journal quality in terms of knowledge accumulation should be based on the distribution of its citations, and not just on the average or the total number of citations. Thus the SIF, unlike the JIF (Journal Impact Factor), concentrates on those articles with higher citation counts. For example, EJOR (European Journal of

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Operational Research) and MS (Management Science) are two of the flagship journals of the field of operational research (OR), but MS has the higher JIF, see Appendix. However, if one takes the citation distributions of these journals into account, it becomes clear that EJOR publishes many more highly cited papers than MS, but also many lowly cited ones, decreasing its JIF. If the aim is to measure a journal's contribution to knowledge accumulation, one should pay more attention to journals publishing many highly cited articles and then conclude that EJOR is the more important of the two, as shown by its SIF (Xu et al., 2015).

2. Sub-impact factors (SIFs) and SIF-sequences

In earlier contributions (Xu, 2011; Xu & Liu, 2013; Xu et al., 2015), the journal sub-impact factor denoted as SIF and derived SIF-sequences have been introduced to measure a journal's contribution to knowledge accumulation. Based on these indicators a new ranking of journals has been proposed. Yet, as their calculation included a discrete step it was shown that anomalies might occur. Now we will adapt the calculation method to include an interpolation procedure. A mathematical proof is given showing that anomalies that may happen in the discrete approach cannot happen anymore when using interpolation. In this way this article clarifies and extends these previous publications.

Admitting that SIFs lead to 'yet another ranking', hence yet another perspective on the scholarly communication network, we point out, following Haustein (2012) that several journal related metrics taken together, may provide a better perspective than just one standard metric. First we recall the main definitions from Xu et al. (2015).

Notation: finite rows are given between square brackets.

Definition. A journal's discrete sub-impact factor at level L.

Let N be the number of articles under consideration and let $C = [c_1, c_2, \ldots, c_N]$ denotes their citations ranked in decreasing order. To simplify the terminology we use "decreasing" when we mean non-increasing and similarly, we use "increasing" when we mean non-decreasing. We define the sub-impact factor (SIF) of a journal at level L (L being a given number of citations) as follows:

$$SIF(L) = \frac{L}{P(L)} \tag{1}$$

where $P(L)$ is the smallest natural number of articles needed to reach at least L citations. Formally $P(L)$ can be obtained as follows: let $(c_j)_{j=1,\ldots,N}$ be the sequence of received citations placed in decreasing order and let $(s_j)_{j=1,\ldots,N}$ be their partial sums, $S_j = \sum_{m=1}^{j} c_m$ (and hence $s_N = T$, the total number of received citations), then $P(L)$ is equal to the smallest integer j such that $s_j/L \geq 1$. For instance, if $L = 50$ and $(c_j)_{j=1,\ldots,4} = [30, 15, 10, 3]$, then $(s_j)_{j=1,\ldots,4} = [30, 45, 55, 58]$ and $P(L) = P(50) = 3$, as 3 is the smallest integer j such that $s_j/50 \geq 1$ (namely $55/50 \geq 1$).

We recall that $SIF(L)$ can be calculated for any given publication and citation window, and this in a synchronous or diachronous way (Frandsen & Rousseau, 2005).

Definition. Discrete SIF sequences (Xu et al., 2015).

Using a strictly increasing sequence $(L_k)_{k=1,\ldots,K}$ consisting of K levels (in short: an L-sequence), with $L_1 > 0$, leads to a $SIF(L_k)$-sequence, which clearly depends on the citation distribution. However, we introduce two additional rules. If the sequence $(L_k)_k$ is given and L_M is the first L-value which is larger than or equal to T (the total number of citations) then we set $SIF(L_M)$ equal to the average number of citations: T/N. The reason for this additional rule is that, without it, articles with zero citations would play no role (we divide by N), while they should as they are an essential part of the citation distribution. If $L > T$ and it is not the first L-value larger than or equal to T, then $P(L)$ is not defined and in that case $SIF(L)$ is set equal to zero. Once a SIF-sequence has value zero it has value zero for all following terms. The series $(L_k)_k$ may be of the form $L_k = kL$, with $L > 0$ given, $k = 1, 2, \ldots, K$, but also general sequences (without regularities) will be used. The L-sequence can be considered a sequence of yardsticks determined by the user. In Xu et al. (2015) for instance, we used decile values of citations received by a set of journals. The length of a SIF-sequence is by definition equal to the length of the corresponding L-sequence, namely K, and has, a priori, no relation with N, the length of the citation sequence.

Let us present an example. If $(L_k)_k = [20, 32, 40, 45, 60, 61]$ and $(s_j)_j = [30, 45, 55, 58, 58, 58]$. Then $P(L_1) = P(20) = 1$; $P(L_2) = P(32) = 2$; $P(L_3) = P(40) = 2$; $P(L_4) = P(45) = 2$; $P(L_5) = P(60)$ is not defined. Hence the corresponding SIF-sequence is [20, 16, 20, 22.5, $58/6 \approx 9.7$, 0]. This sequence is fluctuating.

$SIF(60) = 58/6$ is the average number of citations and basically the Journal Impact Factor (if the proper publication and citation windows are used, and ignoring problems related to the notion of 'a citable publication'). This illustrates the fact that the sub-impact factor generalizes the notion of an impact factor.

Note that there exists an infinite number of SIF indicators depending on the used publication and citation windows (this is completely similar for Journal Impact Factors, see Frandsen & Rousseau 2005 or h-indices Liang & Rousseau, 2009) and this, moreover, depending on the sequence $(L_k)_k$. Hence we actually introduced a whole family of indicators. We recall from Xu et al. (2015) and the previous example that discrete SIF-sequences are not necessarily decreasing, although intuitively, such a property might be expected.

If all articles of a journal (or any other set under investigation) are uncited then its SIF-sequence is by definition the constant zero sequence.

3. An interpolated SIF-value

The approach presented thus far used integer valued $P(L)$-values. Yet similar to the h-index for which there exists an integer valued approach (Hirsch, 2005) and an interpolated one (Rousseau, 2006, 2014) we may also use interpolated values.

Let L be 100 and consider the equidistant sequence (kL), $k=1, 2, \ldots$ Then, when using interpolation the answer to the question "How many articles are needed to get 100 citations?" for the fictitious example $(c_j)_j=[150, 100, 20, 10, 10, 5, 3, 2, 1, 0, 0, 0]$ is not one, but 2/3. Hence the first SIF ratio is 150, the second one is $200/(3/2)=133.3$ and the third one is $300/8=37.5$. The fourth one is the average value $301/12=25.1$ and all other values are zero.

Recall that $(c_j)_{j=1,\ldots,N}$ is a decreasing sequence of received citations and that $(s_j)_{j=1,\ldots,N}$ denotes their partial sums, $s_j=\sum_{m=1}^{j} c_m$, which are increasing by definition. Moreover, we put $s_0=0$. Given a strictly increasing L-sequence $(L_k)_k$ the procedure to determine the interpolated P-value corresponding with L_k, denoted as I_k, is as follows:

For each $k=1, 2, \ldots$

(1) determine the largest natural number m such that $s_m \le L_k$. This number is denoted as m_k; we note that if $s_N \le L_k$, $m_k=N$.
We first consider the special case that $m_k=N$:
(2) if m_k is the first k for which $m_k=N$, then $I(L_k)$ is not determined and $SIF(L_k)=T/N$;
(3) if m_k is not the first k for which $m_k=N$, also then $I(L_k)$ is not determined and now $SIF(L_k)=0$.
Next we consider the general case:
(4) if $m_k<N$, then calculate the ratio $(L_k - s_{m_k})/(s_{m_k+1} - s_{m_k}) = (L_k - s_{m_k})/(c_{m_k+1})$
(5) then $I_k = m_k + ((L_k - s_{m_k})/c_{m_k+1})$ and $SIF(L_k) = L_k/I_k = L_k \cdot c_{m_k+1}/(m_k \cdot c_{m_k+1} + L_k - s_{m_k})$.

We note that c_{m_k+1} in step 4 is never equal to zero. Indeed, if c_{m_k+1} were zero then $s_{m_k} = s_{m_k+1} = s_N$ which is excluded in step 4 (this case was handled in step 2 or step 3).

Example E. Let the sequence $(c_k)_{k=1,\ldots,10}$ be [20, 6, 6, 5, 4, 4, 2, 1, 0, 0]. Hence $N=10$ and $T=48$. The corresponding s-sequence, starting with index zero is $(s_k)_{k=0,\ldots,10}=[0, 20, 26, 32, 37, 41, 45, 47, 48, 48, 48]$. Let the L-sequence be [10, 15, 30, 40, 55, 60] with $K=6$.

Then

$I_1=I(L_1)=I(10)=0+(10-0)/20=10/20$ $(m_1=0)$ and $SIF(10)=20$;
$I_2=I(L_2)=I(15)=0+(15-0)/20=15/20$ $(m_2=0)$ and $SIF(15)=20$;
$I_3=I(L_3)=I(30)=2+(30-26)/6=16/6$ $(m_3=2)$ and $SIF(30)=180/16=11.25$;
$I_4=I(L_4)=I(40)=4+(40-37)/4=19/4$ $(m_4=4)$ and $SIF(40)=160/19\approx 8.42$;
$I_5=I(L_5)=I(55)$ is not determined $(m_5=10=N)$. Hence $SIF(55)=T/N=48/10=4.8$;
$I_6=I(L_6)=I(60)$ is not determined $(m_6=10=N)$ and $SIF(60)=0$.

If $L_K<s_N$, then $m_K<N$ and $SIF(L_K)>T/N$. In this case the average number of citations (impact factor) is not part of the SIF-sequence.

If we denote by s the piecewise linear curve whose graph connects the points (j, s_j) then $I_k=s^{-1}(L_k)$, where s^{-1} is defined on the interval $[0,T]$.

Fig. 1 illustrates the procedure to obtain the I_k-values of Example E. The solid line shows the citation curve and the round dots indicate the L-sequence. Recall that the L-sequence is positive and strictly increasing, but without further restrictions. The s-sequence consists of partial sums of citation values, ranked in decreasing order.

Proposition. *The SIF-sequence based on interpolated values is decreasing.*

Proof. We consider three cases.

(1) Assume that $c_1=\ldots=c_i$ and $L_j \le ic_i = s_i$ then we apply Thales' intercept theorem, also known as the ratio theorem, in the triangles with vertices $O=(0, 0)$, $(1, 0)$, $(1, s_i)$ and O, $(I_j, 0)$, (I_j, L_j). Then I_j is determined by the relation: $L_j/s_1=I_j/1$. Hence $I_j=L_j/s_1$ and consequently $SIF(L_j)=s_1$. Note that this rule also applies for $i=1$ as in Fig. 1, corresponding with for $j=1, 2$. Hence, as long as these requirements apply, the SIF-sequence is constant.
(2) If the previous rule does not apply and $SIF(L_{j+1})=T/N$ we consider the line passing through (I_j, L_j) and (N, T). This line intersects the horizontal axis in the point A. Because citations are ranked in decreasing order, the slopes of the lines connecting points on the s-curve are decreasing. Hence, point A is situated more to the left than point O. Let $|AO|$ denote the length of the line connecting point A and the origin O. An application of Thales' theorem in the triangles A, $(I_j, 0)$, $(I_j$,

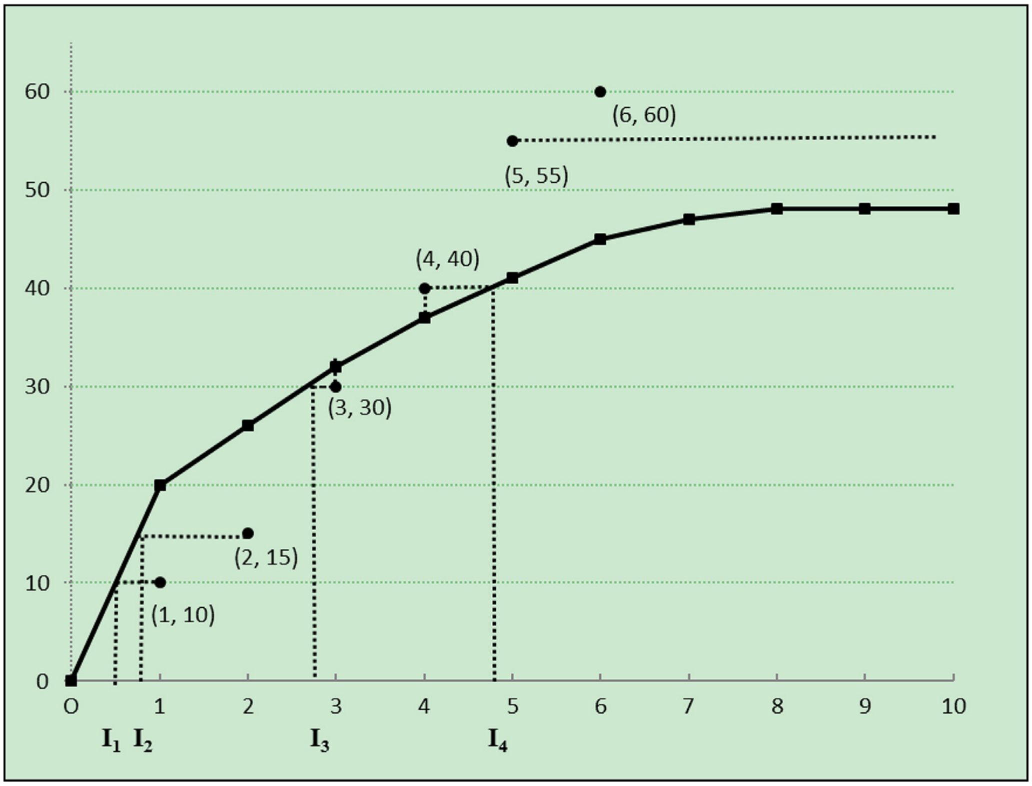

Fig. 1. An illustration of $I_k = s^{-1}(L_k)$.

L_j) and A, $(N, 0)$, (N, T) leads to $L_j/T = (|AO| + I_j)/(|AO| + N) > I_j/N$ or $L_j/I_j > T/N$. Other SIF-values are equal to zero so that also then the SIF-sequence is decreasing (in the sense of non-increasing).

Applied to Fig. 1, $j = 4$, $T = 48$, $N = 10$, $(I_j, L_j) = (4, 40)$, $(N, T) = (10, 48)$ and one can find that the point A has coordinates $(-26, 0)$, hence $|AO| = 26$.

(3) If requirements (1 and 2) are not satisfied we have a 'middle' situation. This case is illustrated by Fig. 2. As citations are ranked in decreasing order, the slopes of the lines connecting points on the s-curve are decreasing. Hence, the line connecting the points (I_j, L_j) and (I_{j+1}, L_{j+1}) intersects the horizontal axis in a point situated strictly before the origin O (in point A of Fig. 2). Again applying Thales' intercept theorem leads to $L_j/L_{j+1} = (I_j + |AO|)/(I_{j+1} + |AO|) > I_j/I_{j+1}$. Hence, also in case 3, the sequence $(SIF(L_j))_j = (L_j/I_j)_j$ is strictly decreasing. This proves the theorem.

This theorem shows that the anomalies which may occur in the discrete case vanish when using interpolation.

A special case. Assume that the s-sequence is equal to the L-sequence (hence also the s-sequence is strictly increasing). Then $I_k = k$ for every $k = 1, \ldots, K = N$. We check that, also in this case, the SIF-sequence is decreasing. In this special case $SIF(L_k) = L_k/k$ and we have to check if: $L_k/k \geq L_{k+1}/(k+1) \Leftrightarrow s_k/k \geq s_{k+1}/(k+1) = (s_k + c_{k+1})/(k+1)$. Hence, we have to show that $s_k \geq kc_{k+1}$. This is correct as the smallest possible value for $s_k = kc_{k+1}$ (if all c_j, $j = 1, \ldots, k+1$, are equal).

4. A sharp or a blunt instrument

Until now we have not considered any requirement about the relation between N, the number of articles under consideration, and K, the length of the L-sequence. Yet, it is obvious that if K is small we just take a few points on the s-curve into account and have a very blunt instrument to describe this curve.

Moreover, if $s_N = T < L_k$ from a certain k-value on, then the corresponding SIF-sequence consists of zeros from index $k+1$ on. Hence if the L-values are (much) larger than the s-values, we obtain little information. Maybe worse, if $L_K \leq s_1$, then we have a constant SIF-sequence, equal to $c_1 = s_1$ for all k-values. Generally, if $L_K < T$ there is a part of the s-curve that is not covered by the SIF-sequence.

We also note that if $T = s_N > L_K$ the average number of citations per article, T/N, corresponding to an impact factor, is not an element of the SIF-sequence.

Consequently, in order to make the SIF-sequence a sharp, and not a blunt, instrument to describe a citation curve, K should not be too small (but larger than N makes no sense). Moreover, L_K (the last L-value) should be larger than T.

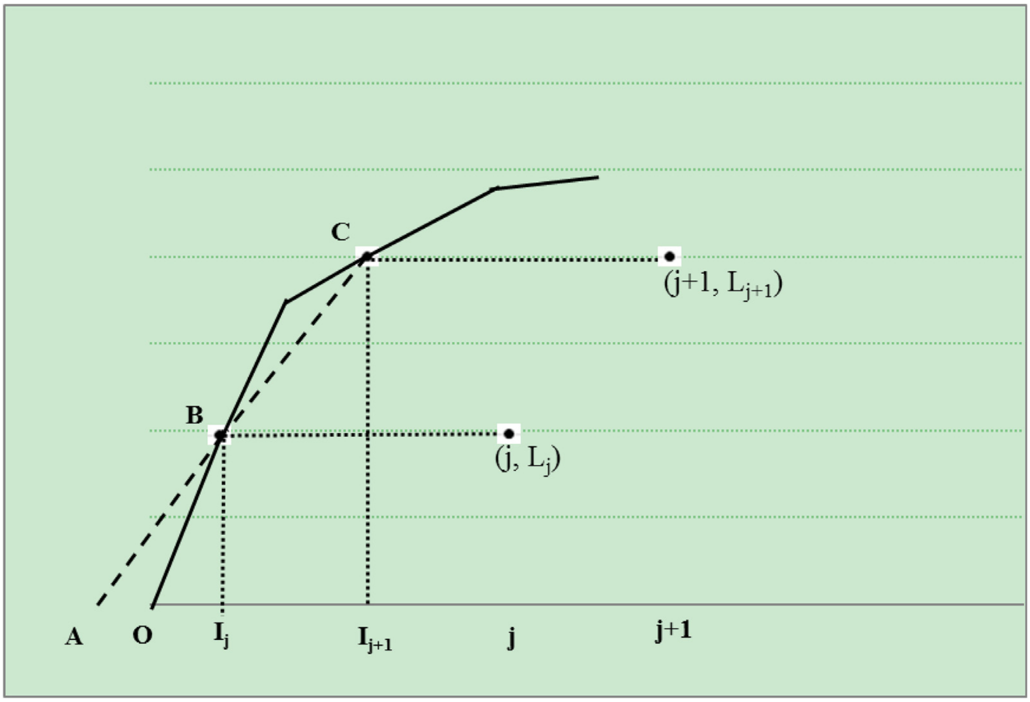

Fig. 2. Illustration of the proof of the theorem (case 3).

Table 1
Comparison of discrete and interpolated aggregated SIF-values (some selected journals).

Journals	$ISIF_{ew}$	$Rank\_ISIF_{ew}$	SIF_{ew}	$Rank\_SIF_{ew}$	5-year JIF	2-year JIF
RELIAB ENG SYST SAFE	30.7	**15**	28.44	**16**	2.593	2.048
TRANSPORT RES E-LOG	30.52	**16**	29.42	**15**	2.943	2.193
PAC J OPTIM	13.87	**23**	12.24	**27**	0.848	0.798
IEEE SYST J	13.82	**24**	13.06	**25**	1.753	1.746
COMPUT OPTIM APPL	13.8	**25**	13.12	**24**	1.355	0.977
OPTIM METHOD SOFTW	12.75	**27**	13.95	**23**	1.271	1.210
OPTIM CONTR APPL MET	10.9	**29**	9.56	**31**	1.293	1.535
OR SPECTRUM	10.42	**30**	10.19	**29**	2.200	1.090
M&SOM-MANUF SERV OP	9.98	**31**	9.68	**30**	2.692	1.450
J SIMUL	6.08	**40**	5.19	**42**	0.000	0.383
MATH OPER RES	5.61	**42**	5.08	**43**	1.259	0.924
NETWORKS	5.51	**43**	5.36	**40**	1.245	0.739
INTERFACES	1.14	**62**	1.11	**63**	0.669	0.443
TOP	1.13	**63**	1.13	**62**	0.955	0.766

5. Ranking journals using a SIF-sequence

Ranking journals when the finite sequences of $(SIF^{J_j}(L_k))_{k=1,\ldots,K}$ values are known for a set of journals $(J_j)_j$, happens in the same way as in the discrete case.

We say that journal $J_1 \succ J_2$ if for each $k = 1, \ldots, K$: $SIF^{J_1}(L_k) \geq SIF^{J_2}(L_k)$ and for at least one k there is a strict inequality.

This $\succ$ ranking is, however, not a total order as it may happen (and often happens in reality) that journals are not comparable according to this ranking.

Again, as in the discrete case we construct, for each journal J, a weighted sum of its SIF-values, to which we refer as the aggregated SIF indicator. A simple and straightforward way is to use equal weights (namely $1/K$), leading to $SIF_{ew} = \sum_{k=1}^{K} SIF(L_k)/K$, where the subscript ew stands for equal weights. Another approach is to use the set of weights $(2/K(K+1)$, $4/K(K+1), \ldots, 2K/K(K+1))$ de-emphasizing highly cited publications, at least with respect to the case of equal weights. This leads to $SIF_{dw} = \sum_{k=1}^{K} 2k(SIF(L_k))/K(K+1)$, where the subscript dw stands for different weights. We note though that occasionally different citation curves may have the same SIF_{ew} or SIF_{dw} values.

6. Other properties of the aggregated SIF-indicator

Now we consider two basic steps in a dynamic publication-citation set (Rousseau & Ye, 2012). The first is adding a new publication with zero citations; the second one is adding one citation to an already published article. We show that the aggregated SIF-indicator behaves as expected.

Proposition 1. *If an uncited article is added then the aggregated SIF-value decreases or stays the same.*

Proof. If an uncited article is added then all $SIF(L_k)$-values stay the same except the average (the Impact Factor) which decreases, hence the value of the aggregated SIF-indicator cannot increase. Note that it does not always happen that the average number of citations is part of the SIF-sequence, hence we are not sure that the aggregated SIF-value strictly decreases.

Proposition 2. *If an extra citation is added to one article then the aggregated SIF-value increases or stays the same.*

Proof. The new *s*-curve is, at least from some point on, strictly above the old one and hence the corresponding *I*-value is larger; surely the last value is larger than before, assuming again that these are included in the SIF-sequence.

As described before the aggregated SIF-value is an elite indicator, in the sense that more importance is attached to highly cited articles. Concretely [32, 0, 0, 0] will never have a lower SIF-value than [8, 8, 8, 8] although the average value (impact factor) is the same. The reason is that the SIF-sequence is derived from cumulative citations. Hence the most-cited articles are always included. This characterization makes the SIF-sequence suitable for measuring a journal's contribution to knowledge accumulation.

7. Rankings of management science journals

Below, we carry out an empirical study using 79 journals in the area of operations research and management science. Data was collected in May 2015. Journals were those included in the JCR 2013 (the latest available JCR version at the data collection time). Citable items of these journals in the years 2010–2014 were manually downloaded from the Web of Science, together with the numbers of citations received during the periods 2010–2014. We observe huge differences in the total citations of these journals going from 33 to 33,914. Thus, it is not a trivial issue to reasonably determine subtotal citation levels, i.e. the *L* sequence to be used. We opted for the following procedure: Journals are ranked in ascending order of the total number of received citations. Then – using Excel software – the decile values of this set are: 172.2-281.6-346.8-465.6-648.0-934.6-1257.8-2466.2-3984.0-33914.0. This sequence is used as $(L_k)_k$ and determines the interpolated Sub-Impact factor (ISIF) sequences. In Tables 1 and 2 we write the discrete version as SIF and the interpolated one as ISIF. Note that we use the same *L*-sequences for calculating both sequences. Table 1 shows some selected journals, while Table 2 (see Appendix) contains the full list.

Clearly, the interpolated approach does not only lead to totally different aggregated SIF-values, but sometimes shifts the rank of these journals. This is particularly the case for OPTIM METHOD SOFTW (SIF rank: 23 and ISIF rank 27). The fact that the Spearman rank correlation coefficient between the SIF and ISIF rankings is 0.999 is a clear proof of this observation. The Spearman rank correlation between the ISIF ranking and those for the 2- and 5-year impact factors (data are given in Table 2) are 0.812 and 0.819 respectively. These results are consistent with the idea that the two approaches measure different, but related journal characteristics. According to the opinion of several management science professors in the UK, the interpolated approach gives rankings closer to their personal opinion.

8. Conclusions

In order to avoid possible unwanted effects it is better to use the interpolated version instead of the original, discrete version, avoiding fluctuating SIF-sequences. Moreover, we recall that in order to make the SIF-sequence a proper instrument to describe a citation curve, it is best if $K \leq N$ and that L_K (the last *L*-value) is larger than *T*. We note that the aggregated SIF-value is an elite indicator, attaching most importance to heavily cited articles.

SIF indicators are applicable to any group of publications, not just articles published in the same journal, such as the publications of a group of researchers or research units. Hence they can be used in any research evaluation exercise. They can, moreover, be used for a set of books (playing the role of publications) and their loans (playing the role of citations), see e.g. Liu & Rousseau, 2009. Although we think that a new indicator may bring a new perspective, we admit that we were also seduced by its nice mathematical properties.

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Author Contributions

Conceived and designed the analysis: Ronald Rousseau
Collected the data: Fang Xu
Contributed data or analysis tools: Fang Xu
Performed the analysis: Ronald Rousseau; Wenbin Liu
Wrote the paper: Ronald Rousseau; Wenbin Liu

Appendix A. Appendix

Table 2

Table 2
Full list of discrete and interpolated aggregated SIF-values.

Journals	$ISIF_{ew}$	Rank $ISIF_{ew}$	SIF_{ew}	Rank_SIF_{ew}	5-year JIF	2-year JIF
EUR J OPER RES	125.02	**1**	107.00	**1**	2.625	1.843
SYST CONTROL LETT	103.03	**2**	86.26	**2**	2.345	1.886
EXPERT SYST APPL	83.68	**3**	72.15	**3**	2.254	1.965
J OPER MANAG	82.18	**4**	71.11	**4**	7.718	4.478
COMPUT OPER RES	51.87	**5**	48.20	**5**	2.335	1.718
DECIS SUPPORT SYST	51.39	**6**	43.79	**6**	2.651	2.036
TRANSPORT RES B-METH	42.79	**7**	38.99	**7**	4.439	3.894
J OPTIMIZ THEORY APP	40.50	**8**	35.83	**8**	1.396	1.406
TECHNOVATION	39.20	**9**	35.66	**9**	3.251	2.704
MANAGE SCI	37.65	**10**	35.53	**10**	3.458	2.524
OMEGA-INT J MANAGE S	37.47	**11**	35.29	**11**	3.626	3.190
MATH PROGRAM	36.22	**12**	33.42	**12**	2.195	1.984
OPER RES	35.09	**13**	32.14	**13**	2.498	1.500
INT J SYST SCI	32.81	**14**	30.78	**14**	1.714	1.579
RELIAB ENG SYST SAFE	30.70	**15**	28.44	**16**	2.593	2.048
TRANSPORT RES E-LOG	30.52	**16**	29.42	**15**	2.943	2.193
INT J PROD RES	27.13	**17**	25.34	**17**	1.718	1.323
ANN OPER RES	25.42	**18**	23.39	**18**	1.312	1.103
SAFETY SCI	24.77	**19**	23.17	**19**	2.020	1.672
INT J INF TECH DECIS	21.70	**20**	20.07	**20**	1.688	1.890
J OPER RES SOC	15.03	**21**	14.49	**21**	1.272	0.911
J GLOBAL OPTIM	14.79	**22**	14.13	**22**	1.547	1.355
PAC J OPTIM	13.87	**23**	12.24	**27**	0.848	0.798
IEEE SYST J	13.82	**24**	13.06	**25**	1.753	1.746
COMPUT OPTIM APPL	13.80	**25**	13.12	**24**	1.355	0.977
PROD OPER MANAG	13.38	**26**	12.63	**26**	2.378	1.759
OPTIM METHOD SOFTW	12.75	**27**	13.95	**23**	1.271	1.210
TRANSPORT SCI	12.41	**28**	11.92	**28**	2.913	2.294
OPTIM CONTR APPL MET	10.90	**29**	9.56	**31**	1.293	1.535
OR SPECTRUM	10.42	**30**	10.19	**29**	2.200	1.090
M&SOM-MANUF SERV OP	9.98	**31**	9.68	**30**	2.692	1.450
J SYST ENG ELECTRON	9.39	**32**	9.03	**32**	0.499	0.605
IIE TRANS	9.00	**33**	8.78	**33**	1.627	1.064
ENG OPTIMIZ	8.97	**34**	8.76	**34**	1.370	1.230
OPTIM LETT	8.89	**35**	8.68	**35**	1.201	0.990
INFORMS J COMPUT	8.86	**36**	8.39	**36**	1.722	1.120
PROD PLAN CONTROL	7.82	**37**	7.61	**37**	1.171	0.991
QUAL RELIAB ENG INT	6.94	**38**	6.72	**38**	0.997	0.994
INT J COMPUT INTEG M	6.64	**39**	6.53	**39**	1.143	1.019
J SIMUL	6.08	**40**	5.19	**42**	0.000	0.383
J MANUF SYST	5.77	**41**	5.21	**41**	1.858	1.847
MATH OPER RES	5.61	**42**	5.08	**43**	1.259	0.924
NETWORKS	5.51	**43**	5.36	**40**	1.245	0.739
OPER RES LETT	5.03	**44**	4.98	**44**	0.903	0.624
OPTIMIZATION	4.82	**45**	4.72	**45**	0.804	0.771
FUZZY OPTIM DECIS MA	4.80	**46**	4.59	**46**	2.055	1.000
NETW SPAT ECON	4.12	**47**	4.00	**47**	1.640	1.803
J SCHEDULING	4.11	**48**	4.00	**48**	1.562	1.186
NAV RES LOG	3.96	**49**	3.86	**49**	1.222	0.563
OPTIM ENG	3.72	**50**	3.62	**50**	1.101	0.955
J QUAL TECHNOL	3.54	**51**	3.44	**51**	1.681	1.271
CENT EUR J OPER RES	2.73	**52**	2.70	**52**	0.842	0.787
INT J TECHNOL MANAGE	2.40	**53**	2.38	**53**	0.659	0.492
J IND MANAG OPTIM	2.33	**54**	2.28	**54**	0.704	0.536
EUR J IND ENG	1.78	**55**	1.73	**55**	1.554	1.500

Table 2 (*Continued*)

Journals	$ISIF_{ew}$	Rank $ISIF_{ew}$	SIF_{ew}	Rank_SIF_{ew}	5-year JIF	2-year JIF
INT T OPER RES	1.76	**56**	1.72	**56**	0.000	0.481
STUD INFORM CONTROL	1.54	**57**	1.53	**57**	0.500	0.605
QUEUEING SYST	1.53	**58**	1.52	**58**	0.911	0.602
APPL STOCH MODEL BUS	1.49	**59**	1.48	**59**	0.751	0.532
SYSTEMS ENG	1.40	**60**	1.40	**60**	1.072	0.923
DISCRETE OPTIM	1.25	**61**	1.23	**61**	0.917	0.629
INTERFACES	1.14	**62**	1.11	**63**	0.669	0.443
TOP	1.13	**63**	1.13	**62**	0.955	0.766
P I MECH ENG O-J RIS	1.11	**64**	1.09	**64**	0.000	0.775
MATH METHOD OPER RES	1.03	**65**	1.02	**65**	0.819	0.539
4OR-Q J OPER RES	0.98	**66**	0.97	**66**	1.181	0.918
DISCRETE EVENT DYN S	0.88	**67**	0.87	**67**	1.010	0.667
FLEX SERV MANUF J	0.78	**68**	0.78	**68**	1.180	1.439
J SYST SCI SYST ENG	0.69	**69**	0.68	**69**	0.839	0.566
ASIA PAC J OPER RES	0.50	**70**	0.49	**70**	0.396	0.220
PROBAB ENG INFORM SC	0.41	**71**	0.40	**71**	0.624	0.328
SORT-STAT OPER RES T	0.30	**72**	0.30	**72**	0.807	0.962
CONCURRENT ENG-RES A	0.26	**73**	0.26	**73**	0.672	0.531
IMA J MANAG MATH	0.25	**74**	0.25	**74**	0.688	0.471
INFOR	0.20	**75**	0.20	**75**	0.465	0.410
QUAL TECHNOL QUANT M	0.19	**76**	0.19	**76**	0.000	0.339
ENG ECON	0.19	**77**	0.19	**77**	0.000	0.647
RAIRO-OPER RES	0.11	**78**	0.11	**78**	0.364	0.333
MIL OPER RES	0.10	**79**	0.10	**79**	0.337	0.312

References

Aarssen, L. W., Tregenza, T., Budden, A. E., Lortie, C. J., & Leimu, J. K. (2008). Bang for your buck: Rejection rates and impact factors in ecological journals. *Open Ecology Journal*, *1*(1), 14–19.

Brumback, R. A. (2004). Further analysis of the impact factors and submission information for the journal of child neurology. *Journal of Child Neurology*, *19*(4), 290–293.

Cahn, E. S. (2014). Journal rankings: Comparing reputation, citation and acceptance rates. *International Journal of Information Systems in the Service Sector*, *6*(4), 92–103.

Frandsen, T. F., & Rousseau, R. (2005). Article impact calculated over arbitrary periods. *Journal of the American Society for Information Science and Technology*, *56*(1), 58–62.

Haustein, S. (2012). *Multidimensional journal evaluation*. Berlin/Boston: De Gruyter Saur.

Hirsch, J. E. (2005). An index to quantify an individual's scientific research output. *Proceedings of the National Academy of Sciences of the United States of America*, *102*(46), 16569–16572.

Kurmis, A. P., & Kurmis, T. P. (2006). Exploring the relationship between impact factor and manuscript rejection rates in radiologic journals. *Academic Radiology*, *13*(1), 77–83.

Leydesdorff, L., & Bornmann, L. (2011). Integrated impact indicators compared with impact factors: An alternative research design with policy implications. *Journal of the American Society for Information Science and Technology*, *62*(11), 2133–2146.

Liang, L. M., & Rousseau, R. (2009). A general approach to citation analysis and an *h*-index based on the standard impact factor framework. In B. Larsen, & J. Leta (Eds.), *ISSI 2009: 12th international conference on Scientometrics and Informetrics* (pp. 143–153). Rio de Janeiro: BIREME & Federal University of Rio de Janeiro.

Liu, Y. X., & Rousseau, R. (2009). Properties of Hirsch-type indices: The case of library classification categories. *Scientometrics*, *79*(2), 235–248.

Rousseau, R. (2002). Journal evaluation: Technical and practical issues. *Library Trends*, *50*(3), 418–439.

Rousseau, R. (2006) Simple models and the corresponding *h*- and *g*-index. E-LIS: ID 6153, http://eprints.rclis.org/archive/00006153/.

Rousseau, R. (2014). A note on the interpolated or real-valued *h*-index with a generalization for fractional counting. *ASLIB Journal of Information Management*, *66*(1), 2–12.

Rousseau, R., & Ye, F. Y. (2012). Basic independence axioms for the publication-citation system. *Journal of Scientometric Research*, *1*(1), 22–27.

Van Fleet, D. D., McWilliams, A., & Siegel, D. S. (2000). A theoretical and empirical analysis of journal rankings: The case of formal lists. *Journal of Management*, *26*(5), 839–861.

Xu, F. (2011). *Measuring research output quality using bibliometric method within the HEFCE framework. (Doctoral dissertation)*. Canterbury: University of Kent.

Xu, F., & Liu, W. B. (2013). Evaluation of SCI journals from the view of knowledge accumulation. *Journal of the China Society for Scientific and Technical Information/Qing Bao Xue Bao*, *32*(10), 1075–1089 (in Chinese)

Xu, F., Liu, W. B., & Rousseau, R. (2015). Introducing Sub-Impact Factor (SIF) sequences and an aggregated SIF-indicator for journal ranking. *Scientometrics*, *102*(2), 1577–1593. http://dx.doi.org/10.1007/s11192-014-1401-9