Improving the Accuracy of Institute for Scientific Information's Journal Impact Factors

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The Institute for Scientific Information (ISI) publishes annually listings of impact factors of scientific journals, based upon data extracted from the Science Citation Index (SCI). The impact factor of a journal is defined as the average number of citations given in a specific year to documents published in that journal in the two preceding years, divided by the number of "citable" documents published in that journal in those 2 years. This article presents evidence that for a considerable number of journals the values of the impact factors published in ISI's Journal Citation Reports (JCR) are inaccurate, particularly for several journals having a high impact factor. The inaccuracies are due to an inappropriate definition of citable documents. Document types not defined by ISI as citable (particularly letters and editorials) are actually cited and do contribute to the citation counts of a journal. We present empirical data in order to assess the degree of inaccuracy due to this phenomenon. For several journals the results are striking. We propose to calculate for a journal impact factors per type of document rather than one single impact factor as given currently in the JCR.

1 Introduction

During the past decade, impact factors (IFs) of scientific journals have gained importance, both in scientific work, scientific information management, and research management or policy. Librarians use IFs as tools for the management of their journal collections (Egghe & Rousseau, 1990). The section "Journals per Category, Ranked by Impact Factor," published in Institute for Scientific Information's (ISI) Journal Citation Reports (JCR), is frequently used. Scientific publishers use the IF as an indicator of journal performance. Scientists increasingly appear to evaluate and redirect their publication strategies partly on the basis of a comparative analysis of journal IFs (de Bruin, Kint, Luwel, & Moed, 1993). IFs are also important indicators in the assessment of performance of research groups, institutes, or even countries (Van Raan, 1988; Todorov & Glänzel, 1988). For instance, in several Dutch universities the articles published by a scientist or a group are evaluated by giving each paper a weight equal to the IF of the journal in which it was published.

The impact of a journal is measured through the number of times it is cited in journals processed for the Science Citation Index (SCI). Journals, however, differ with respect to the number of documents they publish in a year. In order to correct for these differences, ISI constructed an IF in which the number of citations received by a journal is normalized on the number of documents it contains. ISI is one of the very few database producers that process journals "cover to cover." Journals may contain many different types of documents: normal articles, reviews, letters, notes, editorials, corrections, meeting abstracts, and several other types as well. ISI includes all types in the SCI. Some types are hardly cited at all (particularly, meeting abstracts and corrections). At this point, the problem arises as to which types of documents should be taken into account in the calculation of a journal's IF. In order to deal with this problem, ISI introduced the concept of the "citable document." The definition of the IF of a journal in year T given in the JCR then becomes: the number of citations in year T to documents published in the journal in years T-1 and T-2, divided by the number of citable documents published in that journal in years T-1 and T-2. However, to the best of our knowledge, in none of the official ISI publications is the concept of citable document defined accurately.

In our study the following line of reasoning is adopted. We show that large differences exist among the citation rates of different types of documents within a journal. Normal articles, reviews, notes, discussion papers, letters, and editorials have on average a substantial impact. The other types gain few (if any) citations. Letters constitute a rather heterogeneous set of documents. In some journals letters are hardly cited, while in others their av-

Received July 8, 1994; revised October 13, 1994; accepted October 13, 1994.

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erage citation rate is near that of normal articles. A similar conclusion holds for editorials. Therefore, it seems impossible to operationalize the concept of citable documents uniformly in terms of document types to be included. Nevertheless, we obtained strong evidence that ISI, in calculating the nominator of a JCR IF, counts citations to all documents in a journal, while as citable items in the denominator, ISI includes as a standard only normal articles, notes, and reviews. As a consequence, the IF values of a considerable number of journals given in the JCR are inaccurate: Document types not considered as citable, and therefore not included in the IF's denominator, are actually cited and do contribute to the citation counts in the nominator. These inaccuracies particularly affect several high impact journals. For instance, the IF of *The Lancet* is reduced by almost 40%, if only citations are counted to the document types defined in the JCR as citable. The value of a journal's IF depends strongly upon the set of documents included. For instance, including letters in *Nature* would reduce the journal's IF by some 30%. On the other hand, it is extremely difficult to establish a priori which document types should be included in the calculation of the IF. Therefore, we have chosen to present for a journal IFs per type of document rather than one single IF as given currently in the JCR. This would not only yield more accurate data, but also provide a more complete picture of a journal's editorial policy and impact.

We will analyze patterns in citation rates of different types of documents in a large set of scientific journals. Since we have not found in the literature an accurate, detailed description of the procedures applied by ISI in the calculation of the JCR journal IFs, we attempt to give a reconstruction of these procedures. Our analyses constitute essentially an examination of the consistency between two information products offered by ISI.

2 Data and Methodology

ISI extracts bibliographic information from a large number of international scientific journals. The data are included in several information products. Until 1990, the JCR constituted a volume of the printed version of the SCI. Since 1990, the JCR has been available as a separate information product. ISI applies the following procedure in calculating IFs for the JCR. ISI unifies the titles of journals appearing in cited references of all papers processed for the SCI. In addition, ISI takes into account the publication years of the cited papers. This enables ISI to determine the total number of citations, given in a specific year, to documents published in a journal in the two preceeding years. The number of citations to a journal obtained in this way may be considered as a "crude" citation count. With respect to the IF's denominator, ISI determines the number of citable documents, taking into account specific types of documents. Below we will examine empirically which types are included as citable.

ISI created also a "bibliometric" version of the SCI which is called Integrated Citation File (ICF). The ICF contains for each individual document in journals processed for the SCI the number of times it is cited per year. The analyses presented in the journal *Science Watch* are based upon this file, which is not publicly available. Our institute has purchased from ISI a special datafile on scientific journals extracted from the ICF. Our file contains for each journal processed by ISI information on the number of documents published per year and the number of times these are cited in subsequent years. The file covers the time period 1981–1992. The documents in each journal are disaggregated into types, according to the "official" ISI classification. This classification into document types is based upon indications provided by the scientific publisher, but ISI has also defined its own rules. For instance, case reports in clinical medicine are categorized by ISI as letters. Articles published in review journals or review sections of journals, or containing the word "review" or related terms in the title, or including more than 100 references, are categorized as reviews.

The method applied in calculating the citation counts per journal in our special datafile extracted from the ICF differs radically from the method that generates the citation counts given in the JCR. In order to construct the ICF, the cited references in documents processed for the SCI were matched on a paper-by-paper basis to other documents processed by ISI in preceding years (SCI source papers). Next, the citation rates of individual papers in a journal were aggregated, in order to determine the total number of citations to all documents in a journal. Matching cited references and SCI source papers is performed by ISI on an automatic basis. This process takes into account several types of errors or variations in citation, but not all. For instance, if an author intends to cite a particular paper in an SCI journal, but indicates, for instance, a wrong first initial of the first author (e.g., he cites J. Peters instead of H. Peters) or a wrong volume or starting page number, this cited reference will not be matched with the corresponding (intended) SCI source paper. Applying the ICF method, it will not be counted. On the other hand, in the method underlying the JCR data, it will be counted, provided that the journal title and publication year are correct. Consequently, we expect that the citation counts per journal in our special datafile extracted from the ICF are generally somewhat lower than those listed in the JCR. From the point of view of impact measurement of a journal there is no reason to exclude such erroneous citations. However, our research focuses on citations to different document types, and the only way to achieve this is by matching cited references to individual source documents in a journal. As a by-product our findings provide indications of the inaccuracies in citing practices of authors. For more information on inaccuracies in citations we refer to Moed and Vriens (1989).

From the following 16 subject categories covering all

TABLE 1. IFs per type of document for a sample of 320 SCI journals in 1988 (based on ICF data).

Document type	PUB	%	CIT	%	IF
Book review (Boo)	1,770	0.92	53	0.01	0.03
Correction, addition (Cor)	2,147	1.12	359	0.07	0.17
Discussion (Dis)	447	0.23	478	0.10	1.07
Editorial (Edi)	13,456	7.02	7,168	1.43	0.53
Letter (Let)	21,597	11.26	13,038	2.61	0.60
Meeting abstract (Mee)	20,270	10.57	2,017	0.40	0.10
Note (Not)	11,008	5.74	26,752	5.36	2.43
Review (Rev)	4,077	2.13	29,680	5.94	7.28
Normal article (Art)	116,425	60.71	419,948	84.07	3.61
Other (Oth)	564	0.29	30	0.01	0.05
All types	191,761	100.00	499,523	100.00	2.60
Art + Not + Rev	131,510	68.58	476,380	95.37	3.62

parts of the natural and life sciences, we selected the top 20 journals in terms of their IF listed in the JCR for the year 1988: agriculture; astronomy and astrophysics; biochemistry and molecular biology; biology; botany; chemistry; geosciences; immunology; mathematics; medicine, general and internal; multidisciplinary sciences; neurosciences; nuclear science and technology; pharmacy and pharmacology; physics; and surgery. Our sample constitutes about 10% of all journals processed for the SCI. Among the top 50 journals with the highest IF from all SCI subfields, 66% is included in our sample. In two analyses we compiled data with respect to the year 1992 as well.

General Caption to All Figures and Tables

Data obtained from the Journal Citation Reports will be labeled JCR and data from our special datafile extracted from the Integrated Citation File with ICF. Document types will be indicated as follows: art, normal articles (proceedings papers included); let, letters; not, notes; rev, reviews; edi, editorials; mee, meeting abstracts; cor, corrections or additions; dis, discussions; all, all types aggregated. The impact factor (IF) is a citation per publication ratio. The nominator will be indicated as Cit; the denominator as Pub. Between parentheses we indicate the types of documents included. For instance, Cit(rev)/Pub(rev) means: number of citations to reviews, divided by the number of reviews involved. Cit(all)/Pub(art, not, rev) means: the number of citations to all types, divided by the number of normal articles, notes, and reviews. If the sets of documents underlying citation and publication counts are identical, we will use IF to indicate the impact factor, followed between parentheses by the document types included. For instance, IF(let) denotes the impact factor for letters, and equals Cit(let)/Pub(let). The IF for a specific year (e.g., 1992) relates to citations in that year (1992) to documents published in the two preceeding years (1990 and 1991). Data on IFs per document type relate always to the ICF. With respect to data obtained from the JCR, we denote the number of citable documents as Pub@JCR, the total number of citations as Cit@JCR, and the IF as IF@JCR.

3 Results

Table 1 gives the IF per type of document for all 320 journals in our sample and for the year 1988. All data are extracted from the ICF.

Table 1 shows that reviews have on average the highest IF, followed by normal articles and notes. Discussion papers, letters, and editorials have an IF which is lower than that for notes, but still above 0.5. Meeting abstracts, corrections, and book reviews have an IF below 0.2. Table 1 presents overall figures in which documents in all 320 journals are aggregated. In order to obtain insight into the degree of variation among journals, we plot in Figure 1 for each journal containing both letters and normal articles the ratio of the IF of letters to that of normal articles, against the percentage of letters relative to the total number of documents. The number of journals involved is 115.

Figure 1 shows that the category letters is rather heter-

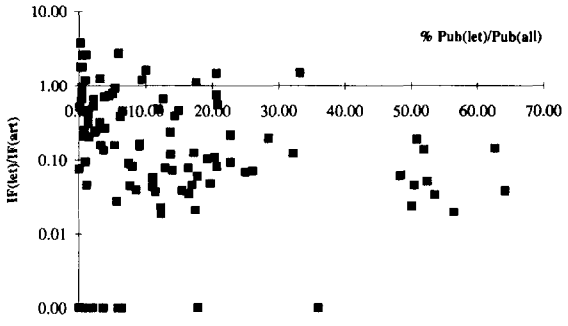

FIG. 1. IF of letters compared to IF of normal articles per journal, in the sample of 320 SCI journals for the year 1988 (based on ICF data).

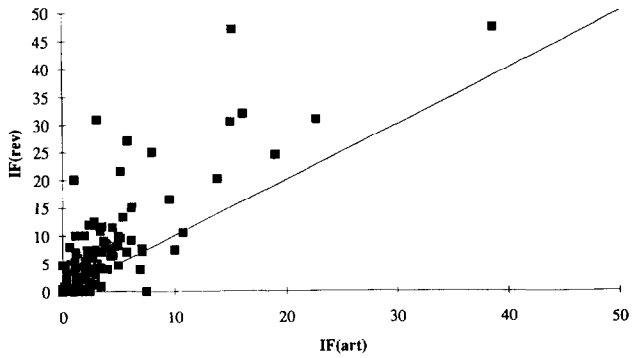

FIG. 2. IF of reviews compared to IF of normal articles per journal (based on ICF data).

ogeneous. In the majority of journals letters are cited less frequently than normal articles. In several journals, letters are not cited at all. These are mainly communications to the editor in which no research findings are reported. There is a cluster of journals containing more than 40% letters, including *The Lancet* and *The New England Journal of Medicine,* for which IF(let) is substantially lower than IF(art). The letters in these journals are mainly case reports. On the other hand, a considerable number of journals publishes letters with an IF near or even above that of normal articles. The journals for which the IF of letters exceeds that of normal articles and contain more than 100 letters are *Astronomy and Astrophysics, Journal of Physics Part A* and *the Japanese Journal of Physics.* Our results suggest that differences exist among subfields of science. In clinical medicine, case reports or letters are rather short communications, typically one page long, and have on average a lower impact than normal articles, while in physics or astronomy letters are somewhat longer, are more similar to normal articles—also with respect to their impact—but are generally published more rapidly.

Figure 2 focuses on reviews, and compares the impact of reviews to that of normal articles with respect to the year 1988, for all journals containing both reviews and normal articles. It shows that the conclusion based upon the overall figures, according to which reviews are cited more frequently than normal papers, is valid for almost all journals involved. It should be noted that typical review journals are not included in this analysis, as they do not publish any normal articles. In order to indicate the impact of editorials, Table 2 gives the top five journals in our sample with the highest IF of editorials. We included only journals with more than 10 editorials in 1986 and 1987.

Our results suggest that meeting abstracts, book reviews, and corrections are hardly cited, and can therefore be considered as uncitable documents. With respect to letters, editorials, and discussion papers such a general conclusion can hardly be drawn. It even depends upon the journal under consideration whether one can define

TABLE 2. Top five Journals with the highest IF of editorials in 1988 (based on ICF data).

	PUB	CIT	IF
Trends in Neuroscience	69	309	4.48
New England Journal of Medicine	269	1,092	4.06
Immunology Today	61	232	3.80
Physical Review Letters	12	37	3.08
Cell	10	30	3.00

these types as uncitable. Therefore, correcting properly for differences among journals with respect to the sizes of their annual volumes—one of the main objectives of the IF—constitutes a serious problem that cannot be solved by defining the concept of citable documents in a uniform manner merely in terms of document types. How did ISI solve this problem?

Figure 3 compares for the 320 journals in our sample the number of citable documents in the JCR (Pub@JCR) to the number of articles, notes, and reviews according to our ICF data (Pub(art, not, rev)), as well as the total number of citations in the JCR (Cit@JCR) to Cit(all) extracted from the ICF. We calculated for each journal the relative difference (Pub@JCR-P(art, not, rev))/(Pub@JCR + Pub(art, not, rev)), and a similar statistic with respect to citations. Figure 3 gives the frequency distribution of these variables. Focusing on numbers of documents first, Figure 3 shows that for 50% of the journals Pub@JCR and Pub(art, not, rev) are equal. The mean and standard deviation of the distribution are −0.008 and 0.096, respectively. A few large discrepancies were found, for which we were not able to find explanations in terms of adding or omitting specific document types.

With respect to differences between Cit@JCR and Cit(all), the picture is more diffuse. The mean value and standard deviation of the corresponding distribution are 0.060 and 0.177, respectively. In Section 2 we predicted that the citation counts per journal in our special datafile extracted from the ICF are generally lower than those listed in the JCR. In fact, our results indicate that the ICF citation counts are in most cases some 10% lower than

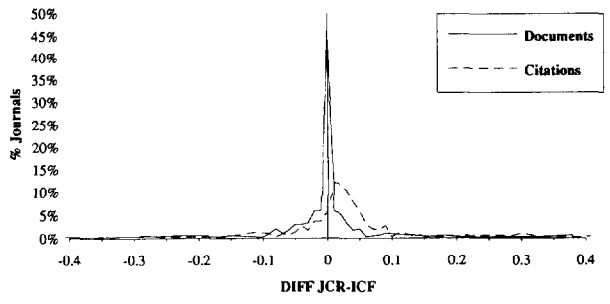

FIG. 3. Differences between JCR and ICF numbers of citations and documents.

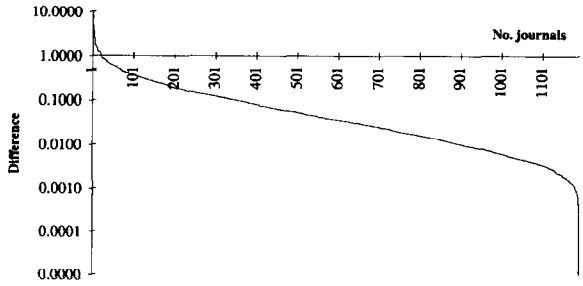

FIG. 4. Absolute differences between "constructed" and "correct" impact factors for 3,730 SCI journals.

the JCR counts. In addition, more variation exists in this respect than in the case of numbers of documents.

Our analyses provide evidence that ISI, in calculating the nominator of the JCR IFs, counted citations to all documents in a journal. With respect to the denominator, ISI's standard procedure is to include only normal articles, notes, and reviews as citable documents. Our ratio Cit(all)/Pub(art, not, rev) can be considered as a reconstruction based on ICF data of the IFs printed in the JCR. However, Tables 1 and 2 and Figure 1 show that letters, editorials, and discussion papers do receive citations. As a consequence, the IF values of many journals given in the JCR are inaccurate: These document types are not defined as citable and therefore are not included in the IF's denominator, but they are actually cited and do contribute to the citation counts in the nominator.

In order to estimate the degree of inaccuracy due to this phenomenon, we plot in Figure 4 the absolute difference between the reconstructed (Cit(all)/Pub(art, not, rev)) and correct IF (Cit (Art, not, rev)/Pub (art, not, rev)) for 3,730 journals processed for the SCI. All data are extracted from the ICF and relate to the year 1992. For 1,150 journals a difference between the two measures was found. Eighty journals show an absolute difference greater than 0.5.

Table 3 shows for a selected set of journals the degree of inaccuracy in the JCR IFs. It gives from left to right the IF obtained from the JCR; our reconstruction of this IF based upon ICF data; the relative difference between these two (DIFF); the correct IF, including citations to notes, reviews, and articles only; and the relative difference between correct and reconstructed IF (ERR (ISI)). We selected the eight journals from our sample of 320 with the highest absolute difference between correct and reconstructed IF, and added two journals with the highest JCR IFs in 1988 (*Science* and *Reviews on Modern Physics*).

Column DIFF reveals that in most cases the reconstructed IF is a few percent lower than the IF listed in the JCR. This is consistent with our findings in Figure 3. Interestingly, for *The Lancet* the relative difference between the two measures is rather high: −17.06%. A secondary analysis shows that this is mainly due to the fact that scientists often indicate an erroneous volume number or do not indicate a volume number at all. Column ERR(ISI) illustrates clearly the effect on the value of the IF of excluding citations to other documents than notes, reviews, and normal articles. *The Lancet* shows the highest decrease in IF (−39.8%), followed by the Journal of Neuropathology and Experimental Neurology (−20.4%), and Trends in Neurosciences (−19.8%).

The question arises as to which documents should be included in the calculation of a journal's IF. Evidently, the value of a journal's IF depends strongly upon the set of documents included. For instance, from the data presented in Table 4, one can infer that including letters in *Nature* would reduce the journal's IF by 28%. On the other hand, it is a priori extremely difficult to establish which document types should be included. Therefore, we suggest to present IFs per type of document rather than one single IF as given currently in the JCR. This would not only yield more accurate data, but also provide a more complete picture of a journal's editorial policy and impact. Table 4 gives for the journals included in Table 3 the IFs per type of document, and can be used to find explanations for the differences between constructed and correct IFs presented in Table 3. For instance, edito-

TABLE 3. Comparison of the JCR and ICF IF for 10 journals in 1988.

	IF@JCR	Cit(All)/ Pub(art, not, rev)	DIFF (%)	Cit(art, not, rev)/ Pub(art, not, rev)	ERR(ISI) (%)
Annals of Internal Medicine	8.47	7.74	−8.62	6.55	−15.37
Immunology Today	10.65	10.08	−5.35	8.45	−16.17
Journal of Molecular Biology	6.56	6.70	2.13	5.82	−13.13
Journal of Neuropathology and Experimental Neurology	4.88	4.79	−1.84	3.81	−20.46
The Lancet	14.48	12.01	−17.06	7.23	−39.80
New England Journal of Medicine	21.15	19.26	−8.94	15.61	−18.95
Nature	15.76	15.14	−3.93	13.91	−8.12
Reviews in Modern Physics	15.13	14.34	−5.22	13.53	−5.65
Science	16.46	16.00	−2.79	15.47	−3.31
Trends in Neuroscience	9.15	8.78	−4.04	7.04	−19.82

TABLE 4. IF per document type for 10 journals (based on ICF data).

Journal	Year	Pub(Art)	IF(Art)	Pub(Rev)	IF(Rev)	Pub(Not)	IF(Not)	Pub(Edi)	IF(Edi)	Pub(Let)	IF(Let)	Pub(Oth)	IF(Oth)
Annals of Internal Medicine	1988	345	7.07	56	7.71	137	4.74	125	1.87	693	0.45	75	1.32
	1992	372	8.31	50	13.08	86	5.16	138	2.83	606	0.32	41	1.34
Immunology Today	1988	101	5.43	67	13.24	2	0.50	61	3.80	57	0.56	7	2.00
	1992	86	11.14	54	26.00	1	4.00	62	7.37	77	0.60	8	5.50
Journal of Molecular Biology	1988	675	5.79	1	27.00	—	—	—	—	181	3.29	11	0.00
	1992	747	5.78	2	13.50	214	2.49	—	—	5	0.60	16	0.13
Journal of Neuropathology and Experimental Neurology	1988	95	3.56	3	11.67	—	—	—	—	6	0.17	406	0.23
	1992	94	3.43	—	—	—	—	1	0.00	14	0.00	544	0.21
The Lancet	1988	902	7.46	1	0.00	52	3.38	1,302	0.09	4,071	1.09	163	0.02
	1992	784	9.10	29	8.00	144	4.12	1,313	0.69	4,181	1.02	1,421	0.64
New England Journal of Medicine	1988	670	15.01	32	30.53	7	4.57	269	4.06	2,057	0.59	164	1.73
	1992	561	20.42	89	16.46	71	7.82	326	3.78	2,057	0.49	174	1.02
Nature	1988	2,322	13.78	52	20.19	1	0.00	2,999	0.62	1,039	1.00	930	0.03
	1992	2,065	19.20	54	37.54	—	—	3,128	0.59	1,215	1.13	693	0.38
Reviews in Modern Physics	1988	20	9.50	27	16.52	—	—	1	0.00	—	—	1	38.00
	1992	13	5.23	29	15.52	—	—	2	9.00	—	—	3	0.00
Science	1988	1,592	15.20	17	47.06	7	1.14	1,473	0.45	522	0.28	586	0.06
	1992	1,712	19.07	10	42.70	10	0.90	2,207	0.52	581	0.22	563	0.09
Trends in Neuroscience	1988	70	4.91	123	8.24	—	—	69	4.48	45	0.58	18	0.11
	1992	68	9.15	73	13.84	—	—	49	8.61	46	1.07	7	0.00

rials and letters in *The Lancet, New England Journal of Medicine,* and *Nature* attract many citations, even though the average impact of these documents compared to the impact of articles is rather low. In the JCR, ISI includes these citations in the calculation of the IF, but does not consider these types of documents as citable.

4 Discussion and Conclusions

We presented strong evidence that for a number of journals the values of the IFs published in ISI's JCR are inaccurate, particularly for several journals having a high IF. The inaccuracies are due to an inappropriate definition of citable documents. Our preliminary results suggest that the differences in IF between top and subtop journals are partly caused by inaccurate measurements of the IF. Our findings reveal that journal editors may very well succeed in raising the IF of their journal—as printed in the JCR—by making specific changes in their editorial policies. Publishing more informal documents such as editorials, discussion papers, and letters may raise the IF since these documents, when they are cited, do contribute to the nominator of the IF, but not to the IF's denominator, as they are a priori defined as uncitable. In a sense, citations to these documents are for free. Our results also suggest that publishing more review articles in a journal may lead to a higher IF.

It should be noted that the JCR gives for a journal separate counts for the number of review articles published in a journal, and that it states clearly that this information should be taken into account when one analyzes and evaluates a journal's IF. Following this line of reasoning, and taking into account the problems related to the definition of citable documents, we propose to calculate IFs per type of document rather than one single IF as given currently in the JCR. This gives a more accurate and complete picture of a journal's impact and editorial policy.

Bibliometric indicators have proven to be valid and useful tools in the assessment of journal performance or research performance. They result from statistical operations according to uniform or objective principles. On the other hand, this basic characteristic constitutes the strength of the bibliometric method. On the other hand, it determines its limitations as well: The bibliometric method cannot take into account all particularities and individual circumstances of the objects to be assessed. This is the principal reason why bibliometric indicators cannot be applied properly without obtaining background knowledge on the objects involved, and why they should be supplemented with information from other sources. The findings presented in this article stress once more the importance of this basic principle. Evaluators of research or journal performance should be cautious in evaluating scientific publications or journals merely on the basis of the IF values printed in the JCR.

Many other aspects of ISI's journal IFs deserve a crit-

ical examination. Firstly, other sources of inaccuracy are involved than those discussed in this paper. For instance, we found evidence that the IF of the "Zeitschrift fur Angewandte Chemie" printed in the JCR is much too high. This is due to the fact that the journal is published in a German and a transliterated English version, and that many citations to a paper are counted twice. Next, it should be noted that the data extracted from the ICF and analyzed in this paper are also not free from inaccuracies. This is not only true for the citation counts, but also for the classification into types of documents. Thirdly, discrepancies between the formal publication year of a paper and the year it was entered into the SCI database affect to some extent the values of a journal's IF, particularly when the time lag between publication and entry date of journal issues varies throughout the years. Next, the IF is basically a mean value of a highly skewed distribution. Calculation of other statistics of this distribution (e.g., de median or mode) may yield different results. Fifthly, the IF is a short-term IF. It indicates the impact of papers 1 or 2 years after publication. The rapidity of decline of the impact of papers as a function of their age is a highly relevant object of study. Finally, citations measure formal use (or utility) of the scientific literature. Analyses of informal use (e.g., browsing) may lead to a more complete picture of a journal's utility.

Acknowledgments

The authors acknowledge the Netherlands Organization for Scientific Research (NWO) for financing the database on journal citation data used in this study.

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