Sense and nonsense of science citation analyses: comments on the monopoly position of ISI and citation inaccuracies. Risks of possible misuse and biased citation and impact data.

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Letter

Journal editors and publishers, authors of scientific papers, research directors, university and research council administrators, and even government officials increasingly make use of so-called 'Impact Factors' to evaluate the quality of journals, authors and research groups. These figures are used in decision-making processes about (dis)continuation of journal subscriptions, selection of journals for submission of papers, ranking of authors and groups of authors, and even for increase and decrease of funding to research groups. All data are based on the counting of citations of the scientific papers of authors. Very few users appear to realize that these figures can be seriously wrong, biased and even manipulated, as a result of: (*i*) citation habits for authors in different fields, (*ii*) selectivity in (non)citations by authors, (*iii*) errors made by authors in citation lists at the end of papers, (*iv*) errors made by ISI in entering publications and citations in databases, and in classifying citations and accrediting them to journals and authors, and (*v*) incomplete and misleading impact figures published by ISI. Although quite a few *bona fide* and competent analysts and organisations specialized in citation analyses exist, the incompetence of many analysts, when using crude ISI data in discussing rankings of journal and/or authors, is an additional factor that makes such analyses often unreliable.

This paper reviews some of the current practices in publications and citations for (bio)chemists and (bio)chemistry journals; critical comments are made with regard to the use and consequences of erroneous and incomplete or too detailed data. A few recent examples are given of the use and misuse of such data, to illustrate and evaluate the (non)sense of current practice.

Originally citation databases were developed for use by scientists to find out who were the (competing) researchers interested in their work, and to find out who had picked up certain methodologies. The use of subject indexes had increasingly become much too time-consuming for this purpose.

More recently, citation records of authors, institutes, universities and journals are increasingly considered as quality indicators, not only by authors, librarians and journal publishers, but also by science policy-makers. In a sense the academic world has gradually become obsessed with impact factors. This whole process originally started with journals analyses, but nowadays has extended to cover also topics like countries, universities, institutes and even individual researchers.

The present paper will review some of the current practices in publications and citations for (bio)chemists and (bio)chemistry journals. Some critical comments will be presented with regard to the use and consequences of erroneous and incomplete or too detailed data. A few recent examples of the use and misuse of such data will be given, to illustrate and evaluate the (non)sense of current practice and their limited value for the evaluation of (small) research groups.

Journal Analyses

With the ever-increasing number of journals and decreasing library budgets worldwide it has become almost common use to rank scientific journals with the aid of a so-called 'Impact Factor' (IF). These IF values can be calculated in several ways and may cover several periods. A very commonly used and published IF is the short-term impact IF, defined as:

The number of citations published in year Y to (all) documents published in years $Y-1$ and $Y-2$, divided by the number of citeable documents published in years $Y-1$ and $Y-2$. (Thus the IF defined by ISI for 1997 relates to citations in 1997 of documents published in 1996 and 1995.)

It has been proven repeatedly that the Institute for Scientific Information (ISI) inaccurately defines what a 'citeable document' is, and that as a consequence the IF values in the Science Citation Index are inaccurate and deviations up to 40% may occur.[1,2] Nevertheless, many libraries take decisions about the discontinuation of journals, and about accepting new journals, based on this often incorrect short-term IF value. Libraries have a duty also to serve future generations, and at least IF values for a period of up to say 10 years (rather than the 2 years now) would be much more useful for those who take decisions about subscribing to or publishing in a certain journal. A recent detailed analysis by Moed *et al.*[3] has shown that the ranking of journals, when periods longer than 2 years are used, can change dramatically. It is possible to get citation data on journals covering longer periods of time from ISI. Unfortunately, it is to be feared that library subscriptions to journals will be increasingly determined by the—so far the only published—short-term impact factors of journals, and certainly so when leading journals even use their IF in advertisements.

Analyses of (Groups of) Scientists

For a variety of reasons, authors increasingly (are encouraged to) publish in so-called high-impact journals, and even more so with the increasing trend to use journal IF values in the evaluation of research. Whether the published citation figures

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of that journal are correct, relevant, or maybe not, is rarely considered. Often at best limited attention is given to matters such as:

(*i*) citation habits for authors differ for different research subfields;

(*ii*) selectivity in (non)citations by authors (easily available papers are easy to cite);

(*iii*) errors made by authors in citation lists at the end of papers (*e.g.*, page, issue and volume numbers);

(*iv*) errors made by ISI in counting and classifying citations and accrediting them to journals and authors; it is crucial to know how ISI inputs publications and citations;

(*v*) incomplete impact figures published by ISI; it is important to know how ISI retrieves citation data; it appears that ISI uses exact matching to analyse the impact of a scientist, so all data that contain even a small error in either input or output will almost certainly get lost.

A few recent papers of Seglen[4] have addressed several problems associated with the use of impact factors and pointed out clearly that no correlation at all exists between the IF of a journal and the individual papers in that journal.[4a]

Given the fact that citations to scientific articles are stored and can be easily retrieved (accurately or not), now also science policy-makers can use these data and the consequences of citation analysis errors (and interpretation errors) can be quite large. Research groups can be discontinued and funding for research can be increased, decreased or even stopped. It appears that nowadays one seems to forget that the primary aim of scientific publication is the improvement of science and NOT to generate funds! In some cases funding is directly and proportionally determined by the 'impact' of publications in previous years; for example, in Finland each 'Impact Point' is worth $15000 in medicinal research funding,[5] incorrectly assuming that the journal impact factor would be automatically valid for ALL its articles. One tends to neglect the fact that even in journals with a high IF, several papers will never get cited! Citation rates of articles determine the journal IF, but not the reverse! Tenure decisions and departmental reviews are other common (mis)uses of citation data.

Methods used for Counting and Analysing Citations

At the least, the following analysis methods of research impact, listed by increasing level of sophistication, can be considered:

A. Simply use the NUMBER of citations (in a given period), called CIT, to an institute (or to a group or a person); this method is rarely used these days (but see below for a www site doing this).

B. Use the number of citations (in a given period) to the papers (as far as known to ISI) published in a certain period by an institution (group, person). Applied parameter: CIT/PUB.

C. The same method as described in B, but now using a threshold value of (say) at least 100 papers by a given author (or group) in a certain period (to avoid effects of one or two papers influencing the average too much).

D. As in method B, but now only the highest cited papers, that is, the top fraction (say 10 or 50%) with respect to their citation scores are considered in the analysis and ranking (to prevent dilution of papers from productive groups).

E. As in method B, but the outcome of CIT/PUB is compared to the average of the journals in which a group has published (*i.e.*, the number of expected citations in *these* journals are considered). So when one publishes in *Nature* or *Science*, one should expect more citations then when one has published in a national chemistry journal. From these data it can be calculated whether the institute (group, author) has a value that is above or below the expected journal-package value.

F. As in method E, but the outcome of CIT/PUB is now compared with the citation average of all articles in the subareas in which the group is active.

These last and quite advanced methods (E, F) are not yet used on a wide scale, but can be quite helpful,[6] even though such analyses also have disadvantages; thus, using method E may, for example, lead to the publication of a top paper (expected to be highly cited) in a low-ranked journal.

In fact, each of these methods and parameters has its value and limitations, which will not be discussed here, although the risk of overestimation appears to be large.[7] Also, as this process goes on it is not unlikely that some scientists will be challenged to cite preferentially papers of their friends (and *vice versa*) or otherwise to bias the data by careless citation practices. Such behaviour would require journal editors to add questions about citation behaviour on their checklists for referees. In a recent study the citation habits in many journals have been analyzed and discussed in detail with respect to author and journal behaviour[8a] and from this analysis it is evident already that care is required in using citation data for evaluating the quality of journals and scientists. In fact, the Royal Society (UK) has recently expressed very critical comments,[8b] referring to corruption of the peer-review process and even the promotion of scientific misconduct.

How useful are such Citation and Impact Analyses?

At this point I do feel that two other important questions need to be raised in discussions about citations and their analysis, namely:

1. Are the published citation data accurate enough to be correct? (Or put another way: how inaccurate are they?)

2. Are these data correctly interpreted by analysts (and politicians)?

Surprisingly, these questions have rarely been addressed so far in the literature. The general public feeling appears to be quite often: 'What a computer produces must be correct and cannot be wrong.' However, one should realize that the quality of the output is directly determined by the quality of the input. Below I shall show that there are good reasons to assume that the data made available by ISI do contain significant errors.

Up until recently, it was not easy and quite labour intensive to find out whether ISI had (correctly) listed and published all citations to a given research paper. One could go to the library-bound volumes and apply manual counting; somewhat later one could consult CD ROMs and databases to perform searches and checks. All of this was and is quite time-consuming.

Quite recently, ISI has started to offer to individual scientists (and also to institutes, research councils, *etc.*) a personal or institutional (or even a university or country) 'profile' with papers and citations (starting from 1981) for a reasonable price. ISI can now provide authors (or anybody who pays) with a database that can be easily analyzed on a PC; it contains all papers (of the scientist or the group of scientists) they have 'collected' in their database and also all 'collected' citations to those papers (full references). Whether or not all data have been correctly included remains to be seen. Nevertheless, this database now allows a direct check between an observed citation and its possible absence/presence in the ISI database. This type of analysis can be done manually by each individual author, but also certain research institutes are doing such detailed analyses, based on information purchased from ISI. Some that can be mentioned are: The Science Policy Research Unit (SPRU) at the University of Sussex, the Information Science and Scientometrics Research Unit (ISSRU) in the Academy of Science Library at Budapest and the Centre for

Science and Technology Studies (CWTS) at Leiden University.

Given the fact that one can now purchase the above-mentioned personal profiles for any scientist from ISI, it has become relatively easy to check for individual authors (and organisations), whether ISI has correctly and completely listed all their papers in the ISI database and correctly and completely listed all the citations to their papers.

Finally, another fashion should be mentioned, introduced in recent years and also to be questioned, it deals with giving ISI (paid) orders such as 'Who is the most cited chemist?' or 'Who is the most cited physicist?' Two interesting (and frequently cited) web sites provide answers to such questions and rank the most cited scientists according to the citations to their papers in chemistry journals (or to be precise: in journals that ISI has classified as belonging to chemistry).

This kind of information can give both too low and too high results because of two major limitations. Papers (if any) of the same authors in journals classified by ISI as, for example, biochemistry or physics are NOT considered. Also, scientists with exactly the same names and initials are not discriminated and in fact are seen as just one person. For interested readers the sites for information on 'chemists' are:

http://fluo.univ-lemans.fr:8001/1000chimistes.html
http://pcb4122.univ-lemans.fr/cgi-bin/perl.exe?chimistes.pl
http://fluo.univ-lemans.fr:8001/chimie/chimistes.html

It should not need saying that data from such a web site should NOT be used in quantitative analyses! Such analyses should only be performed by qualified experts and institutions, AFTER the necessary corrections for errors and omissions have been made.

Critical Comments about the ISI Database Input and Output

Wisely, ISI is not claiming 100% coverage, and it is often assumed that a score of about 90% can be reached by ISI. This number might look quite acceptable, but what if your most-cited paper happens to be in their missing 10%? Will your research council understand or realize that when they assess your research work? What happens when your most-cited paper is mis-referred to by others (*e.g.*, one author name missing or misspelled, year or page mistyped) and subsequently other authors quote the wrong citation, so that every journal reader will notice that your work is cited, but ISI will not (or incorrectly) include it in its database, so that it will often not, or not at all, appear in analyses and assessments?

A few examples of often neglected inaccuracies and errors that currently cannot be easily corrected and that may have serious consequences in evaluations will now be given as an illustration. They primarily deal with correct names and volume numbers of journals. It appears that certain publications, like those in the series *Metal Ions in Biological Systems*, which can be regarded as books or journals, are easily neglected as a source of input or as sources of citations, owing to different author (and journal) practices to refer to work from this series.

Sometimes publishers may decide to combine one or more volumes of a journal, such as in a special issue with volume 39–40. However, this can result is three possible references: to volume 39, to volume 40 and to volume 39–40. ISI will in many cases routinely only accept one of these as the real citation and the others will get lost. Rather recently, *J. Chem. Soc. Chem. Commun.* modified its name to *Chem. Commun.*, but in practice authors that cite papers published in *Chem. Commun.* often still use the old name, and as a consequence the citations might get lost for the journal (and the authors), eventually resulting in a lower Impact Factor for *Chem. Commun.*

In this respect, it will be of interest to see how ISI will respond to recent changes in the organic and inorganic chemistry journals of West European countries, where first (1997) *Recueil des Travaux Chimiques des Pays Bas* merged with *Chemische Berichte* and *Liebegs Annalen der Chemie*, followed in 1998 by a further merger with Belgian, French and Italian national journals to generate *Eur. J. Inorg. Chem.* and *Eur. J. Org. Chem.* (EurJIC and EurJOC).

Browsing through my own publication and citation records over the last 15 years [purchased from ISI in early 1997 (a so-called Personal Citation Report, in a format as they sell it to 'any organisation')] and assuming this output to be a representative case for papers published in the period 1981–1995, I found quite a few papers that contain minor and major errors with respect to the citation scores. I just mention here two serious, and I believe representative, cases.

1. The journal (*Structure and Bonding*) in which one paper was published (1987) is one processed by ISI for inclusion in the Science Citation Index but, for some unclear reason, the reference to it is not included in the ISI database. This paper has been frequently cited during the last decade but, as a consequence of the non-inclusion of the paper in the database, unfortunately it is NOT listed a single time in my personal citation database obtained from ISI.

2. The journal that contains another one of my papers[9] is also an ISI-processed journal; the reference to the paper is listed by ISI as a regular (1992) paper from me; this paper had received over 40 citations in the given period (independently checked from an another source[10a,b]) in regular journals, whereas ISI lists only 2 in their 'commercial database.' It appears that ISI retrieves by exact matches only, and therefore small deviations, such as in ref. 9*b* and 9*c*, are neglected! The origins for this error are to be assigned to ISI and at the moment can only be ascribed to careless input and output procedures at ISI.

I have good reasons to assume that similar errors can occur with other papers and citations from me, or from other authors. When confronting ISI with missing citations and errors, their usual reply will be: 'We have not yet found a way to implement a procedure of systematically identifying and correcting erroneous source or citation data on a paper-by-paper basis in the 13 million record database.' I conclude, therefore, that analyses of groups or individual authors, especially when short periods are concerned, and/or small groups of papers are involved, should never be taken seriously. The ability of ISI to find citations and to store them depends on how they have been cited by others, and as a consequence mis-citations (even minor ones, such as a second initial) may lead to loss of the citation and eventually, even in decreased funding. A warning to all organisations to never use ISI data directly by non-experts is appropriate. In fact, warnings of this type of inaccuracy were already made almost a decade ago.[11]

Recently, the *Second European Report on Science and Technology Indicators* (1998) has appeared, which illustrates beautifully how non-experts can ask the wrong questions of analysts, and subsequently misuse the answers in publications.[12]

Conclusions and Recommendations

It is beyond any doubt that ISI has done and is doing great work in collecting and classifying citations to scientific papers. However, their data should primarily be used for their original purpose: to serve scientists in the progress of research and development (R&D)!

In summary, I arrive at four major recommendations:

1. **Librarians**: Do not take your decisions on journal subscriptions based on 2 year IF values published by ISI; instead try to collect other 'impact factors' covering much longer periods from other sources. Other organisations, such as STN International,[13] do allow specialized searches for librarians.

2. **Authors**: Do not rank journals too much on published 2 year IF values, and do not rely on such inaccurate numbers in deciding where to publish. It is to be regretted that as long as politicians primarily judge science quality based on the 'covers'(=IF) of journals, scientists will choose such journals.

3. **Research councils and science policy-makers**: Do not rank the quality of scientists based on (often inaccurate) ISI citation statistics only. Consult experts and do not rely on crude ISI data only! If you really want to use citation information in your analyses, you had better do it well, otherwise don't do it at all![14]

4. **Journal editors and publishers:** Beware of (even minor) name changes in your journals. It may cost you citations and consequently library subscriptions and even contributions of high-level articles. Never combine volume numbers. Give accurate and unambiguous instructions to your readers on how to cite papers in your journal! Be prepared to give instructions to your referees to check whether the citation list at the end of the paper is well-balanced.

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