“Knowledge is like an ocean: many arms are needed to embrace it.” (saying from the Swahili in East Africa)

1 The $h$-index and the $g$-index

The paper products of science seem to fill an ocean of knowledge. The $h$-index and the $g$-index are two different measures to assess an academic’s scientific impact that are based on the number of the citations of his/her publications. The $h$-index was proposed by J.E. Hirsch. The $g$-index was proposed by L. Egghe, as an improvement on the $h$-index. Given a list of publications and for each publication how often it has been cited:

The $h$-index is the maximum number $n$ such that $n$ publications have at least $n$ citations each.

The $g$-index is the maximum number $n$ such that $n$ publications have at least $n^2$ citations in total.

If $n$ publications have exactly $n$ citations each, that makes $n \cdot n = n^2$ altogether, in which case the $g$-index equals the $h$-index. Otherwise, the $h$-index is lower than the $g$-index. The $g$-index favours authors some of whose publications are cited much more frequently than all other publications.

Let us give some examples. Consider a list of six publications with their number of citations in decreasing order as follows: 333111. There are three publications with at least three citations, the $h$-index of this list is therefore 3. We write $h(333111) = 3$. On the other hand, $h(332111) = 2$: now there are not three publications with at least three citations, but there still are two publications with at least two citations (although these two have in fact three citations, but that does not matter). And $h(311111) = 1$. Also, $h(911111) = 1$: although the author has a publication cited nine times, we cannot ‘reward’ him/her for that notoriety. The $g$-index makes up for that difference: $g(911111) = 3$: the first three publications are cited 11 times, which is more than $3^2 = 9$; whereas $g(311111) = 2$: the first two publications are cited $2^2 = 4$ times—we can’t get a $g$-index of 3 now, as the first three publications are cited only five times, which is less than nine. And this is still better than $h(311111) = 1$, which is also the $h$-index of 111111.
The $h$-index and $g$-index can also be applied to journals, to groups of researchers, and to institutes, in the obvious way. For example, the $h$-index of a journal is the highest number $n$ such that $n$ of the publications that appeared in that journal have been cited at least $n$ times.

2 Publish or Perish

There remains the issue how we determine the list of publications, and the number of citations. Both Hirsch and Egghe based their findings on ISI Web of Knowledge (WoK), a commercial product by Thomson. Egghe already mentions that “the real citation data can be much higher” because WoK uses a restricted set of journals, and does not count citations in articles that are in press.

This is where the program $Publish$ or $Perish$ (PoP) comes into the picture. After its release in 2004, $Google$ Scholar (GS), see http://en.wikipedia.org/wiki/Google_Scholar, quickly became a competing standard for citation analysis of academic output. Anne-Wil Harzing and her team at the University of Melbourne in Australia, see http://www.harzing.com/, developed a program fittingly called $Publish$ or $Perish$, that uses GS data for citation analysis. It was released in 2007.

The main difference between WoK and PoP, is that the analyses in WoK are based on an approved corpus of journals, using a recency-based citation measure. A journal appears in the corpus if its Journal Impact Factor (JIF) exceeds a certain threshold. But GS covers all publications that are found online, disregarding when and where published. Typically, this means more publications and higher figures.

3 Advantages and disadvantages of the PoP $h$-index

3.1 Advantages

**Quality and quantity** Rather than the number of your publications, an indication for the impact of your work is it how often your work is cited by others. Egghe calls the number of publications the quantity of your output and the number of its citations its quality. Hirsch’s explicit purpose to propose the $h$-index is to have a simple measure for the impact of one’s academic output.

**Encouraging collaboration** It is more important to have many citations than to have many publications. This, we think, encourages collaboration. Firstly, you don’t have to be a co-author on each of your students’ papers; it is sufficient to encourage them to cite your work, in case, rather likely, that your work is relevant for the pursuit of their studies. Secondly, you don’t have to be the sole author of a paper for it to later count among your citations, you merely have to be one of its authors. In other words, you may safely credit substantial contributions to your work by inviting the individuals in question to coauthor a forthcoming paper. Thirdly, having good results is not enough, you have to spread them through the community so that others can build upon your work and therefore will cite it: you have to give seminars, courses, spread the paper through the community by your active own efforts, and so on. This is not bad, this is good.
Favouring informal publications  Anything found on GS that is cited counts. This may include technical reports, contributions to informal workshop proceedings, and unpublished manuscripts. If such a publication is frequently cited it will increase your academic peer esteem, even when not published in a real journal.

Favouring low-cost publications  Librarians might welcome it when academics are going to value open resource or cheap journals with frequently cited high-impact publications over expensive journals and their likes. The high cost of some commercial scientific journals is rocking the academic community over the past decade, see Ted Bergstrom’s www.econ.ucsb.edu/~tedb/Journals/jeprevised.pdf.

Higher ratings for the humanities  Unlike WoK, GS includes books and journals with a low JIF, such as is the case for very specialized journals. This results in higher scores for the humanities than for the sciences, when compared with WoK results. A detailed study comparing WoK JIFs with GS-based PoP computed $h$-indices for 838 journals in Economics and Business by Harzing et al. is found on www.harzing.com. A comparison by Gregory Wheeler of 75 philosophical journals by their $h$-indices, and compared to their European Science Foundation classification, is found on http://fleetwood.baylor.edu/certain_doubts/.

Publications not in English  Researchers not publishing in English may have difficulty getting their results known to the community. GS will in principle find such publications. Also, the combination of GS / PoP allows in principle to compute $h$-indices for publications in a given language only, e.g., Chinese, or French.

Less may be better than more  Having more publications does not necessarily give you a higher $h$-index than having less publications. Consider the following. Assume that there are no self-citations in your work and that the level of interest it excites in the community is constant: you will get twelve citations next year regardless of whether you produce one or twelve publications or anything in between. For simplicity, assume these are your only publications. It is then clear that more is not better: having all twelve publications gives you a worst case profile of $h(111111111111) = 1$. Whereas have six only gives you a worst case profile of $h(222222) = 2$. Doing your very best and producing three publications, of therefore higher quality, may get you $h(444) = 3$.

3.2 Disadvantages

Incest  Citation frequenting reinforces closely knit research communities often citing each others’ work. Outsiders with greatly original work off the beaten track will have difficulty getting cited, even when getting published. Although true, this has always been the case. The GS data may help to counteract such features by overvaluing citations from researchers outside such communities (which can be easily expressed in terms of network properties), e.g., when measuring the interdisciplinary character of someone’s work.

Recency is bad  One aspect of a publication’s value is whether it is still cited after ten or twenty years. Programs like PoP unduly increase the value of very recent publications, but work that might never be cited again after some five or ten years. Such publications may
after all not have a high impact. Practitioners in sciences or in humanities seem to hold almost opposite views here: in JIF only citations from the last two years are taken into account, and citations older than that count less (or not at all), inconceivable in the humanities. Note that PoP contains recency-favouring citation measures, such as the contemporary $h$-index, also known as $hc$-index.

**Citation may be to a resource and not to the source** Overview studies, textbooks, and reference manuals do not contain (and are not even supposed to contain) original work but tend to be cited very often. In other words, they are resource, not sources. A researcher’s impact should be based on his original research, not on his ability to disseminate others’ research through the community. On the other hand, as long as overview studies credit their sources, it might also be seen as a good service to the community to write them? So why not credit the authors?

**Very bad science gets very many citations** In 1989, Martin Fleischmann and Stanley Pons reported nuclear reactions in laboratory experiments at room temperature. The report was published as a preliminary note entitled *Electrochemically induced nuclear fusion of deuterium* in the *Journal of Electroanalytical Chemistry*. Their findings were later discredited. It is a classic case of bad science. This publication is cited 355 times in GS. You get cited a lot if everyone quotes you as a bad example. This is not a reason you want to get a high $h$-index. But evidence of a failing system of peer-review does not necessarily constitute evidence of a failing measure for science citation.

**Different citation cultures across academic disciplines** The average publication in, e.g., philosophy contains far less citations than the average publication in, e.g., the medical sciences. Therefore, medical scientists will automatically have higher indices than philosophers. Citation behaviour varies across disciplines. When presenting yourself to committees, make sure that you compare yourself to the peers in your discipline, and not to outsiders.

**The $h$-index as a known policy instrument is less useful** Some twenty years ago, researchers were encouraged to have many publications (and appointments depended on it). Now, every researcher has many publications. Unfortunately, the meaning of ‘publication’ has deflated somewhat these days. Now, researchers may become encouraged to have many publications that are cited often. Therefore, soon enough, every researcher will have a high $h$-index. Communities adapt to the policy instruments enacted upon them. This does not exclude that by careful mechanism design an optimal policy may eventually appear.

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