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EDITORIAL

Scientometrics: A Dismal Science

Measurements, accurately made and carefully documented, form the core of science. Gathering and organizing data, as a prelude to interpretation, is a routine activity in the daily life of scientists. But in a development that has rapidly engulfed science, scientists themselves have become objects of measurement, even as the field of scientometrics expands, fuelled by the technologies of the information age. The primary metric for measuring the performance of researchers in science is by studying their body of published work. This requires assessors who are experts in the area of research; 'peer reviewers' in every sense. Reading and understanding a colleague's scholarly output requires patience, commitment and a genuine interest in the subject being studied. However, there have been dramatic changes in the modes of assessing science and scientists over the last decade or so. The practice of using citation counts and journal impact factors to quickly gauge a scientist's performance has become commonplace. Databases are now widely available; on-line access and powerful software tools provide 'quantitative data' on research publications, at the 'click of a mouse'. In assessing scientists, counting the number of citations their papers have accumulated and inspecting (and sometimes 'averaging') the impact factors of the journals in which they publish has become a widespread practice. The 'average impact factor' seems particularly popular in India; its significance obscure to even its most ardent proponents. The motivation in all these attempts to quantitatively (and presumably, objectively) assess the scientific output of individuals, institutions and countries is to develop 'single number' criteria, that permit rapid comparison. Financial analysts seem comfortable with indices like the Dow Jones in the United States and the Sensex in India as an indicator of a stock market's health; should there not be a simple parameter to judge the productivity and impact of scientists and their institutions?

The world of science has never been the same since Eugene Garfield introduced the Science Citation Index and the idea of the Journal Impact Factor. Slow to be accepted at the beginning, these tools have now been sharpened by the information technology revolution; ensuring that scientists and administrators, editors and publishers self consciously examine performance indices at every step. The joy of science seems to have disappeared for many individuals, who are now consumed by impact factors and citation analysis. There is a more calculated and purposeful approach to science today; the refreshing naivete of the amateur has been replaced by the, sometimes, disturbing realism of the professional manager.

Almost exactly three years ago a posting appeared on the physics on-line archive entitled 'An index to quantify an individual's scientific research output' (Hirsch, J. E., arXiv: physics/0508024, August 3, 2005). The paper begins engagingly: 'For the few scientists who earn a Nobel prize the impact and relevance of their research is unquestionable. Among the rest of us, how does one quantitate cumulative impact and relevance of an individual's scientific research output?' I read this article almost immediately after it appeared online; struck by the simplicity of the '*h*-index', a single number that assesses an individual's consistency of performance. For good measure, the paper contained equations, graphs and integrals, that seemed to invest it with the respectability of the quantitative sciences. The Hirsch definition was simply stated: 'A scientist has index h if h of his or her N_p papers have at least h citations each and the other $(N_p - h)$ papers have $\leq h$ citations each'. The Hirsch paper was republished a few weeks later in the *Proceedings of the US National Academy of Sciences* (*PNAS*, 2005, **102**, 16569), clearly launching it on a career which will accumulate citations in great abundance. 'Scientometrists' (practitioners in the field of scientometrics) have been quick to adopt the *h*-index; the simplicity of the calculation ensuring that it can be applied to any aggregate of publications, permitting classification of individuals, institutions and journals. The *h*-index avoids some of the obvious pitfalls in assessing scientific output. Total citation counts may be skewed by very few highly cited papers, while journal impact factors can be misleading with most papers in high profile journals accumulating only a modest number of citations. Indeed, in an essay entitled 'Escape from the impact factor' the editor of *Nature*, Phillip Campbell notes that an analysis of citations received in 2004 to papers published in 2002 and 2003 revealed that '89% of our impact factor was generated by just 25% of our papers' (*Ethics Sci. Environ Polit.*, 2008, **8**, 5). Campbell views the impact factor from an enviable vantage point as

the editor of journal sought after by the most accomplished of authors. His conclusions are conservative: 'I am sure that citation statistics of large numbers of individual papers can reflect the impact of contributions at the institutional or national level. They can also provide useful input at the level of an individual. But for a sure assessment of an individual, there is truly no substitute for reading the papers themselves, regardless of the journals in which they appear'. Campbell's views appear in a theme section of the journal *Ethics in Science and Environmental Politics* (*ESEP*) entitled 'The use and misuse of bibliometric indices in evaluating scholarly performance' (*ESEP*, June 2008). The articles in this thematic section uniformly appear concerned over the growing misuse of impact indices and the attendant damage to the world of scholarly publishing. At times, the assault on the quantitative indices is entertaining with even Shakespeare (*Julius Caesar*) joining the battle:

> '*Are all thy conquests, glories, triumphs, spoils*
> *Shrunk to this little measure*'
>
> (Lawrence, P. A., *ESEP*, 2008, **8**, 9).

The 'little measure' that appears to have captivated both scientists and analysts is the *h*-index. A flood of papers in *Scientometrics* attempt to improve the *h*-index. The *g*-index is already being discussed (Egghe, L., *Scientometrics*, 2006, **69**, 131), and undoubtedly more indices will follow. In every case the attempts are directed towards balancing the contributions of unevenly distributed citations to publications by an author. Hirsch's original suggestion is striking in its simplicity and ease of computation, making it a dangerous weapon in the hands of naïve analysts. He has both a diagnosis and prescription, after examination of the *h*-index for a large number of celebrated (and some less well known) authors. He recommends that an *h*-index of 20 after 20 years of activity, 'characterizes a successful scientist'. Since longevity must hopefully improve a scientist's *h*-index, Hirsch adds that a value 'of 40 after 20 years . . . characterizes outstanding scientists, likely to be found only at the top universities or major research laboratories', while 'an *h*-index of 60 after 20 years or 90 after 30 years, characterizes truly unique individuals'. Hirsch then prescribes (possibly tongue-in-cheek) norms for career advancement and recognition. An *h*-index of ~12 should qualify for grant of academic tenure (a hurdle that does not exist in our research institutions), $h \sim 18$ is the suggested bar for a professorship and $h \sim 45$ appears a norm for election to the US National Academy. While *h*-indices vary significantly with fields Hirsch notes, somewhat unsurprisingly, 'that Nobel prize winners have substantial *h*-indices', with a median value of 35.

The Hirsch paper has catalysed a burst of scientometric activity. Interestingly, the preoccupation with scientometrics appears disproportionately high in countries with limited scientific activity. Three databases are used by analysts; most often their limitations are not explicitly stated. The oldest and most comprehensive is the ISI Science Citation Index (Web of Science), about which the Editor of *Nature* laments: 'Try as we might, my colleagues and I cannot reconcile our own counts of citable items in *Nature*, several other *Nature* journals and indeed *Science*, with those used by ISI' (Campbell, P., *ISEP*, 2008, **8**, 6)'. The *Scopus* (Elsevier) and *Google Scholar* databases have their own idiosyncracies, which will undoubtedly be highlighted by serious, professional analysts. Unfortunately, scientometrics is the province of a diverse group of analysts; many studies commissioned by agencies of Government of India do not seem to bear the stamp of rigour. The need for understanding the nuances of publication practices in different fields of science is usually ignored. The inability of many 'scientometrists' to appreciate the need to check their data and carry out 'control analyses' renders many studies carried out in India almost useless. Most disturbingly, policy and decision makers often use these poorly conceived and badly executed studies to pronounce judgements. There is a need to insist on a more scholarly approach to scientometrics, which will enable new entrants to the area to understand that rigour is an integral part of the discipline. Citations and *h*-indices are good measures to identify exceptional performers; they are not useful in discriminating between scientists of average attainment. To borrow a widely used term in science and engineering, the signal is submerged in the noise, in such cases. Counting papers and citations has become an inescapable activity in the field of science. Even as the number of parameters that define the quality and quantity of scientific output increase, a little of the joy of doing research appears to be vanishing. Economists are fond of measuring the cost to benefit ratio. Scientists may soon argue that a cost to impact ratio is a valuable parameter. Economics has been famously and unfairly characterized as a 'dismal science', a term that appears in Thomas Carlyle's extensive writings on slavery in the mid-19th century. It would appear that this description is most apt for scientometrics today.

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