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EDITORIAL

Measuring and Assessing Science

When the 'Science Citation Index' was first proposed its major objective was to break the so-called subject index barrier. Out of this bibliographic experiment has evolved a historiographic and sociometric tool of major importance. Like most other scientific discoveries, this tool can be used wisely or abused. It is now up to the scientific community to prevent abuse of the SCI by devoting the necessary attention to its proper and judicious exploitation.

Eugene Garfield
Nature, 1970, **227**, 669–671

Measuring and assessing the output of scientists and scientific institutions has never been an easy task. Garfield's path-breaking proposal for a 'citation index' was made at a time when few could have predicted the scope and magnitude of the revolution in computing and information technology. Today the *Science Citation Index* (*SCI*) and a host of specialized databases, which cater to specific disciplines, are readily available, online, to those who can afford them. In India, a number of national laboratories and central institutions are beginning to have access to the resources of the *SCI*; a development which will undoubtedly catalyse many analyses of the quantity and impact of Indian scientific output. This may, therefore, be an opportune moment to consider some issues which have a bearing on the assessment of science.

The journal *Scientometrics* first appeared a quarter of a century ago (Vol. 1, No. 1, September 1978, Elsevier Science Publishing Company, Amsterdam and Akadémiai Kiadó, Budapest). The 'launching of the journal . . . persuaded all those concerned that a self-contained research field under this name really exists' (Schubert, A., *Scientometrics*, 2002, **53**, 3–20). Today, scientometrics or the measurement of science, appears to be a well-developed field on the fringes of science, which may attract professional science watchers, policy makers, sociologists and historians of science. Practising scientists often view the results of scientometric analysis with some degree of self-consciousness and discomfort. The idea of a readily available, 'objective' tool, for assessment of the impact of one's publications, is hardly likely to meet with an enthusiastic reception from the average scientist. Inevitably, much of the published scientific work may appear mediocre. But as Garfield noted many years ago: '. . . the growth of science is dependent upon an accumulation of many "mediocre" results that are produced by hard work'. He went on to add: 'Long live the mediocrities. Without them how could there be geniuses?' (Garfield, E., *Current Contents* Nov. 4, 1970; *Essays of an Information Scientist*, ISI Press, Philadelphia, 1977, p. 131). The *SCI*, citation counts and journal impact factors are here to stay. The quantitative tools for measuring science published in the journals covered by the *SCI* are now widely available. Scientometrics may soon become a sub-field of science which may face greater scrutiny, as the validity of many quantitative analyses and their interpretations is questioned. This will be particularly true in countries of the Third World, India prominently among them, where the interpretations of scientometric analysis will have to be approached with caution. The *SCI* is a marvellous, indeed spectacularly useful tool, for unearthing bibliographic networks and tracking the development of a field. It may be a double-edged sword in the hands of administrators, who seek to use it to assess individuals and even institutions.

Recently, this journal carried the results of a simple analysis; a comparison of the total number of *SCI* indexed papers, which emanated from India over the period 1980–2000, with that from countries like South Korea, Brazil and Israel. The observation was that while India's publication output has held steady over a two-decade span, the other countries appeared to show an appreciable upward trend. The conclusion reached was that India's publication output, and by inference its science, has stagnated; undoubtedly, a worrisome trend (Arunachalam, S., *Curr. Sci.*, 2002, **83**, 107–108). The reactions to this finding have varied widely. To some, this quantitative and limited analysis only confirms their worst fears; science in India is indeed on the decline. To others, optimists, who view science from the perspective of specialized fields, the quality of publications in some highly visible areas has shown a dramatic improvement; they dismiss 'total counts' as misleading. The measurement of 'quality'

is, of course, more difficult; journal impact factors are arguably, an imperfect measure; citation counts are more difficult (and expensive) and, in the eyes of many, a far from ideal yardstick to measure the 'quality' of the average scientific output that results from research in the developing world. Even reasonably good and useful pieces of work from the Third World are cited less than work of a similar calibre appearing from Western laboratories. Citations and co-citations which bind together an invisible, collegial network of scholarship, can in the modern world be driven by many sociological factors, which, sometimes, have little to do with the scientific quality and utility of a published paper. While editors of major journals in the world have steadfastly maintained over the years that there is little evidence for bias against Third World manuscripts at the level of editorial review, there are no easy methods to assess whether there is a 'citation bias', that tilts against authors from the developing world. Despite the many questions that may be raised about the validity of the conclusions drawn by counts of papers and citations using the *SCI* database, it appears that this activity is now on the increase in India. Even more importantly, governmental agencies and administrators seem to be attracted by the possibility of using scientometric analysis as a tool in assessing scientific performance; often unable to resist the temptation of using that most dubious index, the 'average journal impact factor' (a quantity easily obtained by averaging the current journal impact factors on a list of publications) to compare individuals and institutions.

The use of the *SCI* and scientometric analysis in India is hampered by the fact that there are very few analysts, who understand the nuances and limitations of the databases that they use. Even fewer have any appreciation for the fields whose publications output they analyse in quantitative terms. Most disturbingly, many analysts do not bring the methods of science to their practice of scientometrics; they do not check and recheck their search results, they do not do 'control searches' where the answers are already reasonably well known. The 'clients' for whom this kind of analysis is performed, invariably influential government science administrators, appear touchingly innocent of the meaning of a journal impact factor. For them, impact factors irresistibly lead to absurd conclusions; an institution devoted to biology is stated to be 'doing better' than an institution in the area of geophysics – the conclusion being drawn using the ubiquitous 'average journal impact factor'. Many analysts are even unaware of the nature of the journal coverage in the databases they use; convenience and expedience dictate the choice of databases and any appreciation of the dangers of analysing interdisciplinary areas using restricted journal sets is largely lacking. The appearance of citation searching in *Chemical Abstracts* using *SciFinder Scholar* as an alternative to the *SCI* (now incorporated in the beguilingly named *Web of Science*) adds a new dimension to analyses in chemical sciences. Differences in journal coverage can lead to differences in citation counts as pointed out in a recent model study (Whitley, K. M., *J. Am. Soc. Inf. Sci. Technol.*, 2002, **53**, 1210–1215). This study notes that 'academic administrations find it difficult to ignore the tidy citation figures as an achievement measure'.

The citation game and the benefits of large publication lists in career advancement have led to many curious situations. The development of an 'electronic systematic search tool' permitted the estimation of the 'amount of duplicate publications in the 70 ophthalmology journals listed by *Medline*'. The results are striking. Out of 22,433 articles analysed, 13,967 gave a score in a duplicate-detection algorithm, which appeared significant. Manual review of 2210 papers yielded 60 'genuinely duplicate' publications. The authors regard this as the 'tip of an iceberg' (Mojon-Azzi, S. M., Jiang, X., Wanger, U. and Mojon, D. S., *Nature*, 2003, **421**, 209). While duplicate publication may be relatively uncommon, the tendency to fragment publications will undoubtedly increase, as 'total counts' become an easy measure of achievement. Another recent report notes that most scientists who quote a paper are unlikely to have read it; a conclusion hardly likely to surprise practising scientists. The sociological factors that go into the compilation of reference lists in a published paper can hardly be gleaned from the *SCI*. Using mis-citations of a highly regarded paper in condensed matter physics, M. V. Simpkin and V. P. Roychowdhury, conclude that propagation of citation errors suggests that more than three-quarters of authors have not read the cited papers (see report by Ball, P., *Nature*, 2003, **420**, 594). This estimate is undoubtedly inflated; there are many other innocuous explanations for error propagation. For example, an author may read a paper that he cites but use an incorrect reference copied from a previously published list, during manuscript preparation. This could hardly be classified as deviant behaviour; it is merely a casual act of sloppiness. Nevertheless, such studies raise interesting questions about citation practices.

Journals, papers, impact factors and citations might provide a measure of the health of a nation's academic science. The growing interest in the analysis of quantitative science indicators in India is clearly a good sign; inferences based on hard data are preferable to those based on personal prejudice. But, it may be necessary to critically evaluate the approaches used in analysing science in India and to thoughtfully integrate scientometric analysis into the shaping of public policy. An uncritical plunge into the sea of scientometrics may be unwise.

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