Measure and Mismear of Science

In 1997 Robert May, then the British government’s chief scientific advisor, authored a commentary entitled ‘The Scientific Wealth of Nations’. May’s analysis began thus: ‘The United States took much pleasure from its performance in the Olympic Games, where it won many more medals than any other country. But was this the right measure of performance? Counting four points for gold, two for silver, one for bronze, and calculating the score relative to population size, a different picture emerges. Tiny Tonga was first, Australia led among the larger economies, and overall the United States ranked 37th, well behind most of the European countries (but not the United Kingdom, a lamentable 48th).’ May was, of course, unworried about the Olympics; he was focussing on measuring science, stating clearly his intent: ‘similar questions arise when we ask about the quality of the scientific research output of countries. For many purposes, most notably overall advance in our understanding of nature, it is total output that matters’ (Science, 1997, 275, 793). May’s study was substantially based on an analysis of Australian research, which used the Science Citation Index based on coverage of ‘4000 journals since 1981’. He ranked the top 15 countries, with India coming in respectively at position 8, edging in ahead of Australia, The Netherlands, Sweden, Switzerland and China. India’s share of papers was 2.4%, its share of citations 0.7% and its share of GDP spent on R&D was listed as 0.7%. The relative citation impact (RCI, citations divided by publications) was low for both India and China, 0.27. The two most populous countries ranked 66 and 65 if RCI was used as an index of scientific performance. Some of May’s conclusions based on his data bear retelling. He suggested that the lower ranking of some G7 countries like Germany and France relative to North America or UK may be related to the fact that in the former, basic research is largely done in research institutions (Max Planck and CNRS institutes), whereas in the latter, research is largely the province of the universities. I rather liked his inference: ‘The non-hierarchical nature of most North American and northern European universities, coupled with the pervasive presence of irreverent young undergraduate and postgraduate students, could be the best environment for productive research. The peace and quiet to focus on a mission in a research institute, undistracted by teaching or other responsibilities may be a questionable blessing’. May’s suggestions could well be relevant in India, where science policy is overwhelmingly dominated by those who are votaries of research institutions, with rigidly defined hierarchical structures. Irreverence would hardly be a prized quality in these surroundings.

May’s commentary is over seven years old and I would normally not have revisited it, if it had not been for yet another analysis of ‘the scientific impact of nations’. The author this time is David King, May’s successor in the British Office of Science and Technology. The raw data remains the number of published research papers and their citations, as logged by the SCI (Nature, 2004, 430, 311). In addition to the total number of papers and citations, King uses a more selective parameter; the number of and citation to the top 1% highly cited publications based by division into seven disciplinary categories: clinical medicine; preclinical medicine and health; biological sciences; environment; mathematics; physical sciences; and engineering. King presents data for two periods, 1993–97 and 1997–2001, allowing a view of the growth of scientific output. King notes: ‘Governments also need an indication of disciplinary strengths and weaknesses based on international comparisons. Comparing one discipline across different countries should be easier than comparing two disciplines within one country’. The dangers of cross-disciplinary comparisons of scientometric data are often not apparent to many decision makers in India; even more sadly, most scientists do not seem to sense the pitfalls of such comparisons. King represents the enormous data generated by the ‘national and disciplinary disaggregation process’ as a radial plot, which produces an image of the ‘national footprint’ in science. According to King: ‘The larger the national footprint, the bigger the impact on international science’.

The numbers of papers and citations recorded in this study are staggering; for the period 1997–2001 there are 3,631,638 papers aggregating 41,425,399 citations. The analysis lists 31 countries, which together account for
98% of the world’s highly cited papers. King notes, without comment, that the ‘remaining 162 countries contributed less than 2% in total’. The 2004 rank order places India at position 22, China at 19, South Korea at 20 and Russia at 16. Brazil at 23 is the sole representative from South America, South Africa at 29 is the only African country and Iran at 31 represents the ‘Islamic countries’, a classification that appears to be gaining a measure of prominence. Predictably, the United States, Britain, Germany, Japan, France, Canada and Italy are the top 7 countries. Interestingly, this list of 7 is unchanged, when compared to May’s 1997 analysis. Notably, Switzerland, The Netherlands, Australia, Sweden and Spain make a strong showing, completing the top dozen countries. King’s ranking of nations on the basis of scientific impact, comes closely on the heels of the ‘Shanghai ranking’ of universities worldwide (Curr. Sci., 2004, 86, 1347). The tools of scientometrics appear to now provide global comparisons, which merit attention, particularly from those charged with the responsibility of deciding policy initiatives to strengthen the science base in India. A notable feature of King’s analysis is an attempt to compare private R&D spending, PhD production and numbers of full time researchers as a fraction of the population of employed persons. Unfortunately, he provides figures only for the G8 countries, with the statistics for Russia largely missing. These indices complement publication statistics and should encourage Indian analysts to gather and sift through similar data. King emphasizes the utility of these figures: ‘The knowledge base and economic fortunes of a nation are maintained and developed through the production of highly trained people. This is a necessary but not a sufficient condition for sustainable economic development: both political and macro-economic factors including infrastructure investment must also be in place’ (Nature, 2004, 430, 311).

The discussion on India’s scientific output as measured by publications has been going on for sometime in the pages of this journal. The observation that SCI indexed publication numbers have been stagnant for some years now, in contrast to high growth rates for China and South Korea has met with responses, which have ranged from the indifferent to the hostile. One view has been that such rankings and statistics are irrelevant; Indian science must address local problems, looking inward in a repudiation of the tendency to make global comparisons. Another, and a more forceful view, is that these indicators are not a true measure of the impact of Indian science; rather we must search for a new set of indices which will provide a different picture. A new game has begun, with groups attempting to define a fresh set of indicators. The motivations are clear; let us redefine the parameters so that obvious indicators of technological success can be factored in. Points must now be assigned for the successes in fields like defence, atomic energy, space technology and agriculture. This urge to search for indicators which will show us in better light is fuelled by the insecurity of science administrators, who are largely drawn from the institutions charged with achieving specific technological goals. Published papers are obviously not a good index of success in these areas. What needs to be emphasized is that published output is indeed the only measure by which academic science can be evaluated on a national or global scale. It must also be admitted that a large fraction of work in our network of national laboratories (CSIR, ICMR, ICAR and the DBT/DST institutions) is academic in nature. Even within the Department of Atomic Energy there is a large amount of basic research, which can be judged only when published. The universities and academic research institutions, of course, are intended to do research that can be published. A decline in output or stagnation is then a matter of concern, especially when an upward trend is observed for other rapidly developing countries. If our stated intention is to improve the quality and quantity of scientific research output, then steps must be taken to ensure a higher level of scientific activity, more evenly across the country. The pressures of competition must be felt in a much larger number of academic institutions than at present; academic positions cannot become a sinecure for non-performers in research. Even more importantly, the right signals must emanate from administrators of science. Searching for new measures of science may be a diversion best left to academic analysts; government would be ill-advised to base policy initiatives on newly minted indicators.

Many years ago I came across a book by Stephen Jay Gould entitled The Mismeasure of Man (W. W. Norton & Company, New York, 1981). Gould, in his characteristically compelling fashion, had launched an attack on the measures of human intelligence, studies he believed (and many think, incorrectly) were driven by racist motivations. Initially, I was puzzled by the word ‘mismeasure’, which did not occur in my dictionary; although ‘mis’ is listed as a prefix meaning ‘wrong’. Gould undoubtedly viewed physical estimates of cranial capacity and intelligence tests as mismeasures of man. In thinking about measuring science, Gould’s phrase suddenly came to mind. We must be watchful of mismeasures of science.

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