

Paying for science

Abrol¹, in his note, raises obliquely, a fundamental issue of science policy which has long been neglected in the Western world. Who should pay for 'basic science' – that which is NOT connected in any way to societal values, or goods, such as 'sustainable development' or 'human welfare'? The latter was Nobel's stated goal for his prize winners! This metric is never even mentioned by the current Nobel selectors!

Alvin Weinberg, founding director of Oak Ridge National Laboratory, and I have separately addressed this question^{2,3}, 1963 and 1985. Later I wrote a book with Shapley⁴, the first major critique of the US Science Policy, and raised the same question in-depth. Who should pay for what science? And is the US science doing well at all, when cost-effectiveness is taken into account?

Let me start with another simple criticism of the simplistic use of citation data. In an era of computers and precision accounting, is it not absurd for citation champions to not normalize the number of papers and citations by dollars or yen or rupees spent by governments and industry, even adjusting for PPI. When this is done, the disparities become radically smaller.

Next, in that book, Shapley and Roy made the distinction between 'telestic,' i.e. with goal or purpose and 'atelestic,' with no special external purpose. This is the issue also raised obliquely by Abrol, and addressed cogently by Stokes⁵, which develops further the Shapley and Roy theme. The question that many advocates of 'basic research', i.e. for science's sake alone, worry about is that such research will suffer if applications are stressed too much. Let us look at the data.

Admiral Paul Gaffney, former Head of the Office of Naval Research (ONR), stresses how this 'applications-driven basic

research' was the ruling motif at ONR, which has been recognized by much of the US science community as the best agency for pioneering fundamental research⁶. Even more surprising to most younger policy makers is the fact that the same 'applications-driven' quality was the operative principle at Bell Labs, widely recognized as the most successful industrial laboratory ever. In academia since 1962, when I set up Penn State's Materials Research Labs (MRL), we have used the term 'applications-driven basic research' to describe what we do [following Bill Baker's (President of Bell Labs) advice in his speech on opening the lab]. In 2003, Penn State's MRL was rated #1 in the world by ISI, using most highly cited scientists' data.

'Applications-driven' as a national research and development (R&D) motif has a philosophical basis also. Upon his retirement, a former Vice-Chancellor of Melbourne University stated it best when discussing atelestic science: 'Science never made any country rich, rich countries (and I would add philanthropists) do science'.

My suggestions to analysts of Indian R&D policy include:

(i) Do not be over-bamboozled by Western-based and biased statistics on R&D output. Normalize everything, including those noted above and other obvious improvements such as, for instance, citation-inflation with time, as everyone does even for dollars spent. And ignoring the so called 'informal' citations identified first by Marx and Cardona⁷⁻⁹ who show, for example, that Raman's main paper is under-cited by ISI by a factor of nearly 100.

(ii) Absolutely avoid Western science's – 'fashionable' or 'cult' science – funding procedures. Most have ended as debacles: 'ceramic engines'; 'supercon-

ducting supercollider'; 'High T_c superconductors'; 'bucky balls'; 'nano-' anything.

(iii) Most assiduously, avoid the introduction of these passing fancies into science education. India has profited enormously by having BSc and PhD graduates solidly trained in basic sciences. Here our ideal good has been modified slightly to 'applications-connected basic science' education. All students should, early on, be fully grounded in the fact that true science is rooted in reproducible data, facts – not theories.

1. Abrol, I. P., *Curr. Sci.*, 2007, **93**, 902–904.
2. Weinberg, A. M., *Minerva*, 1963, **I**, 159–171.
3. Roy, R., *Minerva*, 1985, **22**, 316–328.
4. Shapley, D. and Roy, R., *Lost at the Frontier – U.S. Science and Technology Policy Adrift*, ISI Press, Philadelphia, 1984, p. 223.
5. Stokes, D. E., *Pasteurs Quadrant: Basic Science and Technological Innovation*, Brookings Institution Press, 1997.
6. Gaffney, P., *Bull. Am. Ceram. Soc.*, 2000, 57–61.
7. Marx, W. and Cardona, M., <http://arxiv.org/abs/physics/0701135>.
8. Cardona, M. and Marx, W., *J. Superconductivity Novel Magn.*, 2006, **3–5**, 19.
9. Cardona, M. and Marx, W., <http://arxiv.org/abs/physics/0601113>.

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