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The future of science

Text of an address given on the occasion of Jerry Ravetz's 90th birthday

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Let me start by paying tribute to Jerry Ravetz – he has been well ahead of the curve in thinking through many of the issues through numerous important contributions[1]. Jerry's thought piece, which he wrote to introduce this session, essentially says it all[2] and I am not sure I have much to add. I have only known him in recent years but what a marvelous person he has been to interact with.

Scientific knowledge is a true public good, and every challenge at any level of society and in every realm of human activity, will be addressed by better applying robust science. But the institution of science, itself, is also having to change; and it is indeed changing, in response to both external and internal pressures. The scientific community and its partners – the funders, governments and civil society – will need to work together to find ways to strategically evolve what is a complex system, and it is less obvious how this will be done. The situation of science early in the 21st century reflects many of the issues Jerry wrote about a long time ago.

I am President-elect of the newly formed International Science Council, which finally brings the social and natural science communities together under one umbrella. In its draft action plan you will see recognition of both the internal and external pressures that continue to drive change.

I will focus briefly on a few aspects, each of which is worthy of much more detailed examination.

The first is that driven by the changing nature of science. As Dan Sarewitz has written about in his marvelous, but somewhat uncomfortable to many, essay, 'Saving Science'[3], science evolves in no small part due to the technologies that science itself invents.

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[1] Funtowicz, S. and Ravetz, J., 1993. "Science for the post-normal age", Futures, 31(7): 735-755; Funtowicz, S. and Ravetz, J., 1990. Uncertainty and quality in science for policy. Dordrecht: Kluwer Academic Publishers; Ravetz, Jerome R. (1979). Scientific knowledge and its social problems. Oxford: Oxford Univ. Press; Ravetz J (1990), The Merger of Knowledge with Power : Essays in Critical Science. Bloomsberry.

[2] https://www.insis.ox.ac.uk/resources

[3] https://www.thenewatlantis.com/publications/saving-science

Computational advances in particular have shifted much of science from a series of independent largely linear observations to a systems-based approach. That means that much of science is moving from being an individualistic activity to being team based and interdisciplinary. Yet, funding, peer review and reward systems in many cases need to adapt to reflect these changes. Scientists in any domain need to find language that can speak to other domains and the public. Social and natural scientists in particular need to find some common language.

That leads me to the second point – that of incentives. Scientists are not superhuman; they will naturally respond to the incentives within their system, as will others within theirs. The science system has become dominated by perverse incentives about individuals and metrics that virtually everyone recognises as misleading. Yet universities, academies and funders cannot wean themselves off of them. DORA[4] made some fine promises, but the very practices it was intended to inhibit still continue. The word 'impact' needs to be better and more broadly understood. But this requires a combined effort from funders, employers, academies and the science community to find better ways of managing the incentive structures within the system. The ISC hopes to take some lead in this direction.

Jerry long ago pointed out the problems of industrialization of science, and indeed there are many ways in which public science has become an industry where, it might be argued, the primary goal is to keep those doing it employed. Last year, perhaps 3 million papers were published in 30000 journals by 7 million authors. Of that volume of papers, how many will have real impact and be of value to society, who ultimately pays for it? A bibliometric analysis (with all its limitations) will show that the distribution of academic impact is very skewed: a minority of studies have significant impact, and we know little of the true societal impact beyond the contribution to academic education.

And linked to this is the point Jerry, Silvio Funtowicz, John Ioannidis and others have made: that much of what is published does not meet the quality ideals that we should expect of professional scholarship. Issues of reproducibility and of statistical design have been well reported. And the matter is becoming even more complicated by the emergence of big data and AI approaches, which threaten to replace scholarship and can identify apparent patterns that may or may not be causally linked. The shift in big science from hypothesis formulation and testing to automated data exploration clearly has great value in many areas of science, but it has implications that merit reflection. This is not to say that all good research is necessarily hypothesis-driven, but it is when it becomes strictly data-driven that we need to take a reflective step back.

And in the drive to respond to competitive incentives, has science lost some of its scholarship? Papers have shorter discussions; they do not speculate beyond their data; the scholarly review is discounted.

My third point relates to funding. Perhaps 70% of all research is now private sector funded. The private sector, especially through platform companies, is now a big generator of basic and discovery research, not just later stage development. Issues of its trustworthiness (and separately – its public legitimacy) become increasingly important. The issues of its

[4] https://sfdora.org

reliability and accessibility of the knowledge generated as a public good, while allowing companies a return on their investment, will need to be considered. Private sector research is important, but does it have the institutions to build trust in it in the same way that the public sector does have, to a greater degree? So much relies on the role of regulators and the market rather that the institutions of peer review, publication, review boards and the like.

It goes without saying that private sector research is important, but does it have the institutional capacity to build the kind of trust that the public sector holds? Governments tend to want public sector research to support private sector development to grow the economy. They also want the private sector to support research in public institutions to fuel the innovation economy. This is a complex mix and the interests need to be transparent. Beyond medical research, where some protocols to manage the interests exist, much of the public science system has yet to work out how mixed interests should be managed. And it is not only about the private sector; NGOs as funders also have interests, and the science system itself creates interests. By definition we cannot create a system where interests do not exist. Yet we cannot ignore research just because interests exist, so we need institutions and protocols that can handle such situations. The ultimate goals must be trustworthiness and legitimacy, whether it is to avoid another Wakefield-MMR affair (which was a public sector issue) or manipulated diesel emissions.

As the science community has, over the years, successfully argued for greater expenditure of taxpayer's money, it is inevitable that a more utilitarian perspective is being taken by governments who seek more obvious impact. But fortunately, that has not diminished their commitment to discovery research, and indeed we are seeing greater diversity in its origins as more diverse countries especially from the global south and the east invest in public research.

As science has become more systems-based, its application to areas of public interest such as environmental science, societal science, human science has grown. Thus, it is inevitable that science has moved increasingly from normal to post-normal in its fundamental characteristics. And some components of the science system are beginning to respond. Co-production, co-design and citizen science are more common. In some places such as New Zealand, there are intensified efforts to find ways to link mainstream science with indigenous knowledge production methods. The biggest deficit may still be in the training of scientists where these concepts, understanding of the relationship between science and society, the philosophy of science, and science policy interactions continue to be largely ignored.

Finally, let me turn to the complexities of one of science's biggest challenges: a challenge that is complex because it is both an incredible opportunity and a significant risk. That is, the democratisation of knowledge via the internet. On one hand, greater accessibility can increase the reach and expand the scope of scientific knowledge as a public good. On the other hand, the use of social media as the main means by which the public consumes knowledge has meant that what people read is pre-filtered by algorithmic selection due to one's own online consumption patterns and peer-group biases. This situation has both polarised societies and played a major role in the evolution of a post-trust, post-truth, post-elite world; in a sense post-truth has always been there but technology makes its

diffusion and impact far greater. The tragedy of the measles epidemic reflects that. It shows in no small part the loss of a role for knowledge mediators – that is experts, scientists and doctors who have translated science into understandings. Instead this role has been replaced by online influencers.

Dan Sarewitz in 'Saving Science[5]' makes the point that science evolved in part because science creates new technologies that then enable the next tranche of science. His essay is compelling even if many scientists do not accept it. But science driven technologies are creating a raft of new challenges where the societal decisions over their use or non-use will become more important. I think issues of social consensus for new technologies will place post-normal science far more centrally within our discourse and practices. How will we make decisions over issues like meiotic gene drive to deal with malaria, or gene editing in all sorts of applications or human-machine interfaces, or AI-driven decision making or the boundaries that should apply to the internet of things? And this is made more complex when many emerge from private rather than public science.

Increasingly, there are real trade-offs. For example, do we need more extensive use of gene editing in agriculture to reduce greenhouse gas emissions? How would we deal with geoengineering if sadly we need it to save ourselves and the planet? These issues are not only local and domestic, but also increasingly global and trans-national. Will we be able to even identify, let alone, parse the trade-offs? How can we be sure that our decisions are truly informed? Informed decisions about trade-offs are needed if societies are to tackle our biggest challenges. Yet these challenges that require urgent attention and use of science are occurring in an environment of decreasing trust, and willful manipulation of truths and facts at a time when nationalism is replacing globalization.

Science is critical to our way through the challenges of the global commons, be it climate change or declining social cohesion or rising rates of mental ill-health in young people. Post-normal approaches will be essential in doing so, but post-normal approaches will do best if they are mainstreamed. It is easy to talk to the converted, but to date the language that has been used in this discourse has not been convincing or informative to much of the mainstream scientific community. The use of phrases such as "crisis in science" has not necessarily been helpful in creating momentum for change. Change is inevitable. Internal and external pressures are relentless. But to use a cliché, let us not throw the baby out with the bathwater. Science has done so much to improve the human condition; it can do so much more, but for this, we need to continue to evolve our present system. Thank you, Jerry, for pointing the way.

[5] https://www.thenewatlantis.com/publications/saving-science