Scepticism, science and statistics

There is much public scepticism about the way science and statistics are used within government, says **Ian L. Boyd**, a former scientific adviser. But rather than close ranks against scepticism, the science professions within government should embrace it, he argues, and use it to test their own assumptions and motivations

Official statistics are important for creating trust in government. Statistical information can be used to assess the performance of policies or the current state of the many critically important systems which government has some responsibility for managing, from the food supply to the economy. It is essential that people believe these statistics, so institutions have been established in the form of the Office for National Statistics and the UK Statistics Authority to generate and authenticate them.

This trusted reporting of information is a much narrower use of statistics than I was used to in academia, where statistical methods were used across many scientific disciplines to explore the outer boundaries of knowledge. Turning bare statistical facts into compelling and verifiable storylines about how the world is structured and functions is the business of science. Expressing those storylines in probabilistic terms is the role of statistics.

Virtually everything produced by science ends up being framed within the language of statistics. There is thus a close partnership between science and statistics but, in contrast to the methodical production of national statistics, this is part of a free-form creative process. Rather than being an end in itself, statistics is a tool to be applied by creative minds to solve problems.

While we may have solved the problem of the trustworthiness of information within the narrow context of national statistics, how should we believe the outcomes of science and what role does statistics have in authenticating those beliefs? How should this information then be used in decision-making within government?

Scepticism about uncertainty

When I entered government from academia in 2012, I thought I had a pretty firm grip on

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reality because of the ways in which I applied the various techniques collectively known as the "scientific method". Before becoming chief scientific adviser at the UK Department for Environment, Food, and Rural Affairs (Defra) I had experienced the practicalities of applying science in the field of public policy, but even this had not prepared me for the level of scepticism about claims made by science in certain sectors of society, including within government, which now became important to me. In spite of the levels of trust people appear to have in scientists (bit.ly/3mNJFyS), this scepticism is likely to reflect views across society as a whole.

Is this scepticism justified? Much scepticism is self-serving. If science is saying things which are inconvenient to specific vested interests, it is unsurprising that those aligned with said interests first resort to discrediting the science. However, an understandable reaction to scepticism could be compensatory behaviour involving apparent unjustified confidence by scientists and others, such as statisticians and economists, in their methods and their conclusions. There is a strong incentive to close ranks about uncertainty when others are just going to use openness about how little we really know as a lever to undermine what science and statistics are saying.

I saw many instances of deep reluctance towards openness on this subject within government. The kind of excuses made included that audiences misunderstand probabilistic ranges, or that these ranges might be so broad that the analysis would be deemed by key audiences to be uninformative.

Both of these reasons are getting into tricky ethical territory. The reluctance to be explicit about levels of confidence in estimates relevant to critical policies has the effect of shifting the power of decisions towards those who are undertaking analysis. Those who control the analysis increasingly control the decision. Sometimes this might be justified so long as it is made clear what is happening. In fisheries, for example, the confidence around estimates is rarely provided on the grounds that those making decisions will consistently be pressured into choosing options towards the upper end of a probability range, behaviour which if repeated year after year is guaranteed to result in overfishing. But many cases are not nearly as clear as this.

Communicating broadly "scientific" information to people whose interests may not be best served by listening to and acting on this information[1] is undoubtedly challenging, but this often overshadows a debate which needs to take place about the methods used to develop scientific advice in the first place. There is a need to look inwardly at the scientific process itself in search of improvement.

To assist this search, I am offering comments on two main problems, namely the importance of undeclared interests of experts and the dangers there are from inappropriate framing of the problems faced by government.

Neutralising interests

As the contemporary philosopher Peter Singer has argued, we all have interests.[2] By implication, these extend to those who work in the broad science professions, including the fields of natural and social science, statistics, economics and operational research. (In broad terms, this represents the set of professions active within government which service the need for quantitative analysis.) A key question for these professionals is how they neutralise their own interests to minimise outputs being biased by those interests.

Often the interests remain buried under a layer of process and accreditation which may neutralise them to some extent, but the institutions created to act specifically in the interest of these science professions tend to reinforce rather than neutralise interests. In government, for example, there are groups set up to support statisticians, economists and social scientists working as part of the civil service, and these communities are active in carving out their own spheres of influence, proactively promoting their own interests.

This carving out is notionally to improve the quality of information flowing to decision-making. There may be functionality in allowing different interests to compete for attention in this way, but these are not generally the terms under which the science professions are understood to operate. They are, instead, seen to be the components of government which strive for objectivity, but how true is this in practice?

There is a delicate balance to be struck between sustaining good communications to those in power and having to deliver unwelcome messages. Two kinds of consequence are evident within government to deal with this balance. The first involves subliminally – or sometimes intentionally – biasing the messages from quantitative analysis in ways which help support the interests of those in power. This comes from the wish to please. The second is to weight the rule book under which government operates to ensure that those in power have to take account of certain types of analysis. Within government, both statistics and economics have successfully managed to establish rules of operation which mean their voices must be heard. This is a good foundation, but only so long as statistics and economics can show that their own interests have been neutralised.

There is evidence that this is not the case. For example, there are branches of economics which are dominant in government, such as those which promote gross domestic product as a measure of national economic performance, or which support the neoliberal economic model. These are positions which

affect the kind of outcomes of analysis. While there is an argument that government needs to pin its colours to one academic discourse or another because it needs to get on with making decisions, in this case deep-seated and institutionalised representations of interests probably stifle the consideration of alternative discourses.

The formation of "expert" groupings, such as the Scientific Advisory Group for Emergencies (SAGE) which was formed to provide scientific advice during the Covid-19 pandemic, is only a partial solution. There are unavoidable trade-offs in this case between rigorous challenge to scientific analysis and agility. Asking mutually independent groups to carry out the same analysis based on different analytical approaches is one solution. In the Covid-19 SAGE this allowed any discrepancies in results to be questioned and understood in the context of potential analytical bias, and much the same method is used in climate prediction. But these methods still suffer from the potential that professional analyst groupings converging on consensus are reflecting shared values rather than common results. Those providing scientific advice, whether about climate or epidemics, are not a normalised sample from across the population of values.

Therefore, understanding the interests of those who generate knowledge is almost as important as the knowledge itself, because it helps us assess how much to believe in what they are saying. I often witnessed politicians trying to make this kind of calculation about what they were hearing based on the "evidence". To many of them, the source of evidence appeared to be just as important as the evidence itself.

This kind of assessment might attract a lot of criticism. It is veering perilously close to the people "have had enough of experts" comment from Michael Gove during the 2016 Brexit campaign (bit.ly/3aAg1Ya). Having worked with Gove for a while and seen how seriously he took scientific advice, I think by "experts" he meant analysts who were predicting certain untestable outcomes against no verifiable counterfactual. Setting aside his motivations for making the comment, which were blatantly political, there is more than a grain of truth in the idea that the analyses to which he was referring had underlying political motivation. The "experts" to whom he referred had undeclared interests, and they were failing to neutralise them. Ironically, in so doing, their messages failed to reach the very people they most sought to influence.

Constructing arguments based on logical foundations

The interests of the *scientific* professions in government arguably create ways of working which reduce the value of their outputs.

Decision-making, especially in government, is largely informed by deductive (often deterministic) analysis because there is a perception of a need to service political preference for an answer, a single statistical truth upon which to act with apparent (though often quite fictitious) confidence. The government machine has been constructed to demand this kind of information and the technical advisory functions in government grind out analyses to cater for this demand.

This is exemplified by the cost–benefit analyses which underpin almost all government decision-making. They are an expression of the relative utility of different decisions, yet, instinctively, nobody quite believes these analyses. I suspect this is mainly because the analyses often apply deductive reasoning in a situation where inductive and inferential reasoning is really needed.

To deal with this I suggest we need to see science in government through two distinct lenses. One involves the provision of technical solutions, such as the invention of vaccines to treat disease or the development of new forms of sustainable energy generation. This is a deductive pathway and many people within and beyond government expect science to play this role. Indeed, for many people it is how they understand the role of science to be.

However, science involves a way of thinking about problem-solving which is about understanding fundamentals and considering how to solve problems upwards from those foundations. This inductive process is exemplified by systems thinking and systems analysis or modelling. In general, the activities of governments are concerned with managing systems from, for example, the climate to health care.

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Understanding the emergent properties of these systems and, therefore, how these systems respond to external pressures or to management interventions is going to be increasingly important to governments in future. Analysis, including statistics, has the capacity to describe the current or past state of those systems, and process models built upon scientific knowledge of how different system components interact could provide us with knowledge of the dynamics of those systems.

Shifting to an inductive system of logic for analysis could change the role of science in government from something akin to a technical support function to something where science leads the policy development process.

Shifting the philosophy of science and analysis in government

My thesis is, therefore, that much of the science and analysis carried out in government is not built upon the most appropriate philosophical foundations to address the problems faced by government. The result is that much of it is not as robust as it could be. Technical *post-hoc* descriptions of system states abound in government and are stuck in bygone empiricist traditions. They mostly fail to recognise that there is a massive and largely unexploited range of statistical methods available to assist with understanding the business of government. Moving from deductive to inductive science will also mean moving from reductionist to holistic thinking; the equivalent of moving from only estimating the number of fish which can be harvested from the sea to estimating the overall productivity of the sea and optimising the use of the sea for a range of outcomes.

Bayesian statistics and other similar inferential methods used to assess the fit of models to complex multidimensional processes, where data are often sparse, could provide a methodological boost to support this transition. They have the capacity to make uncertainty explicit. Competition between models to fit to the data from the real world is often the key to creating a greater belief in the robustness of the outcome.

Ironically, the current avalanche of data may be holding up this transition because it blinds us to thinking carefully about how data might be used in the context of models of the world. To paraphrase Richard Feynman's expression of exasperation – "shut up and calculate" – when faced with the complexities of quantum mechanics, we tend to shut up and analyse when faced with the deluge of data. Despite its apparent abundance, I suspect we are beguiled into thinking more data leads to more knowledge and also that large amounts of data about some things is equivalent to large amounts of data about everything. Despite this, large parts of our world remain relatively unknown, let alone understood.

One of the most powerful illustrations of success in this transition process comes from meteorology. Highly capable atmospheric models are now used to construct weather forecasts. Every 6 hours a new output is tested against reality in the form of increasingly accurate empirical measurements. The result is that the predictive skill of these models has been improving at a rate of about one forecast day per decade.[3] This is convergence on reality by iteratively challenging models of the world with real data. Moreover, multiple models with different characteristics and assumptions are run in parallel, leading to a richer appreciation of the strengths and weakness in our understanding of how the dynamics of the atmosphere translates into weather.

The transition to inductive methods is not a new philosophical concept. Wittgenstein called for them in 1918 and others have developed these ideas, including the move from reductionism to holism advocated by W. V. O. Quine in his cutting 1951 critique of empiricism.[4] It is the accessibility of increasingly powerful computing that has made this transition possible in those areas which have embraced the change. Today, sufficient computing power is available for analysts working on desktop computers to use these methods, but government remains firmly rooted in the empiricist tradition in spite of this.

Perhaps the sluggish progress in government happens precisely because such a move towards inductive, holistic analysis helps to neutralise the interests of those involved in carrying out analysis. Under this transition, models become public property rather than the private domain of individual analysts, and for government to make its working known and to lose control to the outside world is uncomfortable. Model performance through the explicit fitting to the real world can provide even non-experts with a way of assessing the level of belief they should have in the conclusions being provided by these models – witness the judgements we all make about weather forecasting – but this is another message which governments have traditionally wished to control. The transition, therefore, has the capacity to combine the social process of science itself with the social process of communicating its conclusions, cutting out the vested interests within government to control messages.

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Scepticism reborn

Therefore, is the scepticism which many people have about science (including all forms of analysis) justified? Certainly, within the context of how it is implemented within government, I suggest that it is. Even if those involved in this process do not accept my argument that there needs to be a significant shift from deductive and reductionist methods to inductive and holistic methods, at the very least there needs to be a resurgence of scepticism.

In the Cartesian tradition, experts need to be eternally sceptical, and no more so than about their own assumptions and motivations. A lot has been said recently about the reliability of science mainly based on judgements about replicability and because of high-profile cases of misconduct. It would be churlish, therefore, just to focus in on the use of science, together with all the other forms of quantitative analysis, in government alone. This is a much wider problem concerning the outputs from natural and social science as well as statistics and economics.

For the most part, individuals are not to blame except inasmuch as they conform to traditions embedded within their professional tribe, and tribalism is alive and well not only within the quantitative disciplines sitting in government but also, I suspect, elsewhere. Only when one has the social licence to break out of this tribalism, as I found I had when I became a chief scientific adviser, is it feasible to proactively apply scepticism, and this was a sobering experience. In contested areas, such as those concerned with the use of pesticides,[5] I found very little published scientific evidence to be reliable, and distinguishing the reliable from the unreliable was impossible. In such cases one resorts to a judgement based on who has produced the science, thus reducing the judgement about the quality of science, once again, to a social process.

Rudyard Kipling, in exalting the students at the University of St Andrews to be free-thinkers, once said: "Because if a man has *not* his rations in advance, for any excursion of any kind he proposes to himself, he must stay with his Tribe."[6] I suggest we need to empower scientists and statisticians by giving them their rations – such as proper training in philosophy – so that they can leave the tribe if they wish. Such a change will build wider trust which drains away when there is closing of tribal ranks. This will create a more robust picture (to use the phraseology of Wittgenstein) of the world around us and how to interact with it in ways which can produce better outcomes. Believing the outcomes of science will only happen if there is a continued close relationship between science and statistics. ■

Disclosure statement

The author declares no competing interests.

References

1. Pielke, R. A. (2014) *The Honest Broker: Making Sense of Science in Policy and Politics*. Cambridge: Cambridge University Press.

2. Singer, P. (2006) *Practical Ethics*. Cambridge: Cambridge University Press.

3. Stern, H. and Davidson, N. E. (2015) Trends in the skill of weather prediction at lead times of 1–14 days. *Quarterly Journal of the Royal Meteorological Society*, **141**(692), 2726–2736.

4. Quine, W. V. O. (1976) Two dogmas of empiricism. In S. G. Harding (ed) *Can Theories be Refuted?: Essays on the Duhem-Quine Thesis*. Dordrecht: Springer.

5. Boyd, I. L. (2018) An inside view of pesticide policy. *Nature Ecology and Evolution*, **2**, 920–921.

6. Kipling, R. (1923) *Independence: Rectorial Address Delivered at St Andrews, October 10, 1923*. London: Macmillan.