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Original Article

Governance for Effective Policy-Relevant Scientific Research: The Shared Governance Model

Mark Burgman*

Abstract

Despite the aligned aspirations of many applied scientists and policy-makers that science should contribute directly to policy decisions, there are significant gaps between what scientists provide and what policy-makers can use. This article outlines the features that encourage effective adoption of scientific advice in public policy. It reviews some of the major impediments to its use. It describes governance mechanisms that aim to overcome these impediments, and discusses their strengths and weaknesses. Opportunities exist for designing governance mechanisms that will better support the development and persistence of the personal relationships that underpin the most effective delivery of science for policy.

Key words: risk, science, shared governance, biosecurity, policy-relevant science

* School of Biosciences, The University of Melbourne, Melbourne, Victoria 3010, Australia. email <markab@unimelb.edu.au>.

1. Introduction

Different organisational structures and social norms impede effective communication between science and policy. Most scientists communicate their work primarily through academic publications and professional meetings. In many instances, public servants hope to capture relevant scientific input by inviting public comment and technical review of draft documents. Many applied scientists aspire to having the results of their work contribute to evidence-based policy decisions. Many public servants often lack important information and crave unfettered, unbiased and well-informed scientific input. There is strong demand for evidence-based policy in most areas of government, including agriculture, the environment, natural resource management and public health.

French (2012) identified several key roles that scientists play in the policy arena. Often, public servants who are responsible for a decision will consult a scientist for relevant and authoritative advice and data. The decision-makers alone are responsible for the decision. Sometimes, the scientists are also the decision-makers. Finally, scientists often provide information without a decision in mind, such as when they write academic papers and text books.

Broadly, in the first of these roles, when scientists are consulted, they help with three kinds of questions (Burgman 2015). First, they estimate clearly defined, verifiable facts such as:

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- How prevalent is this disease in the population?
- What is the maximum weight this bridge can carry?

Second, they predict events, such as:

- Will the regional rainfall be much lower than average next year?
- How many traffic accidents will there be if we don't install safety measures?

Finally, they advise on more general questions about a best course of action, such as:

- What is the best way to manage this problem?
- Is this the best portfolio of investments for my organisation?

In many jurisdictions, interactions between researchers and government-based policy-makers have moved beyond scientific articles and public comment periods. However, despite their aligned aspirations, there remain significant gaps between the kinds of information that scientists provide and the kinds of inputs that public servants find useful. The scientific literature abounds with articles on the divisions between scientists and policy-makers, especially when the topic involves socially or politically charged issues; examples include the management of salmon in the Pacific north-west of the United States (Ruckelshaus et al. 2002), wildlife disease control in Brazil (Costa 2011), forest management in New Zealand (Thompson et al. 2011) and climate change globally (Hinkel 2011; Kahan 2013). I provide more detail on some of these examples, below.

Many articles in the scientific literature provide advice on the things scientists and policy-makers can do to ensure that science contributes effectively to policy (for example, Cortner 2000; Pannell 2004; Briggs 2006; Roux et al. 2006; Gibbons et al. 2008; Rudd 2011, Sutherland et al. 2013, 2014; Spruijt et al. 2014). Briggs (2006) suggested that science communication improves if policy and science organisations reward effective collaboration, develop mutual respect, share power and better anticipate research needs of policy issues so that scientists can respond in a timely manner. Pannell (2004) suggested that researchers should understand the policy-maker's perspective and the broad issues on which they are working, and that they should be pragmatic and persistent. Sutherland et al. (2013) focused their attention on the frailties of scientists in providing policy advice. They outlined 20 'tips' for policy-makers to better deal with these frailties in their interactions with scientists. They exhorted policy-makers to exercise prudent scepticism of scientists' claims by insisting that scientists disclose all sources of uncertainty, and by questioning the basics of experimental design, interpretation of data and claims of cause and effect.

Rose (2015) reiterated the need for rigorous science that serves policy goals. He noted that scientists often construct narratives about the policy relevance of their work to enhance its influence (for example, Lawton and Rudd 2014), but argued that this does not go far enough. To ensure that evidence is persuasive in policy-making processes, he suggested that scientists should reframe their work so that it is relevant to political contexts and engage more productively in discussions to negotiate the boundary between science and policy.

The reviews and commentaries outlined above describe many features of interactions between scientists and policy-makers that would contribute to better understanding and more useable science. Yet they are far from universally applied. This article reviews several general systems for governing interactions between scientists and public policy-makers, and suggests that even the prescriptions of Rose (2015) are incomplete. Scientists' actions need to be set within a framework that encourages and sustains trust and cooperative problem-solving. The purpose of this article is to explore the potential for governance mechanisms to shape and reinforce the basic conditions that encourage policy-relevant science, thereby enhancing the quality of scientific input to policy decisions. It identifies and discusses how to deal with three main problems: (i) the lack of trust that may arise between academic scientists and public policy-makers; (ii) the lack of awareness by

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policy-makers of available scientific expertise and its potential to address policy issues; and (iii) the concern that scientific research findings may not be supportive of or be relevant to the policy agenda.

2. Impediments to the Adoption of Scientific Advice in Policy

As noted above, despite the aligned aspirations of policy-makers and scientists, gaps persist. Tensions arise when policy-makers appear to disregard scientific advice for political reasons, when university researchers appear to comment naively on policy, or when policy initiatives lead decision-makers to devise measures of effectiveness and the scientific literature criticises them (Hinkel 2011).

2.1 Academic Freedom and the Flow of Information

Policy-makers may appear to disregard scientific advice for reasons that the scientists would support if they were privy to the full context of decisions. Policy-makers often need to navigate a host of competing aspirations and conflicting objectives among diverse stakeholders. Guided by political mandates and public good, a solution that is suboptimal from a single scientific perspective may be the only tenable one in the short term, and may be part of a longer term, more ambitious policy objective.

Policy-makers may wish to exert a degree of control over the release of scientific information. This runs against the grain of many scientists who work in universities and other research institutions and who jealously guard their academic freedom. However, control over the flow of information may be necessary so that policy changes can be managed among diverse stakeholders. Risk communication is as much about framing and context as it is about the substantive content of the message (Slovic 1999), and the ultimate success of policy change may depend sensitively on how changes are orchestrated.

2.2 Values

If decision-making were an entirely objective, detached scientific process that led inexorably to a single, rational outcome, finding and using scientists would not be problematic for policy-makers. Many scientists believe there is a pool of people with appropriate qualifications, extensive experience and sound technical skills that policy-makers can call on to estimate or predict in a consistent manner.

Unfortunately decisions involve both facts and values. Values are statements about what we want or what we think is important (Gregory et al. 2012). Estimates and predictions are statements about quantities and events. They describe the conditions of a system or the outcomes of actions that could be verified with independent information, at least in theory.

Facts are uncertain and are often coloured by values, perceptions and emotions (Slovic 1999; Burgman 2015). There is no single, right way of assessing values. Nor are scientists entirely objective and independent (Krinitzsky 1993; O'Brien 2000). In most practical situations, the pool of potential scientific experts is small, composed of people with differing values and partially overlapping experiences (French 2012). And some are just incompetent.

Decision theory has evolved to assist decision-makers reconcile differences of opinion. Tools such as contingent valuation and structured (multi-attribute) decision analysis are deployed more routinely now than 20 years ago (Pidgeon & Gregory 2004; Gregory et al. 2012). Science can help to clarify what is at stake in a decision, but it can offer little to reconcile differences of opinion and the tradeoffs necessary to make a decision.

2.3 Advocacy

Policy-makers are aware that scientific advice is inevitably coloured by the perspective, values and context of the particular scientific expert providing it. It may be that the scientists advocate a scientific position on behalf of a client, such as a proponent for a particular project or decision. Advocacy, defined as

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active, covert or inadvertent support of a particular policy or class of policies (Lackey 2007), is especially strident when issues are emotionally or politically charged (Burgman 2015).

One of the most visible examples is the politicisation of climate science, especially in the United States. This arena has the benefit of relatively mature data and sound physical understanding. Nevertheless, scientists become sharply polarised, and training is no protection from motivated reasoning (Kahan 2013). If anything, technical training helps scientists to use selective scientific evidence more effectively in support of their position, but no less biasedly.

More localised debates suffer the same kinds of polarisations and motivated arguments. For example, salmon in Canada and the Pacific north-west of the United States are economically, socially and culturally valuable and people have strong opinions about them. Declines may have been caused by habitat degradation, dams, harvesting, fish hatcheries, El Niño events, predation and invasion of exotic organisms. Data are often unavailable or equivocal. Recovery teams are composed of people with technical backgrounds, and yet '[m]ajor technical disagreements stemming from philosophical differences that seem to run as deep as religious beliefs are commonplace in such technical teams' (Ruckelshaus et al. 2002).

Policy does not arise overnight; policy decisions may take years or even decades to develop and are the product of many social and political factors (Molitor 1977). They may be driven by catastrophic events or by slow changes in social values and preferences, but policy-makers mediate changes of any significance by exposing specific elements of a broader issue to public debate and engaging scientific experts for advice or to compile summaries and meta-analyses. Policy-makers evaluate the social, economic and political implications of change, well before a change is implemented in law or regulations. Most academic scientists are unaware of the time scales and complexities of these deliberations.

2.4 Uncertainty

One of the greatest hurdles scientists face is to communicate the uncertainties in the facts and stories of cause and effect that they provide to policy-makers. In almost all cases, science does not produce logically indisputable proofs or unequivocal evidence. At best it produces a robust consensus based on data and reasoning that allows for scrutiny, re-examination and revision (Oreskes 2004). Indeed, many scientific pronouncements, including those based on hard data, turn out to be wrong (Poynard et al. 2002; Ioannidis 2005). Within a scientific community, different individuals often weigh evidence differently and reach different, sometimes diametrically opposed, conclusions (for example, Kahan 2013). Finally, many scientists misunderstand the tools of inference on which science depends, mistakenly drawing inferences from their data and experiments that are not supported by the evidence (Fidler et al. 2004).

2.5 Work Cultures and Rewards

'Usable' science most often arises when researchers and policy-makers work closely together and iterate problem formulation and solutions (Dilling & Lemos 2011). In some instances, science contributes to public policy effectively because researchers and public servants have developed a personal relationship (Gibbons et al. 2008). Unfortunately, people turn over their roles and responsibilities quickly, especially in government, often at a pace that outstrips the time required to develop personal relationships.

The reward system for academics is heavily skewed towards unfettered publication. It is generally easier to publish rapidly on problems researchers themselves identify, rather than on the hard problems that arise in practical circumstances. Similarly, most public institutions and agencies do not readily reward involvement of their staff in relatively speculative scientific activities that do not guarantee a practical outcome.

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3. Approaches to Improving Science for Policy

The impediments outlined above to the effective use of science in policy are substantial, and while informal personal relationships between researchers and policy-makers can be effective in some circumstances they are inadequate to overcome them consistently. Many applied scientific research institutions and governments have designed mechanisms to improve the delivery of policy-relevant science. The following section outlines a few of the most valuable.

3.1 Exchange Programs

Universities sometimes take the initiative to improve interactions between academics and policy-makers, brokering interactions by providing access to appropriate expertise and encouraging interactions through workshops and personnel exchanges. Gibbons et al. (2008) noted characteristics of sabbatical exchanges in which university-based research personnel are seconded to government, namely that the research needed to be relevant to the department's policy interests, the academic was subject to security conditions, and the department needed to approve publications that arose from the visit. The latter condition may rankle many university-based scientists unused to conceding the right to publish.

The Cambridge University Centre for Science and Policy (CSaP) promotes interactions between policy professionals, scientists, engineers, business leaders, early career researchers 'and others who have an interest in the relationship between science and policy' (CSaP 2015). Exchange programs are a core activity. CSaP Policy Fellowships bring decision-makers from government and industry to the university to work with researchers to engage in university activities and to solve problems relevant to them, and over 2 years to build lasting personal relationships. CSaP's Professional Development Programme introduces early career researchers to policy through workshops, internships and secondments in government. This model is driven by a single university and relies on the university to manage the relationships. It requires a separate source of funds to maintain it.

3.2 Informal Working Groups

Gibbons et al. (2008) suggested that small working groups that comprised policy-makers and researchers make an effective device for developing and disseminating science in public policy, at least for some issues. They noted that to work effectively, working groups require a well-defined problem and outputs, as well as time frames and reward systems that are sensitive to all parties.

They described an example of the development of a policy-relevant measure of conservation 'value'. The project was attractive to researchers because of well-defined policy needs, evidence that the project would have an impact on policy, a collaborative approach to developing the project brief, a willingness to entertain novel approaches to the problem and an agreement that aspects of the work could be published. The outcomes were attractive to policy-makers because the researchers consulted widely among their peers, the outcomes were presented as a set of options, and the outcomes were mindful of operational constraints and policy needs. Ongoing interaction between the policy-makers and researchers allowed policy-makers to better understand the product, which in turn allowed researchers to refine the product based on policy feedback.

This model includes many of the aspirations outlined in the introduction above, including shared responsibility for outcomes, joint development of objectives and outcomes, and iteration leading to more relevant and useful research products. The resources for such interactions would normally be generated by the value of the work products resulting from the interaction, the cost of which would be borne by the policy-maker. Working group creation is ad hoc and usually depends on a pre-existing relationship between scientists and policy-makers.

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3.3 Cooperative Research Centres (CRCs)

The CRC program was established in Australia 1990 to improve the effectiveness of Australia's research effort by bringing together researchers in the public and private sectors with the end-users (CRCA 2014). Private sector organisations, industry associations, universities and government research agencies such as the Commonwealth Scientific and Industrial Research Organisation (CSIRO), and other end-users, contribute resources to a centre and are involved in setting the research themes and priorities. End-users help to plan the direction of the research and monitor its progress (CRCA 2014). To meet the research demands, CRCs assemble multidisciplinary teams and allocate resources to deliver pragmatic outcomes. The CRC management teams and boards set research themes and priorities within them, and manage activities and outcomes.

Many research organisations with a pragmatic focus such as CRCs use annual conferences to impart information. Gibbons et al. (2008) point to the Federation of Australian Scientific and Technological Society's annual 'Science Meets Parliament' forum, which brings together scientists politicians, lobbyists and parliamentary staffers, and to the Australian Bureau of Agricultural Resource Economics and Science's annual Outlook Conference. Similarly, most CRCs run an annual science exchange. At these conferences, most of the talking is done by scientists who mark their conclusions with statements about the relevance of their work for industry or government policy. Generally, CRCs are concerned with providing outputs that are relevant to industry, rather than to public policy.

3.4 Policy Scientists

Policy organisations such as government departments often recruit and rely on their own scientists. This model is effective because in-house scientists understand the policy context, are bound by the confidentiality prescriptions of the employers, have ready access to confidential data, and are aware of operational constraints and other practical limitations on research outputs. They respond readily to changing policy imperatives. However, in almost all regulatory settings, the suite of projects and research needs facing an organisation is much broader than the organisation can maintain. The best available scientific expert for a particular topic may be outside the organisation, even if competent people are available in-house. Furthermore, because these scientists are internal to a department or organisation, the public or other stakeholders may perceive them to be captured, advocating a view that accords with their employer. Almost inevitably, in most circumstances, policy-relevant science depends on people outside the policy organisation, at least to some extent.

3.5 Australian Research Council (ARC) Centres of Excellence

The ARC funds Centres of Excellence. Their purpose is to provide 'foci of expertise through which high-quality researchers collaboratively maintain and develop Australia's international standing in research areas of national priority' <http://www.arc.gov.au/ncgp/ce/ce_default.htm>. They aim to involve collaboration between universities, governments, business and other research bodies to support 'outstanding research'. Centres are strongly focused on the proponent's research ideas and vision. The funding rules note that centres are selected in part based on the innovative and potentially transformational nature of the proposed research program, its capacity to lead to significant advances in knowledge, expertise and technologies, and the extent to which the proposed research builds effective collaboration and critical mass among researchers. The funding rules do not stipulate a governance structure, although they allude to the value of participation of end-users and partners in strategic research planning and Centre governance, and they stipulate that each Centre must have an expert Advisory Committee that provides broad representation of the research and end-user communities. There is a strong

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motivation to generate research outcomes that earn the Centre an international scientific reputation.

3.6 Shared Governance

Several government-funded research centres in Australia have developed unique governance structures that aim to bring the research objectives of scientists closer to the needs of policy-makers. One of these, the Centre of Excellence for Biosecurity Risk Analysis (CEBRA), developed a governance system that essentially co-manages or 'shares' the development of research priorities and outcomes between policy-makers and scientists. Governments (in this case, the Australian Department of Agriculture and more recently the New Zealand Ministry for Primary Industries) provide the bulk of the resources and sign a research agreement with a single institutional provider (in this case, The University of Melbourne). The single provider has the advantage that it can respond flexibly and quickly to the immediate research demands of its research partners.

The researchers rely on policy-makers to identify research themes and ideas. A government steering committee composed of senior executives considers the research ideas and sets priorities. The university and government researchers then develop the prioritised research ideas into fully detailed, workable research project descriptions and budgets. The final set of projects to be undertaken depends on the priority list and the available resources.

Shared responsibility extends beyond setting the research themes and priorities. A university-based researcher and a government-based scientist or bureaucrat are jointly responsible for meeting milestones and generating deliverables. In addition, at least one senior bureaucrat 'sponsors' each project and champions its delivery through government, where necessary facilitating acquisition of relevant data and allocating staff time and other resources. The university centre is responsible for finding the best people to deliver the research outcomes, and for expenditure of the budget. Thus, the university centre acts as a source of research funds and looks to cooperate with researchers in other institutions to deliver outcomes. An independent advisory board composed of university, government and external people, and an independent chair, oversee the centre's policy decisions and expenditure.

This model encourages participation in science by policy-makers because they have direct control over the research themes and deliverables. It is best suited to policy scientists working together with university-based researchers, but people with minimal previous scientific exposure can play an effective role if partnered with a university scientist, especially if the topic lies on the boundary between science and policy (Jasanoff 1987; Rose 2015). Senior bureaucrats are involved throughout, identifying topics and setting priorities, thereby ensuring their attention to the research outcomes and enhancing opportunities for adoption.

The mode of interaction is appealing to government because scientists maintain their independence. Just as importantly, the scientists are perceived to be independent by other stakeholders in industry and the wider community.

The model circumvents an important impediment in many science-policy research environments. In it, there are no constraints on publication, beyond those mandated by confidential data. Policy-makers are free to endorse (or not) the products of the research. This recognises the fact that university researchers will comment publicly and privately as they see fit, providing an avenue for policy-makers to disassociate themselves from advice or commentaries that they consider to be improper, inaccurate or conflicting with public policy. The centre can seek scientific input from any university, thereby providing access to the best possible scientific support, wherever it may reside. This governance model motivates university scientists because they help identify research ideas and shape them into workable projects. They retain their academic freedom. Lastly, they have direct, unfettered access to senior bureaucrats who devise and implement public policy, so that their work is directly relevant to policy where it may have immediate and substantial impact.

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This governance model was first implemented in 2009, generating several outputs that have substantially influenced biosecurity policy and that have also produced sound scientific publications. Robinson et al. (2011) devised a system to allocate inspection resources to optimise a multicriteria problem involving the number of detections and information about changes in the pest status associated with different biosecurity exposure pathways. This approach was deployed by the Department of Agriculture in Australia to enhance the efficiency of the quarantine inspection system, substantially influencing the behaviour and improving the efficiency of many inspection staff. In another application resulting from this governance model, Lyon et al. (2011, 2013) documented the development of innovative software that searches open source information on the web for emerging threats, pests and diseases, providing early warning. In one example, the system detected a report from an oyster farm in the United Kingdom that had an outbreak of oyster herpes virus after deploying equipment previously used in France to refurbish oyster beds. The role of used aquaculture equipment in disease spread had not previously been prominent. Internet sites specialising in the online trade of aquaculture equipment provide a way for producers such as salmon, abalone or oyster farmers to liquidate farm assets after their stock has been wiped out by disease. As a result of the risks posed by the movement of used aquaculture equipment from disease-affected areas, within weeks of the threat becoming recognised, the Australian Government introduced preventive measures to ensure that all used equipment exported to Australia is decontaminated on arrival (DAFF 2010). Interestingly, the majority of publications from CEBRA produced under the shared governance model are co-authored by university and government staff (as were Robinson et al. 2011, and Lyon et al. 2011, 2013).

4. Discussion

The list of governance mechanisms above is not complete. Other mechanisms for interaction between policy-makers and scientists include peer review of draft reports, formally constituted scientific panels, and scientific consultant input to scientific assessments and analysis. Scientists can also work with policy-makers by participating in policy-relevant foresight workshops (Sutherland et al. 2009).

Scientific research often misses the mark because university-based scientists create outputs they believe policy-makers need, without listening carefully to the policy-makers' objectives and constraints. The successful models outlined above have several common elements. Effective systems encourage personal interaction and the development of lasting personal relationships. These are, in turn, built on shared development of research agenda and priorities, and mutual respect that arises from working closely together to deliver research outcomes (Lauber et al. 2011). Adoption of research outcomes is enhanced when research objectives are shaped by policy needs, and when the conduct of the research remains the personal responsibility of the policy-maker who suggested it and argued for its position in the list of priorities.

There is widespread support among social commentaries on science for the importance of reciprocity and personal interactions between policy-makers and scientists (Jasanoff 1987; Lidskog & Pleijel 2011). All the commentaries cited in the introduction that discuss successful interactions advocate these same principles. Yet gaps remain, primarily because it takes time and effort to build personal relationships, which then are subject to the vagaries of the priorities and availabilities of the people involved. People change their roles, usually faster in government than in universities, and contacts, trust and goodwill may be lost.

The shared governance model outlined above overcomes several critical problems that emerge in other governance systems. It provides a means for policy-makers to be confident that their needs are being addressed by the research agenda because they alone set the priorities. The formal system encourages ongoing development of trust and effective cooperation. This compensates for the turnover of people by creating incentives for the incoming

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person to be briefed on their responsibilities and the details of working relationships by the person leaving the role, and for the incoming person to take up these roles quickly and effectively. It provides direct, ongoing access to senior bureaucrats by scientists. The bureaucrats remain involved and seek opportunities to adopt the outcomes of the research because they are personally involved in and responsible for delivery of research outputs.

Objective research may focus in areas that are inconvenient for governments. Thus, governance and organisational structures in which government and researchers jointly set priorities may encourage uptake of science, but these priorities may avoid important topics that could run counter to current government policy. Shared governance arrangements should not replace independent, interest-led research. Rather they may serve to orientate some research towards pressing current needs, and when deployed strategically may have immediate benefits for the environment and the economy that far outweigh the investments in the research.

There is potential for university-based participants in the shared governance model to fear that they may give up their academic freedom, at least the part that allows them to identify broad research topics. This is indeed a risk of this approach. This is not an impediment if the university scientist is already motivated to work on problems of the kind that are likely to arise in the policy context at hand. Indeed, the cost may be more than compensated by the benefit that the topic of research is contextualised in the real world, rather than as a narrow and often unrealistic perception of a problem. Our experience has been that, once trust is established, the problems that policy-makers propose are harder than the problems that scientists can pose for themselves. That is, if pragmatic and scientifically credible solution were easy, many policy-makers would have found them for themselves. The things that require serious scientific input typically are conceptually and technically difficult, requiring cross-disciplinary collaboration and iteration of research goals and outcomes.

The shared governance model may not be ideal for all interactions between researchers and policy-makers. It requires sustained financial support and institutional commitments over many years. Short-term research demands may be better met by other approaches such as informal working groups. The model depends on there being scientific expertise and reasonable familiarity with science in-house, because the partners are co-responsible for the delivery of scientific outputs. If the requisite scientific skills are not present in the policy organisation, then it may be more efficient to share priority setting, but to make the research organisation alone responsible for the delivery of outputs. Nevertheless, in many cases in which delivery of public policy could be enhanced by scientific methods and evidence, the shared governance model offers many advantages.

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