From Climate Change to Social Change

Perspectives on Science-Policy Interactions

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3 Creating Useful Knowledge

The Role of Climate Science Policy

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3.1 Introduction

Climate science policy decisions are those concerned with governing the climate science research enterprise, and can be distinguished from *climate policy* decisions, which are those made in anticipation of or in response to climate change (e.g., mitigation, adaptation). Of course, decisions made about climate science policy influence the knowledge that is available when making climate policy decisions, including knowledge of various alternative courses of action and their possible consequences. This chapter discusses the role of climate science policy in the context of climate policy.

Science policy decisions shape the conduct and output of climate research by guiding resource allocations, disciplinary and interdisciplinary priorities and methods, institutional design, human resources, and standards of evaluation. Science policy decisions are made in the face of uncertainty about the outcomes and utility of research. Over the past few decades, science policy decisions worldwide have allocated tens of billions of dollars, and mobilized thousands of scientists at hundreds of institutions, for climate research and assessment. A principal goal of these diverse activities has been the reduction of uncertainty about future climate behavior as an aid to decision makers.

The public investment in climate science is justified by the expectation that the resulting scientific knowledge will enable, support, and improve climate policy decisions – that is: decisions related to the impacts of climate on society, and of society on climate. It is the job of science policies to fulfill this expectation. But given that the funding of scientific research is almost always justified in terms of the potential for achieving beneficial societal outcomes, in pursuing a particular societal outcome, how can we know if one research portfolio is more likely than another to fulfill such expectations?

Society's ultimate success for responding to and preparing for climate change in the face of ongoing uncertainty thus hinges in no small part upon the relationship between science policy decisions and climate policy decisions. This relationship has been the explicit focus of our research over the past five years. Specifically we have focused on three aspects of this relationship:

1. How might climate research agendas be effectively developed and implemented in the context of stakeholder demands?
2. How might specific issues be prioritized given the multiple causes of global environmental change?
3. How can experts orient themselves in a highly contested political arena?

This chapter discusses our work in each of these areas.

3.2 *Reconciling the Supply of and Demand for Climate Research*

We borrow from economics the concepts of 'supply' and 'demand' to discuss the relationship of scientific results and their use for several reasons. First, the analogy is straightforward. Decisions about science (i.e., science policy decisions) determine the composition and size of research portfolios that 'supply' scientific results. People in various institutional and social settings who look to scientific information as an input to their decisions constitute a 'demand' function for scientific results. Of course, the demand function can be complicated by many factors, e.g., sometimes a decision maker may not be aware of the existence of useful information or may misuse, or be prevented from using, potentially useful information. In other cases, necessary useful information may not exist or may not be accessible. But our key point is that there is reasonable conceptual clarity in distinguishing between people, institutions, and processes concerned with the supply of science, and those concerned with its use. Indeed, conventional notions of science policy exclusively embody decisions related to the former.

Nonetheless, a second reason for characterizing scientific research in terms of supply and demand is to recognize that, just as in economics, in the case of science, supply and demand are closely interrelated. Science policy decisions are not made in a vacuum but with some consideration or promise of societal needs and priorities. Thus there is a feedback between the (perceived) demand for science and the (perceived) characteristics of supply.

At the same time, we recognize the power and importance of scholarship over the past several decades that documents the complex manner in which science and society co-evolve, or are co-produced. The insights from such work dictate that categories such as 'supply' and 'demand' cannot be understood as conceptually discrete or fully coherent. Moreover, both supply of and demand for information emerge from complex networks of individuals and institutions with diverse incentives, capabilities, roles, and cultures. Yet in the face of such complexity, decisions about resource allocation, institutional design, program organization, and information dissemination have been and are still being made. That is, while notions of 'supply' and 'demand' may embody considerable complexity, they also represent something real and recognizable: on the one hand, people conducting research that has been justified in terms of particular societal outcomes, and on the other, people making decisions aimed at contributing to those outcomes.

Progress in climate science has led to important insights into climate processes and advances in forecasting capabilities, with direct implications for societal problems such as management of hydrologic, agricultural, and fisheries resources. In recent years, social science research has yielded new insights into the contexts and conditions under which society responds to climate – that is, the human dimensions of climate. In making science policy decisions, we often lack systematic knowledge about how the supply side for scientific information – the broad climate research portfolio, in essence – relates to the demand for information among climate decision makers, and to the capacity of decision makers to use the information they do receive. Indeed, research in human dimensions (and in decision sciences more generally) documents a pervasive mismatch between the information available to decision makers and the information used to support actual decisions.

Various longstanding frameworks for understanding policy decision contexts, ranging from Lindblom's 'muddling through' (Lindblom, 1959) to Lasswell's 'central theory' (Lasswell, 1956) to Simon's 'bounded rationality' (Simon, 1953) suggest that the effective use of knowledge and tools by policy makers does not demand accurate quantification or reduction of uncertainty (Lindblom, 1959; Simon, 1983). In practice, policy makers often cope with and learn about uncertainties by first making decisions and then experiencing the outcomes. This insight has been formally applied to ecosystem management through the idea of adaptive management. Our own work on prediction and environmental decision making indicates that transparency, communication, and mutual understanding are more important to facilitating effective policy decisions than reduction of uncertainty.

From such perspectives, we have argued that a challenge for climate science policy is to develop knowledge and tools that can increase the ability of the supply side -climate information providers – to understand, respond to, and meet the diverse needs and capabilities of the demand side – the broad range of relevant decision makers. In 1999 the U.S. National Research Council acknowledged this priority when it observed that "the utility of [climate] forecasts can be increased by systematic efforts to bring scientific outputs and users' needs together."

In this context we have proposed a straightforward methodology of science policy research for assessing and reconciling the supply and demand functions for climate science information. The methodology consists of a demand side assessment, a supply side assessment, and a comparative overlay that assesses the match between supply and demand.

A Demand Side Assessment Focuses on the Following Question: What Information do Decision Makers Want when Making Decisions about Climate Policy?
Research on the human dimensions of climate, though modestly funded over the past decade or so, has made important strides in characterizing the diverse users of climate information (be they local fisherman and farmers or national political leaders); the mechanisms for distributing climate information; the impacts of climate information on users and their institutions. This literature provides the necessary foundations for constructing a general classification of user types, capabilities, attributes, and information sources. This classification can then be tested and refined, using standard techniques such as case studies, facilitated workshops, surveys and focus groups. Given the breadth of potentially relevant stakeholders, such a demand side assessment needs to proceed by focusing on particular challenges or sectors, such as carbon cycle management, agriculture, ecosystems management, and hazard mitigation.

A Supply Side Assessment Focuses on the Following Question: What Knowledge is Available from Research on Climate?
Perhaps surprisingly, the detailed characteristics of the supply side – the climate research community – are less well understood than those

of the demand side. One reason for this of course is that over the past decade or so there has been some programmatic support for research on the users and uses of climate science, but no similar research on climate research itself. Potentially relevant climate science is conducted in diverse settings, including academic departments, autonomous research centers, government and private sector laboratories, each of which is characterized by particular cultures, incentives, constraints, opportunities, and funding sources. Understanding the supply function demands a comprehensive picture of these types of institutions in terms that are analogous to knowledge of the demand side, looking at organizational, political, and cultural, as well as technical, capabilities. Such a picture should emerge from analysis of documents describing research activities of relevant organizations, from bibliometric and content analysis of research articles produced by these organizations, and from workshops, focus groups, and interviews. The result is a taxonomy of suppliers, supply products, and research trajectories.

A Comparative Overlay Evaluates the Degree of Correspondence between Demand and Supply
Assessments of supply and demand sides of climate information can then form the basis of a straightforward evaluation of how climate science research opportunities and patterns of information production match up with demand side information needs, capabilities, and patterns of information use. In essence, the goal is to develop a classification, or 'map', of the supply side and overlay it on a comparably scaled 'map' of the demand side. A key issue in the analysis has to do with expectations and

Table 3.1 'Missed opportunity' matrix

		Demand: Can User Benefit from Research?	
		YES	NO
Supply: Is relevant information being produced?	NO	Research agendas may be inappropriate	Research agendas and user needs poorly matched
	YES	Sophisticated users taking advantage of well-deployed research capabilities	Unsophisticated users, institutional constraints, or other obstacles prevent information use

capabilities. Do climate decision makers have reasonable expectations of what the science can deliver, and can they use available or potentially available information? Are scientists generating information that is appropriate to the institutional and policy contexts in which decision makers are acting? Useful classifications of supply and demand functions will pay particular attention to such questions. The results of this exercise can be tested and refined via stakeholder workshops and focus groups.

The 2 x 2 matrix schematically illustrates the process. We call this the 'missed opportunity' matrix because the upper left and lower right quadrants indicate where opportunities to connect science and decision-making have been missed. Areas of positive reinforcement (lower left) indicate effective resource allocation where empowered users are benefiting from relevant science. This situation is most likely to emerge when information users and producers are connected by, and interact through, a variety of feedback mechanisms. Areas of negative interference may indicate both opportunities and inefficiencies. For example, if an assessment of demand reveals that certain classes of users could benefit from a type of information that is currently not available (upper left), then this is an opportunity – if provision of the information is scientifically, technologically, and institutionally feasible. Another possibility (lower right) would be that decision makers are not making use of existing information that could lead to improved decisions, as Callahan et al. (1999) documented for some regional hydrological forecasts. An important subset of the problem represented in this quadrant occurs when the interests of some groups, for political or socioeconomic reasons, are actually undermined because of the ability of other groups to make use of research results, as Lemos et al. (2002) demonstrated in a study of regional climate forecasts in northeast Brazil. Finally (upper right), research might not be relevant to the capabilities and needs of prospective users, as Rayner et al. (2002) demonstrated in their study of water managers.

The Importance of Institutional Context

Decisions emerge within institutional contexts; such contexts, in turn, help to determine what types of information may be useful for decision-making. Supply and demand must ultimately be reconciled within science policy institutions, such as relevant government agencies, legislative committees, executive offices, non-governmental advisory groups, etc. Institutional attributes such as bureaucratic structure, budgeting, reporting requirements, and avenues of public input, combine with less tangible factors including the ideas and norms embedded within an institution, to drive decision-making about the conduct of research and the utility of results. How do research managers justify their decisions? Are those justifications consistent with the decisions that they actually make? What ideas or values are implicit in the analyses and patterns of decisions that the institution exhibits? What incentives determine how information is valued? These sorts of questions can be addressed through analysis of internal and public documents, interviews, and public statements about why and how research portfolios are developed. McNie (2007) provides a thorough discussion of what is known about how science policy institutions help to mediate the relationship of supply and demand.

Our analysis of the evolution of the climate science enterprise in the U.S. indicates that policy assumptions and political dynamics have largely kept the supply function insulated from the demand function except, in some cases, in the area of the international climate governance regime. Decisions about climate science priorities are typically made within the scientific community of academics and their funders, with little input from those decision makers in whose names the research is justified. Some modest experiments, notably the RISA (regional integrated sciences and assessment) program of the National Oceanographic and Atmospheric Administration, have sought to connect scientists and research agendas to particular user needs at the local level, but these lie outside the mainstream of the climate science enterprise (McNie, 2007).

A research effort of the type sketched here can illuminate how well climate science supply and demand are aligned and who benefits from existing alignments. It can highlight current successes and failures in climate science policy, identify future opportunities for investment, and reveal institutional avenues for, and obstacles to, moving forward. The value of the method will in great part depend on how receptive (reconciliation) science policy makers are (demand) to learning from the results of such research (supply). Of course, knowledge generated about science policy is subject to the same pitfalls of irrelevance, insulation, neglect, mismatch, and misapplication that motivate our investigation in the first place. But the current context for science policy decision-making gives two reasons for optimism. First, the fundamental justification for the public investment in climate science is its value for decision-making. This justification, repeated countless times in countless documents and public statements, thus defines a baseline for assessing accountability and measuring performance via the type of approach we have described here. Second, and of equal importance, the very process of implementing the method we describe will begin to create communication, reflection, and learning among science policy decision makers and various users and potential users of scientific information hitherto unconnected to the science policy arena. In other words, the research method itself creates feedbacks between supply and demand that will expand the constituencies and networks engaged in science policy discourse, expand the decision options available to science policy makers, and thus expand the opportunities to make climate science more 'well ordered'. Undoubtedly, institutional innovation would need to be a part of this process as well, given the scale and scope of the climate science enterprise and the potential user community.

3.3 *Sensitivity Analysis – Research to Show Where Policies Can Make a Difference*

A key function of policy relevant research is to help policy makers identify where their actions can make a practical difference. The complexities of the real-world mean that the path from action to consequence can be difficult to anticipate with ineffectiveness and unintended consequences always a risk. Interdisciplinary research that identifies the sensitivities of outcomes to various actions can help to identify actions with outcomes robust to uncertainties and, critically, the role of assumptions in such analyses. Consider the following two examples, the first for a case of adaptation policy and the second on mitigation policy.

The Role of Adaptation in Disaster Policies

Scientists have warned that the costs of future disasters will likely increase due to more frequent and intense extreme events such as storms and floods. But this is only part of the reason for expecting increasing disaster losses. Society changes over time as well, with the net result being more property, people, and wealth in locations exposed to the impacts of extreme events. Figure 3.1 dramatically illustrates changing patterns of development on Miami Beach. The implications for hurricane damage are obvious.

If policy makers wish to address the escalating costs of disasters then it is important to understand how various alternative actions are likely to

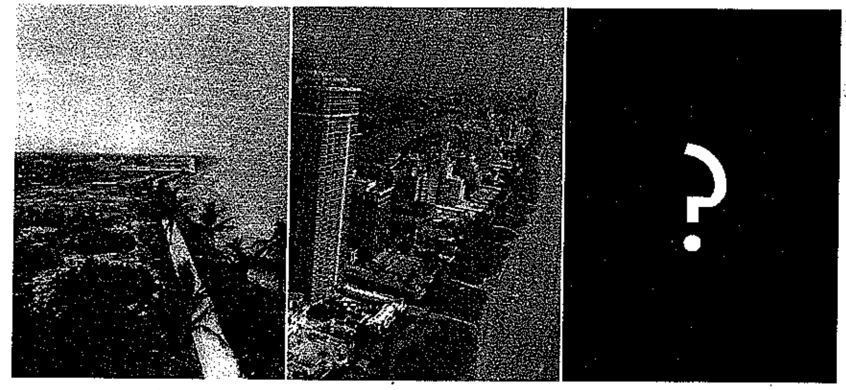

Figure 3.1 The changing character of Miami Beach

influence future damages. Policy debates on climate change often focus on energy policies, but have more recently begun to acknowledge that adaptation must also be a part of the discussion, especially as related to disasters. The reason for this is simple. Damage from extreme events has a lot to do with patterns of human development, like the presence of trillions of dollars of property in beachfront locations. Development involves choices made every day in regions that experience extreme events, and these choices influence the nature of future disasters.

In our work we have sought to quantify the *sensitivity* of future losses to possible changes in climate and possible patterns of future development. Our goal has not been to predict the climate, development, or future losses, but instead to assess what factors are likely to be most responsible for the future costs of disasters across a wide range of assumptions, so that decision makers can identify policy actions robust to uncertainties. Our research finds that the most important factors in the growing costs of disasters, at least to 2050, are patterns of development, under any scenario of climate change. Figure 3.2 illustrates this point in the context of global tropical cyclone (hurricane) damage. It shows that for every dollar in damages in 2000, under the assumptions of this scenario, we should expect $4.60 in damages in 2050, or an increase of $3.60. Half of this increase is due to development, whereas only a sixth is directly due to changes in climate. The overwhelming importance of societal change in driving future losses is robust across all scenarios of climate change, development, and damage projections, and in other scenarios the role of development is much greater. A robust conclusion from this work is that

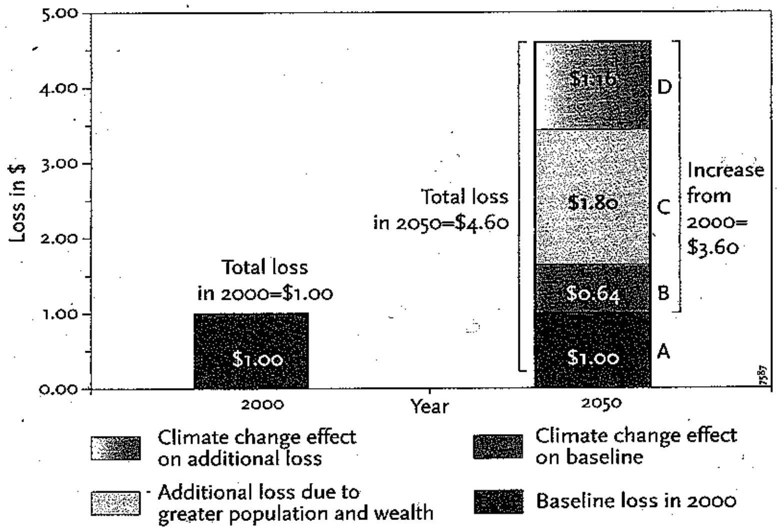

Figure 3.2 Tropical cyclone losses in 2050: with climate and societal change

adaptation must be at the center of climate policies focused on extreme events.

Because any changes to energy policies resulting in lower emissions of greenhouse gases will take many decades to have a discernible effect on the climate system, and because the exact relationship of greenhouse gases and patterns of extreme events remains somewhat uncertain and contested, these finding should be welcomed by decision makers. What these research results mean is that we have considerable ability to influence the nature of future economic losses from disasters by focusing on choices that we make in the development of regions exposed to extreme events. These results mean that scientific uncertainty about the pace and magnitude of climate change need not stand in the way of decisions that might influence the growing rate of disaster losses around the world.

The Role of Technological Innovation in Mitigation Policy

All estimates of the magnitude of future emissions reductions (and associated costs) consistent with various stabilization trajectories require some estimate of the amount of future emissions. Projections of future emissions in turn depend upon assumptions of technological innovations that will allow the global economy to grow while becoming

more efficient, as occurred during 1980-2000. Identifying the role of these assumptions in our policy analysis can show how significantly policy arguments depend upon them.

In April, 2008, Tom Wigley, Chris Green, and I published a commentary in Nature that examined assumptions underlying scenarios of future carbon dioxide emissions, and what these assumptions imply about the level of effort needed to stabilize concentrations at some desired level in the atmosphere (Pielke et al., 2008). These assumptions are based on expectations of future technological innovations that will result in an automatic decarbonization of the global economy, with 'automatic' meaning that no specific climate policies need to focus on meeting the challenge of stabilization. Under such assumptions, future emissions of carbon dioxide are expected to increase more slowly than either the increase in the global use of energy or the growth in the size of the global economy.

Figure 3.3 shows a range of 'automatic' emissions reductions (grey) in the scenarios used by the Intergovernmental Panel on Climate Change (IPCC) in its 4th Assessment report. Total cumulative emissions to 2100 associated with a 'frozen-technology' baseline (i.e., the technologies available presently) are shown for: six individual scenarios, the means of these scenarios, and for all 35 IPCC scenarios, and the median of the scenario set (AR4). Additional emission reductions will have to be achieved by climate policy (black), assuming carbon-dioxide stabilization at about 500 parts per million (ppm), leaving allowed emissions for this

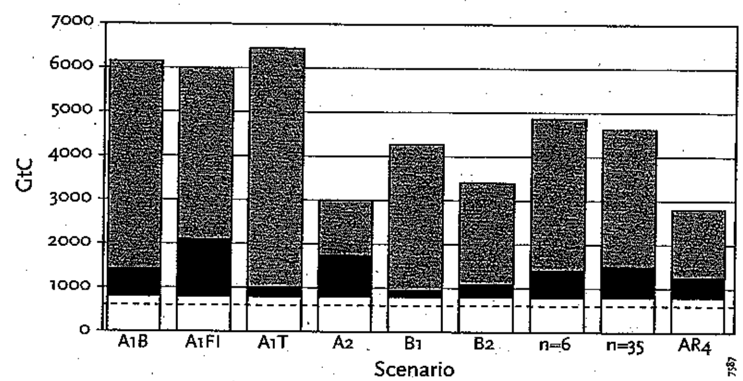

Figure 3.3 Assumptions of the effects of technological change on future emissions in the SRES scenarios and IPCC AR4

stabilization target (white, the dashed black line shows the same for a 450 ppm target).

Automatic technological innovation would be good news for those seeking to stabilize atmospheric concentrations of greenhouse gases. If the global economy spontaneously decarbonizes, then it reduces the magnitude of the mitigation challenge. But if carbon dioxide accumulates in the atmosphere at a faster rate than has been assumed, then the challenge of mitigation would obviously be much larger and cost more. Unfortunately, in the first decade of the 21st century the world appears to be recarbonizing rather than decarbonizing the global economy, contrary to the assumptions that underlie assessments of the magnitude of the mitigations challenge, including those published by the Intergovernmental Panel on Climate Change. One reason for the rapid growth in emissions is the unexpected pace of fossil fuel-intensive development in Asia, and in China in particular. Some scholars believe that the rapid pace of growth will continue for decades.

We argue that analysts and policy makers alike should (a) be aware of the assumptions of spontaneous technological innovation in virtually all scenarios of future emissions, and (b) also recognize that current trends are unfolding in a manner quite different than was assumed. One implication of our paper is that policy makers should consciously reflect on the full scale of the technological challenge of mitigation, rather than assuming that some large part of that challenge will be met spontaneously. Initial reactions to our paper saw some resisting the call to critically examine earlier assumptions. One reason for this resistance is undoubtedly that political commitments are built upon the justifications in policy analyses. Calling into question policy analyses may necessitate rethinking aspects of the political debate, which is never easy, but is especially difficult in the context of the highly politicized arena of climate change.

3.4 *The Roles of the Researcher in Highly Politicized Contexts*

When former US Vice President Al Gore (2007) testified before the United States Congress in 2007 he used an analogy to describe the challenge of climate change: "If your baby has a fever, you go to the doctor. If the doctor says you need to intervene here, you don't say, "Well, I read a science fiction novel that told me it's not a problem." If the crib's

on fire, you don't speculate that the baby is flame retardant. You take action".

With this example Al Gore was not only advocating a particular course of action on climate change, he was also describing the relationship between science (and expertise more generally) and decision making. In Mr. Gore's analogy, the baby's parents (i.e. in his words, 'you') are largely irrelevant to the process of decision making, as the doctor's recommendation is accepted without question.

But anyone who has had to take their child to a doctor for a serious health problem or an injury knows that the interaction between patient, parent, and doctor can take a number of different forms. In my book *The Honest Broker: Making Sense of Science in Policy and Politics* (Pielke, 2007), I describe various ways that an expert (e.g., a doctor) might interact with a decision maker (e.g., a parent) in ways that lead to desirable outcomes (e.g., a healthy child). Experts therefore have choices in how they relate to decision makers, and these choices have important effects on decisions but also the role of experts in society.

Mr. Gore's metaphor provides a useful point of departure to illustrate the four different roles for experts in decision making that are discussed in *The Honest Broker*. The four categories are very much ideal types – the real world is more complicated, but nonetheless I do argue that they help to clarify roles and responsibilities that might be taken by experts seeking to inform decision making.

- *The Pure Scientist* – seeks to focus only on facts and has no interaction with the decision maker. The doctor might publish a study that shows that aspirin is an effective medicine to reduce fevers. That study would be available to you in the scientific literature.

- *The Science Arbiter* – answers specific factual questions posed by the decision maker. You might ask the doctor what are the benefits and risks associated with ibuprofen versus acetaminophen as treatments for fever in children.

- *The Issue Advocate* – seeks to reduce the scope of choice available to the decision maker. The doctor might hand you a packet of a medicine and say "give this to your child." The doctor could do this for many reasons.

- *The Honest Broker of Policy Options* – seeks to expand, or at least clarify, the scope of choice available to the decision maker. In this instance the doctor might explain to you that a number of different treatments is available, from wait-and-see to taking different medicines, each with a range of possible consequences.

Scholars who study science and decision making have long appreciated that efforts to focus experts only on the facts, and to keep values at bay, are highly problematic in practice. As Sheila Jasanoff (1998) has written: "The notion that scientific advisors can or do limit themselves to addressing purely scientific issues, in particular, seems fundamentally misconceived."How does the overlap of science and values occur in practice?

The analogy suggested by Al Gore is conceptually simplistic, with few actors, narrow relevant knowledge, and easily identified desired outcomes. The decision makers are not facing a 'fire hose' of knowledge, nor are there conflicting interests opposed to each other. But even in this simplistic case, there can be hints of the complexities facing advisors to decision makers.

Consider the *Pure Scientist* or *Science Arbiter* as described above. How would you view your doctor's advice to take ibuprofen if you learned that she had received $50,000 last year from a large company that sells ibuprofen? Or upon hearing advice to perhaps forgo medicine for this particular ailment, what if you learned that she happened to be an active member of a religious organization that promoted treating sick children without medicines? Or if you learned that their compensation was a function of the amount of drugs that she prescribed? Or perhaps the doctor was receiving small presents from an attractive drug industry representative who stopped by the doctor's office once a week? There are countless ways in which extra-scientific factors can play a role in influencing expert advice. When such factors are present they can lead to 'stealth issue advocacy', which I define as efforts to reduce the scope of choice under the guise of focusing only on purely scientific or technical advice. Stealth issue advocacy has great potential for eating away at the legitimacy and authority of expert advice, and even a corruption of expert advice.

Then how does one decide what forms of advice make sense in what contexts? In *The Honest Broker* I argue that a healthy democratic system will benefit from the presence of all four types of advice but, depending

on the particular context of a specific, some forms of advice may be more effective and legitimate than others. Specifically, I suggest that the roles of *Pure Scientist* and *Science Arbiter* make the most sense when values are broadly shared and scientific uncertainty is manageable (if not reducible). An expert would act as a *Science Arbiter* when seeking to provide guidance to a specific decision and as a *Pure Scientist* if no such guidance is given. In reality, the *Pure Scientist* may exist more as historical legend than anywhere else. In situations of values conflict or when scientific certainty is contested, that is to say most every political issue involving scientific or technical considerations, then the roles of *Issue Advocate* and *Honest Broker of Policy Options* are most appropriate. The choice between the two would depend on whether the expert wants to reduce or expand the available scope of choice. Stealth issue advocacy occurs when one seeks to reduce the scope of choice available to decision makers but couches those actions in terms of serving as an *Pure Scientist* or *Science Arbiter* (e.g., "The science tells us that we must act...").

So your child is sick and you take him to the doctor. How might the doctor best serve the parent's decisions about the child? The answer depends on the context.

- If you feel that you can gain the necessary expertise to make an informed decision, you might consult peer-reviewed medical journals (or a medical Web site) to understand treatment options for your child instead of directly interacting with a doctor.
- If you are well informed about your child's condition and there is time to act, you might engage in a back-and-forth exchange with the doctor, asking her questions about the condition and the effects of different treatments.
- If your child is deathly ill and action is needed immediately, you might ask the doctor to make whatever decisions are deemed necessary to save your child's life, without including you in the decision making process.
- If there is a range of treatments available with different possible outcomes, you might ask the doctor to spell out the entire range of treatment options and their likely consequences to inform your decision.

The interaction between expert and decision maker can be complicated, and understanding the different forms of this relationship is the first step towards the effective governance of expertise. The central message that I seek to present in *The Honest Broker* is that we have choices in how experts relate to decision makers. These choices shape our ability to use expert advice well in particular situations, but also shape the legitimacy, authority, and sustainability of expertise itself. Whether we are taking our children to the doctor, or seeking to use military intelligence in a decision to go to war, or using science to inform policies, better decisions will be more likely if we pay attention to the role of expertise in decision making and the different forms that it can take.

3.5 *Conclusion*

We believe that careful attention to (a) the supply of and demand for research, (b) the sensitivity of outcomes to the integrated factors shaping human-environment systems (as well as sensitivities to simplifying assumptions), and (c) the political role of expert advisors can help provide useful tools to assist in the creation and implementation of effective science policies.

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