Science in Environmental Policy

The Politics of Objective Advice

Ann Campbell Keller

1

Theories of Science in Policy Making

. . . the conception of the social nature of fact perception should be useful to political science. In regard to policy, it suggests one of the limits to the usefulness of uncommitted social intelligence to the politician.

—Ralph K. Huitt (1954)

Early studies of the role of science in policy making tend to frame the central problem of using science for policy decisions as an issue of maintaining proper boundaries between the work of science and the work of politics.[1] The idea of a clear separation between science and politics, in theory, might guard against two potential failure modes in democratic decision making: technocracy and the politicization of science. Technocratic outcomes arise when scientists dominate decision making to the exclusion of other legitimate participants in democratic processes[2]; politicization occurs when individual or group interests in policy outcomes introduce bias into scientists' actual work or their representation of their work in policy settings.[3] For a number of scholars, setting the boundary between science and non-science correctly can lead to better decision making.

Interest in boundaries between science and non-science has continued in more recent studies of science in policy making.[4] However, this more recent work contains a notable turn in the analytic approach to the boundary.[5] Instead of assuming that science and non-science can be objectively separated and pursuing the "correct" separation, those engaged in analysis of boundary work ask how such separations are made and whom they serve (Gieryn 1983, 1995, 1999; Jasanoff 2004a; Jasanoff and Wynne 1998; Star and Griesemer 1989). This approach emphasizes the social and contingent aspects of drawing a distinction between science and non-science. Further, it addresses the allocation of

power that accompanies setting such a boundary, and it focuses the analytic lens on how actors work to achieve, stabilize, and, on occasion, destabilize such settlements.

I begin this chapter with an overview of the traditional approach to separating science from policy in the policy process. Next, I present several analyses of decision making that do not rely on the notion of a clean division between science and politics and view persuasion and negotiation as irreducible elements of the policy process. These analyses demonstrate the impracticality and even the impossibility of settling the question of the proper boundary between science and policy.

At the same time, I explore the extent to which the idea of science as objective—descriptively inaccurate as that idea might be—continues to have rhetorical weight in that actors involved in decision making use it, sometimes convincingly, to make their case.[6] In this chapter, without assigning objectivity to science in policy making, I consider the work that "claims of objectivity" can do in closing off political debate. Further, I address why such claims retain persuasive power in light of scholarly work that demonstrates the social nature of science/non-science settlements. This exploration of science in decision making lays the groundwork for subsequent chapters in which the interplay between the social elements of science and the frequent rhetorical claims of scientific objectivity are examined. That these idealized images of science and scientists continue to circulate in policy-making settings suggests that analysts must attend to the actual workings of science in policy making while also being attentive to the persuasive potential of the invocation of "objective science" in policy debates.

Boundaries between Science and Non-Science

The idea of creating a boundary between science and policy as a way to preserve the norms of each is based on a rationalist conception of science. According to the rationalist perspective, science is a useful resource in decision making because of its capacity for connecting means with ends. The ability of science to provide causal explanations for events, both current and future, improves policy makers' ability to achieve desired outcomes. Reliance on science is successful when scientific information enables policy makers to choose a policy solution that (a) brings them closer to their stated policy goals and (b) outperforms other solutions in achieving those goals. Science, under these circumstances, should not

help policy makers define their goals. Rather, science is applied *after* those goals have been agreed upon and is merely used as an aid in finding the most effective, efficient means to of achieve them.[7] Ideally, this method of drawing science into decision making preserves democratic norms in that it protects against an elite minority—i.e., scientists— substituting their policy judgments for those of the majority. Further, according to the rationalist account of science, a boundary between science and policy making does double duty in that it protects science from political bias that would undermine its capacity to provide decision makers with reliable, valid information.

The rationalist view of the role of science in policy making is given institutional expression in the policy process through a number of structures and procedures designed to preserve a boundary between science and policy.[8] Ideally, such a boundary will define formal and controlled situations in which science and policy will interact. Most prominently, the boundary has been expressed through a supposed division of labor between Congress and administrative agencies such that Congress manages the political aspects of policy making and then turns to Executive Branch agencies for their expertise in implementing congressional decisions. This view of administrative agencies has its roots in the Progressive-era effort to create "neutral competence" within the bureaucracy (Knott and Miller 1987).[9] Although the idea that bureaucracies are apolitical and have no policy-making role has been overturned, a number of procedures established in bureaucratic agencies still draw on a conception of politics and scientific expertise as separate and separable endeavors.[10]

A second model of science in decision making that also finds institutional expression in the policy process conceives of the relationship between science and policy somewhat differently. This model views science as a resource in resolving policy controversies and is based on a logical positivist perspective that scientists' description of reality corresponds exactly with that reality. According to this view, technocracy might be not a failure mode but a desired outcome, in that science can offer a definitive answer about the efficient allocation of resources. The assumption here is that what is missing in cases of persistent political conflict is information. If scientific uncertainties are resolved, political debate will follow suit. According to this view, by introducing information that is consonant with reality and fact, science can bring erstwhile opponents into agreement over policy choices and even goals. Starting from this perspective, democratic norms of decision making are not

necessarily violated when a scientific elite dominates decision making because science is truth-based and therefore is not subject political debate. If science reveals truths about the world, anyone with the proper training and the proper methodological tools would arrive at the same incontrovertible endpoint.

A softer version of this view assumes that, though science does not eliminate value conflict, it can limit its scope. Scientific information, by explaining our physical surroundings and our relationship to those surroundings, delineates plausible and implausible courses of action. Value debates remain, but they must be carried out in light of existing scientific realities. This softer version of the logical positivist position is consistent with the argument that conducting scientific research is an important preliminary step in resolving policy controversy, an argument that is made routinely in environmental politics.

The interaction between scientists and policy makers according to the soft-positivist perspective differs from the model above, in which ends are selected through a democratic process and science is used to find efficient, effective means. Instead, science is viewed as a mechanism for *understanding* political goals (for example, whether ozone depletion poses risks for humans and the environment). This perspective still relies on a boundary between science and politics, in that science must be unadulterated by politics in order to come to the truth. However, the orientation toward the potential for technocracy is different in these two models specifically regarding how each model conceives of the role of science in decision making. Efforts in the political process that seek to avoid technocratic outcomes clearly carve out space for the legitimacy of the judgment of non-scientists in decision making, whereas policy mechanisms that advance science as a way to contain or reduce policy debate rely on the putative link between science and truth to skirt the worries that come with technocracy.

A second important distinction between the rationalist and positivist views of science in decision making is when science should enter the process. Rationalists view science as helping find means to achieve goals once the policy process has selected a set of goals. The positivist view invokes science as a prerequisite for policy debate such that science defines the terrain that is factual and uses that to circumscribe issues that remain open for debate.

Both the rationalist and the positivist models of decision making make use of the idea of a science/policy boundary to address the problem of

using science in setting policy. However, that solution has been discarded resoundingly by scholars of the policy process.

In this chapter, I present several critiques of the rationalist and positivist models of science in decision making. These critiques differ in their views of the potential for technocratic outcomes. At issue is the power that actors claiming scientific insight have to shape policy debates in terms that encourage reliance on scientists or science in shaping public policy outcomes.

The Limits of Rationalism in Decision Making

Alvin Weinberg's concept of "trans-science" offers a practical criticism of the rationalist approach to decision making. Weinberg (1972) applied the term "trans-science" to policy-relevant questions that have scientific or technical components but cannot be resolved through scientific means. This is the case, for example, in using scientific experiments to judge the health risks associated with low-level radiation—as Weinberg argues, the numbers of mice required to have confidence in experimental results is on the order of 8 billion (ibid.: 210). In general, trans-scientific problems can be *approached* through scientific methods, but irreducible uncertainties make reliable *conclusions* unlikely. Weinberg argues, instead, for a type of science-policy interaction—"trans-science"—that is separate from what we normally think of as science (ibid.: 209). The role for scientists in approaching trans-scientific questions, according to Weinberg, is to point out irreducible uncertainties, thereby noting the limits of science in settling policy debates. Here Weinberg implies that an identifiable boundary between science and policy would be helpful in decision making. This approach is consistent with soft positivism, in which science sets the terms of debate by demonstrating what is known and what remains uncertain. At the same time, Weinberg argues that scientists themselves do not agree about these limits and suggests that, for better or worse, both scientists and non-scientists will argue about the applicability of science in policy making. Weinberg lays out a model for how science might be useful in policy making. On the other hand, he does not offer much guidance on how debates about the role of science will be settled or who might settle them.

A more radical departure from the rationalist model comes from Charles Lindblom, who, in one of the most cited works in political science, argues that the synoptic approach to decision making is both

descriptively inaccurate and normatively misguided (1959).[11] Lindblom rejects the idea that policy alternatives are evaluated in light of their ability to maximize stated goals and thereby to lead to the selection of the most effective and efficient means by which to achieve collective ends. Instead, decision making proceeds through an analysis of only a limited set of options that represent incremental changes from current policy.

Lindblom's criticism of the synoptic model of decision making is largely practical. First, decision makers lack the time and resources to evaluate systematically all possible solutions to a stated policy problem. A second and related point is that by considering small policy changes decision makers *decrease* the knowledge requirements associated with predicting outcomes of new policy options. By limiting the uncertainty that participants face about likely future outcomes, decision makers *increase* the chances of forming consensus among participants in support of proposed policy options. Third, Lindblom argues that the ability to judge a policy option as good or bad, in rationalist terms, depends on agreement about the goals. If participants to do not agree about goals, there are few objective criteria by which to evaluate a particular policy option—for example, is it better to balance the budget than to expand a program that provides health insurance to children? Lindblom argues that goals are not judged independently from means. Instead, he argues, valued outcomes are discovered and elaborated through examination of a set of policy options that make explicit necessary tradeoffs that are inherent in choosing one option over another.

Lindblom's description of the policy-making process rejects both the rationalist and the positivist models of decision making. For Lindblom, a rationalist approach would be time-consuming, would inevitably be incomplete, and might suggest a route that strays too far from the comfort zone of participants in the policy process. Equally, Lindblom defines the quality of a policy decision not by its consonance with reality or truth, as the positivists would, but by the process that led to the decision. Lindblom's more practical approach allows for learning by participants who can make small policy changes and then evaluate the extent to which those changes achieved desired policy outcomes. Scientists might play a role in Lindblom's decision making by providing insights about the outcomes associated with a policy or by making persuasive arguments about policy alternatives. However, Lindblom carves out no value-neutral place from which scientists can or should operate.

Lindblom simply casts aside the need for a boundary between science and policy.

A comparison of Lindblom's view of decision making with Alvin Weinberg's illustrates Lindblom's nuanced rejection of rationalist and positivist views. Whereas Weinberg falters on the issue of who should demarcate science and trans-science, Lindblom is able to skirt the issue of the proper boundary by arguing that decision making can proceed without resolving major uncertainties. Through evaluation of successive, limited comparisons, decisions are made without stretching participants past their willingness to proceed. Participants learn by evaluating outcomes associated with existing policy settlements and can re-engage policy decisions as needed. In addition, rather than viewing stakeholders as a force that distorts otherwise sensible policy choices, Lindblom sees interested actors are crucial pathway by which pertinent information reaches decision makers. For Lindblom, the approach is not a step away from rationality toward relativism. Instead, it is a practical way to proceed despite inherent uncertainties.[12] This allows Lindblom to conceive of a decision-making process in which the decision makers are neither all-knowing nor operating without any helpful information.

Notably absent from Lindblom's model is a role for objective information. Good decisions are not judged on the basis of objective criteria such as efficiency, effectiveness, or truth. Instead, a good decision is one on which participants can agree. This model posits democratic decision making as a solution to the problem of irreducible uncertainties. Rather than democratic decision making being an irrational process that needs to be propped up by science in order to avoid going hopelessly astray, it is a practical way of proceeding in the face of uncertainty.

Deborah Stone, in her more recent account of the policy process (1997: 8–13), attacks the rational model of decision making as descriptively inaccurate. However, in contrast with Lindblom's view of the policy process, science is a specific and useful resource in Stone's view. Stone rejects the rationalist model because it does not acknowledge that actors involved in policy actively attempt to alter the ways in which other actors perceive the contest. Instead, the rational model of decision making takes for granted public consensus about "the way things are" or presumes that consensus can be produced through the provision of facts and information. Stone argues, to the contrary, that facts are always contested in policy making such that the consensus that information is supposed to produce is elusive (ibid.: 310). Instead, actors mobilize ideas with the

intent to provide accounts of events that are more persuasive than other actors' accounts. Stone asserts that ideas, as tools for influencing the policy process, are "more powerful than money and votes and guns" (ibid.: 11).

For Stone, one of the most important ways to integrate ideas into policy making is through the construction of policy narratives and causal stories. Stone finds two routine story lines that shape most policy narratives: (1) a story of decline, in which some previously happy state of affairs is slipping away, and (2) a story of control, in which a tolerated but unwanted state of affairs can now be alleviated through newly available courses of action. Problems of environmental policy, for example, often are framed in terms of decline and often imply the need for intervention to halt or slow a looming crisis. The idea of addressing poverty through federal housing projects fits a control plot line. The availability of a solution—i.e., low-income housing as a basis for economic development—brings a long-standing problem onto the political agenda not as a function of a perceived change in the severity of the problem, but in response to the claim that there is a course of action that might address the problem. In this way, policy narratives make a case that action is warranted and feasible.

In addition, policy narratives can contain more precise descriptions of policy problems that Stone calls "causal stories." Causal stories draw clear links between problems and solutions, assign blame, and suggest more likely and less likely options for remediation. Stone's (1989, 1997) analysis of causal stories turns on the flexibility one has in locating a problem in the realm of accident and fate versus locating it in human agency. If a policy problem is understood to be within the realm of human control, arguments about the need for government action are more likely to be convincing. Stone's work on causal stories highlights the need to persuade in order to have one's view of a policy problem accepted. But Stone also emphasizes a subtle trick of the causal story; its persuasive element is masked. Political actors, Stone writes, "use narrative story lines and symbolic devices to manipulate so-called issue characteristics, all the while making it seems as though they are simply describing facts" (1989: 282). In Stone's view, the attempt to present a causal story as if one is merely presenting "the way things are" is an important component of that story's persuasive power. If the audience accepts the claim of the causal story—i.e., "this is, in fact, the way things are"—the members of the audience do not see themselves as having been

lobbied. Instead, they view the interaction as one in which they learned something new.

Stone recognizes social and cultural norms that place limits on how much flexibility one has in creating a convincing policy narrative or a causal story. For example, her emphasis on familiar plot lines implies that an innovative policy entrepreneur who diverges from such plot lines might risk his or her credibility with the audience.[13] In addition, Stone emphasizes that policy narratives invite counter-narratives. Contestants in a political process are often anything but passive recipients of one another's framings. Stone conceives of such struggles in terms of battles over boundaries:

Each mode of social regulation draws lines around what people may and may not do and how they may or may not treat each other. But these boundaries are constantly contested, either because they are ambiguous and do not settle conflicts, or because they allocate benefits and burdens to the people on either side, or both. Boundaries become real and acquire their meaning in political struggles. (1997: 13)

For Stone, a boundary between science and policy is crucial in that it sets out the space of what can be contested and what will be left out of the arena of policy debate because participants view some features of the world as factual and therefore beyond debate. Rather than trying to argue about where the boundary should be drawn, Stone is interested in the resources policy adversaries use to advance their claims about what is factual and therefore not open to debate.

Unlike the rationalists and positivists who would carve out a safe space for scientists to create and provide relevant information to policy makers, Stone sees science, or at least the rhetoric of science, as a resource that participants use in the game of persuasion. Successful participants create a boundary between science and policy when they convince other actors that their view of reality is correct. By implication, there is no fixed boundary between science and policy, or at least not one that participants in the policy process will agree on. Stone's approach differs from the soft positivist approach in that she views efforts by participants in the policy process to persuade others as the normal and legitimate currency of political engagement rather than an undesirable process that interrupts a more objective approach.

Science plays a more visible role in Stone's account of policy making than in Lindblom's. The causal story, a crucial resource in Stone's policy world, borrows heavily from the idiom of science, i.e., the notion of

identifiable causality. In addition, one of the marks of success of the policy story is its ability to present its normative framing as if it is factual. To do this, proponents of causal stories often draw on scientific studies to bolster their claims. Stone characterizes science as being able to "command enormous cultural authority as the arbiter of empirical questions" (1997: 204). At the same time, Stone does not argue that science or scientists carry the day. Instead, she characterizes science as useful but certainly not sufficient in convincing others to accept one's policy narrative (1989: 295).

Sheila Jasanoff's 1990 study of science advisors in regulatory policy making offers an empirically grounded assessment of the tenuousness of boundaries erected between science and policy and draws on theoretical contributions from science studies scholarship to elucidate the processes she observes in regulatory decision making. Jasanoff considers two models that address the problem of science in decision making: (1) technocracy, in which the application of sound science can rationalize policy making, and (2) democracy, in which broader participation by stakeholders improves outcomes (1990: 15). Jasanoff argues that the presence of science advisors in regulatory decision making and the need for regulators to consult scientists and to maintain strong ties to the science community are evidence of the dominance of the technocracy model (ibid.: 229). At the same time, Jasanoff highlights, throughout her book, the weakness of technocratic solutions in policy debates. Jasanoff provides detailed examples of the complex negotiations involved in trying to develop consensus around scientific evidence in order to use that evidence to legitimize regulatory decisions at the Environmental Protection Agency and the Food and Drug Administration. Jasanoff finds that scientists often cross the presumed boundary between science and policy by incorporating subjective judgments into the advice they offer while maintaining their authority as experts. Likewise, agency administrators face incentives to redraw the boundary between science and policy from one regulatory decision to the next as a consequence of the contingencies associated with a particular instance of agency rule making. Administrators in the study have an array of institutional mechanisms available to them—for example, contracting with independent advisory groups versus relying on in-house advisors—for incorporating scientific information into decision making.[14]

For Jasanoff, efforts on the part of participants to create a reliable boundary are not only elusive but also misguided. Jasanoff argues that

efforts to draw science into decision making in ways that blur the boundary between science and policy often lead to policy outcomes that are *less controversial* than efforts that attempt to maintain an unrealistic division between expert advice and democratic decision-making authority (1990: 231). Her analysis suggests that a rejection of the myth the rationalist model of decision making could lead toward a more productive, if less defined, relationship between science and policy. The lack of a clear boundary between science and policy should not be troubling if, as Jasanoff argues, the balance between democratic and technocratic forms of decision making are kept in a "creative dialectic" by actors on either side of the science/policy boundary (ibid.: 228).

A notable feature of Jasanoff's treatment of science advisors in policy making is that political contests over the role of science in the formation of policy have not limited the tendency to rely on science advisors, in spite of scientists' limited capacity to close off political debate. "Consultation between agencies and [science] advisory committees," Jasanoff writes, "has become almost routine, even when not required by law." (ibid.: 1) The cases she presents do not lead easily to the conclusion that scientists are shaping outcomes. At the same time, the recourse to science advisors has not abated.

There is a notable consistency between the perspectives offered by Stone and Jasanoff, in spite of the differences in their approach to the subject matter. Neither of their treatments requires *a priori* agreement about how to draw the science/policy boundary, nor, in view the stakes involved in demarcating this valuable political terrain, should such agreements be expected. Thomas Gieryn, who has made substantial contributions to the literature on boundary work, predicts repeated efforts to demarcate science from non-science, not only in policy domains, but in any domain where science is held out as a distinct form of knowledge (1983, 1995, 1999). "Boundary-work abounds," Gieryn writes, "simply because people have many reasons to open up the black box of an 'established' . . . representation of science—to seize another's cognitive authority, restrict it, protect it, expand it, or enforce it." (1995: 407) Gieryn goes on to argue that, because such boundaries are continually contested, there is little stability in what is considered scientific:

. . . neither actual scientific practice and discourse in labs or journals nor earlier maps showing the place of science in the culturescape *determine* how the boundaries of science will get drawn next time the matter comes up for explicit debate. . . . In this sense, then, the space for science is empty because, at the outset

of boundary-work, nothing of its borders and territories is given or fixed by past practices and reconstructions in a deterministic way. (ibid.: 406)

This picture of science in policy making, in which actors must continually renegotiate what constitutes "sound science," raises the issue of how society can cope with such indeterminacy. Gieryn offers a clue when he acknowledges the potential for stability in negotiated settlements around science. In a move that sounds somewhat akin to Stone's approach, Gieryn argues that there is a repertoire from which participants draw from when they articulate science/non-science boundaries, and that some demarcations are easier to defend than others. He clarifies that some representations of science "achieve a provisional and contingent obduracy that may preempt boundary-work" (ibid.: 407).

David Guston's (2000) analysis of the administration of grants given by the National Institutes of Health offers a concrete example of how such "obduracy" might be achieved. Guston explores changes in the rhetoric describing government support of basic scientific research from World War II to the end of the twentieth century, focusing specifically on the erosion of the laissez-faire model that dominated postwar public funding. This erosion arose from an increasing willingness on the part of legislators in charge of the purse strings to ask whether basic research was in fact benefiting society in a way that justified the costs. Researchers who had assumed that basic science was inherently worthy and who bristled at the idea that non-scientists might exercise any oversight of their domain found their behavior in policy domains increasingly scrutinized. Guston develops the concept of the "boundary organization" to explain how the dual expectations of scientists and policy makers have been managed within the National Institutes of Health in order to keep the relationship from breaking down.[15] Guston describes the NIH as a boundary organization that is able to internalize negotiations along the science/policy boundary and to stabilize them in ways that allow actors on each side of the boundary to protect their interests. In this case, the routine of a bureaucracy helps create the obduracy that Gieryn posits.

When comparing Guston's analysis against Jasanoff's, one can see that the policy setting is likely to have a substantial influence on the ability to create stable boundaries around science. Arenas of distributive politics, of which NIH grant giving is a clear example, are relatively non-competitive when compared with regulatory policy settings (Lowi 1964, 1972). That Jasanoff finds few routinized boundary settlements in Food and Drug Administration and Environmental Protection Agency

regulatory decision making is consistent with expectations about politics in regulatory versus non-regulatory domains.

Notably, none of the scholars treated here endorses a relativist approach. Rather, each of them explores the persistent role of science in policy making. It is this persistence that is of interest. If we accept the social underpinnings of science and accept the frustratingly infrequent examples we have of science being instrumental in resolving political debate, we must wonder why we have not revised our view of the importance of science in the policy process. This calls attention to the work that "the idea of science" can do in society. A central argument in the present volume is that participants in politics cling to the idea of applying science for policy making because of the appeal of finding the "correct" or "best" answer, especially if one assumes that the alternative is endless debate. The idea of using "sound science" to inform policy decisions creates an incentive for participants to demonstrate that science supports their positions.

Here we can see two orthogonal currents running in the arena of science in decision making. On a scholarly level, researchers advocate for solutions that dispense with the traditional notion of separating science and policy (Jasanoff 1990; Sarewitz 1996; Guston 1999, 2000). At the level of practice, recourse to the traditional notion of scientific objectivity as a powerful epistemological basis for resolving political debate remains in high currency. Perhaps, as a function of these two currents, recent scholarship is divided about the trajectory of science in policy making, with some researchers decrying the decline of science while others cite its pervasiveness.

Trends in the Recourse to Science in Decision Making

Yaron Ezrahi (1990) makes a strong case that scientific norms are in decline and argues that, because of this decline, ideology will supersede rationality as the basis for legitimate state action. In a vast work tracing the links between Enlightenment views of science and democracy, Ezrahi argues that political action, once justified in rational and instrumental terms, is increasingly understood in moral, emotional, and symbolic terms. Ezrahi demonstrates convincingly the foundational role Enlightenment thinking had in the creation of modern democracies and explores how visions of industrialization and mechanization have been used to articulate the rationale for legitimate state action.

Ezrahi makes his case by arguing that rationalist thinking during the Enlightenment led to a concept of democracy such that citizens could hold leaders accountable for their actions. This accountability, according to Ezrahi, stems from the capacity to judge an action of the state in light of its consequences. Citizens, by observing the state's action, assess the extent to which state officials achieve their goals.[16] This notion, according to Ezrahi, relies on a visual culture that assumes that state policies are goal oriented and can be "measured" with reference to their ability to reach those goals (1990: 75; 89). Ezrahi argues that the visual culture of politics and the idea of constraining state action on the basis of instrumental expectations about outcomes are now in decline.

Ezrahi's account, however, captures at least two trends that turn out to be moving in opposite directions rather than changing together. Certainly trust in scientists, and in professionals more generally, has declined in the United States since the 1950s. But one can argue that this decline in trust is the consequence of citizens *exercising* rather than rejecting the visual, attestive culture that Ezrahi argues is the foundation of democratic politics. Society's experience with technological developments since World War II has been one of glowing promise followed by disillusionment as the public experiences unforeseen costs that accompanied many technological advances. For example, promoters of pesticides promised an increase in agricultural production, but now face a public that is wary of the costs to the environment and public health that have accompanied widespread pesticide use (Baumgartner and Jones 1991). A similar account can be made of nuclear power, whose proponents argued it would provide "energy too cheap to meter" without focusing on the costs associated with maintaining safety in such complex, large technical systems and with managing the waste (Baumgartner and Jones 1991; LaPorte and Keller 1996). A more recent example concerns claims about the ability of stem-cell research to provide cures for several degenerative diseases; such predictions do not include an accurate picture of the long time horizons involved before such treatments will reach medical clinics. These examples suggest that expert claims about the promise of science and technology may well have been judged in instrumental terms such that a decline in scientific and technical authority has occurred as a consequence of a visual, attestive culture. Declining trust in scientists may be evidence that that culture is alive and well.

Further evidence that scientists are subject to increasing scrutiny that has its underpinnings in Enlightenment thought comes from Guston's analysis of changes in the administration of NIH grants (2000). Guston provides evidence that a laissez-faire approach to scientific research has been replaced with specific rules of accountability that govern publicly funded grants. Moreover, members of Congress initiated this change in response to questions regarding whether the "social contract for science" articulated after World War II was, in fact, accurate—i.e., did public support of basic scientific research reap benefits for society? Guston's analysis shows the visually attestive culture that Ezrahi describes in action. Moreover, it was this culture of observing and judging outcomes that eroded the social contract for science and placed scientists under increasing scrutiny as a condition of accepting pubic funding for their research.

Curiously, the erosion in the social status of scientists has been matched by an increase in the use of analysis in policy making. Although a number of political scientists point to the limits of science in guiding political decisions or resolving political controversy, policy making in the United States has seen an increase in recourse to expertise since the 1970s. Jasanoff's 1990 study responds to the proliferation of science advisory boards around agencies involved in environmental and health-related regulatory decision making. A number of scholars have noted a similar trend with respect to Congress, the branch of government that, according to classic political science, faces institutional incentives that make recourse to analysis and expertise unlikely.[17] During the 1970s, Congress created a number of offices (including the General Accounting Office, the Congressional Research Service, the Congressional Budget Office, and the Office of Technology Assessment) to provide expertise to its members (Bimber 1996). Legislators, eager not to be outflanked by the Executive Branch in policy making, created these new sources of congressional expertise (ibid.). Independent "think tanks" have increased in number over a similar time period, equally suggesting a market for policy expertise (Jenkins-Smith 1990; Ricci 1993; Smith 1991). Moreover, several scholars argue that both status and congressional access are allocated to interest groups who have reputations for being scientifically informed (Carpenter, Esterling, and Lazer 1998; Esterling 2004; Heclo 1978). Similar trends are occurring among state legislatures (Hird 2005). It is difficult to acknowledge this proliferation in sources of expertise across arenas of policy making

while accepting the notion that rationalist justifications for decision making are in decline.

One approach to understanding science and policy making that captures elements of the two seemingly orthogonal trends in science in policy making is that of "co-production" (Jasanoff 2004a; Jasanoff and Wynne 1998). The term "co-production" refers to the notion that natural and social orders are produced together, a notion that avoids both natural and social determinism in explaining outcomes of interest (Jasanoff 2004a: 3). More important than avoiding the pitfalls of the "science wars," however, those advancing the idiom of co-production challenge the social sciences to address more directly the role of science and technology in culture and politics. Jasanoff (ibid.: 1) charges that the social sciences have "[retreated] into a conspiracy of silence" on the question of the relationship between science, technology, culture, and power. The co-production framework can address cultural and social elements of the advancement of "technoscientific" objects without discarding science and technology as powerful symbols of social order in current society.

A powerful application of the co-production framework comes from Clark Miller's (2004a) analysis of the role of the Intergovernmental Panel on Climate Change as a site for the renegotiation of scientific and political orders within a "global" context. Miller shows how the notion of global climate change altered the status of nation-states as capable actors in confronting global environmental problems. At the same time, Miller argues that scientists' representation of the environment in global terms gained credence only through institutional mechanisms that supported the notion that such claims were representative of broad, even global perspectives. Thus, the ability of scientists to argue that their understanding of climate change was universal depended on the creation of an institution that could advance that notion in a convincing framework of global representation.

Co-production addresses, among other things, the emergence and stabilization of new scientific/technical framings (Jasanoff 2004a: 38). This echoes Gieryn's discussion of the "obduracy" of certain science/non-science settlements, and it touches on one of the central themes of the present volume. Jasanoff argues that political order is expressed through institutions, and that institutions provide societies with "tried-and-true repertoires of problem-solving, including preferred forms of expertise,

processes of inquiry, methods of securing credibility, and mechanisms for airing and managing dissent" (ibid.: 40). The co-production framework alerts us to the cultural and scientific underpinnings of such institutional arrangements and cautions against attending to only one of these in addressing an institution's origins.

Science for Environmental Policy Making

The above examples from political science and from the more interdisciplinary field of science and technology studies are consistent in their broad rejection of rationalist and positivist descriptions of the application of science in policy making. At the same time, although science does not seem especially useful in resolving policy debates, the availability of expertise and analysis is on the rise in several arenas of public decision making. Moreover, both the rationalist and the positivist conception of the role of science in policy making continue to have rhetorical significance among actors involved in policy making. Work by Jasanoff (1990) and by Stone (1989, 1997) point to the continued appeal of the notion that science will simplify policy making by clarifying what is true and beyond the realm of political debate, in spite of the fact that that notion is not supported by repeated experience.

The persistent view that science will simplify policy choices raises an important question about the role of scientists and science in policy making. If actors believe, or act as if they believe, that science produces reliable, objective information that may be of use in resolving policy debates, this belief will continue to be relevant for understanding policy-making processes. Such reliance on rationalist and positivist models of science in policy making can certainly be instrumental, as Stone points out. At the same time, some participants in policy making may turn to science because of an earnest belief in its objectivity and neutrality. If the idealized image of science informs participants' understanding of the role of science in decision making, then the rationalist and positivist models, though inaccurate, must be recognized for their symbolic importance in shaping actors' expectations and, potentially, in shaping outcomes. This may be especially true in domains, such as environmental policy, where participants view scientific and technical information as central. From an analytical standpoint, the challenge is to demonstrate the extent to which the rationalist and positivist accounts motivate

interactions in the making of environmental policy without also suggesting that such accounts are accurate descriptions of science in society.

My analysis starts with the puzzle of the unique cultural authority of science. Though it cannot be adequately explained in rationalist or positivist terms, the authority of science is materially relevant through its expression in policy making. Though the status of science is invoked rhetorically, when that rhetoric is persuasive it becomes materially significant through the creation of public policy which allocates resources toward some goals and away from others.

In the next three chapters, I focus on negotiations of the science/policy boundary and examine the extent to which the negotiations themselves become the subject of policy debate. The capacity to keep such negotiations out of political discourse is a major concern of this analysis in that a lack of debate signals participants' acceptance of a particular settlement of the science/policy boundary.