Institutions and the Growth of Knowledge: Evidence from International Environmental Regimes

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Accepted 25 November 2003

Abstract. This article argues that institutions not only reflect ideas prevalent at the time of their creation, but also play vital roles in driving the growth and dissemination of knowledge. Because institutions are not actors in their own right, however, it is essential to identify the mechanisms through which they influence the behavior of those who are producers and consumers of knowledge. The central section of the article explores three distinct mechanisms or families of mechanisms that come into play in this context: (1) framing the research agenda, (2) privileging certain types of knowledge claims, and (3) guiding the application of knowledge to specific policy concerns. The article's concluding section examines the policy implications flowing from the proposition that institutions play significant roles in creating knowledge regarding the issues they address. Throughout, observations relating to international environmental or resources regimes provide a source of illustrations.

Key words: agenda formation, causal mechanism, institution, knowledge claim, policy application, regime

1. Introduction: The Issue Defined

Institutions understood as collections of rights, rules, and decision-making procedures governing human actions in specific issue areas are social constructions (Onuf 1989). The establishment or refinement of institutions or regimes as they are often called (e.g. the arrangements governing human uses of living resources or the arrangements designed to protect stratospheric ozone and the Earth's climate system) thus involves acts of creation rather than processes of discovery. It follows that we should expect to find these governance systems bearing the stamp of theories, discourses, ideologies, or, more generally, patterns of thought that were influential at the time of their formation. We have no trouble understanding the differences between early fisheries regimes based on models of maximum sustainable yield (MSY) and newer arrangements that reflect the growing influence of the idea of whole ecosystems with its concern for non-harvested as well as harvested species and for the interactions among them that make it essential to pay attention to complex systems. Similarly, the rapid rise of interest in what have become known as incentive
mechanisms in contrast to command-and-control regulations has prepared us to see provisions involving tradable permits (e.g., emissions trading under the terms of the climate regime) showing up with increasing frequency in a variety of environmental regimes. Nothing in these observations is meant to contradict the views of those who argue that environmental regimes reflect the preferences of actors or interest groups able to exercise power during processes of regime formation (Strange 1983; Håselevekar et al. 1997). But this does not contradict the proposition that governance systems are built on existing intellectual capital. Even powerful actors are limited by their understanding of the institutional options available to them, a fact that highlights the role of knowledge in the growth of institutions.

There is much more to be learned about the ways in which knowledge systems affect the character of specific institutions and what this means for the effectiveness of governance systems addressing a variety of environmental problems. My strategy in this article, however, is to turn the causal arrow around and ask how the operation of environmental regimes influences the growth and dissemination of knowledge. Specifically, I examine the roles that the environmental regimes play in determining: (1) what is studied by structuring research agendas, (2) how issues are studied by privileging certain types of knowledge claims in the thinking of influential analysts and practitioners, and (3) what becomes of the resultant knowledge by affecting whether it is brought to bear in efforts to fulfill key stated or unstated goals. Having demonstrated that institutions are important drivers of the growth of knowledge, I comment on the design implications of this line of analysis. The fact that institutions influence the growth of knowledge is not in itself a good or bad thing. Yet it is important to bear this feature of institutions in mind in creating and implementing regimes designed to deal with specific problems.

The roles that institutions play as determinants of the growth of knowledge are generic; they arise with respect to governance systems dealing with a wide range of substantive issues and operating at different levels of social organization. But to lend substance to the argument presented in this article, I draw on examples relating to international environmental and resource regimes. Specifically, I rely on illustrations drawn from experience with fish and other living resources, biological diversity, transboundary air pollution, and climate change.

2. Causal Mechanisms

Institutions provide the rules of the game under which actors pursue their individual goals; they are not actors in their own right (Young 1999a). To make a convincing case that institutions drive the growth of knowledge, therefore, it is necessary to identify one or more causal mechanisms through which the operation of these arrangements can influence the behavior of actors responsible for the production and dissemination of knowledge (Young 1999b; Hovi 2003). In this section, I explore three propositions that point to specific mechanisms or families of mechanisms
through which institutions play a role in shaping the growth of knowledge. These mechanisms are not mutually exclusive; they may operate at the same time and even interact with one another in specific situations. Yet they direct attention to distinct pathways through which institutions affect the growth of knowledge.

2.1. Framing the Agenda

**Proposition 1:** International environmental regimes affect the growth of knowledge by structuring research agendas and, as a consequence, influencing what is studied. Perhaps the most direct role of institutions and certainly one of the easiest to document centers on the ways in which these arrangements serve to frame issues and channel resources toward improving our understanding of priority issues. It is apparent, for example, that the efforts that have gone into creating and implementing the climate regime under the terms of the 1992 UN Framework Convention on Climate Change (UNFCCC) and the 1997 Kyoto Protocol (KP) have contributed to a remarkable rise in the time, energy and resources devoted to understanding the nature of climate change, projecting the impacts of climate change, and evaluating the relative merits of different responses to climate change (Miller and Edwards 2001). This is not a matter of the extent to which this regime has proven effective as a response to the problem of climate change. It is perfectly possible for a regime to focus energy and resources on efforts to improve our understanding of a problem, whether or not the arrangement proves successful in solving the problem. As the case of climate change suggests, in fact, regimes may be particularly influential in shaping research agendas when initial efforts to solve problems fail, triggering a need for the development of new intellectual capital. It would be difficult to make a compelling case that climate change is more important in some general sense than the problem of poverty at the global level or issues relating to the provision of freshwater to meet the needs of a human population of 8.9 billion. But it is undeniable that the climate change regime has had an extraordinary impact on the concentration of energy and resources devoted to efforts to improve our understanding of the Earth’s climate system.

What is more, institutions can play a role in concentrating attention on particular aspects of larger issues or problems. The case of climate change is interesting in this regard as well. Both the UNFCCC and the KP emphasize efforts to reduce net emissions of greenhouse gases and especially emissions of carbon dioxide. The effect of this orientation is to focus thinking on what is generally known as mitigation or, in other words, the challenges involved in taking steps to stabilize emissions of greenhouse gases at a level that “would prevent dangerous anthropogenic interference with the climate system.” It is understandable, under the circumstances, that mitigation has emerged as a primary focus of attention within the research community. Nonetheless, there is every reason to expect that climate change will become a reality during the foreseeable future, regardless of our best efforts to devise new ways to reduce or control emissions of greenhouse gases. In some regions (e.g. the
Circumpolar North), the effects of climate change are already clearly discernible. This means that studies of adaptation or, in other words, efforts to prepare for the onset of climate change and to minimize the adverse consequences of climate change once it occurs deserve equal billing with research on mitigation. So far, the climate change regime's emphasis on mitigation has served to deflect attention from the study of adaptation. It will be interesting to observe, in this connection, whether the rising tide of interest in adaptation that became apparent at UNFCCC COP 9 in India during the fall of 2002 triggers a significant shift in interest on the part of the research community in the direction of systematic research on various aspects of adaptation.

While the roles that regimes play in framing issues and channeling resources are particularly easy to document, this is not the only mechanism through which the operation of institutions can shape the contents of research agendas. Regimes often exert substantial influence on the development and diffusion of analytic tools, and especially policy-relevant models. MSY models existed within the scientific community well before they gained prominence during the middle of the last century in regimes dealing with marine fisheries. Much the same is true of whole ecosystem models in relation to the regime for living resources in Antarctica established under the 1980 Convention on the Conservation of Antarctic Marine Living Resources (CAMLR) and the biodiversity regime created under the 1992 Convention on Biological Diversity (CBD). Still, there is no denying that the incorporation of these models into major environmental regimes has played a role both in expanding the body of scientific knowledge surrounding the models themselves and in increasing the salience and legitimacy of these models in the minds of scientists and policymakers alike. The need to operationalize MSY models and to apply them to a wide range of real-world situations, for example, clearly contributed to moving this line of analysis into the scientific mainstream and adding a range of new elements to the analysis of sustainable yields beyond those likely to have emerged in the absence of a growing demand for policy-relevant applications of this family of models (Gulland 1974).

As the case of transboundary air pollution suggests, moreover, the operation of environmental regimes can trigger the development of analytic constructs and models that did not exist prior to the creation of the regimes in question. The growth of the idea of critical loads and the models created to demonstrate their relevance in conjunction with the implementation of the regime set forth in the 1979 Convention on Long-Range Transboundary Air Pollution (CLRTAP) in Europe offers a striking case in point. Before CLRTAP came on stream during the 1980s, it was customary to deal with airborne pollutants one-by-one. But with the emergence of a growing collection of CLRTAP protocols dealing with sulfur dioxide, nitrogen oxides, volatile organic compounds, and so forth, it soon became apparent that understanding the impact of airborne pollutants on ecosystems requires consideration of the suite of pollutants present in a given situation. The idea of critical loads grew directly out of the work of EMEP, a monitoring and assessment program operated by the UN
Economic Commission for Europe as an element of the transboundary air pollution regime (d’Primi 1996). This, in turn, triggered the development of the Regional Acidification and Simulation (RAINS) model under the auspices of the International Institute for Applied Systems Analysis (Wettestad 2000). Undoubtedly, efforts to improve our understanding of the dynamics of air pollution would have increased even in the absence of the European transboundary air pollution regime. But it is hard to deny that CLRTAP has played a significant role since its inception in directing the attention of the research community to the problem of long-range air pollution and in stimulating the development of models that have proven useful not only in understanding air pollution in Europe but also in providing techniques of analysis that are useful in addressing analogous problems in other parts of the world (e.g. Northeast Asia).

Going a step further, the creation of environmental regimes frequently gives rise to new phenomena that soon become objects of study in their own right. Consider the examples of individual transferable quotas (ITQs) in the marine fisheries, tradable emissions permits relating to airborne pollutants, and intellectual property rights pertaining to genetic materials and products derived from these materials. ITQs in the fisheries are a recent invention. But they have spread to many parts of the world in the wake of the establishment of exclusive economic zones (EEZs) under the 1982 UN Convention on the Law of the Sea (UNCLOS) and the efforts of a growing number of coastal states to address problems of sustainability and efficiency within their zones (Judicello et al. 1999). Efforts to control emissions of sulfur dioxide gave rise to the creation of tradable emissions permits at the domestic level (Tietenberg 2002). Corporations that expect mandatory controls on greenhouse gases to emerge during the foreseeable future have begun to experiment on a voluntary basis with systems of tradable permits for carbon dioxide (UNCTAD 1995). The circumstances under which actors can establish intellectual property rights (IPRs) under the terms of the Convention on Biological Diversity (CBD) and the related arrangements dealing with plant genetic materials remain controversial (May 2000; Sell 2003).

At this stage, it is not easy to forecast what the track record of these mechanisms will be. But this does not alter their significance in terms of the growth of knowledge. The existence of uncertainty and controversy does not reduce interest in policy instruments of this sort on the part of members of the research community. On the contrary, these features of harvest quotas, emissions permits, and intellectual property rights make them particularly attractive as targets for research. The fact that these instruments are being introduced under the terms of specific regimes despite the fact that their operation is surrounded by uncertainty highlights the need to mount research programs designed to enhance our understanding of how they will work in specific settings. Worth noting in passing is that this is a case where the issues in question are of interest primarily to social scientists rather than to natural scientists, a fact that emphasizes the role institutions play in shaping the growth of knowledge across a wide range of substantive fields. But the essential point is that
institutions can and often do shape the growth of knowledge not only by framing the issues and allocating resources or through the development of influential models but also through the creation of phenomena that would not have come into existence, much less become matters of interest to the research community, in the absence of the formation of the institutions in question.

2.2. Privileging Knowledge Claims

Proposition 2: International environmental regimes influence the growth of knowledge by privileging certain types of knowledge claims and, as a result, affecting how key issues are studied. Although the roles that regimes play in shaping the contents of research agendas are important, the observation that they play these roles is not likely to provoke controversy. Most observers will be prepared to acknowledge both the existence of these roles and their significance. But the influence of environmental regimes on the growth of knowledge extends well beyond the process of agenda setting. Institutions commonly privilege some types of knowledge claims and, in the process, de-emphasize or even marginalize others. A striking case in point involves the preference embedded in most environmental regimes for western, scientific knowledge in contrast to traditional ecological knowledge or other types of knowledge claims that may prove useful in understanding ecosystems. Consider the protracted and contentious battles over assessments of fish stocks and other living resources in this light. The track record of assessments based on studies of population dynamics carried out through the application of scientific procedures leaves much to be desired. Even in cases featuring sizable and sustained investments in research on the dynamics of fish populations, scientists are regularly surprised by dramatic fluctuations in the condition of key stocks (Harris 1998). Yet the scientific committees attached to most fisheries regimes seldom pay much attention to inputs from members of the user community who lack scientific training but who are able to provide longitudinal observations relating to the relevant stocks (Dobbs 2000). Partly, this is a consequence of the fact that it is hard to devise suitable procedures for merging inputs from the scientific community and from members of user communities to arrive at integrated stock assessments. In considerable part, however, it reflects the fact that most regimes dealing with living resources have built-in preferences for knowledge claims that can be justified as products of procedures conforming to mainstream conceptions of science.

A similar phenomenon occurs with regard to the selection and operation of policy instruments. There is mounting evidence to suggest that traditional, often informal, management practices that evolve over time to guide human uses of common-pool resources can produce outcomes that are sustainable over long periods (Ostrom et al. 2002). Yet most resource regimes in existence today have a hard time acknowledging the effectiveness of such practices. Instead, they focus on the relative merits of incentive-compatible systems (e.g., ITQs or tradable emissions permits) and command-and-control regulations. The result is an imbalance between the energy and
resources devoted to studies of various types of incentive systems and regulatory arrangements, on the one hand, and more traditional mechanisms for guiding behavior, on the other. The growing popularity of the concept of co-management in a variety of settings may play a role in reducing this imbalance (Singleton 1998). But this is by no means a foregone conclusion. Experience to date makes it clear that it is hard to find ways to merge traditional and modern approaches to regulation in the process of developing policy instruments suitable for specific regimes. Although it is too early to draw clearcut conclusions about such matters, there is a pronounced tendency for those responsible for operating specific regimes to grant greater credence to arguments pertaining to policy instruments presented in the form of scientific analyses. The implications of this preference for the growth of knowledge are easy to see.

A corollary to the preceding argument involves a marked preference in most international environmental regimes for the development of quantitative analyses and the construction of analytically tractable models. The attractions of quantification are easy to understand. Whether the issue concerns the setting of total allowable catches (TACs) for individual fisheries, the potential costs of the impacts of various forms of climate change, or the efficiency of different policy instruments for the achievement of emissions reductions, it is helpful to be able to attach specific numbers to the major options. Yet the price to be paid for this apparent precision can be high. As those who have experienced the problems associated with many forms of contingent valuation and risk analysis can attest, the appearance of precision can mask more or less serious distortions, producing decisions whose consequences are both unforeseen and undesirable from a variety of perspectives. None of this is to argue that efforts to develop quantitative analyses are undesirable and should be abandoned. Rather, the point of interest regarding the growth of knowledge is that the operation of environmental regimes privileges certain forms of analysis in a manner that not only devalues other techniques of analysis but that also can eventuate in decisions that are suboptimal.

Much the same is true with regard to the role of environmental regimes in promoting the development and use of analytic models. Models obviously have their advantages, especially in conjunction with efforts to manage complex systems. Among other things, they allow users to think systematically about the impacts of actions whose consequences are difficult to foresee in the absence of procedures directing attention to interactions that are unintended yet critical in terms of the overall performance of institutional arrangements. Even so, models can be misleading, fostering the illusion of comprehensiveness while systematically deflecting attention from important elements of complex systems. The use of MSY models focusing attention on the population dynamics of harvested species of fish without taking into account broader ecosystem dynamics provides a familiar example (Larkin 1977). There is much to be said, in this instance, for using whole ecosystem models even though they are much less fully developed and exhibit a tendency to become intractable. Comparable remarks are in order with regard to the
development of general circulation models (GCMs) in efforts to produce a holistic understanding of the Earth's climate system (Edwards 2001). Although GCMs clearly have their uses, it is now well understood that they overlook or distort a variety of processes occurring at the meso or regional scale. The purpose of these observations is not to deny or diminish the value of models as useful tools in conjunction with the operation of environmental regimes. But because regimes privilege models over other forms of knowledge, it is important to be conscious of the pitfalls as well as the advantages associated with their use.

A particularly interesting consequence of the development of international environmental regimes is the growth of interest in scientific (or integrated) assessments (Parson 2003; Mitchell et al. in press). In one sense, there is nothing new about assessments construed as efforts to take into account and merge the full range of scientific knowledge concerning a given environmental problem (e.g. climate change or the loss of biological diversity). In recent years, however, scientific assessments have become both more comprehensive and more systematic. As exemplified by the reports of the Intergovernmental Panel on Climate Change (IPCC), scientific assessments now consume large quantities of time and resources that could be invested in other activities. It is important to note in this connection that assessments differ substantially from research in the ordinary sense (Bolin 1997). They are intended to integrate and synthesize existing knowledge about policy-relevant matters and to encourage efforts to arrive at policy-relevant conclusions based on the best available information. There is undoubtedly a place for procedures of this kind. But it is important to note that scientific assessments divert resources from the pursuit of new knowledge, exert pressure to arrive at consensual results in situations where available knowledge is insufficient to warrant consensus, and are subject to manipulation on the part of actors or interest groups seeking to pursue their own objectives regarding the problem in question (Boehmer-Christiansen 1997). These concerns do not lead to the conclusion that we should back away from the growing tendency to make use of scientific assessments in connection with efforts to solve environmental problems. But they do suggest that a note of caution is in order as we move into an era characterized by the growth of interest in assessments in a variety of issue areas (e.g. the work of the Ozone Trends Panel, the Millennium Ecosystem Assessment, the Arctic Climate Impact Assessment).

2.3. Guiding Applications

**Proposition 3:** International environmental regimes affect the growth of knowledge by guiding applications of knowledge to public issues and, as a consequence, enhancing the credibility of favored streams of research. So far, I have been considering the ways in which institutions influence what is studied and how studies are carried out with regard to matters like the depletion of fish stocks, the spread of transboundary air pollution, and the loss of biological diversity. But there is another family of mechanisms through which institutions affect the growth of knowledge. By
influencing how knowledge is brought to bear on public issues and determining which types of knowledge claims prove effective, regimes send signals to the research community that influence the behavior of producers of knowledge.

Most regimes establish one or more portals that serve to structure the science/policy interface, and the nature of these portals affects the incentives of those who produce knowledge. Again, the case of climate change is a source of interesting examples. Initially, the climate regime relied primarily on the work of the IPCC as a source of scientific input (Sköldvin 2000). More recently, however, the Subsidiary Body on Scientific and Technical Advice (SBSTA), established under the provisions of Article 9 of the UNFCCC, has begun to reach out to other suppliers of knowledge expected to prove relevant to the treatment of climate change. This certainly does not mean that the IPCC will now go into decline. The influence of a variety of specific IPCC products, such as the special report on Land Use, Land Use Change and Forests (LULUCF), makes it clear that the IPCC remains a major player (Watson et al. 2000). But the efforts of SBSTA to assume a higher profile in this realm have led to a growing concern for issues like adaptation that are of interest to the developing world as well as for inputs from the community of social scientists working on matters like vulnerability, resilience, adaptation, and institutional responses to the problem of climate change. The mechanism at work in this case is not a matter of privileging some types of knowledge claims over others. Rather, it has to do with establishing preferences for certain suppliers of knowledge. Because different suppliers of knowledge engage in distinctive types of research and arrive at different conclusions, however, the effect is to exert influence on the types of knowledge that flourish and achieve influence in the policy process.

As the preceding discussion suggests, the desire to produce knowledge that is usable in connection with international environmental regimes exerts substantial pressure to reach consensus and to downplay areas of disagreement or controversy within the scientific community. This is perfectly understandable. The operation of any regime involves a political process; interested parties invariably seize upon indications of uncertainty or disagreement and manipulate them to their own advantage. Yet the resultant pressure to minimize disagreement can prove antithetical to the adversarial processes that are important to the growth of knowledge (Boehmer-Christiansen and Kellow 2002). Within reason, disagreement is a positive force in the scientific world. It motivates individuals to examine the arguments of their peers critically and to make a concerted effort to articulate their own arguments as forcefully as possible. The assumption here is that a constant process of challenge and response will yield more compelling results than a process in which producers of knowledge are encouraged to negotiate with one another and to make compromises in the interests of arriving at a united front in their interactions with the policy community. No doubt, it is important to avoid going to extremes in this connection.

Still, the pressures regimes exert on the producers of knowledge to converge on results they can represent as a consensus of the scientific community is a cause for concern in thinking about the impacts of institutions on the growth of knowledge.
Beyond this, institutions can affect the growth of knowledge by influencing the allocation of the burden of proof regarding issues of interest to the public. Consider the role of the precautionary principle in this connection (Freestone and Hey 1996). As applied to assessments of fish stocks, for instance, a precautionary approach would require the setting of TACs at levels calculated to minimize or even eliminate the dangers of serious stock depletions. In the absence of such an approach, on the other hand, managers can raise TACs so long as there is no decisive evidence that harvesting will lead to severe stock depletions. The knowledge required to demonstrate the existence of some (possibly low) probability of a stock depletion is quite different than the knowledge needed to show that a stock depletion will definitely follow from a certain level of harvesting. What makes this observation particularly interesting, however, is that the difference often goes beyond efforts to attach probabilities to specific events. Whereas a precautionary approach requires no more than a demonstration that adverse consequences are possible, showing that stock depletions will definitely follow requires a more deterministic form of analysis. Similar observations are in order with regard to climate change. It is one thing to demonstrate that climate change may occur as a result of increased concentrations of greenhouse gases in the Earth’s atmosphere. It is an altogether different matter to show that climate change will occur, much less to forecast how climate change will affect a variety of other systems. The policy relevance of these differences is obvious. Whereas those opposed to placing limitations on greenhouse gas emissions demand unambiguous proof of the adverse effects of climate change, supporters of limitations would require no such certainty concerning the biophysical and the socioeconomic processes involved. But the point I want to stress in this discussion is that different standards built into regimes regarding such matters can have substantial impacts on the growth of knowledge.

3. Policy Implications

What is the significance of the line of reasoning I have developed in the preceding section, and how should we respond to this reasoning in our efforts to create and operate environmental regimes to address a range of large-scale problems? One interesting inference to be drawn from this account has to do with the matter of regime consequences (Underdal and Young 2004). Institutions can and often do affect the growth of knowledge, whether or not these arrangements prove effective in the sense of solving or alleviating the problems that lead to their creation. Many fisheries regimes have had little or no success in ensuring sustainable harvests of targeted species, much less protecting marine ecosystems from collateral damage caused by large-scale fishing operations (Peterson 1993). The climate regime has failed to reverse trends involving emissions of greenhouse gases (IPCC 2001). Few would argue that the CBD has proved effective so far in dealing with worldwide losses of biological diversity (LePrestre 2002). Yet there is unambiguous evidence that these arrangements have contributed significantly to the growth of knowledge.
regarding the issues at stake. Difficulties associated with the use of MSY models have played a role in the shift toward whole ecosystems management emerging over the last several decades. The operation of the climate regime has contributed to the growth of research on climate change as a cottage industry in the scientific community. Activities associated with the CBD have helped to draw attention to a range of issues regarding the ecological and human health consequences of genetically modified organisms. Needless to say, the effects of these regimes do not constitute the whole story regarding the growth of knowledge regarding such matters. But it is hard to avoid the conclusion that they have provided some of the impetus behind the growth of knowledge in these areas.

Interestingly, there are cases marked by an inverse relationship between the effectiveness of regimes measured in terms of problem solving and the roles these regimes play in catalyzing the growth of knowledge. The mechanism at work here is simple. When existing models and techniques of analysis seem to produce acceptable outcomes, there is little incentive to adopt a critical perspective and to initiate a search for new ideas and new ways of understanding problems. Failure, on the other hand, gives rise to incentives to reexamine existing models and to develop new techniques in order to improve performance in the future. As the case of climate change suggests, this incentive to improve knowledge is apt to direct attention toward the need to learn more about the biophysical systems associated with specific environmental problems. But note that this mechanism can generate incentives to improve knowledge relating to the human dimensions of large-scale environmental problems as well. If a regime produces outcomes judged to be highly inefficient or seriously inequitable, for instance, participants will have reason to ask whether there are more efficient ways to achieve the desired results or procedures that can improve equity without undermining efforts to promote sustainability. Although the literature is imprecise on this point, it seems reasonable to describe the growth of knowledge attributable to the operation of this mechanism as a form of social learning (Social Learning Group 2001).

These comments demonstrate the need to examine the impacts of regimes on the growth of knowledge, even in cases where the performance of institutions is disappointing in terms of problem solving. But what other policy-relevant inferences can we draw from this account of institutions and the growth of knowledge? It is clear, to begin with, that there are no cognitively neutral regimes. Whether we like it or not, regimes function as driving forces in the growth of knowledge. It may be hard to determine whether new modes of thought serve to enhance social welfare or produce winners and losers in the sense of favoring the interests of some members of society over others. But there is every reason to think hard about the probable consequences for the growth of knowledge associated with different institutional designs and to factor this consideration into the assessment of alternative designs during processes of regime formation.

It is appropriate as well to enquire about cognitive opportunity costs associated with the operation of specific regimes. If we make the reasonable assumption that the time, energy and resources available to society to invest in the development of new
techniques of analysis and models are finite, it becomes relevant to ask about alternatives that cannot or will not be pursued when resources are channeled to the development of knowledge in a particular issue area. Needless to say, the relevant resources are not entirely fungible, especially in the short run. A scientist working on climate models cannot simply switch to research on issues relating to biodiversity when the institutional landscape changes. But as the case of the climate regime suggests, an institutional arrangement can produce striking consequences regarding the allocation of energy and resources among alternative research agendas. Other things being equal, the growth of knowledge will proceed more rapidly in areas favored as a result of the allocation of support for research. It is understandable, therefore, that those whose primary concerns center on matters like the alleviation of poverty or the improvement of human health will react with skepticism to the arguments of those who advocate sharp increases in the resources allocated to an issue like climate change.

Beyond this, it is important to draw a clear distinction between issues that are matters of policy and issues that can be addressed effectively through the pursuit of knowledge. Consider the idea of the precautionary principle again as a case in point. Should the burden of proof be assigned to users of natural resources who must show conclusively that their actions will not lead to environmental disruption or to opponents who must make a compelling case that these actions will prove disruptive? Additional research cannot produce a conclusive answer to this question; it is ultimately a policy choice. On the other hand, research may well improve our knowledge of the nature of environmental impacts arising from specific uses of natural resources and our ability to predict the likelihood of their occurrence. This, in turn, may help policymakers to decide whether or not to subscribe to the precautionary principle. The implications of this argument are clear. Although institutions are major drivers of the growth of knowledge, it is unrealistic to expect improved understanding to eliminate the need for policymakers to make choices about a range of matters like the adoption of the precautionary principle.

Finally, it is important to observe that there is no reason to suppose that all institutions are alike with respect to their impact on the growth and dissemination of knowledge. As is the case with other types of institutional effects, variance is a prominent feature of the landscape in this realm. If the argument this article presents is correct, therefore, efforts to explain or account for this variance will emerge as an important focus for research in the future. In the preceding account, I have touched on this subject in passing. But my primary concern has been to identify and illustrate the causal mechanisms through which regimes shape the growth of knowledge and guide its application to specific situations.

Acknowledgement

This article is dedicated to the memory of Virginia Walsh who played a central role in guiding the project on the Institutional Dimensions of Global Environmental
Change (IDGEC) toward a sustained interest in the links between institutions and
knowledge but who passed away before reaping the benefits of the resultant line of
enquiry.

Notes

1. The quotation is from Article 2 of the UNFCCC.
2. A multi-year study known as the Arctic Climate Impact Assessment (ACIA) and scheduled
   for completion in 2004 will offer a comprehensive review of these effects.

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