WHY CONVENTIONAL TOOLS FOR POLICY ANALYSIS ARE OFTEN INADEQUATE FOR PROBLEMS OF GLOBAL CHANGE

An Editorial Essay

The past three decades have witnessed an explosive growth in the development and use of tools for quantitative policy analysis. As policy analysts have turned to the consideration of climate and other problems of global change, they have found it natural to employ such now standard tools as utility theory, benefit-cost analysis, statistical decision theory, multi-attribute utility theory, and contingent valuation. However, many issues in global change involve temporal, spatial and socio-political scales that are significantly broader than those encountered in most traditional policy analyses. In such cases, the uncritical application of conventional tools can violate the assumptions on which they are based, produce silly or misleading findings, and occasionally lead to heated controversy, such as the one which erupted over value of life estimates in Chapter 6 of Working Group III in the report of the Intergovernmental Panel on Climate Change (Masood, 1995; Masood and Ochert, 1995; Pearce et al., 1996).

The source of difficulty is illustrated in Figure 1. Most tools of modern quantitative policy analysis were developed to address problems that lie near the origin in this space. As one moves outward from the origin, more and more of the underlying assumptions upon which conventional tools are based begin to break down. Because many problems in global change lie far from the origin on all three dimensions, one can expect that the straightforward application of standard ideas and methods will often fail.

1. Assumptions of Conventional Analysis

The best way to understand those limitations is to examine the basic assumptions on which most conventional policy analysis tools are based. In the discussion that follows we address six: (1) the assumption that there is a single public-sector decision maker who faces a single problem in the context of a single polity; (2) the assumption that the impacts involved are of manageable size and can be valued at the margin; (3) the assumption that values that are known, static, and exogenously determined, and that the decision maker should select a policy by maximizing expected utility; (4) the assumption that time preference is accurately described by conventional exponential discounting of future costs and benefits; (5) the assumption that uncertainty is modest and manageable; and, (6) the assumption that for most questions of interest, the system under study can reasonably be treated as

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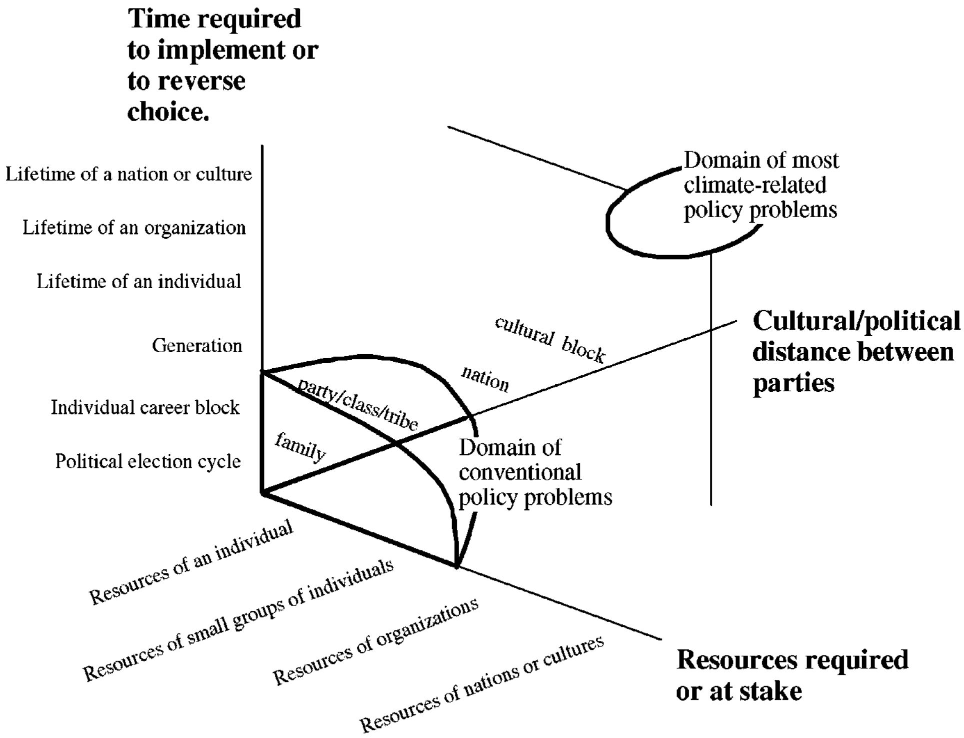

Figure 1. Policy problems can be placed in this space and their location used to evaluate the appropriateness of applying various policy analysis tools. For any particular policy problem the axes indicate the amount of resources required or at stake; the time-scale, both to implement and to reverse the effects of the choices available; and the degree of political and cultural homogeneity of the people involved. Most tools of modern policy analysis work best when the problem lies near the origin in this space. As one moves outward from the origin, more and more of the underlying assumptions on which these tools are based break down. Many problems of global change lie far from the origin on all three axes. Global change issues may involve very large costs, are often characterized by long temporal scales and associated intergenerational equity issues, and may involve a large political and cultural distance between many different parties, and an associated lack of shared metrics.

linear. Of course, not all conventional policy analysis makes all these assumptions. Even when it does, good analysts are often aware of the limitations imposed and take steps to address them, or at least discuss their implications for the results obtained. But, the difficulties that these assumptions pose appear to us to be greater in the context of global change than they are for most other domains of policy analysis. In the paragraphs that follow, we examine each in turn. While we have tried to be aware of these issues as we have addressed problems in global change, many of the criticisms outlined below can be leveled at our own work, as well as that of others.

The assumption that there is a single public-sector decision maker who faces a single problem in the context of a single polity: Some problems in global change do indeed involve a single decision maker: 'should I buy a house on the beach or on the hill?' But most problems involve multiple actors. Despite this fact, many analyses have been framed in terms of a single 'global commoner' (Peck and Teisberg, 1992; Manne et al., 1994; Nordhaus, 1994; Chao, 1995). Results from such analyses provide limited insight since many of the key decisions for a problem such as climate change will be made in a distributed manner by a variety of governments, private and public sector managers, and citizens. None of these actors can be expected to make decisions based on globally averaged values. Instead their decisions will be influenced by the specific costs they incur and choices they face. Their decisions will largely be influenced by local political context, local preferences and constraints, short-term economic needs, the set of options that they have available, and their associated local costs and benefits (Kingdon, 1995). Increasingly integrated assessment models are beginning to include spatial disaggregation to address this fact, but they still have difficulty incorporating the diffuse multi-party nature of the decision processes that will actually occur.

Global change affects many cultures and nations. However, in contrast to some 'global commoner' optimization models, most policy actors are not primarily concerned with maximizing joint utility functions. They want to stay in power, promote local industrialization, address distributional issues, and maintain cultural and political autonomy. Within single nations it might be possible to frame these differences as involving different values and decision rules within a single shared analytical perspective. On a global scale, even the language and ideas used in framing the problem may not be shared. Analysis that is not sensitive to these issues runs the risk of escalating pre-existing international tensions, making it even more difficult to reach agreements.

Problems that can arise in using a conventional analysis tool on a cross-cultural or multiple polity problem can be observed in debates over the classic investment rate to prevent premature mortality, sometimes termed the 'value of life'. While such numbers may have resource allocation meaning *within* a society (Graham and Vaupel, 1980; Viscusi, 1992; Tengs et al., 1995), there are serious problems involved in using them across societies. The authors of Chapter 6 of the IPCC Working Group III multiplied expected mortality estimates by local willingness to pay (in U.S.$) and summed these estimates to arrive at a global value. This approach makes several dubious assumptions: that methods for valuing life in terms of marginal changes in risk are appropriate even to those placed at high risk (Howard, 1980); that all players are prepared to accept such a utility-based framing; that dollars are the correct metric (as opposed, for example, to measures normalized in terms of the marginal utility of a dollar in each society, or the person-hours required to obtain particular resources in each society); and finally, that aggregation across disparate societies is meaningful.

The assumption that the impacts involved are of manageable size and can be valued at the margin: Many analyses of global change policy assume that impacts on society will be small compared with societal resources. Sometimes it is also assumed that they will be small for individuals. If changes are not small, they cannot be valued by extrapolating from valuations done at the margin. For someone who lives on potatoes, the cost of cutting back from 1000 potatoes per year to 100 per year is probably not just 9 times the cost of cutting back from 1000 to 900.

Barring catastrophes, it is likely that the average resident of industrialized countries will face modest market-based impacts from global change. However, this does not preclude some groups in industrialized countries from experiencing *very* large losses. Past experience with the victims of hurricanes, earthquakes, floods and crop failures suggests that the affected parties may exercise considerable political leverage and be able to induce very large social expenditures on their behalf (such as inducing the government to spend tens of millions of dollars on sea walls that protect homes worth hundreds of thousands of dollars). Such behavior is typically not included in global change analyses, with the result that actual costs to society may be underestimated.

The assumption of marginal valuations underlies the potential Pareto optimality criteria required for performing benefit-cost analysis (Mishan, 1973). Such analyses presume that beneficiaries can reimburse those who bear the costs (and that the losers should be willing to accept compensation in place of the benefit they forego). Marginal costs may indeed often be modest in the industrialized world. But, while analysts sometimes acknowledge the possibility of larger costs in the industrializing world, they typically employ valuation methods based on marginal analysis.

Benefit-cost analyses of global change that are applied to situations with manageable impacts often use willingness to pay metrics rather than willingness to accept compensation (Fankhauser, 1994; Pearce et al., 1996). For example, the recent IPCC analysis (Pearce et al., 1996) assumes that parties will accept compensation at the level of their willingness to pay. However, because people have finite resources, this value is often much smaller than the value of compensation that people would actually accept. This approach biases outcomes to reflect the choices and preferences of the economically wealthy who have substantial disposable income. Much as they may dislike some outcomes, poor nations do not have income with which they can pay.

Experimental results from behavioral decision theory have clearly demonstrated an ‘endowment effect’. Even for small changes, a loss is valued more than an equivalent small gain (Kahneman and Tversky, 1979). Thus, quite apart from income effects, small losses may feel bigger than equivalent small gains. Of course, such problems are not unique to global change. But as one moves further out from the origin in Figure 1, more and more people are likely to grow unhappy with an assumption that loss functions are, or should be, symmetric about the world’s current economic and ecological endowment.

In the less industrialized world, significant climate change may place entire cultures and ways of living at risk. Sea level rise may ultimately submerge some small island states. Cultures that are tightly tied to a particular ecosystem may no longer be able to pursue traditional practices. Even if their existence is not threatened, global change could have large negative impact on their agrarian economies (Lave and Vickland, 1989). Because the assumption that impacts are marginal is clearly violated in these cases, normal utility-based policy analytic valuation tools, such as benefit-coast analysis, will in general not be adequate to deal with such circumstances.

The assumption that values that are known, static, and exogenously determined, and that the decision maker should select a policy by maximizing expected utility: Most policy analysis does not address the question ‘where do values come from?’ Values are assumed to be there. If one needs to know values, ask the relevant parties and they will tell you. Elaborate procedures, such as contingent valuation, have been developed for eliciting responses (Fischhoff, 1997; NOAA, 1993).

Most people probably can accurately describe their values when the choices involved are choices they have faced repeatedly such as: ‘how much would it be worth to forego your favorite special blend coffee and instead have regular lunch-counter coffee?’ But global change decisions often involve evaluating choices with which people have not had past experience, such as: ‘how much is it worth to forego having maple trees in Vermont and instead have oaks?’ The assumption that people have well-articulated values for such changes seems highly dubious (Fischhoff, 1991). However, policy analysis on problems in global change sometimes proceeds as though foregoing maple trees in Vermont can be valued as readily as foregoing special blend coffee, and the values assumed can be the dominant variables in determining preferred policy responses (Lave and Dowlatabadi, 1993).

In addition, treating values as exogenous in environmental analyses ignores the fact that ‘a person’s or community’s *chosen* actions alter the characteristics of the chooser’ (Tribe, 1973). There is strong evidence in the psychological literature that people adapt and re-calibrate their values to their circumstances (Kahneman and Tversky, 1979). Consider, for instance, the changes in environmental values in the U.S. population over the last generation (Lowenthal, 1990), or, on a longer time-scale, the sweeping changes in the views of Anglo-Americans toward the ecology of North America (Cronon, 1983). We stand little chance of being able to predict future values. At the same time assuming that values will not change in the future is clearly wrong. An essential part of the challenge then is to incorporate uncertainty about future values into our analyses and to choose strategies that preserve future flexibility.

Since many considerations can be included in the definition of utility, in principle utility maximization can include a consideration of such issues as justice and equity. In practice, it is almost always implemented in fairly narrow economic terms, with the result that it becomes equivalent to maximizing economic efficiency absent costs associated with inequity and injustice. In addition, the different marginal utility of changes in personal or national income that are experienced by different actors is typically ignored. Such considerations may be acknowledged, but are treated as second order issues which can be resolved once the efficient solution has been found.

Most real decision makers do not hold out for optimal decisions. Rather they 'satisfice', accepting any option they find that gets 'close enough' to meeting their needs (Simon, 1945). Moreover, for governments, particularly representative democracies, considerations of justice and equity are often much more important than considerations of economic efficiency since distributional considerations can directly affect important political constituencies. Thus, even for analysis on problems that lie fairly close to the origin in Figure 1, finding the point of optimal efficiency is often not the true decision criterion. In problems of global dimension, distributional heterogeneity raises equity considerations of paramount importance.

Beyond this, there is a more basic problem. Many people are not prepared to frame all issues in terms of utility, arguing, for example, that some of the key issues involve basic rights and responsibilities, which can not properly be characterized in a framework which implicitly allows trade-offs between all attributes. The analyst may be able to describe these views with a very non-linear utility function, but the people involved are likely to insist that such a formulation violates their basic beliefs: 'don't try to tell us how much wealth this activity could produce, it is simply not acceptable'. Combinations of utility- and rights-based formulations may be more acceptable. However, because they believe that humankind has a responsibility for environmental stewardship, they may not be prepared to accept any trade-off for very large ecosystem losses (Kempton et al., 1995). Lastly, not all societies share a strong belief in a causal world over which humans can exercise considerable control. Utility maximization becomes particularly problematic when some of the actors adopt a fatalistic perspective.

The assumption that time preference is accurately described by conventional exponential discounting of future costs and benefits: Most quantitative methods for evaluating different long-term strategies require the aggregation of present and future costs and benefits to a common basis. The outcome of many global change analyses is highly conditioned on how these time preferences are treated. Following standard practice, analyses of global change typically discount future streams of costs and benefits denoted in monetary terms using an exponential weighting function and a single discount rate. There are a number of reasons to doubt the appropriateness of this strategy.

Economists typically differentiate pure time preference from the changes in marginal income that occur over time as consumption increases in a growing economy. They argue that when asked to value a single outcome at a fixed moment in the future, people typically display positive time preferences, that is, they prefer to get benefits as soon as possible and to postpone costs for as long as possible. This finding is experimentally supported when the valuation is for a single fixed cost or benefit. However, when future benefits and costs are embedded in a sequence of outcomes, positive time preference is often replaced by negative time preference. Summarizing the experimental literature, Loewenstein and Prelec (1993) argue that 'in general, an individual's valuation of complex sequences cannot be extrapolated in a simple way from his or her valuation of components but responds instead to certain "gestalt" properties of the sequence ... [People typically display] a preference for improvement and a desire to spread consumption over time'. While such time preference is often very much at odds with conventional exponential discounting, it can be perfectly rational. For example, many people would prefer two weeks in the Virgin Islands this winter followed by two weeks there several winters from now, over the option of two weeks there this winter followed by two weeks next winter. Such portfolio considerations are common, but are generally not addressed with normal discounting.

Denoting everything in dollars, rather than as utility, has the operational benefit that dollars can be added up, whereas utilities can not. However, as noted above, it is not apparent that the resulting sums have meaning, since the marginal value of a dollar varies widely with level of income. Other possible normalizations, such as in terms of the amount of time people have to work to earn a dollar in different parts of the world, also present problems. For example, life expectancy may differ by as much as several decades between the industrialized and the industrializing worlds. To complicate matters further, Axtell (1992) has shown that when one combines the valuations of a number of individuals, each of whom is prepared to use exponential discounting, the resulting combined valuation is not properly represented as an exponential.

Global change problems can involve impacts that occur across wide intervals in culture, space and time. Schelling (1995) has argued that investments made today to avoid or reduce global change amount to an income transfer to future generations. Thanks to technology and economic growth, future generations who live in the developed world will probably enjoy a much higher income than we do. Unless the non-market impacts of global change are very large, such a policy constitutes a transfer from us to wealthier people who we will never know. Public policies which transfer income to anonymous wealthy people are typically unpopular and hard to defend.

Barring catastrophes, it seems likely that more wealthy future generations in the developed world will be able to deal with the impacts of global change without too much difficulty. The principal beneficiaries of investments made today will be the residents of the economically less developed world. Schelling suggests that one should compare the efficacy of proposed transfers of income to future generations in these regions with income transfers made today to improve education, public health, population control, infrastructure, etc. The routine application of conventional discounting masks such difficult choices.

The assumption that uncertainty is modest and manageable: There are well developed tools for dealing with parameter uncertainty as well as limited strategies for dealing with uncertainty about the proper functional form of models (Morgan and Henrion, 1990). A growing number of contemporary models of global change processes explicitly include probability distributions for model variables

(Weyant et al., 1995). However, global change problems entail interactions between complex natural and social systems over long time-scales. The structure of some of these systems may be known, but the structure of others, can not be reliably predicted on century time-scales. Yet, many models that combine economic, ecological and geophysical models are frequently run for a century or more into the future. The failure to recognize, analyze, and report the mixed levels of uncertainty in such analyses can produce results that are seriously misleading. When the basic structures of the models are uncertain, and when uncertainties change significantly over the time horizon of the analysis, conventional tools for analysis and display of uncertainty are inadequate.

System linearity: Problems of global change involve complex nonlinear interactions among physical, ecological and social systems, many of which are not well understood. In order to make progress, it is often necessary to isolate and linearize key parts of these systems. While this procedure allows us to understand some important issues, it can mask others, such as key feedbacks and irreversibilities. Thus, a variety of different analytic formulations is needed, along with a process of iterative refinement. Analysts must be modest in the generalizations they reach and must search constantly for issues that current analyses do not address.

2. Conclusions

Conventional tools of policy analysis, routinely applied, can lead to wrong or silly answers in studies of global change. To avoid such failures, analysts (among whom we include ourselves) must think much more carefully about the assumptions on which their ideas and tools are based before applying them to problems that lie far from the origin in Figure 1. All of us must work to use the available tools in appropriate ways, point out problems when we see them misused, devote more of our attention to devising new analytical strategies to overcome clear difficulties, and interpret results with appropriate caution and humility.

Though widely promoted, by ourselves and others (Dowlatabadi and Morgan, 1993; Weyant et al., 1995; Rotmans and Dowlatabadi, 1998) integrated assessment, at either a local or a global scale, does not automatically address or resolve these problems. The point of integrated assessment is to synthesize the scattered knowledge available on a problem, along with associated uncertainties, in order to better understand where we are, where we are going, and what we might do. In performing such synthesis, analysts must start by employing the tools and techniques at their disposal, most of which are the same tools we have discussed in this article. If they are observant and self critical, they will understand that these tools have limitations, and they can work to make improvements or find alternatives. The process of trying to perform integration can help to make the limitations of tools more apparent, but the simple fact of integration does not make the problems go away.

Some problems, such as predicting future human values, future technological capabilities, or the structure of future socio-economic systems, are probably insoluble. In such cases, we must find strategies, such as parametric analysis, to work around the limitations. In some cases, we may only be able to specify broad behavioral patterns. In such cases, we may still be able to gain insights with analyses that use new methods. For example, rather than modeling social systems directly, we may be able to model behaviorally realistic sets of artificial, interacting adaptive agents in order to explore winning strategies of learning and response in an uncertain evolving world. In this way, we may be able to gain an understanding of the general character of responses that can be expected under various circumstances, even if prediction of specific responses is beyond our abilities.

Even the best analyses cannot offer magic solutions to the difficult global policy problems such as climate change. But thoughtful analysis, both qualitative and quantitative, is really the only approach we have to improve the quality of our understanding. We in the analysis community must stop viewing global change as yet another opportunity to apply our existing tool kit. We must view the problems of global change as an opportunity to better recognize the limitations of current tools, and as a test bed in which to develop new formulations and analysis methods. Unless this happens, the recent flap over Chapter 6 of IPCC Working Group III, will be only a foretaste of things to come, and formal analysis may become increasingly marginalized in future policy debates.

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