Values in the Economics of Climate Change

MICHAEL TOMAN*

RAND Corporation
Washington DC
Email: mtoman@rand.org

ABSTRACT

Economics has played an important role in assessing climate change impacts, and the effects of various individual and policy response strategies. Proponents of a key role for economics in analysis of climate change policies and goals argue that its capacity to incorporate and compare a variety of costs and benefits makes it uniquely useful for normative assessment. Critics of economic analysis of climate change have questioned not only its empirical capacities, but also its fundamental usefulness given some of the important but often implicit assumptions on which it is based. After reviewing this debate and its implications for public policy on climate change, the paper sketches a way in which more technical economic analysis and public dialogue might be combined.

KEY WORDS

Climate change economics. integrated assessment. cost benefit analysis. discounting. sustainability

INTRODUCTION

Economic analysis has played a significant role in the analysis of various aspects of climate change. This is illustrated well by its role in the assessments produced by teams of international experts under the auspices of the Intergovernmental Panel on Climate Change (IPCC; see particularly McCarthy et al. 2001 and Metz et al. 2001). Economics has figured prominently in the assessment of impacts on human society of climate change and in the assessment of the pros and cons of various response strategies, with respect to both adaptation and mitigation.

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* This paper was prepared while the author was an adjunct faculty member, Nitze School of International Studies, Johns Hopkins University and Bren School of the Environment, University of California Santa Barbara.

The role played by economic analysis of climate change in the IPCC and in other contexts is part of a broader effort that seeks to improve scientific understanding of climate change processes and their consequences in support of determining, in the spirit of Article 2 of the 1992 UN Climate Convention (UNFCCC 1999a), what constitutes 'dangerous anthropogenic interference' with the climate system. Efforts to improve scientific understanding are important contributions to better decision making. However, such efforts can also mask deeper and more complex disagreements about social values. Neither science in general nor economics in particular can resolve the fundamentally moral issues posed by climate change. What scientific understanding, including economic understanding, can do is to help inform the definition and application of moral principles used for assessing the danger and developing public policy responses. To play this role in turn requires that the key assumptions and value judgments underlying the various analyses be understood.

No less important is the clear understanding of the principles underlying various policy prescriptions themselves. Advocates for a wide range of views regarding the risks of climate change rely upon a variety of principles to justify prescriptive positions. The very diversity of these principles highlights the difficulties encountered in establishing broader social agreement on what is needed and what should be done. In this context, advocates of economic analysis argue that its capacity to incorporate and compare a variety of costs and benefits makes it an important or even uniquely qualified tool. Critics of economic analysis of climate change have questioned not only its empirical capacities, but also its fundamental usefulness given some of the important but often implicit assumptions and value judgments on which it is based.

These value assumptions need to be more broadly understood in order to evaluate what economic analysis can and cannot contribute to understanding of climate change policy.[1] But once these assumptions are understood, the question of how or if to use economics to assess climate change risks and policies remains. Some critics of economics seem also to be questioning the general usefulness of traditional scientific practices for climate change risk and policy assessment. One implication of this view is that a focus much more on the procedures of societal evaluation, information sharing and decision making is needed to advance morally acceptable and politically sustainable results.

I think there is great merit in this. However, a relatively exclusive focus on the processes of societal dialogue and decisions in the belief that these will generate good answers seems to me as problematic as trying to rely primarily on technical analysis to justify a moral decision. Climate change is fraught with basic uncertainties; nonetheless, economics can contribute useful information to the debate on how to address the issue. To conclude the paper, I sketch and discuss an admittedly idealised process for integrating technical analysis and public give-and-take in the direction of climate change policy.

CLIMATE CHANGE AND THE SCOPE OF ECONOMIC ANALYSIS

Since the literature already contains several very clear and complete treatments of the challenges climate change poses as a public policy issue, and the scope of economics as applied to climate change, this section of the paper will only summarise some of the key points.[2] 'Climate change' is an umbrella term for a number of very complex changes in a very complex natural system. The impacts from a policy perspective are the results of complicated chains and feedback loops involving changes in the earth's atmosphere and the physical implications of those atmospheric changes. The human consequences range from changes in agricultural productivity due to altered temperature and rainfall patterns, and threats to human health from extreme weather and an increased range of tropical diseases, to loss of species and alteration of natural systems whose value may be emotional and spiritual as well as ecological.

It is commonplace to observe that climate change is an issue fraught with uncertainty. However, this word tends to have different layers of meaning that need to be separated in this context. As scientific understanding of climate change increases (including the economic dimensions), it becomes more possible to describe the risks of climate change in a quantitative way. At this stage, however, both the level of scientific ignorance about the phenomena, and the sheer scale of the potential implications in time and space, suggest that uncertainty about climate change involves more than risk assessment; key aspects about the impacts and their consequences are indeterminate or may lie beyond the grasp of human imagination. This uncertainty encompasses not just the chain of physical consequences, but also the identification of what impacts are important from a policy perspective. Values themselves are uncertain, which implies a challenge for the design of scientific investigation which incorporates implicit value judgments about what is important to investigate.

While there is some diversity in the field with respect to approaches and assumptions, climate change economics by and large falls more or less within the mainstream of economics generally. It is based on an individualistic conception of preference satisfaction through utility maximisation. The climate economics literature, like the environmental economics literature more generally, emphasises the presence of externalities and the need for corrective policy actions.

Economic analysis explores the ways that individuals may respond to specified change impacts, or climate change policies, and the implications of those impacts and response strategies (personal and policy related) on individual well-being. With respect to behavioural responses, much of the literature on mitigation policy is concerned with how individuals may respond to changes in energy prices or regulations, since fossil fuel combustion is the principal source of greenhouse gas emissions (GHGs).[3] Key analytical uncertainties in this literature echo previous controversies in energy policy literature related to resource scarcity and economic regulation of energy markets. One of the most important controversies involves the nature of individual incentives for energy efficiency and conservation, and the extent to which non-price regulations like appliance and vehicle efficiency standards can engender low-cost or even negative-cost improvements.

Economics is also important for understanding the potential for adaptation to anticipated or realised climate change impacts.[4] For example, to the extent that individuals can anticipate changes in temperature and rainfall, they can change what they grow as well as where, and they can organise individual and collective investments in research to increase adaptation options. Over the past decade or more, a growing number of micro-level analyses have been exploring the potential role that adaptation can play in reducing the long-term threat of climate change (see e.g. Mendelsohn 1999 and Mendelson, Nordhaus and Shaw 1994). For example, analyses of long-term cross-sectional agricultural productivity differences have been used to understand what long-term adaptation could accomplish in adjusting to a new climate regime. These kinds of studies have been supplemented by a smaller number of analyses of the costs of adjusting to a new climate system, and of how climate variability itself could give rise to costs as well as how adaptation could limit these costs.

While uncertainties and controversies remain abundant in this literature, it has definitely contributed to our understanding of the *potential* for adaptation and how that potential can be affected by economic incentives. The economics of adaptation also encompasses an assessment of institutional and resource scarcity barriers to better adaptation responses. Adaptation potential will be lower, for example, where knowledge or finances to alter crop patterns are limited, including subsistence agriculture practiced by the poor.

Normative economic analysis has been applied to climate change impacts and policy scenarios in an effort to understand the impacts and policy implications in terms of human welfare measures. For example, a model of how temperature and rainfall may change as a result of climate change can be combined with a model of how these factors influence crop yields, and that model in turn can be combined with economic data on returns to agriculture and demands for commodities to evaluate how climate change will have economic consequences for agricultural sector incomes, for household food costs, and for overall economic well-being. Studies of this type across the range of potential climate change impacts can shed light on the costs of climate change across space and time, though in practice empirical measures of these costs are still limited and very uncertain.

Much of the economic analysis of mitigation policy has addressed the economically quantified benefits and costs of policy options to make statements about 'efficient' or 'optimal' policy interventions. These approaches start with a monetarily quantified aggregate climate change cost function which also represents the economically measured benefits of averting or slowing impacts, ideally once adaptation has also been taken into account. Information on avoided costs, along with information on the costs of mitigation primarily through reduced net greenhouse gas (GHG) emissions, provide a basis for comparing economically different combinations of mitigation measures (e.g., reforestation to sequester CO_2, renewable energy development to lessen gross emissions, and improved landfill and agricultural management to reduce emissions of CH_4, a much more potent GHG).

Typically 'optimal' mitigation economics is studied through application of relatively compact reduced-form 'integrated assessment' models that combine summary and aggregative representations of monetised climate change impacts with reduced form models of economic activity (in particular energy use) that are the sources of climate-forcing GHG emissions (see Weyant et al. 1996 for a summary of the approach and Nordhaus 1993 for a pioneering example). These models basically are examples of intertemporal cost-benefit analyses using a discounted present value criterion as a welfare measure (the present value could be of net consumption possibilities or of consumption utility depending on the model). In these models mitigation is a global public good in that GHG reductions occurring anywhere create benefits in reducing climate change damage costs everywhere. A spatially disaggregated integrated assessment analysis can indicate a globally optimal time path of emissions mitigation according to the aggregated net present value criterion employed, and allocate shares of the mitigation across national units based on cross-country relative costs (efficiencies) of mitigation. A refinement of this analytical outcome also considers any locally realisable co-benefits from GHG mitigation in allocating shares of mitigation action (e.g., different degrees of local air quality improvement).

Economic analysis has made key contributions to the design of GHG mitigation policy, drawing on broader lessons for policy design identified in the general literature on environmental economics. The use of emissions trading to lower overall mitigation costs and soften political objections in the allocation of mitigation costs is reflected in the European Trading System for CO_2 emissions, which began operating in 2005. This same idea is captured in the Clean Development Mechanism of the 1997 Kyoto Protocol (UNFCCC1999b), which provides for voluntary and mutually beneficial collaboration in project-level GHG mitigation and sustainable development by richer and poorer countries.

Economic modelling has highlighted the potential for cost-saving intertemporal flexibility in GHG mitigation. As shown by Wigley, Richels and Edmonds (1996) and subsequently elaborated by others, there can be several advantages to setting ambitious medium to long term global mitigation targets while also approaching their implementation more gradually. Aside from the most immediately apparent argument that mitigation costs incurred later have a lower discounted present value, a gradual approach also allows a less costly phasing out of more GHG-intensive technology and a more opportunistic phasing in of new advances in long-lived GHG technology as they occur.

There are controversies in the economics literature on mitigation policy design as well, even if one accepts the underlying valuation metric. One practical concern is that economists may oversell incentive mechanisms by making them seem like a panacea that does not require any real regulatory effort. Policies such as emissions trading do not work if there are no credible mechanisms for setting limits and assessing compliance as well as for sanctioning non-compliance. This is especially difficult internationally, but it is also a challenge in developing countries (see e.g. Blackman and Harrington 2003).[5] With respect to intertemporal flexibility, a more gradual approach provides weaker incentives for inventing and testing breakthrough technologies for providing lower-GHG energy services, versus locking in a higher-GHG energy system that is costly to undo later. It could also become a rationale for ongoing renegotiation of future targets to push unpleasant costs into the future.

HOW MUCH CLIMATE CHANGE IS TOO MUCH?

If it were known or understood with high probability that climate change will engender completely catastrophic losses (e.g. destruction of human society, despite adaptation) within a certain time frame or at a certain threshold level in terms of changes in the atmospheric concentration of GHGs, it would be relatively easy to answer the question posed above. This is not the case, however. Certain key features of climate change and its impacts illustrate the extreme difficulties in wrestling with this question, and provide a backdrop for considering various approaches to illuminating possible answers.

The scale and complexity of climate change risks indicate that it is, at the very least, challenging to approach the issue using typical constructs of individual decision making under risk. The kinds of problems that could result from climate change, in terms of size and timing, are difficult to characterise in ways that can be evaluated in terms of tradeoffs. This suggests that personal evaluations of climate risks or the benefits of policies will greatly depend on how people interpret these unfamiliar potential outcomes relative to more familiar experiences, and that these evaluations will evolve over time as people individually learn more about climate change and as they participate in public dialogues on the subject. It is therefore important to be able to communicate a variety of different kinds of information about climate change risks and policy impacts, including information about physical consequences as well as economic benefits and costs. It is important also to communicate as much as possible about the range of possible outcomes and their consequences, even if this must be done heuristically given the absence of more statistically based risk distributions.

The nature of climate change as a global and intertemporal externality further complicates its assessment in a policy context. Climate change will likely have sharply different impacts on poorer versus wealthier societies; at least in a relative sense there will be important differences between winners and losers. Moreover, the risks of climate change, and the benefits of policies undertaken to mitigate it or promote adaptation, will redound much more to future generations than the present, while the costs of policies will be borne more in the nearer term. Evaluation of climate change policies thus cannot be separated from values and principles related to intergenerational altruism and responsibility, even though the altruism and responsibility apply to entire generational cohorts, not just to narrower affinity groups (family, community, even nation).

Against this backdrop, we can identify some of the key challenges or limitations in the application of normative economics to climate change policy. Perhaps the most discussed feature of the integrated assessment approach for evaluating GHG mitigation policies is the use of the discounted present value criterion, and the associated challenge of selecting a discount rate. As noted for example by Howarth (2005), Gardiner (2004) and a number of authors in Portney and Weyant (1999), the present value approach takes a formulation of intertemporally efficient resource allocation by a single individual and converts it to an approach for characterising optimal intergenerational allocation.

The approach almost inherently implies relatively modest mitigation efforts by the current generation and a bequest of a larger climate change problem to future generations (absent highly successful adaptation, which is not usually assumed in the models). This is the case even with relatively low settings of the intertemporal discount rate, and even if there is a probability of a future climate catastrophe (see the modelling experiments in Manne 1996 for illustration of this).[6] The resulting intertemporal allocation of mitigation activity and of social welfare is quite different than would be implied by alternative criteria, be they classical utilitarianism that weighs all generations equally or a human rights-based approach (implemented analytically perhaps through an overlapping generations model of the type in Howarth 1996) in which future generations are treated as having an entitlement to a minimum level of well-being.[7]

Discounting is important in economic analysis of policies in order to reflect the opportunity cost of capital. If resources diverted to GHG mitigation would have had higher marginal value added in other uses, future generations would be better off if the resources were put into those alternative uses, even if the result also is a more degraded climate system. However, this reasoning depends on the assumption that it is physically possible as well as socially acceptable to admit a wide range of tradeoffs between climate change damages and other economic values. There are possibilities of severe adverse impacts, though their likelihood may be small; the standard integrated assessment approach gives equal probability-adjusted weight to all possible outcomes, as opposed to incorporating some form of risk aversion (see e.g. Roughgarden and Schneider 1999).

The level of aggregation in integrated assessment models may also blur some other distributional issues. Typical models consider either the entire world as a single unit, or countries or groups of countries as units of decision and points of impact. It is thus difficult to reflect cross-sectional differences in vulnerability to climate change and in benefits from mitigation. If lower-income people benefit more in a relative sense from cost-reducing mitigation precisely because they are poor (and therefore have a higher marginal utility of income as well as greater vulnerability), then an aggregate net benefit measure should incorporate weights that differentiate benefits from mitigation for rich and poor (for an example see Azar and Sterner 1996).

Even when the mitigation analysis models are disaggregated to a country level, the analysis of globally optimal mitigation does not indicate who should pay for the mitigation. This fairly obvious point is highlighted by the negotiations that led to the formulation and the ratification of the Kyoto Protocol, as well as by analytical work on the political economy of international environmental agreements (e.g., Barrett 2003). The developing countries have not accepted numerical targets for their emissions; only voluntary opportunities for GHG mitigation with side payments through the Clean Development Mechanism. Developed countries for their part have (in varying degrees and with varying amounts of candour) been reluctant to accept numerical targets that would imply an uncomfortable level of domestic burden. They appear to have been relatively unmoved by the plethora of alternative equity criteria that have been advanced in the literature (e.g., Rose and Brandt 1993, Gardiner 2004). While genuinely concerned in many cases about the future of the global environment and about the plight of poorer countries, there has been nonetheless a relatively strong adherence to the *de facto* property rights of incumbent emitters, as opposed to an alternative that might envisage a greater sense of liability and responsibility for mitigating or financing mitigation by others more actively.

Based on cost-benefit assessments and political economy analyses, some analysts have called not just for greater attention to adaptation – seemingly a non-controversial point – but for a primary emphasis on adaptation. This argument is probably made most penetratingly by Schelling (see e.g. Schelling 1997).[8] He argued not just that adaptation may be more cost-effective, but also that support of it may be more compatible with incentives of those in rich countries who would have to provide support for responses to climate change in developing countries as well as their own. Schelling asserts, in essence, that while foreign assistance incentives seem generically to be low, it may be easier to make the case for supporting current residents of developing countries in efforts to improve their lives *and* make them more resilient to climate change, than it will be to make the case for costly mitigation measure – especially if those measures are borne initially mainly by the richer countries and especially if future citizens of developing countries are expected to be a lot richer after successfully adapting to climate change.

Schelling's argument depends on the assumption that adaptation is highly likely to succeed in blunting the worst effects of climate change. It would then be irrational to invest in adaptation to the point that no residual impacts were realised, since that would likely involve incremental costs to the developing country beneficiaries of the effort well in excess of the benefits. Another key premise is that citizens of rich countries do not have established moral obligations to assist either their poorer neighbours today, or future generations in their own or other countries to cope with the longer-term consequences of GHG emissions that still arise primarily from actions by richer citizens (see e.g. Jamieson 2005).

As noted, the potential for adaptation may be highly constrained in poor countries by poverty itself or by its consequential limitations in human capital, access to technology, or institutional capacities. The realisation of the potential for adaptation depends on actions to lower these barriers (and even some similar barriers in richer countries). Yet economic analysis of climate change often treats adaptation as a private good that the poor countries must provide to maximise their own utility within the limits they face on doing so. The *de facto* property rights assigned to the richer countries with respect to their past and current usage of GHG sinks implies no liability for assisting in adaptation either, except insofar as they see it in their own self-interest to do so (whether that self interest is altruistic or born of a desire to avoid risks from international ecological degradation, or other factors).

One other critique of climate change economics as a guide to policy involves the use of a single-dimension net benefit measure for evaluating different outcomes. This reflects the standard assumption in economics that all costs and benefits are commensurable and interchangeable once expressed in a common metric (a monetary metric as a representation of unobservable utility). There may be serious measurement problems in implementing such a reductionistic metric, but as a concept the notion of full tradeoffs and thus full *potential* compensability of losses from climate change is ubiquitous in the economic model. This view differs from alternatives that see different kinds of values as less commensurable, e.g., some losses of natural beauty or function simply cannot be compensated by other welfare gains (see e.g. Norton and Toman 1997 for further discussion of some of the controversies surrounding the commensurability issue and the implications for policy).

INTEGRATING ECONOMIC ANALYSIS AND PUBLIC DECISION MAKING FOR CLIMATE CHANGE POLICIES[9]

The challenges posed by climate change and the challenges to applying economic analysis raise the question of what can be done with respect to normative analysis of climate change risks and policies. One relatively unprofitable strategy is to minimise the urgency of the problem. This can be done in different ways and is not the unique province of one political persuasion. Within the administration of George W. Bush the emphasis has been on the need to augment 'sound science' and broaden participation by developing countries before taking significant or mandatory actions. Within the Clinton Administration, on the other hand, the tendency often was to downplay economic analyses of GHG mitigation costs, and to argue that a combination of voluntary measures and international emissions trading would make significant GHG cuts possible at negligible or even negative cost.[10]

Another approach is to argue that decisions about GHG mitigation and adaptation policies are essentially political. Arguments for this view include the idea that technical analysis of costs and benefits from GHG policies inherently cannot reflect the complex preferences and values of 'real people;' and that scientific analysis (physical, not just economic) cannot provide a robust basis for evaluating policy options since scientists themselves make value judgments about what facets of climate change are important to understand better and how to go about studying them (Norton 1992). In this view, climate change policies become legitimated through transparent and fair political processes that command sufficiently broad public support.

Transparent and fair political processes are clearly important to the determination of sound climate change policies. But informed processes are important as well. While admittedly somewhat of a caricature, the view expressed in the previous paragraph seems to be too nihilistic with respect to the ability of scientific analysis to provide useful information, and the ability of the public to assimilate and benefit from that information. Some intermediate position seems more profitable. One such approach can be outlined by combining two ideas already discussed in the environmental literatures: the notion of methodologically pluralistic approaches to goal setting and evaluation, and the notion of iterative processes for public information and decision making.

Climate change seems to be an issue well suited to 'two-tier' frameworks for structuring goals and assessment of options, though there are still serious operational problems to be overcome in using such an approach (see Toman 1994 and Norton and Toman 1997 for discussions). In this sort of framework, decision makers first consider what criteria and management tools to apply to a particular issue. Human impacts on the environment that are larger in scale and longer in duration give rise to greater concerns about the opportunities for well-being available to future generations (as well as to the present), and about the constraints on opportunities for amelioration of adverse effects through resource substitution and innovation. In such cases, standard economic calculations need supplementing with information about the physical robustness of underlying ecological systems and the potential consequences over time, and by information about social norms (e.g., basic presumptions about fairness to existing communities and future generations) that might be affected. Impacts that are smaller in scale and shorter in duration are more amenable to being treated through conventional cost-benefit tools, supplemented with information about nonmonetisable impacts and distributional consequences.

In the context of climate change, mitigation policies undertaken by the current generation will impose costs (and generate some ancillary benefits, like air quality improvements) for the current generation. These costs should be assessed to the extent possible using the best state of the art in economic analysis, including procedures for intragenerational discounting that reflect the opportunity costs of changes in consumption and investment streams. The benefits of action or the costs of inaction, on the other hand, are more complex to assess since they involve significant redistributions of income between current and future generations; they will accrue globally, not just to our own heirs; they are difficult to estimate; and they will depend on the actions taken – for example, actions to reduce future risks by limiting greenhouse gas emissions, versus actions to promote adaptability to future climate change that can also provide more immediate economic development benefits. Simply calculating the present value of these effects as they appear to the current generation does not provide an adequate basis for evaluating different outcomes. An alternative is to provide a description of the effects (monetary and otherwise) and their timing, so that decision makers can weigh these effects and their costs against a variety of ethical criteria and the expressed wishes of various stakeholders.

This approach uses multiple normative perspectives in the first tier to assess how an issue should be judged, and then in the second tier in evaluating the issue and decisions (though the mix of perspectives will vary depending on the first tier outcome). This is not just an application of 'scientific' policy analysis, as can be underscored by the fact that value judgments will permeate the first tier categorisation as well as guiding the second tier evaluation. The process thus can operate successfully only if it is superimposed on a mature ongoing social discussion about which values matter in which contexts. This superimposition enables an interaction between science, on the one hand, and the process of values formation and education, on the other.

To go further along these lines, we can envisage an approach to evaluating climate change policy goals and options that is not only pluralistic but also iterative, to reflect and support processes of public learning and value formation. The process might take the following very stylised form:

(1) *Prior assessment of what criteria and evaluation tools should apply to the issue*. In the two-tier model sketched above, this amounts to assessing where the issue lies on a continuum between a basic analysis of economic tradeoffs and an analysis more circumscribed by physical limits on substitution and the operation of broader social norms, which themselves must be identified.

(2) *Assessment of physical impacts from different courses of action to the extent possible, with particular attention to their scale, to the identification of impacts that are difficult to evaluate in monetary terms, and to distributional issues across space and time*.

(3) *Assessment of economic benefits and costs from different courses of action to the extent possible, as well as their incidence in space and time.*

(4) *Further identification of whether and how social values or norms beyond the quantified benefits and costs may be affected by a decision.*

(5) *Engagement of public discourse about both the consequences of different actions and the applicable social values, especially where operable norms are not clear-cut or are conflicting*. This is the step that explicitly acknowledges that the decision process cannot be purely scientific. The public engagement can take various forms, from educational programs to multiple-stakeholder negotiations to interagency debates characterised by disclosure and electoral accountability.

(6) *Decisionmaking based on the pluralistic approach and criteria outlined above*.

(7) *Using the results of the decision process to consider what new information and uncertainties have been revealed about both science and social values, and plugging these insights back into both the values discourse and scientific research agendas*.

This conceptual model retains an important role for economic analysis, but it seeks to broaden the analysis beyond a single net benefits calculation and to embed it in a broader discussion of social values and potential actions. The approach seeks also to emphasise that debate on climate change (or more generally, on sustainability) cannot be resolved solely by recourse to natural or social scientific inquiry. For example, substantial progress in resolving uncertainties about the effects of greenhouse gases on the world's climate system, and the effects of climatic changes on ecological systems and human well-being, will not in themselves address basic disagreements about the importance of humans versus nature.

As already indicated, the application of the idealised approach sketched here presents enormous practical challenges, especially given that the issue touches on everybody (versus, for example, a local land use squabble) and involves such high levels of uncertainty. How to translate this almost metaphorical set of ideas into action is itself an important research task beyond the scope of this paper.11 Even if climate policy debates remain mainly the province of public officials and technical specialists, however, there are still lessons to be drawn. Informed consumers of climate change policy analysis can ask for greater clarity in underlying assumptions about principles as well as methodologies. Analysts can organise their work in ways that reflect the need for pluralistic evaluations, multiple types of information. Both analysts and policy makers can communicate conclusions in ways that better support evolving public understanding and values with regard to climate change.

NOTES

This paper owes much to many exchanges over the years with several friends and colleagues too numerous to name here. It has also greatly benefited from the comments of two referees. I alone am responsible for the ideas expressed here, and for any errors and weaknesses in their exposition.

[1] Assumptions also need to be made transparent in other approaches. For example, some initial attempts in the climate policy literature to define a 'precautionary principle' for climate change mitigation with reference only to scientific data on climate change and its impacts assume incorrectly that such data in themselves can resolve moral issues.

[2] See in particular Spash (2005).

[3] The mitigation literature also is expanding to include how changes in land use and forestry policy, or solid waste policy, may alter net emissions of carbon dioxide and methane.

[4] Anticipated impacts are themselves the product of scientific modelling and other analyses, with their attendant uncertainties.

[5] It is important to keep in mind that non-incentive-based regulatory alternatives still give rise to both monitoring and compliance problems.

[6] A very low discount rate, or a probability of catastrophe that endogenously grows as GHGs accumulate as a consequence of current economic activity, can engender more aggressive optimal mitigation early on.

[7] As several authors including Howarth (2005) and Weitzman (1998) have pointed out, even within a very mainstream approach to climate change a case can be made for discounting the future at a lower effective rate in integrated assessments of GHG mitigation since mitigation also conveys benefits in reducing the overall variability of income over time.

[8] In a more recent article, Schelling (2002) makes a stronger argument for the need by developed countries to do more on GHG mitigation.

[9] This section of the paper draws from Toman (1999, 2005).

[10] For further discussion see Toman (2004).

[11] Advances in information and communications technology make putting some of these ideas into practice less far fetched than it might first seem. The bottom up way in which content on Wikipedia develops and is reviewed is one example.

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