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Short communication

Some thoughts on perspective

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This issue of *Global Environmental Change* (and the OECD Workshop from which it emerged) focuses our attention on the benefits of climate policy—specifically, the damages of climate change and climate variability that could be avoided by mitigation. Having some idea of the size of the benefits that can be attributed to mitigation would certainly seem to be a critical piece of information for decision-makers who are contemplating global responses to climate change from a cost-benefit perspective. Notwithstanding the contributions of the authors whose work appears in this issue and elsewhere, however, we should be concerned that the research community has not yet advanced to the point where it can offer these decision-makers reliable estimates of global benefits that they require. Building on the insights reported by Yohe and Schlesinger (2002), this brief note explains why in Section 1 *it is essential to recognize, however, that these concerns do not imply that decision-makers should delay mitigation interventions until our knowledge of global benefits improves*. Instead, as argued in Section 2, these concerns suggest that a different, risk-based precautionary perspective might be a more appropriate context within which to frame discussions of near and medium-term mitigation strategies.

1. Sources of concern

The benefits of climate policy are derived primarily from damages that can be avoided by mitigation. Many of the papers offered in this issue address the issue of estimating avoided, but a careful reading of their content reveals that the benefits of mitigation cannot be estimated with any degree of confidence for two reasons. On the one hand, it is difficult to quantify avoided impacts when the physical manifestations of various levels of mitigation are likely to be quite similar over long periods of time. As illustrated clearly by Jacoby (2004), we can expect, if we are honest with ourselves, that analyses of mitigation policies will at best indicate how the distributions of possible impacts of climate over time might change. On the other hand, residual impacts attributed to climate stress after mitigation cannot be portrayed accurately without considering adaptations that would either occur autonomously as people observe changes in local conditions or be the result of planned public interventions by citizens, communities, institutions and governments. Adaptation will surely fall short of eliminating all climate-related damages; and adaptation is certainly not free. Still, as reported in Cropper and Oates (1992, pp. 680–681), we must express the benefits attributed to mitigation (environmental policy) in terms of residual (post adaptation) damages that mitigation can reduce net of changes in the cost of requisite or anticipated adaptation.

Having made this point, a second source of concern emerges from one of the fundamental conclusions of the Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC):

> Current knowledge of adaptation and adaptive capacity is insufficient for reliable prediction of adaptations; it is also insufficient for rigorous evaluation of planned adaptation options, measures and policies of governments. (IPCC, 2001, p. 880).

In offering this conclusion with a very high degree of confidence, the IPCC recognized that the relative abilities of systems to adapt depend on at least two distinct sets of factors. Site-specific determinants of exposure to climate change and climate variability populate the first set of factors. The second set depends on site-specific and path-dependent determinants of adaptive capacity—the ability to affect favorably the relationship between exposure and sensitivity. The determinants of adaptive capacity include access to resources and risk-spreading mechanisms, stocks of human and social capital, the abilities of responsible

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decision-makers and institutions to process complex information, and so on (Yohe and Tol, 2002, among others). The IPCC simply made the point that we cannot anticipate the efficacy of adaptation at any location unless and until we understand how these factors would interact as the future unfolds and climate impacts materialize.

Can adaptation at a local level really make a significant difference? Existing analyses of the economic cost of sea level rise along the developed coastline of the United States clearly provide an example where the answer is emphatically affirmative in a context where adaptive responses can be anticipated. The critical actors on decisions of whether or not to protect developed property are well known, as are the cost-benefit decision criteria that they apply in making their decisions. Moreover, the resources necessary to underwrite adaptation are widely available. Still, the series began when Yohe (1989) produced estimates of the cost for the United States under the assumption that none of its coastline would be protected. This earliest work reported only the current value of all of the property that would be inundated by rising seas through the year 2100. Yohe et al. (1996) subsequently reported estimates for the same representative sample of coastal locations that were derived from a model that allowed property values to appreciate over time and included decisions to protect or to abandon property based on cost-benefit analyses conducted at a very micro-level. Even with no foresight and therefore no autonomous adaptation, planned adaptation based reduced total estimated economic costs for the United States by nearly 80% along sea-level-rise scenarios that spanned the IPCC-SAR range of possibilities through the year 2100 (10–90 cm). Adding perfect foresight allowed market-based autonomous adaptation to reduce estimated costs by another 10 percentage points across the same wide range of sea-level futures. In both cases, though, some residual damage remained because not all property was protected and because protection was not free. The difference between the first two estimates reflects the significant role that planned adaptation can play in affecting the costs associated with climate change. The difference between the second two estimates reflects the significant role that autonomous adaptation can play in augmenting those plans.

Subsequent work by West and Dowlatabadi (1999) inserted a stochastic time series of coastal storms into the same methodology and applied the resulting model to a representative community; their results offer preliminary insight into how climate variability, extreme events, and local reconstruction regulations might influence estimates of the economic cost of climate change. In their model, storms could destroy or damage property directly by rain and wind or indirectly from erosion, but damaged structures could be rebuilt if the expected value of reconstruction exceeded the cost. This decision rule allowed the same structure to exist multiple times in multiple storms (and it could be a structure that would ultimately be abandoned in the face of rising seas). It also allowed a property destroyed by a storm not to be rebuilt so that damage could be correctly attributed to storms and not to rising seas. Running multiple manifestations of the same stochastic storm profile over 50 years with and without sea-level rise showed that the cost that could be attributed to rising seas could increase costs by as much as 50% (relative to the perfect foresight base, so still an 80% reduction relative to the no-adaptation vulnerability results). However, the cost could also fall by as much as 10% if large storms claimed significant property before the rising seas took their toll.

Given examples like this from limited locations for specific climate stressors, it is clear that specific adaptations and other policies must be included in benefit calculations for mitigation policy because they might significantly effect the size of residual damages. It follows from the strong IPCC conclusions, however, that the research community is hamstrung in its efforts to make these net calculations in many parts of the vulnerable world by a limited ability to predict net damages that can be attributed to climate. Combining these two conclusions therefore casts serious doubt on our current ability to produce aggregate global estimates of net damages and thus to produce meaningful estimates of the potential benefits of a global climate policy.

2. A risk-based alternative

It is critically important to recognize that pessimism permeating from Section 1 *cannot be used as a valid excuse for delaying mitigation* while we wait for the research community to provide more clarity on the benefit side of the policy debate. The concerns raised in Section 1 suggest, instead, that a new decision paradigm be adopted in policy deliberations—one designed to accommodate the uncertainty that clouds our understanding of the future. Jones (2003), Harremoes (2003) and others have proposed looking that the policy problem be viewed through the lens of a risk-based precautionary approach in mitigation in the near to middle-term is offered as part of a hedging strategy designed to diminish the likelihood of intolerable outcomes in the future. What sort of information would be required to inform decisions based on such an approach? Some description of possible intolerable outcomes (thresholds beyond which the impacts of climate change and variability become so severe that we cannot adapt adequately) would certainly be required. In addition, some description of the sensitivity of the likelihood of crossing these thresholds to changes in climate variables would be necessary, as would some quantifiable understanding about how mitigation might influence the distribution of those variables. Can the research community meet these requirements? In a growing number of cases, absolutely.

Jones (2003), for example, reports results from three case studies in which a risk-based approach was employed to portray vulnerability in terms of the likelihood of crossing specific thresholds. In the first case, he relates the likelihood of crossing specific sea level rise thresholds to long-term climate scenarios. While our ability to predict a specific outcome turned out to be low, the probability of exceeding specific thresholds turned out to be relatively insensitive to input assumptions that produced enormous uncertainty about how the climate would change over the next century. In the second case, Jones describes how climate change could affect the frequency and severity of coral bleaching at a specific location along the Great Barrier Reef. Coral mortality is determined by a duration–temperature relationship that can be estimated from past experience; and linking that relationship to climate scenarios demonstrated how the likelihood of exceeding critical thresholds might change dramatically over time as the ocean warmed. Finally, Jones reviews analyses of the sensitivity of water supplies in a specific Australian catchment to changes in precipitation and rates of evaporation. Uncertainty is particularly troublesome in applications of this sort, because it is so difficult to link changes in precipitation to overall climate change. Nonetheless, Jones reports that trajectories displaying the relationship between the likelihood of crossing critical supply thresholds and climate change are accessible, contingent on broad categorization of not-implausible climate futures. On a broader scale, Schneider (2004) offers a description of the sensitivity of the likelihood of a shut-down in the thermohaline circulation (THC) of the North Atlantic to atmospheric concentrations of greenhouse gases and the pace of their accumulation. The implications of a collapsed THC are unclear, but most students of climate change would agree that they could be quite severe. As reported in Pittenger and Gagosian (2003), even the United States Defense Department of the United States takes the risk of widespread impacts very seriously.

The missing piece of the puzzle in all of these cases is tracking the effect of mitigation policy on these threshold-based risk assessments, but Jacoby (2004) suggests that climate modelers can now provide this information. His work displays the implications of achieving one particular mitigation target on the distribution of temperature change and, in the background, the pace of temperature change. Relating this change in the distribution of critical climate variables to the THC vulnerability relationships reported by Schneider or to the three threshold relationships reviewed by Jones would be sufficient to evaluate the efficacy of achieving his chosen target. If Jacoby, and others, could expand their analyses to cover a wide range of mitigation targets (and there is no reason why they could not), then it would be simple to relate mitigation targets to the likelihood of crossing critical thresholds. Notice, as well, that scale would not really matter. The approach could handle impacts as large as the shutdown of THC or as narrowly focused as bleaching of a specific coral reef.

Adopting a risk-based precautionary perspective in the evaluation of short- and medium-term climate policy would have a number of advantages over the implicit cost-benefit perspective embodied in the question "What are the benefits of climate policy?" First of all, adaptation responses can easily be incorporated into examinations of the effect of mitigation on the risk of intolerable impacts for locations where our understanding of those processes is most well developed. One needs only superimpose the effects of mitigation on the cumulative distribution function of a specific impact variable or vector over a coping range defined by current and anticipated adaptations to see whether or not mitigation makes any difference. In addition, adaptation studies in support of such an approach would not have to span the full range of "not-implausible" futures to provide useful insight; they could focus, instead, on the extremes with an eye toward defining the threshold of "tolerance".

Secondly, adopting a risk-based approach makes it clear that mitigation and adaptation can work as complements in reducing risk rather than as substitutes working on one side or the other of the cost-benefit calculus. The advantage, here, is that a risk-based perspective allows discussions of how to integrate adaptation and mitigation to move beyond simply looking for "win–win" options (where adaptation improves mitigation or vice versa) and into looking for synergies in simultaneously reducing exposure (mitigation) and sensitivity (adaptation).

Finally, decision-makers have experience in applying risk-based precautionary approaches to environmental issues of, admittedly, a less global and more specific nature; and while the cost of achieving certain reductions in risk are computed, they are not the fundamental determinant of risk thresholds. Viscusi (1996) recently published estimates of the cost of using the precautionary principle to justify limiting human exposure to various hazards. Table 1 displays a sampling of his results. The cost estimates reported there reflect the average cost of saving a life by imposing a particular limit to human exposure to risky substances or events. They are widely disparate in large part because they are averages (and so they are low or high when adaptation costs are low or high and/or when many or a few people can benefit from reduced exposure, respectively). They

Table 1
The cost of risk-limiting regulations[a]

Regulated substance	Regulating agency	Initial annual risk	Annual lives saved in the US	Cost per life saved
Benzene emissions	EPA	2.1 per 100,000	0.31	$2.8 million
Benzene in manufacturing	OSHA	8.8 in 10,000	3.8	$17.1 million
Asbestos	EPA	2.9 in 100,000	10	$104.2 million
Formaldehyde	OSHA	6.8 in 10 million	0.01	$72 billion
Airbags (in cars)	NHTSA	9.1 in 100,000	1850	$300,000
Airplane seat flammability	FAA	1.6 in 10 million	37	$600,000

[a] *Source*: Viscusi (1996).

are all, nonetheless, the product of applying the US Environmental Protection Agency target that the chance of a death over a 70-year lifespan from exposure to an external risk should be no larger than one chance in 100,000. Risk thresholds of this sort are products of the political systems, to be sure, but they are no less legitimate as a policy targets than an economically determined efficient solutions to cost-benefit constructions.

3. Concluding remarks

The concerns raised here are perhaps best summarized by a word of caution. Asking for estimates of the benefits of mitigation calibrated in currency (so that they can be compared to the cost of mitigation) may not be the best question to raise in an effort to inform the current climate policy debate. The cost-benefit approach to the policy that underlies this question is not necessarily flawed, but the inability to provide reliable and comprehensive estimates for the benefit side of such an important global policy question weakens the ability to guide policy. The concerns raised here cannot, however, be used to argue that climate policy must be delayed because the science is too uncertain. Indeed, adopting a risk-based approach would make uncertainty *the reason* to initiate climate policy as soon as possible. Why? Because waiting would increase the cost of meeting any mitigation target, even if future costs were severely discounted. The question is not whether to intervene now, but by how much in light of "mid-course" corrections that will surely be required as the future unfolds.

References

Cropper, M., Oates, W., 1992. Environmental economics: a survey. Journal of Economic Literature 30, 675–740.

Harremoes, P., 2003. The need to account for uncertainty in public decision making related to technological change. Integrated Assessment 4, 18–25.

Intergovernmental Panel on Climate Change (IPCC), 2001. 2000—Impacts, Adaptation, and Vulnerability. Cambridge University Press, Cambridge.

Jacoby, H., 2004. Informing climate policy given incommensurable benefits estimates. Global Environmental Change 14 (3), 289–299.

Jones, R., 2003. Managing climate change risks. ENV/EPOC/GCP22 (2003), Organization for Economic Cooperation and Development, Paris.

Pittenger, R., Gagosian, R., 2003. Global warming could have a chilling effect on the military. Defense Horizons 33, 1–8.

Schneider, S., 2004. Abrupt non-linear climate change, irreversibility and surprise. Global Environmental Change 14 (3), 247–260.

Viscusi, K., 1996. Economic foundations of the current regulatory reform efforts. Journal of Economic Perspectives 10, 119–134.

West, J., Dowlatabadi, H., 1999. On Assessing the economic impacts of sea-level rise on developed coasts. In: Downing, T., Olsthoorn, A., Tol, R.S.J. (Eds.), Climate Change and Risk. Routledge, London, pp. 205–220.

Yohe, G., 1989. The cost of not holding back the sea—economic vulnerability. Ocean and Shoreline Management 15, 233–255.

Yohe, G., Schlesinger, M., 2002. The economic geography of the impacts of climate change. Journal of Economic Geography 2, 311–341.

Yohe, G., Tol, R., 2002. Indicators for social and economic coping capacity—moving toward a working definition of adaptive capacity. Global Environmental Change 12, 25–40.

Yohe, G., Neumann, J.E., Marshall, P., Amaden, H., 1996. The economic cost of greenhouse induced sea level rise for developed property in the United States. Climatic Change 32, 387–410.