R E S P O N S E

A Response to *Climate Change and U.S. Interests*

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Economic analysis occupies a central role in national debates over climate and energy policy. As the scientific consensus on climate change becomes clear and unambiguous, the case for inaction on climate change is increasingly argued on grounds that it will be too costly to initiate more than token initiatives. While many scientists advocate stringent emissions targets aimed at stabilizing atmospheric greenhouse gas concentrations during this century, recent economic models of climate change recommend a more cautious approach, involving only modest early actions to limit emissions with gradually increasing limits over time.[1] Freeman and Guzman provide an excellent reckoning of the "fatal flaws" in economic analyses of climate change impacts that explain the disconnect between climate science and economics.

There is a large and growing literature in economics that demonstrates rigorous economic support for immediate, large-scale policy responses to the climate crisis. Two years ago, colleagues and I at Economics for Equity and the Environment Network surveyed this literature and compiled an online reader's guide called the *Real Economics of Climate Change*.[2] This literature reflects a healthy debate within economics over the integrated assessment models (IAMs) that contribute much of the grist for the "climate winner argument" that Freeman and Guzman critique.

IAMs compare the expected costs of emissions reduction against the expected benefits of avoided climate change for the purpose of identifying the "optimal" policy response. If the models do a poor job translating the predictions of climate scientists into economic impacts, or if the models over-state the costs of reducing emissions, the models will recommend very modest emissions reduction (or none at all). Identifying the contestable assumptions and limitations of IAMs is an important part of debunking the climate winner argument.

On the surface, IAMs look very similar to the large-scale computer models that have helped build the scientific consensus around climate change and have a good reputation in the scientific community. Climate science models, however, are grounded in physical laws that are well-established both theoretically and empirically. Their extensive descriptions of the physical processes of climate change are testable either directly or indirectly through "backcasting" of historical climate data. In contrast, IAMs, like all economic models, are assumption driven.[3]

IAMs use the same discounted utility framework that underlies most economic analysis. They start from a particular understanding of human nature and preferences and seek to identify the choices that will maximize the satisfaction of those desires. Climate outcomes enter the analysis as factors that increase or decrease human satisfaction. The "optimal" target is not a safe or pre-determined climate stabilization level, but rather the maximum subjective satisfaction.[4]

Climate change poses significant challenges to the discounted utility framework. For one, it demands a comparison of mitigation costs in the present to the benefits of avoided climate change in the future. To compare welfare across generations, economists must decide how much additional weight to attach to present outcomes over future outcomes. When economists discount the future, the present value of the harms caused by future climate change can shrink to the point where it is hardly "worth" doing anything in the present to avoid climate change. The results of IAMs are highly sensitive to the choice of discount rate, but there is no "right" discount rate to use. The choice of discount rate reflects contestable assumptions about the future growth rate of the economy, the

1. *See, e.g.,* David L. Kelly & Charles C. Kolstad, Integrated Assessment Models for Climate Change Control, *in* International Yearbook of Environmental and Resource Economics 1999/2000: A Survey of Current Issues 171 (Henk Folmer & Thomas H. Tietenberg eds., 1999); Richard Tol, *The Social Cost of Carbon: Trends, Outliers, and Catastrophes, Economics*, 2 Open-Access, Open-Assessment E-Journal 1 (2008), *available at* http://www.economics-ejournal.org/economics/journalarticles/2008-25; Richard Tol, *Estimates of the Damage Costs of Climate Change Part II: Dynamic Estimates*, 21 Envtl. & Resource Econ. 135 (2002); Alan S. Manne, Perspective Paper 1.2., *in* Global Crises, Global Solutions 49-55 (Bjorn Lomborg ed., 2004); Robert Mendelsohn, Perspective Paper 1.1., *in* Global Crises, Global Solutions 44-48 (Bjorn Lomborg ed., 2004); William Nordhaus, A Question of Balance: Weighing the Options on Global Warming Policies (2008); William Nordhaus & Joseph Boyer, Warming the World (2000).
2. *See* Real Climate Economics, www.realclimateeconomics.org.
3. See Frank Ackerman et al., *Limitations of Integrated Assessment Models of Climate Change*, 95 Climatic Change 297 (2009), for further discussion.
4. *See id*.

opportunity cost of capital, and society's preference for present versus future outcomes.[5]

The discount rate dilemma is widely acknowledged, but often dismissed as simply a normative issue. Normative assumptions, however, can be just as important as the technical details. As one leading critique of IAMs states:

> A present generation that cares nothing about the fate of future generations will do nothing to preserve the stability of the Earth's climate, and no economic calculations can show otherwise. But whether and how much people care about the future can be represented in various ways—through the rate of subjective time preference in optimal growth models, through the weighting of different generations' welfare in overlapping generations models[6], through thought experiments in which the generations are able to transact with one another[7]—and the results, not unexpectedly, will reflect the depth and strength of the intergenerational ties.[8]

The second area where climate change poses problems for the discounted utility framework involves estimates of climate change impacts. IAMs rely heavily on future predictions about how human societies and natural systems will respond to carbon dioxide concentrations and temperatures that are outside of the range of human experience. To deal with uncertainty, these models typically focus on likely climate impacts based on extrapolation from limited data and case studies; this approach minimizes the importance of uncertain but potentially catastrophic climate impacts. The extreme events have the potential to cause the greatest human suffering and economic disruption. Freeman and Guzman explain how IAMs exclude whole categories of impacts that are difficult to quantify, interrelated, and stem from international spill-over effects.

Even if IAMs could give more inclusive treatment to a wider range of climate impacts, and could better account for low probability but potentially catastrophic climate events, they would still confront the unavoidable problem of assigning meaningful monetary values to human life, health, and natural ecosystems.[9] Inevitably, this entails value judgments. This means that even if IAMs could achieve greater precision in predicting climate impacts, they cannot match the rigor and scientific objectivity of their climate science counterparts.[10]

Compounding this problem is the fact that many IAMs include dubious benefits from warming temperatures in the short term. These benefits include things such as longer growing seasons, subjective preferences for warmer temperatures, increase in summer recreational activities, and declines in cold-related deaths. These benefits, even if they were to manifest, seem to be of a very different order of magnitude than the impacts to fresh waters supplies, food systems, public health, and ecosystems that scientists warn are possible if temperatures exceed 2 degrees Celsius.[11] At high enough discount rates, however, short-term benefits will outweigh climate change damages in the distant future. For example, Richard Tol's widely cited analysis of climate damages based on the FUND model projects that the world will actually be better off in economic terms from the first 3 degrees Celsius of warming.[12]

Third, climate economic modeling involves estimates of mitigation costs that misrepresent the dynamic, socially determined nature of technological change. Estimating mitigation costs in dollar terms is more straightforward, in principle, than measuring mitigation benefits. The adoption of energy-efficient equipment, appliances, industrial processes, and automobiles, as well as more widespread use of combined heat and power technologies, wind energy systems, solar panels, and other measures for reducing emissions all involve purchases of marketed goods and services whose attendant cash flows can be easily counted. The evolution of these technologies is uncertain, however, particularly over the long time periods involved in climate modeling. IAMs typically invoke pessimistic assumptions about the pace and direction and technological change that tend to overestimate the costs of achieving emissions reduction targets. These models typically do not account for the emissions reduction potential of energy efficiency improvements, learning-by-doing, and the positive role public policy can play in steering investment choices and promoting technological change. Instead, IAMs assume an annual rate of productivity improvement in energy use, which leads to a paradoxical result: if climate change is a long term crisis, and technological change will make it easier and cheaper to reduce emissions in the future, the "optimal" solution is to wait before addressing climate change.[13]

5. *See id.*
6. Richard B. Howarth & Richard B. Norgaard, *Environmental Valuation Under Sustainable Development*, 82 Amer. Econ. Rev. 473 (1992); Richard B. Howarth, *Climate Change and Overlapping Generations,* 14 Cont. Econ. Policy 100 (1996).
7. Stephen J. DeCanio & Paul Niemann, *Equity Effects of Alternative Assignments of Global Environmental Rights,* 56 Ecological Econ. 546.
8. Ackerman et al., *supra* note 3.
9. See Frank Ackerman, Can We Afford the Future: The Economics of a Warming World (2009), for a lengthier discussion.
10. Ackerman et al., *supra* note 3.
11. Researchers have steadily decreased earlier estimates of potential near term benefits to agriculture from climate change. Any near term potential benefits from longer growing seasons and increased CO_2 fertilization are now expected to decline as temperatures rise steadily later in the century; as weeds, pests, and diseases flourish under the new climate conditions; and as the incidence of extreme weather events rises. Wolfram Schlenker & Michael J. Roberts, *Nonlinear Temperature Effects Indicate Severe Damages to U.S. Crop Yields Under Climate Change*, 106 Proc. Nat. Acad. Sci. 15594 (2009); William Cline, *Washington, DC: Center for Global Development & Peterson Institute for International Economics, Global Warming and Agriculture: Impact Estimates by Country* (2007), *available at* http://www.cgdev.org/content/publications/detail/14090.
12. *See* Frank Ackerman & Charles Munitz, E3 Network, Climate Damages in the Fund Model: A Disaggregated Analysis (2011), *available at* http://www.e3network.org/papers/Climate_Damages_in_FUND_Model_March2011.pdf; Interagency Working Group on Social Cost of Carbon, Appendix 15A. Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866, *in* U.S. Department of Energy, Final Rule Technical Support Document (TSD): Energy Efficiency Program for Commercial and Industrial Equipment: Small Electric Motors (2010), *available at* http://www1.eere.energy.gov/buildings/appliance_standards/commercial/pdfs/smallmotors_tsd/sem_finalrule_appendix15a.pdf.
13. *See* Ackerman et al., *supra* note 3.

Can integrated assessment models be "fixed" to provide better estimates of the economic costs and benefits of avoiding climate change, or should we abandon the discounted utility framework entirely in favor of some alternative approach?

We know that IAMs that use lower discount rates and more fully account for impacts of climate change yield higher estimates of damages that seem more in-line with the predictions of climate science. The Stern Review, for example, represented a real advance over standard practice in economics by using a much lower discount rate and better methods for estimating the effects of uncertainty in many climate parameters. Yet even Stern's results, which were widely embraced by climate advocates and denounced by many economists, likely underestimated the damages from climate change.[14]

Recent economic research has proposed new ways of dealing with the uncertainties inherent to climate change.[15] The work of Martin Weitzman is path breaking in this regard. According to Weitzman, in a world with uncertain future outcomes, the best available estimate of the true probability distribution has fat tails. If people are risk-averse, as some evidence might suggest, the avoidance of losses from worst case scenarios dominates decision making.[16] As Weitzman argues, fine-tuning estimates of the most likely climate damages is less important that determining how bad and how likely the worst case scenarios of climate change really are. As Ackerman et al. state:

> There is little doubt that the 95th percentile, or 98th percentile, of possible adverse climate outcomes over the next century (to pick two arbitrary points out in the tail of the distribution) looks like the devastation of the planet in a science-fiction dystopia, not like a matter for carefully weighing costs and benefits.[17]

Though we may be able to improve integrated assessment modeling, we cannot escape entirely from the fundamental limitations of the discounted utility framework as applied to climate change. Stabilizing the earth's climate system is as much a scientific and moral issue as it is an economic issue. There are limits to applying cost-benefit analysis to climate change when the damages accrue to future generations and involve consequences for human lives and ecosystems that are virtually incalculable and uncertain. Precaution, risk assessment and risk management may be more appropriate frames for evaluating climate policy.

The appropriate role of economics in climate policy debates should not be to determine the optimal level of emissions reduction. Emissions goals should be informed by the best and latest scientific information and motivated by our moral obligations to future generations. The tools and insights of economics are then most appropriate to the complex and intellectually challenging tasks of determining least-cost strategies for achieving those targets, designing policies that effectively and with confidence meet those targets, identifying the potential economic impacts of failing to meet those targets and sharing responsibility fairly for the costs and implementation of that strategy. Economists should be more open and explicit about the viewpoints and values underlying their analyses. As Freeman and Guzman conclude, policy makers also need to be more fully aware of the significant limitations of climate economic models that give rise to the climate winner argument.

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14. *See* Nicholas Stern et al., The Stern Review: The Economics of Climate Change 105 (2006); William D. Nordhaus, *A Review of The Stern Review on the Economics of Climate Change,* XLV J. Econ. Lit. 686 (2007). Stern's model assumes that adaptation will eliminate 100% of the impacts on the US from the first 3.6°F of warming. Not surprisingly, the *Stern Review* predicts that US damages from climate change by 2100 will be small, equivalent to roughly one-half of a percent of current U.S. GDP (roughly $140 billion) on an annual basis from now into the future. Frank Ackerman &Elizabeth Stanton, Natural Resource Defense Council, The Costs of Climate Change: What We'll Pay if Global Warming Continues Unchecked (2008) adapts the PAGE model used by the Stern analysis by removing adaptation efforts and including catastrophic risks. Using the revised PAGE model, they estimate that the annual costs to the US from climate change could reach 3.6% of U.S. GDP by 2100.
15. See Jon Gjerde et al., *Optimal Climate Policy Under the Possibility of a Catastrophe* 21 Resource & Energy Econ. 289 (1999); Graciela Chichilnisky, *An Axiomatic Approach to Choice Under Uncertainty With Catastrophic Risks*, 22 Resource & Energy Econ. 221 (2000); Darwin C. Hall, Richard J. Behl, *Integrating Economic Analysis and the Science of Climate Instability*, 57 Ecological Econ. 442 (2006); Partha Dasgupta, *Discounting Climate Change*, 37 J. Risk & Uncertainty 141 (2008), *available at* http://www.springerlink.com/content/633517qw4j526470/; Martin L. Weitzman, *A Review of the Stern Review on the Economics of Climate Change,* XLV J. Econ. Lit. 703 (2007); Martin L. Weitzman, *Subjective Expectations and Asset-Return Puzzles,* 97 Amer. Econ. Rev. 1102 (2007); Martin L. Weitzman, *On Modeling and Interpreting the Economics of Catastrophic Climate Change* (2008), *available at* http://www.economics.harvard.edu/faculty/weitzman/files/modeling.pdf, for examples.
16. For example, young couples that purchase life insurance can be said to be risk-averse. Homeowners rarely find a compelling reason to go without fire insurance, even when not required to by the terms of a mortgage. The probabilities in any given year of a home burning down or a healthy young person dying are measured in the tenths of one-percent, but the impacts, should the unlikely events occur, are substantial. This suggests that people routinely insure themselves against personal catastrophes that are less likely than worst-case climate catastrophes for the planet. See Ackerman et al., *supra* note 3, for a lengthier discussion.
17. Ackerman et al., *supra* note 3.