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The Stern Review: Implications for Climate Change

Stern Review of the Economics of Climate Change

Reviewed by Gary W. Yohe and Richard S. J. Tol

The *Stern Review of the Economics of Climate Change*,¹ produced at the request of the Prime Minister and the Chancellor of the Exchequer of the United Kingdom, was released with considerable fanfare during the last week of October 2006. Its authors, economists and policy analysts working with some of the world's experts on climate impacts, were brought together by Sir Nicholas Stern, the former chief economist and senior vice president of the World Bank and more recently second permanent secretary at Her Majesty's Treasury. Together, the authors accepted the task of applying the economic paradigm to new knowledge about climate change with the intent of making an economic case for immediate action to reduce emissions of greenhouse gases. The *Stern Review* (including its background material) compares in scope to the various assessments of the literature on climate change published by the Intergovernmental Panel on Climate Change (IPCC).² Indeed, its authors evaluated much of the same literature that has been taken on board by the authors of IPCC's fourth assessment report, which will be published later this year. The *Stern Review* is, however, far more policy prescriptive than any IPCC document can be; thus it is unfortunate that the *Review's* attempts to construct an argument for immediate action on economic grounds may have produced another source of significant climate risk.

To be clear, economic analysis, per se, is not the source of this unintended consequence. Rather, its source lies in the Stern team's trying to force the complexities of climate change into a structure designed explicitly to compare the benefits and costs of climate policy instead of approaching the policy problem from an equally rigorous risk-management perspective—a perspective that would have been competently informed by the sound assessment of current knowledge about the risks of climate change provided fairly early in the *Review* itself.

Overview of the Stern Review

Before elaborating on its potential as a source of climate risk, it is helpful to offer a more detailed outline of the *Stern Review*: What did its authors set out to accomplish and how did they go about doing so? In their own words, the authors were charged with, among other things, assessing “the economics of moving to a low-carbon global economy, focusing on the medium to long-term perspective, and drawing implications for the timescales for action, and the choice of policies and institutions.”³ Most of its work in accomplishing the first task was informed by an elaborate comparison of the costs of climate change impacts and the costs of mitigation (Chapters 6–17). These are the pages that report estimates of annual economic damages and mitigation (prevention) costs. Informed by the sound assessment of current knowledge about climate risks provided in Chapters 3 through 5 as well as ten supporting documents, these estimates have attracted most of the attention of the media and of many world leaders, including former United Nations Secretary-General Kofi Annan.⁴ These estimates are, as well, the most controversial parts of the *Review*.

It is important to note that the *Stern Review* actually begins not only with a brief presentation of the science of climate change in Chapter 1, but also with a careful description of how equity issues are handled throughout the subsequent calculations of costs and benefits in Chapter 2. Indeed, Chapter 2 makes it clear that these calculations rely heavily on assuming minimal social impatience for consumption in the future (that is, a very low discount rate that allows costs and benefits that will be felt by future generations to weigh heavily on current decisions). It also makes it clear that the estimates of costs and benefits reported later will recognize inequities in the burden of climate impacts.

In other words, the critical role played by intertemporal and international equity in completing the “timescales” task noted above is highlighted at the outset. Elaborations of mitigation (Chapters 14–17) and adaptation policy design (Chapters 18–20) are relegated to later chapters along with coverage of the details of international coordination in creating a global price for carbon, promoting technology transfer, reversing emissions from land-use change, and supporting adaptation across the globe (Chapters 21–27). Unfortunately, coverage of the issues in these final seven chapters offers a more limited discussion of adaptation options and policies before providing compelling evidence of the need for international collective action.

On the basis of its assessment of the current state of knowledge, the *Stern Review* reports quite accurately that the climate is changing more rapidly than was thought just five years ago.* The author team concludes that impacts are likely to be more severe than previously thought, that some anticipated impacts have been observed already, and that other impacts are likely to be felt sooner rather than later. In addition, Figure 2 of the *Stern Review*’s executive summary clearly demonstrates that no

and risks that are equivalent to an average reduction in global per capita consumption of at least 5%, now and forever” and that adding catastrophic risk and non-market damages could increase “total cost of BAU climate change to the equivalent of around a 20% reduction in consumption per head, now and into the future.”** These estimates are taken to be evidence of “risks of major disruption to economic and social activity, later in this century and in the next, on a scale similar to those associated with the great wars and the economic depression of the first half of the 20th century.”** The *Review* argues that the cost of reducing greenhouse gas emissions to stabilize concentrations at 500–550 parts per million (in carbon dioxide (CO₂) equivalents) can be “limited to around 1% of global GDP each year.” The problem is that these estimates are, quite simply, incredible.

The Skeptics’ Reaction

Skeptics of climate change and critics of climate policy have seized on the weakness of these estimates to—in the spirit of an “if you cannot convince them, confuse them” strategy—mislead

It is unfortunate that the Stern Review’s attempts to construct an argument for immediate action on economic grounds may have produced another source of significant climate risk.

temperature target can be guaranteed by achieving any practicable concentration target and that significant mitigation will be required to reduce significantly the likelihood of serious impacts (this figure appears here as Figure 1 on page 38).* For now, it is enough to note that some of these conclusions have been known for some time, and the *Review* strongly reinforces their validity. Other conclusions are reflections of emerging new knowledge, and the *Review* appropriately brings them to the fore.

Reasons for Concern

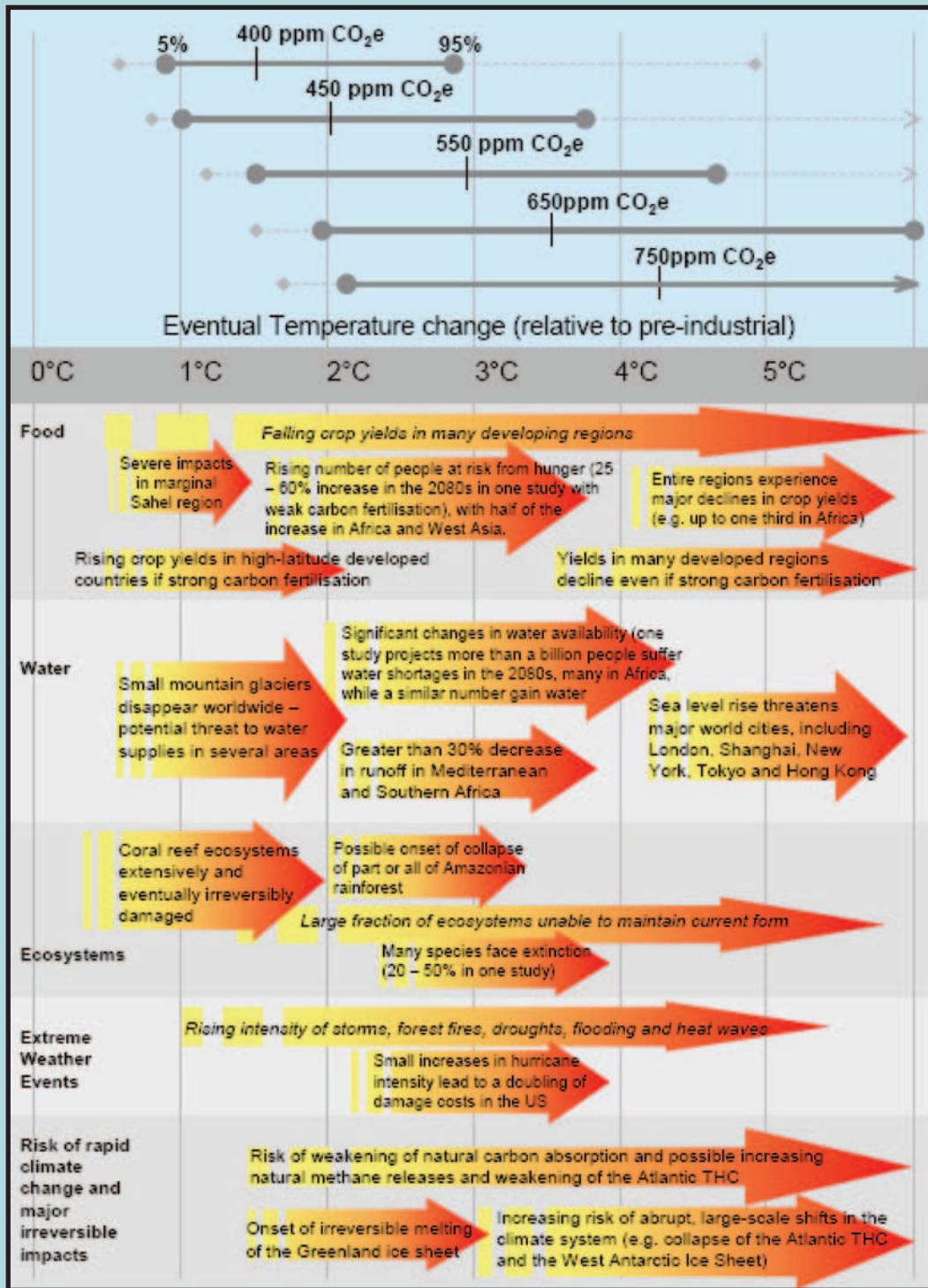
Many statements in the *Stern Review* are troublesome, largely because the authors did not see their work as a contribution to a risk management approach to the climate problem even as they subjected academic standards to political goals. To reiterate a point made above, they forced a complex subject into an unsuitable structure, placing its list of diverse impacts, calibrated in terms of a multitude of economic and non-economic impact metrics, into a benefit-cost framework that was not at all well equipped to handle the uncertainty in the current understanding of how the climate system will respond to unprecedented concentrations of greenhouse gases or the multiplicity of climate change impacts that are expected.

The *Stern Review* estimates, on the basis of this attempt, that “total cost over the next two centuries of climate change associated under BAU [business-as-usual] emissions involves impacts

the general public and policymaking communities around the world. A few, like Ruth Lea (the director of the Centre for Policy Studies based in London) have adopted a scattershot approach that begins by questioning how one factor like carbon emissions can have any predictable effect on something as complex as the global climate system. She continued her attack by emphasizing the complexity of making economic predictions (as opposed to offering ranges of “not-improbable” projections) and by attributing a motive to the entire effort (moral justification of increased fuel taxation).* Others, like Bjørn Lomborg, seem to accept climate change when they acknowledge the *Review*’s “many good references,” but they have happily focused attention on its fragile domain of damage and policy cost estimates.**

Skeptics such as Lomborg as well as several other commentators have wondered out loud how one more assessment of the existing literature could have produced damage estimates that are 10 to 20 times higher than earlier efforts. They claim that the *Review* double-counted sources of climate risk, “cherry-picked” high impact studies that ignore adaptation and economic growth, chose such a low discount rate that high damages were guaranteed (that is, they pre-ordained their conclusion about the need for immediate policy), created an obscure metric of “risk-adjusted per capita consumption equivalents,” and so on.** The intent of some of these attacks is to create such noise that the *Review*’s major and fundamentally sound messages (about the economic rationale for immediate action based on climate risk) will be lost on the general public; if they are successful, progress

Figure 1. Stabilization levels and probability ranges for temperature increases



SOURCE: N. Stern et al., Stern Review on the Economics of Climate Change (Cambridge: Cambridge University Press, 2007), Figure 2 at page v. Accessible via http://www.hm-treasury.gov.uk/media/8AC/F7/Executive_Summary.pdf. Reprinted with permission of Stern Review authors.

toward climate policy will be delayed for years if not decades. Herein lie the seeds of yet another risk to the climate system.

What is the harm if these critics and skeptics are successful in delaying the implementation of the climate intervention that the *Review's* authors hoped to promote? Additional damages attributed to greenhouse gas emissions that will go unabated for another 5 or 10 more years come to mind, but they might not be the most significant source of climate risk. Perhaps more importantly, climate damage attributed to inaction over the next 5 to 10 years would be driven by long-term investments in transportation and building infrastructure that will not have adopted the most efficient carbon-saving technologies but will have defined the emissions profile of the developed world for the next 10 to 50 years. It is a profile that would be expensive to alter and one that would commit the planet to decades of additional warming beyond the immediate implications of 5 or 10 years of inaction.

Table 1 on page 40 summarizes the major sources of concern—and reasons these are concerns—regarding the *Stern*

In terms of particular sectors, the *Stern Review* did not consider adaptation when calculating impacts on water resources or damages that could occur due to sea level rise. When adaptation is missing, it is almost an accounting identity that costs are necessarily exaggerated. People always try to cope with changes in their environments. Their efforts are hardly ever completely successful, and they are certainly not without cost; but the very fact that they make the effort means that they are likely to be better off after doing so.** Moreover, the *Review* ignored economic growth when calculating climate change impacts on food and health. When economic growth is ignored (and the underlying economic scenarios upon which the analyses were based include economic growth across the globe and convergence between the living standards of developed and currently developing countries**), the possibility of enhancing adaptive capacity is ignored. It follows immediately that reported damages are probably exaggerated.** The list goes on, but the point is made. Although any one of these issues by itself might not

Many statements in the Stern Review are troublesome, largely because the authors did not see their work as a contribution to a risk management approach to the climate problem even as they subjected academic standards to political goals.

Review, illustrating an assessment of the associated risk to advancing the case for climate policy and thus the risk that climate change will proceed unabated over the near term.

New Interpretations of Existing Data

The first row in Table 1 serves as an opening for criticism; it underscores the point mentioned above that the *Stern Review* does not present new estimates of either the impacts of climate change or the costs of greenhouse gas emission reduction. Its authors have drawn their results from existing material by exercising an existing model, so it is indeed surprising that they produced estimates of aggregate damages that are so much higher than nearly every peer-reviewed estimate in the existing literature.** The sound bite is already being crafted: “How could something so different come from the same old stuff?” Probably not those words, exactly; indeed, many far more caustic statements have already been uttered.

High Estimates

Higher estimates of damages can be attributed to many sources; in the *Stern Review*, two broad categories stand out (see the second and third rows of Table 1). First, there is a significant catalog of problems with the calibration of damages from impacts on particular sectors. Second, the damage calculations were derived using a very low discount rate.

present a high risk to the *Review's* credibility, the sum of these problems do present a concern because, in each case, the underlying damage functions were constructed from studies that produced the highest (not-implausible) damages. The aggregation process that produced the global damage estimates essentially piled one extreme on top of another. Taken together, this selection criterion makes the combined estimates vulnerable to the “cherry-picking” critique.

The other potential source of high estimates of damages is that the *Stern Review* expressed them in terms of an artificial per capita consumption metric; thus, they are highly sensitive to the chosen discount rate and the chosen representation of aversion to risk. This is a source of enormous risk to near-term climate policy because it will be roundly criticized and its defense is largely ethical and philosophical.** The upshot of this ethical argument is that the *Review* discounts utility at 0.1 percent even though many other economic assessments have used rates as high as 3 percent. The economic ramifications of choosing such a low discount rate are difficult to understand, especially if it is applied only to public investment and climate policy and not, for example, to public investment in education, infrastructure, research, or pensions. Moving from a discount rate of 0.1 percent to 1 percent would lower damage estimates by nearly 60 percent; moving to 2 percent by roughly another 20 percent, and moving to 3 percent by yet another 15 percent.** As a result, damages calculated from the same underlying data with a 3 percent discount rate would produce damage esti-

mates between 10 and 20 percent of the estimates reported in the *Review*.

It is perhaps more unsettling to note that more than 50 percent of the reported damages can be attributed to the residual term in discounted value calculation.** That is, more than 50 percent of the damages included are attributed to impacts that would be

felt beyond the year 2200. For higher discount rates, however, these residuals are much smaller. This beyond-2200 residual is not just a technicality. The uncertainty about society and climate so far into the future is very large, but it is hard to imagine that no solution will have been found after two centuries of climate change in terms of emission reduction, geo-engineering, or other

Table 1. Reasons for concern over damage estimates in the Stern Review

Source of concern	Reason for concern
No new literature and no new models supporting damage estimates	Damage estimates are three standard deviations higher than the mean of earlier peer-reviewed estimates ^a
Impacts of climate change	Water: does not address adaptation ^b Sea level rise: does not address adaptation ^c Food: ignores growth ^d Health: ignores growth ^e Attributes observed increase in natural disasters exclusively to climate change ^f Refugees: uses most pessimistic scenarios ^g Double-counts sources of catastrophic risk ^h
Very low discount rate employed in damage estimates	Future impacts weigh heavily ⁱ High residuals past 2200 ^j Leads to inefficient investment ^k
Mitigation cost estimates truncated at 2050	Mitigation must continue past 2050 ^l
No justification of the 550 parts-per-million target	Lower target implied Damages metric not comparable ^m

^a R. S. J. Tol, "The Marginal Damage Costs of Carbon Dioxide Emissions: An Assessment of the Uncertainties," *Energy Policy* 33, no. 16 (2005): 2064–74.

^b N. W. Arnell, "Climate Change and Global Water Resources: SRES Emissions and Socio-economic Scenarios," *Global Environmental Change* 14, no. 1 (2004): 31–52.

^c R. J. Nicholls and R. S. J. Tol, "Impacts and Responses to Sea-Level Rise: A Global Analysis of the SRES Scenarios over the Twenty-First Century," *Philosophical Transactions of the Royal Society A: Mathematical Physical and Engineering Sciences* 364, no. 1841 (2006): 1073–95.

^d M. L. Parry, C. Rosenzweig, A. Iglesias, M. Livermore, and G. Fischer, "Effects of Climate Change on Global Food Production under SRES Emissions and Socio-economic Scenarios," *Global Environmental Change* 14, no. 1 (2004): 53–67.

^e R. S. J. Tol and H. Dowlatabadi, "Vector-borne Diseases, Development & Climate Change," *Integrated Assessment* 2, no. 4 (2001): 173–81.

^f R. A. Pielke, Jr., C. Landsea, M. Mayfield, J. Laver, and R. Pasch, "Hurricanes and Global Warming," *Bulletin of the American Meteorological Society* 86, no. 11 (2005): 1571–75.

^g N. Myers and J. Kent, *Environmental Exodus: An Emergent Crisis in the Global Arena* (Washington, DC: Climate Institute, 1995).

^h W. D. Nordhaus and J. G. Boyer, *Warming the World: Economic Models of Global Warming* (Cambridge, MA, and London, UK: The MIT Press, 2000).

ⁱ R. S. J. Tol, "Estimates of the Damage Costs of Climate Change, Part II. Dynamic Estimates," *Environmental and Resource Economics*, 21, no. 2 (2002): 135–60.

^j G. Yohe, "Some Thoughts on the Damage Estimates Presented in the Stern Review—An Editorial," *The Integrated Assessment Journal* 6, no. 3 (2006): 65–72.

^k W. Nordhaus, *The Stern Review on the Economics of Climate Change*, published on the Web 17 November 2006, <http://nordhaus.econ.yale.edu/SternReviewD2.pdf>.

^l D. Anderson, *Costs and Finance of Abating Carbon Emissions in the Energy Sector* (London: HM Treasury, 2006), http://www.hm-treasury.gov.uk/media/8A3/32/stern_review_supporting_technical_material_dennis_anderson_231006.pdf, Figure 2.1.

^m R. Clarkson and K. Deyes, *Estimating the Social Cost of Carbon Emissions*, Working Paper 140 (London: HM Treasury, The Public Enquiry Unit, 2002).

NOTE: The "reason for concern" column refers to concerns that the damage estimates reported in the Stern Review on the Economics of Climate Change will be legitimately vulnerable to criticism so that debate over their applicability will divert attention from the fundamental message about the risks of climate change.

SOURCE: Compiled by G. W. Yohe and R. S. J. Tol, 2006.

technological breakthroughs that would effectively shield us from the vagaries of the weather.

Problems with Mitigation Cost Estimates

Two more critical problems arise in the *Stern Review*'s treatment of climate change mitigation cost estimates (see the last two rows of Table 1). The *Review* focuses on a 550 parts-per-million concentration target but reports only the costs through

A quick thought exercise using Figure 1 shows how. Find something in the lower portion of the figure that appears to be a "dangerous" or "intolerable" consequence of climate change. Now move to the top to determine the temperature threshold associated with the onset of this consequence. Then move up farther to see what achieving various concentration targets would do to the currently estimated likelihood of crossing that threshold. Anyone who can identify a "dangerous" consequence can, by completing this exercise, create a personal case for cli-

The Stern Review does not conduct a proper optimization exercise, nor does it give any indication of the cost of delay—the very question that skeptics of climate change and critics of climate policy will ask.

2050—even though emission reduction would have to continue throughout the next 150 years to sustain the target. Moreover, cost-and-benefit estimates reported in the *Review* do not match a policy conclusion that 550 parts per million is an appropriate policy objective. If the impacts of climate change are so dramatic and the costs of emission reduction are so small, then a concentration target that is far more stringent than the one recommended should have been proposed. It is also impossible to compare damages avoided (that is, benefits) expressed in terms of percentage reductions in per capita consumption with costs expressed in terms of reductions in gross world product. It would have been far more appropriate to indicate, for all the scenarios run in the exercise (using the same discount rate and the same attitude to risk), the cost of achieving the specified concentration target expressed in the same per capita consumption metric employed in the damage calculations. Then it would have been possible to calculate net damages that would persist in the wake of such a policy—and it would have been possible to calculate the cost of delay. The *Stern Review*, in short, does not conduct a proper optimization exercise, nor does it give any indication of the cost of delay—the very question that skeptics of climate change and critics of climate policy will ask.

Conclusion

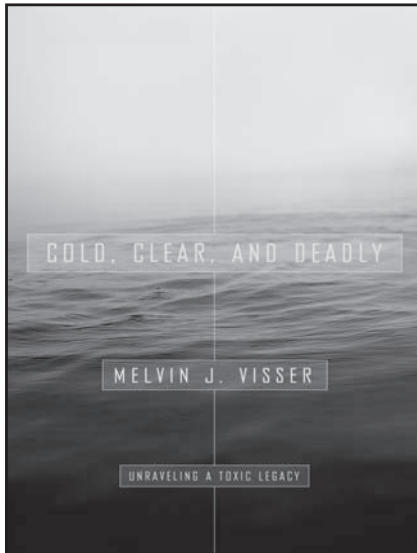
Notwithstanding all these objections, a convincing argument can be made that the *Stern Review* has done all the work required to accomplish its unstated objective: to make an economic case for taking immediate action to reduce emissions of greenhouse gases. Truly, a strong case for emission reduction, even in the near term, can be made without relying on suspect valuations and inappropriate summing across the multiple sources of climate risk. Economic analysis reveals without qualification that doing nothing in the near term is *never* part of a minimum (discounted) cost climate policy, and the risk analysis underlying the *Stern Review* makes it clear that some sort of policy will be required.

mate policy without referring to the *Review*'s damage estimates. And how can that policy be implemented at least cost? By starting *now*.

This short exercise does more than make a case for near-term policy intervention, however. Perhaps more importantly, it quiets the skeptics of climate change and the critics of climate policy. After all, it is their deliberate manipulation of public opinion that is the source of concern—the reason the *Stern Review* is labeled above as a risk to the climate—so quieting them is a significant contribution. How is this accomplished? It is clear that Figure 1 (which is, it might be recalled, Figure 2 of the *Review*'s executive summary) displays climate risks. As soon as it is established that one of those risks is possible (and even most skeptics must acknowledge that the *Stern Review* has accomplished this task), then clearly it can be said that there is an established need for climate policy. To argue to the contrary, skeptics and critics have to *guarantee* that *none* of the impacts highlighted in Figure 1 can *ever* occur. They have to make the case that there is *no chance* that the climate is changing. Because they know that they cannot support such a claim, they know that they will win the hearts and minds of the public at large and the policymakers that represent them over the short-run only if they focus debate about the *Stern Review* on damage and cost estimates that are extremely suspect in their best light and completely indefensible in the worst case scenario. We cannot let that happen.

Gary W. Yohe is the Woodhouse/Sysco Professor of Economics at Wesleyan University in Middletown, Connecticut. He has published more than 80 papers on climate change in scholarly journals over the past two decades where his work has spanned the mitigation and impacts side of the issue. Yohe was a lead author on four separate chapters in the Third Assessment report of the Intergovernmental Panel on Climate Change. He is currently serving as convening lead author of Chapter 20 ("Perspectives on Climate Change and Sustainability") in the contribution of Working Group II to the IPCC's Fourth Assessment Report as well as member of the core writing team for the Synthesis Report. He can be contacted via e-mail at gyohe@wesleyan.edu. Richard S. J. Tol is a senior research officer at the Economic and Social Research Institute in Dublin, Ireland, and is also affiliated with Vrije, Carnegie Mellon, and Hamburg Universities. As economist and statistician, his work focuses on climate change, particularly economic impacts, international climate policy, and earth system modeling. He is an editor of *Energy Economics*. He has played an active role in international bodies such as the Stanford Energy Modeling Forum, the Intergovernmental Panel on Climate Change, and the European Forum on Integrated Environmental Assessment. Tol can be contacted via e-mail at Richard.Told@esri.ie

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NOTES

•• N. Stern et al., *Stern Review on the Economics of Climate Change* (Cambridge, UK: Cambridge University Press, 2007). The *Review* was originally published online October 2006 and is accessible via http://www.hm-treasury.gov.uk/independent_reviews/stern_review_economics_climate_change/sternreview.

•• The first three IPCC assessments can be found at www.ipcc.ch/. Members of *Environment's* editorial board reviewed the second assessment (*Climate Change 1995*) in its November 1997 issue, pages 23–39; the third assessment was reviewed in K. E. Trenberth, "Stronger Evidence of Human Influences on Climate: The 2001 IPCC Assessment," *Environment* 43, no. 4 (May 2001): 8–19. The full report of Working Group I on the scientific basis should have been released in February; the full reports of Working Groups II and III (on impacts and mitigation) should be available in April and May, respectively. The final document of the fourth assessment, a synthesis report, should be available in November 2007.

•• Stern, note 1 above, page i.

•• See K. Annan, United Nations Secretary-General, address to the Climate Change Conference, Nairobi, 15 November 2006, <http://www.un.org/News/Press/docs/2006/sgsm10739.doc.htm>.

•• See also R. F. Warren et al., *Spotlighting Impacts Functions in Integrated Assessment*, Working Paper 91 (Norwich, UK: Tyndall Centre for Climate Change Research, 2006).

•• Stern, note 1 above, page v, Figure 2.

•• Stern, note 1 above, page x. On page 163, 5 percent of gross domestic product (GDP) is in fact the mean for one particular scenario. The 5th percentile was reported to be as low as 0.3 percent of GDP, while the 95th percentile may be as high as 33 percent.

•• Stern, note 1 above, page ii.

•• R. Lea, "Just Another Excuse for Higher Taxes," *Telegraph*, 31 October 2006, <http://www.telegraph.co.uk/opinion/main.jhtml?xml=/opinion/2006/10/31/do3102.xml>.

•• B. Lomborg, "Stern Review: The Dodgy Numbers Behind the Latest Warming Scare," *Opinion Journal*, 2 November 2006, <http://www.opinionjournal.com/extra/?id=110009182>.

•• The *Stern Review* created a metric of damage that synthesizes the damages caused by climate change across a wide range of possible futures (thousands of them) that are all discounted back to present value. It is based on the calculation of an *artificial and guaranteed* consumption path for 200 years that would produce a level of welfare equal to the expected value of welfare across the entire set. The planet would never actually see this consumption path, but it would be just as happy if it did as it is now facing all of the incumbent uncertainty about how the future will evolve. See Stern, note 1 above, pages 161–62 for details.

•• The *Stern Review* damage estimate is three standard deviations higher than the mean of peer reviewed estimates surveyed in R. S. J. Tol, "The Marginal Damage Costs of Carbon Dioxide Emissions: An Assessment of the Uncertainties," *Energy Policy* 33, no. 15 (2005): 2064–74.

•• This point is made in terms of the water sector in N. W. Arnell, "Climate Change and Global Water Resources: SRES Emissions and Socio-economic Scenarios," *Global Environmental Change* 14, no. 1 (2004): 31–52; for vulnerability to sea level rise, see R. J. Nicholls and R. S. J. Tol, "Impacts and Responses to Sea-Level Rise: A Global Analysis of the SRES Scenarios over the Twenty-First Century," *Philosophical Transactions of the Royal Society A: Mathematical Physical and Engineering Sciences* 364, no. 1841 (2006): 1073–95.

•• The *Stern Review* works with the so-called IPCC Special Report on Emissions Scenarios (SRES) story lines; for a complete description from the source, see N. Nakicenovic and R. J. Swart, eds., *IPCC Special Report on Emissions Scenarios* (Cambridge: Cambridge University Press, 2001).

•• M. L. Parry, C. Rosenzweig, A. Iglesias, M. Livermore, and G. Fischer, "Effects of Climate Change on Global Food Production under SRES Emissions and Socio-economic Scenarios," *Global Environmental Change* 14, no. 1 (2004): 53–67; and R. S. J. Tol and H. Dowlatabadi, "Vector-borne Diseases, Development & Climate Change," *Integrated Assessment* 2, no. 4 (2001): 173–81.

•• See Stern, note 1 above, Chapter 2.

•• G. Yohe, "Some Thoughts on the Damage Estimates Presented in the *Stern Review*—An Editorial," *The Integrated Assessment Journal* 6, no. 3 (2006): 65–72.

•• *Ibid.*

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