

The worth of an ice-sheet

***A critique of the treatment of catastrophic impacts in
the Stern Review***

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The well-publicized headline message of the Stern Review on the Economics of Climate Change, which my readers are likely to have heard about, was that stringent mitigation, consistent with stabilization of greenhouse gas concentrations at 550 ppm CO₂-equivalent or lower, is strongly warranted by economic (cost-benefit) analysis. According to the report, mitigation at this level can be accomplished at a cost of about 1% of world GNP, compared to welfare losses equivalent to 5% to 20% of GNP under “business as usual” climate change.¹

Much less publicized is the fact that the Review also concludes that stabilization targets below 450 ppm CO₂-equivalent or lower are not economically warranted, and that even seeking stabilization at 450 ppm CO₂-e is probably not justified.² Thus, using relatively uncontroversial estimates of the probabilities for temperature rise, the report accepts up to a roughly 50% likelihood of exceeding 3°C, and effectively dismisses the “2°C threshold” endorsed by the European Commission among others.³

There is a great deal to be said about the importance of the Stern Review as a benchmark not just in the debate about climate policy, but also as a contributor to a broader debate about sustainability, economic growth, and global justice, and as an example of the role that economic argument plays in the science/policy domain. I hope in the coming months to take up many of these considerations, here and in other fora. But for now, I want to focus quite specifically on the key climate policy recommendations, and particularly on the implicit claim that the 2°C target should be disregarded. And I will do so by highlighting the ways in which the Review actually incorporates catastrophic risks and their “valuation” - the “worth of an ice sheet,” as I suggest in the title. What I hope to show is that those of us who (prior to the Stern Review) thought that such risks justified the 2°C threshold, have good reasons to reject Stern’s conclusion.

Again, Stern does not explicitly dismiss the 2°C threshold; but he endorses 450 ppm CO₂-e as the lower limit on reasonable stabilization targets, in spite of it having at best even odds of staying below 2°C and a roughly 20% chance of exceeding 3°C. Thus, put simply, either:

1) Stern is wrong that stabilization targets lower than 450 ppm CO₂-equivalent are not economically justified;

2) Stern is wrong that cost-benefit analysis should determine whether we try to stay below the 2°C threshold; or

3) Stern is right, and we should quit arguing for lower stabilization targets that in fact have a high likelihood of staying below the 2°C threshold.

As should be clear from my subtitle, the Stern Review in no way persuades me to abandon the goal of keeping below a 2°C warming. Nor, I suspect, will most of those who also favor such an objective be persuaded by Stern to give up their “preference” for a more stringent policy. On the contrary, I suggest that in fact Stern himself supplies many of the crucial premises in support of more stringent targets, and that it is only by making a series of necessarily controversial assumptions that he is able to conclude that accepting a 20% to 50% risk of exceeding 3°C is economically warranted - and, implicitly, politically warranted.

Importantly, I am prepared to concede that Stern may well believe that our best chance of keeping below the 2°C target requires that we avoid explicitly advocating it. Yet based on my own studies of the likely temperature consequences of emissions reductions scenarios,⁴ the most optimistic reductions timelines envisioned by Stern imply significantly greater risk of exceeding 2°C than a more stringent “crash program,” one which is still possible but requires inconvenient honesty about the urgency of the problem. And, worse, the way in which the Stern Review justifies its conclusions provides reasons for mitigation opponents to argue against more stringent targets.

Stern recognizes that quantitative policy analysis of the “climate problem” - posed as justifying a “desirable” level of emissions reductions - requires incorporating both scientific uncertainty and controversial value choices. Indeed, Stern’s methods are designed to make many of these judgments relatively explicit. The validity of his conclusions, then, depends on the claim that his methods incorporate these factors adequately; that is to say, that his methods for treating scientific uncertainty and “value choices” are “good enough.” Thus to fairly evaluate Stern’s recommendations requires a careful examination of both his methods and the ethical assumptions reflected in his “value choices.”

Much of the detailed discussion of the Stern Review so far has focused on its choice of a very low discount rate, an important value choice which does in fact significantly influence the results, as noted by several economists who have commented on it.⁵ However, for now this is not my primary concern; rather I will ask a different question, concerning how the possibility of catastrophic impacts such as the melting of the Greenland ice sheet is handled in the study. By many accounts including the Stern Review itself, this is among the crucial examples of potential climate risks that climate policy must aim to reduce; presumably the handling of such an example must be “good enough” if the review’s overall analysis is to be considered robust. In what follows, I will explain how Stern does in fact incorporate such risks, and suggest why I believe his methods in the end are inadequate and the conclusions he draws unsupported.

I begin with Stern’s iconic representation of the risks of climate change.

On page 5 of the Executive Summary of the Stern Review is a chart on which various potential impacts of climate change are represented by arrows laid out on a grid of increasing temperature. The arrows are light yellow at the left (low) end and turn from orange to red with increasing temperature; clearly modeled on the famous “burning embers” diagram of the IPCC’s Third Assessment Report (TAR), they might perhaps be similarly called “flaming arrows.”

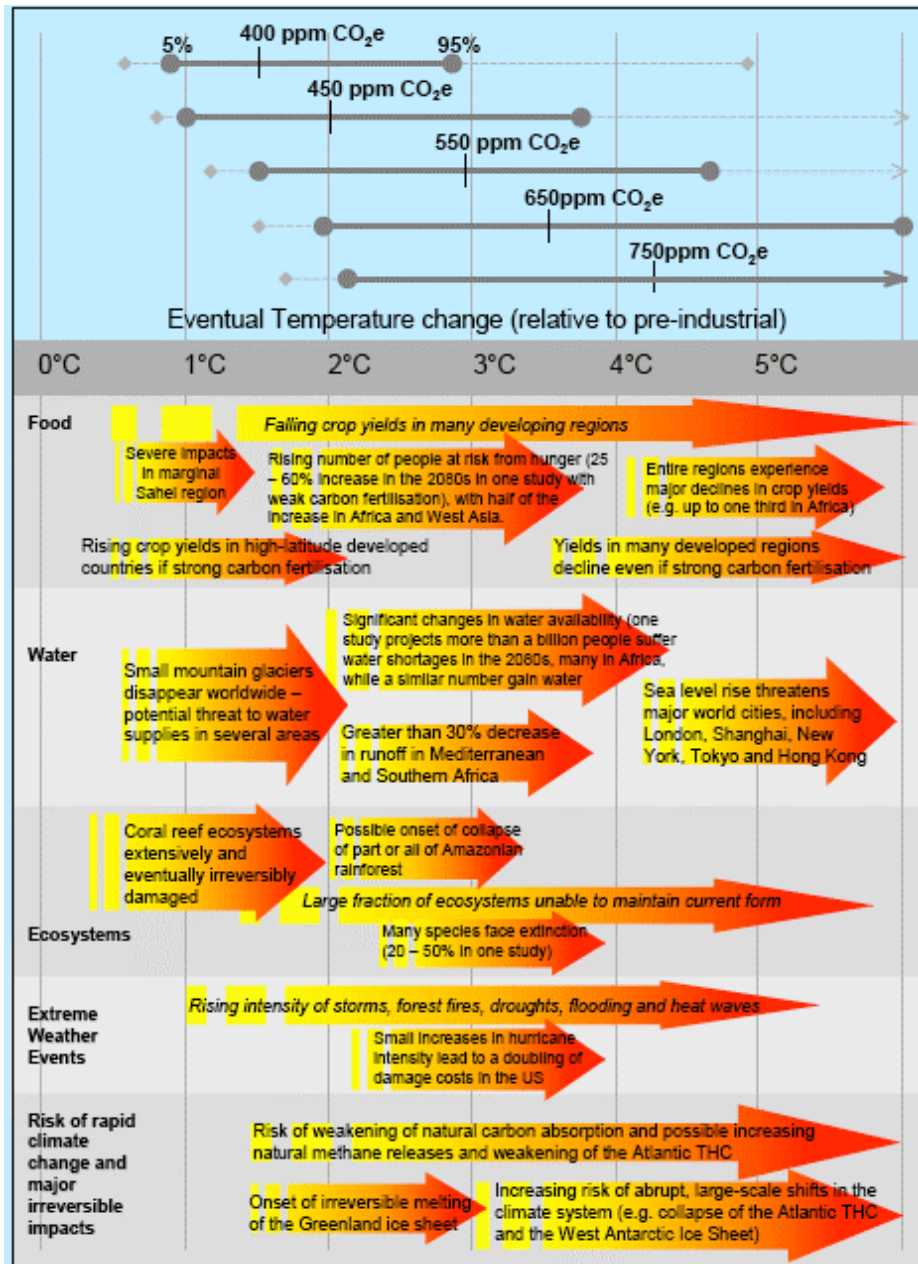


Figure 2 from Stern Review Executive Summary

I will for now look at just one of these arrows, the one labeled “onset of the irreversible melting of the Greenland ice sheet.” This arrow (the left arrow at the bottom) begins (and is colored yellow) at about a temperature increase of 1.5°C above pre-industrial, is orange by the time the arrow crosses 2°C, and is red at the tip of the arrow, which just barely crosses the 3°C line.

As shown, this “flaming arrow” appears with many others directly below a graphic representation of the likely increase in global average temperature associated with alternative stabilization levels for GHGs. The lower bound of the Review’s recommendations - 450 ppm CO₂-equivalent - is shown to have a central risk estimate of 2°C and a roughly 20% risk of exceeding a 3°C warming at equilibrium, and at the higher bound (550 ppm CO₂-e) there is a 50% risk of exceeding 3°C and a roughly 20 percent risk of exceeding 4°C. Given this, one might expect that a careful analysis had been done of the associated consequences of taking a high risk of melting the Greenland ice sheet (or causing other impacts whose risk arrows are “red” at or below 3°C). But in fact nowhere in the report is either the likelihood or the value of such specific and potentially catastrophic outcomes actually quantified; rather the “worth of an ice sheet” (and the probability with which irreversible melting will be initiated at any particular temperature) is rolled into a single, and I argue inadequate, estimate of the “expected value of catastrophic risk.”

And of course it is not merely ice sheets that Stern has implicitly valued in these aggregated damage functions; as shown by other of the “flaming arrows,” it is also the survival of countless species, and the lives of potentially millions upon millions of people, particularly in poor countries.⁶ Species extinctions were the focal example of the classic article by Silvio Funtowicz and Jerry Ravetz, “The Worth of a Songbird,” to which my title refers; their article is a pointed critique of William Nordhaus’s famous cost-benefit analysis of climate change and its dependence on irreducibly subjective (and ethical) judgments,⁷ and my criticism of the Stern Review reprises the same basic themes. And though I do not here get into the “valuation of human lives” question, it has been a major source of controversy in the past,⁸ and it is an issue for the Stern Review as well; indeed, I could equally well write an article on “The Worth of an African.”

Stern is well aware of the ethical issues associated with making such diverse types of risks commensurable, and acknowledges in various places that “value” is plainly not reducible to economic value. For example, Stern writes on page 145, “Our preference is to consider the multiple dimensions of the cost of climate change separately, examining each on its own terms. A toll in terms of lives lost gains little in eloquence when it is converted into dollars; but it loses something, from an ethical perspective, by distancing us from the human cost of climate change.” Yet nonetheless the report in practice concludes that economics *does* in fact tell us what risk of exceeding 2°C or 3°C, with the associated “expected costs,” we should take.

A complete unpacking of the methods and assumptions that Stern uses in estimating the “expected costs” of climate change (and that metaphysical darling, the “social cost of carbon”) would itself be a lengthy report. Indeed it would require a full exposition of what Stern explicitly refers to as “the standard assumptions of welfare economics,” including the never-ending discussion of discount rates. here, however, as I said previously, I just show how “the worth of an ice sheet” is actually included in the report’s modeling results, and argue that because of the inadequacy of his methods for such addressing such problems, his policy recommendations for a lower limit on stabilization goals should be rejected.

As I stated earlier, the specific risks implied by the “flaming arrows” are nowhere quantified directly. Instead, there is a single number calculated for “catastrophic impacts,” based on a probability distribution for the temperature threshold at which the risk begins, and for the “value” (in terms of lost GNP) if the catastrophe occurs. The parameters of this “damage function” are in turn based on an expert survey done by William Nordhaus in 1994.⁹ According to Stern (p. 153), “When global mean temperature rises to high levels (an average of 5°C above pre-industrial levels), the chance of large losses in regional GDP in the range of 5 - 20% begins to appear. This chance increases by an average of 10% per °C rise in global mean temperature beyond 5°C.”

The results of a Monte Carlo calculation calibrated this way are given in the scatterplot below, reproduced from Tyndall Working Paper Number 91.¹⁰ This graph of 1000 runs of the PAGE2002 model (the same model on which all of Stern’s damage calculations were based) shows that “catastrophic” damages never exceed about 3% of GNP until temperature increase exceeds almost 4.5°C. Indeed, up until about a 3°C increase, the possibility of measurable catastrophic impacts appears to be effectively zero.¹¹

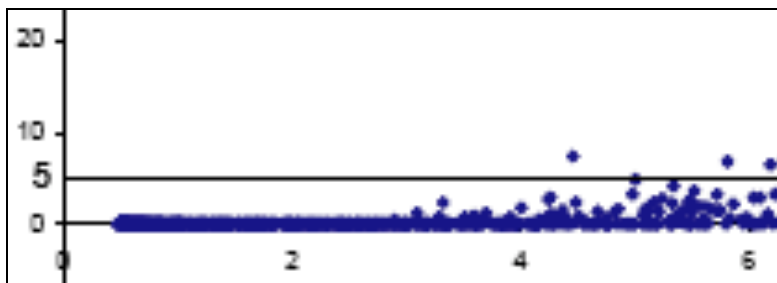


Figure 3.3 (third panel) from TWP91 (p. 41), scatterplot of Monte Carlo model results for “catastrophic damages” (in percent of GDP lost on the y axis) at different levels of temperature increase (in degrees C on the x axis). The figure is an enlargement of the lower left quadrant of the original, with a gridline at 5% of GDP drawn in.

It is here in this calculation that the “worth of the ice sheet” is hidden. We know from the “flaming arrow” that we have an “orange” risk of starting the melting of the ice sheet at 2°C, and a “red” risk at 3°C. Yet this risk must be so small that it

has no influence on the estimated catastrophic damages of temperature increase. How small does the probability assigned have to be, and/or how small the value of the consequences, for this to be the case?

Remember, we're not talking here about maybe just melting 1% or 10% of the ice sheet, we're talking about possibly starting an irreversible melting of the whole thing, eventually leading to up to a six or seven meter rise in sea level. It might take many hundreds of years, but it would transform the world beyond recognition. Are we confident that this risk is irrelevant in evaluating the consequences of a 3°C temperature increase?

There are two different points to be made here. The first is that plainly this "catastrophic damage function" doesn't adequately capture all the reasonable interpretations of the likelihood and value of melting the Greenland ice sheet, to say nothing of other potential "catastrophes." Thus, it follows that the upper bound on damages for any different stabilization level has not been established. This alone should be enough to conclude that the economic justification for the lower-bound of 450 ppm CO₂-e stabilization can't be robust.

Second, though I can only sketch the argument here, the way in which Stern's model might logically include alternative assumptions about such values would in practice demonstrate its dependence on contested ethical choices. Put most generally, the model has "parameters" which model certain kinds of value choices (like the discount rate and the value associated with lives, species, or sea-level rise); if you hold all the "scientific" parameters fixed, it is straightforward to see how far which "value" knobs would have to be turned to justify any "optimal" policy outcome. To give an example, I can say that "I think it's warranted to spend 10% of GDP to reduce the risk of melting the Greenland Ice Sheet to under 5%," and you can infer from that what my "value parameters" are - but you can't say that I'm wrong to have them.

Serious economists are not unfamiliar with this problem. Indeed, their typical response is not an unreasonable one: "if you - or anyone - actually did value risks like the melting ice sheets so greatly, you would be doing other things which you are quite evidently not doing." This is in effect an argument that there is empirical evidence about what people's "real" values are, in terms of discount rates, "inequality aversion," "existence values" and other quantifiable indicators.

Here then is where mainstream economics and its critics finally part company. Put simply, Stern and others look at the problem and say "evidently people don't value the Greenland ice sheet enough to save it." I and many others look at the problem and say "what are we going to have to do to save it?" That means starting with the recognition that "the worth of an ice sheet" is something that we decide through a social process - a process which is clearly only beginning, and in which the fact that such a consequence is beyond our practical experience is taken as a reason for caution.

There is much, much more to be said here, but I hope by now I've made my point clear: for those of us who think that avoiding impacts like melting ice sheets warrants a high likelihood of keeping temperature increase below 2°C, Stern offers no compelling counter-argument. There are additional reasons - such as his method for modeling risk aversion, and his badly argued rejection of "peak and decline" (or "overshoot") scenarios - why his recommended lower limit on stabilization is poorly justified, and I hope to address these further subsequently. But I want to conclude here with two different points about context rather than content.

The first is that the Stern Review is a highly political document. Its authors surely recognized that the ways in which its recommendations will be used do not depend solely on the quality of the arguments, but also on the interests and commitments of its various "audiences." And to put the matter bluntly, Stern apparently believes that any suggestion that necessary mitigation might actually significantly reduce economic growth in either poor or rich countries would discredit his argument with the audiences that count. Global environmental policy is still dominated by the neo-liberal consensus that unrestricted economic growth is the solution to whatever ails us, and Stern knows this.¹² Stern's suggestion that the "necessary" mitigation will only cost 1% of GDP, although high risks of melting the ice sheets will remain, seems to be driven by this political "realism" rather than by the rigorous comparison of marginal costs with marginal benefits.

The second point is that while the report was designed to counter the prevailing opinion that "economics" does not justify even moderately stringent mitigation, the mainstream climate economists who have weighed in publicly have all effectively rejected his conclusion, primarily because of his use of a very low discount rate.¹³ Many and perhaps most mainstream climate economists remain committed to using much higher discount rates (perhaps treating lower rates as "sensitivity cases"). Thus those who have used economic arguments to justify delaying mitigation will still be able to find respected academics to back them up, and we are likely to find that Stern's intervention is not as decisive as it might initially appear.

Indeed, I fear that in either supporting Stern against those who support even weaker mitigation, or in arguing on economic grounds for more stringent targets, it will be too easy to be drawn into a discussion about economic technicalities like discount rates, risk aversion and contingent valuation. The crucial questions are about our ethical obligations to those distant in time and space, and about our ideas and ideals for the world we want for our descendants and for the rest of our own lives. An analysis of Stern's approach can show that its conclusions aren't compelling, but the positive case for a truly precautionary policy must stand on other grounds. Developing these arguments is truly an urgent matter.

Acknowledgements

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Notes

¹ The final report of the Stern Review and additional supplemental documents are available at <http://www.hm-treasury.gov.uk>.

² Stern nowhere flatly rules out 450 ppm CO₂-e, but his arguments in many places suggest he believes that the marginal costs of achieving it would be greater than the marginal benefits. In part this is because he (for, in my opinion, no good reason) rules out returning to 450 ppm CO₂-e from above, which makes the required reductions unimaginably steep. I will take up his dismissal of “peak and decline” (or “overshoot”) scenarios another time.

³ The European Union (see for example the Environment Council Conclusions from October 2004 [here](#)), the Climate Action Network ([here](#)), and many other institutions and individuals have argued that global mean temperature should not be allowed to exceed 2°C above the preindustrial (compared to about an 0.7°C increase today). None however have suggested how large a risk of exceeding this “2°C threshold” should be considered acceptable.

One notable critique of the Stern Review’s conclusions, arguing that it does not recommend stringent enough mitigation to protect poor and vulnerable people from climate change, is from Andrew Pendleton of Christian Aid (<http://www.christianaid.org.uk/news/media/pressrel/061030p1.htm>). Disclaimer: I and my colleagues at EcoEquity are currently collaborating with (and being paid by) Christian Aid on related work; see <http://www.ecoequity.org/GDRs>.

⁴ See Baer, P. with M. Mastrandrea, 2006, *High stakes: designing emissions pathways to reduce the risk of dangerous climate change*, Institute for Public Policy Research, London, available at <http://www.ippr.org>.

⁵ Three prominent mainstream climate economists who have commented on the discount rates in the Stern Review are William Nordhaus (<http://nordhaus.econ.yale.edu/SternReviewD2.pdf>), Gary Yohe (http://journals.sfu.ca/int_assess/index.php/iaj/article/view/247), and Richard Tol (<http://www.fnu.zmaw.de/fileadmin/fnu-files/reports/sternreview.pdf>). These commentaries are all worthy of examination in their own right, but my own comments on them will have to wait; there is some interesting discussion at the Prometheus science-policy blog (see e.g., [here](#)).

⁶ Stern has a category of “non-market impacts” that are separate from “catastrophic impacts,” in which the loss of lives and species is presumably included. As noted by Richard Tol (see note 5), this may involve

some double counting; however because both categories are aggregated so that neither the likelihood nor valuation of any specific impact can be determined, it is impossible to evaluate the significance of this problem.

⁷ Funtowicz, Silvio and Jerry Ravetz, 1994. The Worth of a Songbird: Ecological Economics as a Post-Normal Science. *Ecological Economics* 10:197-207, available at <http://www.nusap.net/downloads/funtowiczandravetz1994.pdf>.

⁸ Aubrey Meyer of the UK's Global Commons Institute famously challenged the differential valuation of the lives of rich and poor in the economic analysis of climate change as assessed in Working Group III of the IPCC's Second Assessment Report. His report on the events can be found at <http://www.gci.org.uk/vol/vol.html>.

⁹ Nordhaus's expert survey was published in Nordhaus, W. D. (1994), "Expert Opinion On Climatic-Change," *American Scientist* 82(1): 45-51. Perhaps unsurprisingly, the estimated damage consequences of various temperature scenarios were significantly skewed between economists and natural scientists, as discussed in the original and in Roughgarden, T. and S. H. Schneider (1999), "Climate change policy: quantifying uncertainties for damages and optimal carbon taxes," *Energy Policy* 27(7): 415-429, which also reanalyzes Nordhaus's cost-benefit analysis by treating the disagreement among experts as another source of uncertainty.

¹⁰ Warren, R., C. Hope, M. Mastrandrea, R. Tol, N. Adger and I. Lorenzoni. *Spotlighting Impacts Functions in Integrated Assessment*. Tyndall Centre for Climate Change Research, Working Paper 91, September 2006. Available at http://www.tyndall.ac.uk/publications/working_papers/twp91.pdf.

¹¹ The fact that none of the model runs shown have measurable impacts at a 3°C increase does not mean that there is a zero probability in the model. Using my own Monte Carlo analysis to reproduce the formula used in PAGE2002 gave a likelihood of "discontinuity" (catastrophic) impacts of 0.16% at 3°C increase. In PAGE2002, the value of a discontinuity impact if it occurs is calculated separately; I did not attempt to recreate this component of the calculation. Thanks to Chris Hope for his help with this.

¹² For example, Stern writes in the short version of the Executive Summary (in a bold sub-head), "Action on climate change is required across all countries, and it need not cap the aspirations for growth of rich or poor countries."

¹³ See note 5 above.