

THE STERN REVIEW OF THE ECONOMICS OF CLIMATE CHANGE: A COMMENT

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Introduction

The Stern Review of the Economics of Climate Change (Stern *et al.*, 2006) is a report to the Prime Minister and the Chancellor of the Exchequer of the United Kingdom. A team of 23 people, led by Sir Nicholas Stern and supported by many consultants, worked for a little over a year to produce a report of some 700 pages on the economics of climate change. The report says many things, some better supported than others. In this comment, I focus on two conclusions. Firstly, the Stern Review argues that “the overall costs and risks of climate change will be equivalent to losing at least 5% of global GDP¹ each year, now and forever.” These are “risks of major disruption to economic and social activity, on a scale similar to those associated with the great wars and the economic depression of the first half of the 20th century”. Secondly, the Stern Review argues that “the benefits of strong early action outweigh the costs”. This action would keep concentrations of greenhouse gases below 550 ppm CO₂ equivalent.

Intriguingly, the 550 ppm CO_{2eq} target coincides with climate change target adopted earlier by the UK government (RCEP, 2000). The Stern Review should therefore not be understood as a revision. Earlier, HM Treasury had released a report (Clarkson and Deyes, 2002) that justified the 550 ppm CO_{2eq} target. The earlier report has been criticized for being out of step with the peer-reviewed literature (Pearce, 2003; Tol, 2005). For anyone familiar with the literature on the economic impacts of climate change (Smith *et al.*, 2001) or the literature on cost-benefit analysis on climate change (Nordhaus, 1991), the headline conclusions of the Stern Review come as a surprise too: **The Stern Review estimates are well outside the usual range.** The Select Committee for Economic Affairs of the House of Lords (2005) had warned the UK government for being out of step with the economic literature on climate change. The Stern Review missed an opportunity to help align UK climate policy to this literature.

In this commentary, I review the impact estimates in the Stern Review and assess the cost-benefit analysis in that report before reaching a conclusion.

Economic impacts of climate change

¹ On page 163, 5% of GDP is in fact the mean for one particular scenario. The five-percentile may be as low as 0.3% of GDP. The 95%ile may be as high as 33%.

Let us first examine the Stern Review conclusion that climate change will cause economic disruption now and forever. The “now and forever” is preposterous.² The world economy is growing briskly; immediate threats to economic growth are imbalances in the US, overheating in China, and lack of reform in the EU. But the “forever” part is also problematic. It assumes that society will never get used to higher temperatures, changed rainfall patterns, or higher sea levels. This is a rather dim view of human ingenuity. It contradicts what we know about technological progress, adaptation, and evolution.

The Stern Review highlights several impacts of climate change. One is water. The work here is based on Arnell (2004). The Stern Review correctly that Arnell (2004) does “not include adaptation” and is therefore severely biased. Food is another highlighted impact. Climate change would hamper agricultural productivity in some parts of the world, particularly Africa. This would be a problem in today’s world. However, in all of the socio-economic scenarios used by the Stern Review, African economies would grow rapidly. This is inconsistent with famine. Middle-income countries would import food (global food production is not threatened by climate change) rather than starve. Furthermore, it is hard to imagine rapid economic growth without substantial improvements in agriculture productivity; at present, African agriculture is particularly inefficient. For health, the Stern Review makes the same mistake: It worries about people dieing of diarrhea and malaria, diseases that can be controlled at little expense. The Stern Review extrapolates the increase of damage due to weather-related natural disasters. It uses the estimates of Muir-Wood *et al.* (2006), ignoring the opposite (and peer-reviewed) conclusions by Pielke *et al.* (2005) and Pielke (2005).³ For water, agriculture, health and insurance, the Stern Review consistently selects the most pessimistic study in the literature. For refugees, the Myers and Kent (1995) are the highest, and the Stern Review duly highlight that “some estimates suggest that 150-200 million people may become permanently displaced”. Myers and Kent (1995) was not peer-reviewed.⁴ Norman Myers is a known alarmist. For sea level rise, the Stern Review only quotes the “millions at risk” from Nicholls and Tol (2005) – this metric ignores adaptation, which is very effective against sea level rise –note that Nicholls and Tol (2005) do report impact measures with adaptation too.

In the chapter on the impact of climate change on development, the Stern Review quotes the works of Nordhaus (2006) and Sachs (2001) – who find that a tropical climate negatively affects economic development. The Stern Review ignores the work of Acemoglu *et al.* (2001) and Easterly and Levine (2003), who argue that climate has at most a minor, indirect effect in the (distant) past – and the climate-change-specific studies of Fankhauser and Tol (2005) and Tol (forthcoming), who show that climate change will have a limited effect on development. In their poverty projections, the Stern

² It is clear from page 162 that this is in fact an annuity. Note that the used discount rate is particularly low, and at odds with the discount rate recommended by HM Treasury (2003). See Guo *et al.* (2006) for a discussion of discount rates and marginal damage costs of CO₂ emissions.

³ It is surprising that the Stern Review overlooked Pielke’s work, as it was presented at the same meeting as Muir-Wood’s work.

⁴ The current author was on the advisory board of the project that led to the Myers and Kent report. The board was very critical of its findings.

Review mistakes the income-loss-equivalent-welfare-losses of the PAGE2002 with actual income losses.⁵

The economic impact estimates of the Stern Review are in fact all based on a single integrated assessment model, PAGE2002 by Hope (2006). Although a single model makes for easy presentation, it also implies a lack of robustness. Integrated assessment models differ considerably in their representation of impacts (cf. Tol and Fankhauser, 1998). The PAGE2002 model stands out for two reasons. First, the model assumes that climate change impacts are necessarily negative (cf. Mendelsohn *et al.*, 2000). Second, the model assumes that vulnerability to climate change is independent of development (Yohe and Tol, 2002). Both assumptions are at odds with the state of the art –and both assumptions imply that the impact estimates are overly pessimistic.

Cost-benefit analysis and emission reduction targets

The Stern Review overestimates the impacts of climate change, and therefore the benefits of emission reduction. Its estimates of the costs of emission reduction are largely inspired by the Innovation Modeling Comparison Project (Edenhofer *et al.*, 2006; Grubb *et al.*, 2006; Koehler *et al.*, 2006), a group of models that make overly optimistic assumptions on technological progress and the costs of emission abatement (see Weyant, 2004, and van Vuuren *et al.*, 2006, for more mainstream estimates). High benefits and low costs together imply that the Stern Review recommends more stringent emission reduction than the standard cost-benefit analysis (Azar and Lindgren, 2003; Keller *et al.*, 2004, 2005; Maddison, 1995; Manne *et al.*, 1995; Nordhaus, 1991, 1993, 1994; Nordhaus and Boyer, 2000; Nordhaus and Yang, 1996; Peck and Teisberg, 1992, 1994; Tol, 1997, 1999, 2001, 2002).

The Stern Review does not, in fact, present a formal cost-benefit analysis. Instead, it compares the magnitudes of the costs of abatement (around 1% of GDP) to the costs of climate change (5-20% of GDP) and concludes that the latter justifies the former. There are two mistakes here. Firstly, the costs of climate change do not equal the benefits of emission reduction – any abatement will only slow climate change rather than avoid it altogether – therefore, the benefits of emission reduction are smaller than the costs of climate change (Tol and Yohe, 2006). Secondly, marginal costs should be compared to marginal benefits, rather than total costs to total benefits.⁶ The Stern Review is silent on marginal abatement costs. It does report marginal damage costs though. For instance, it says “the mean value of the estimates in the study by Tol [2005] was about \$29/tCO₂” but omits that Tol (2005) concludes that “it is unlikely that the marginal damage costs of carbon dioxide emissions exceed \$50/tC [\$14/tCO₂] and are likely to be substantially smaller than that.” The Stern Review does report that “the current social cost of carbon [...] might be around \$85/tCO₂”, but it does not provide any more detail – except that this number is preliminary and results from PAGE2002 (Hope, 2006). \$85/tCO₂ equals \$314/tC, and is therefore an outlier in the marginal damage cost literature (Tol, 2005).

⁵ This is a puzzling mistake to make. Sir Nicholas used to be the chief economist at the World Bank. Mistakes like this are usually corrected when one studies for a Master's degree in economics.

⁶ This can be found in any textbook on cost-benefit analysis, and in many a textbook on economics. It is puzzling that economists of HM Treasury can make such basic mistakes.

Conclusion

In sum, the Stern Review is very selective in the studies it quotes on the impacts of climate change. The selection bias is not random, but emphasizes the most pessimistic studies. The discount rate used is lower than the official recommendations by HM Treasury. Results are occasionally misinterpreted. The report claims that a cost-benefit analysis was done, but none was carried out. The Stern Review can therefore be dismissed as alarmist and incompetent.

This is not to say that climate change is not a problem, nor that greenhouse gas emissions should not be reduced. There are sound arguments for emission reduction. However, unsound analyses like the Stern Review only provide fodder for those skeptical of climate change and climate policy.

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References

- Acemoglu, D., S.Johnson, and J.A.Robinson (2001), 'The Colonial Origins of Comparative Development: An Empirical Investigation', *American Economic Review*, **91**, 1369-1401.
- Acemoglu, D., S.Johnson, and J.Robinson (2005), 'The Rise of Europe: Atlantic Trade, Institutional Change, and Economic Growth', *American Economic Review*, **95**, (3), 546-579.
- Arnell, N. W. (2004), 'Climate change and global water resources: SRES emissions and socio-economic scenarios', *Global Environmental Change*, **14**, 31-52.
- Azar, C. and K.Lindgren (2003), 'Catastrophic events and stochastic cost-benefit analysis of climate change', *Climatic Change*, **56**, 245-255.
- Clarkson, R. and Deyes, K. (2002), *Estimating the Social Cost of Carbon Emissions*, The Public Enquiry Unit - HM Treasury, London, Working Paper 140.
- Easterly, W. and R.Levine (2003), 'Tropics, germs, and crops: how endowments influence economic development', *Journal of Monetary Economics*, **50**, 3-39.
- Edenhofer, O., K.Lessmann, C.Kempf, M.J.Grubb, and J.Koehler (2006), 'Induced Technological Change: Exploring its Implications for the Economics of Atmospheric Stabilization -- Synthesis Report from the Innovation Modeling Comparison Project', *Energy Journal* (Endogenous Technological Change and the Economics of the Atmospheric Stabilization Special Issue), 1-52.
- Fankhauser, S. and R.S.J. Tol (2005), 'On Climate Change and Economic Growth', *Resource and Energy Economics*, **27**, 1-17.
- Grubb, M.J., C.Carraro, and H.-J.Schellnhuber (2006), 'Technological Change for Atmospheric Stabilization: Introductory Overview to the Innovation Modeling

- Comparison Project', *Energy Journal* (Endogenous Technological Change and the Economics of the Atmospheric Stabilization Special Issue), 1-16.
- Guo, J., C.J.Hepburn, R.S.J.Tol, and D.Anthoff (2006), 'Discounting and the Social Cost of Climate Change: A Closer Look at Uncertainty', *Environmental Science & Policy*, **9**, 205-216.
- Hope, C.W. (2006), 'The Marginal Impact of CO₂ from PAGE2002: An Integrated Assessment Model Incorporating the IPCC's Five Reasons for Concern', *Integrated Assessment Journal*, **6**, (1), 19-56.
- House of Lords (2005), *The Economics of Climate Change*, HL Paper 12-I, Select Committee on Economic Affairs 2nd Report of Session 2005-06, London.
- HM Treasury (2003), *The Green Book: Appraisal and Evaluation in Central Government*, TSO, London.
- Keller, K., M.Hall, S.-R.Kim, D.F.Bradford, and M.Oppenheimer (2005), 'Avoiding Dangerous Anthropogenic Interference with the Climate System', *Climatic Change*, **73**, 227-238.
- Keller, K., B.M.Bolker, and D.F.Bradford (2004), 'Uncertain climate thresholds and optimal economic growth', *Journal of Environmental Economics and Management*, **48**, 723-741.
- Koehler, J., M.J.Grubb, D.Popp, and O.Edenhofer (2006), 'The Transition to Endogenous Technical Change in Climate-Economy Models: A Technical Overview to the Innovation Modeling Comparison Project', *Energy Journal* (Endogenous Technological Change and the Economics of the Atmospheric Stabilization Special Issue), 17-55.
- Maddison, D.J. (1995), 'A Cost-Benefit Analysis of Slowing Climate Change', *Energy Policy*, **23**, (4/5), 337-346.
- Manne, A.S., R.O.Mendelsohn, and R.G.Richels (1995), 'MERGE - A Model for Evaluating Regional and Global Effects of GHG Reduction Policies', *Energy Policy*, **23**, (1), 17-34.
- Mendelsohn, R.O., W.Morrison, M.E.Schlesinger, and N.G.Andronova (2000), 'Country-specific market impacts of climate change', *Climatic Change*, **45**, 553-569.
- Muir-Wood, R., S. Miller and A. Boissonade (2006), *The Search for Trends in a Global Catalogue of Normalised Weather-Related Catastrophe Losses*, Climate Change and Disaster Losses Workshop, Hohenkammer.
- Myers, N. and J. Kent (1995), *Environmental Exodus: An Emergent Crisis in the Global Arena*, The Climate Institute, Washington, D.C.
- Nicholls, R.J. and R.S.J. Tol (2006), 'Impacts and responses to sea-level rise: A global analysis of the SRES scenarios over the 21st Century', *Philosophical Transaction of the Royal Society A – Mathematical, Physical and Engineering Sciences*, **361** (1841), 1073-1095.
- Nordhaus, W.D. (1991), 'To Slow or Not to Slow: The Economics of the Greenhouse Effect', *Economic Journal*, **101**, 920-937.
- Nordhaus, W.D. (1993), 'Rolling the 'DICE': An Optimal Transition Path for Controlling Greenhouse Gases', *Resource and Energy Economics*, **15**, 27-50.

- Nordhaus, W.D. (1994), *Managing the Global Commons: The Economics of Climate Change* The MIT Press, Cambridge.
- Nordhaus, W.D. (2006), 'Geography and Macroeconomics: New Data and New Findings', *Proceedings of the National Academy of Science* (www.pnas.org/cgi/doi/10.1073/pnas.0509842103).
- Nordhaus, W.D. and J.G. Boyer (2000), *Warming the World: Economic Models of Global Warming* The MIT Press, Cambridge, Massachusetts - London, England.
- Nordhaus, W.D. and Z. Yang (1996), 'RICE: A Regional Dynamic General Equilibrium Model of Optimal Climate-Change Policy', *American Economic Review*, **86**, (4), 741-765.
- Pearce, D.W. (2003), 'The social cost of carbon and its policy implications', *Oxford Review of Economic Policy*, **19** (3), 1-32.
- Peck, S.C. and T.J. Teisberg (1994), 'Optimal Carbon Emissions Trajectories When Damages Depend on the Rate or Level of Global Warming', *Climatic Change*, **28**, 289-314.
- Pielke, R.A., Jr. (2005), 'Misdefining "Climate Change": Consequences for Science and Action', *Environmental Science & Policy*, **8**, 548-561.
- Pielke, R.A. Jr., C. Landsea, M. Mayfield, J. Laver and R. Pasch (2005), 'Hurricanes and Global Warming', *Bulletin of the American Meteorological Society*, **86** (11), 1571-1575.
- RCEP (2000), *Energy – The Changing Climate*, Royal Commission on Environmental Pollution, London (<http://www.rcep.org.uk>).
- Sachs (2001), *Tropical Underdevelopment*, Working Paper 8119, National Bureau of Economic Research, Cambridge.
- Smith, J.B., H.-J. Schellnhuber, M.M.Q. Mirza, S. Fankhauser, R. Leemans, E. Lin, L. Ogallo, B. Pittock, R.G. Richels, C. Rosenzweig, R.S.J. Tol, J.P. Weyant and G.W. Yohe (2001), 'Vulnerability to Climate Change and Reasons for Concern: A Synthesis', Chapter 19, pp. 913-967, in J.J. McCarthy, O.F. Canziani, N.A. Leary, D.J. Dokken and K.S. White (eds.), *Climate Change 2001: Impacts, Adaptation, and Vulnerability*, Cambridge University Press, Cambridge.
- Stern, N., S. Peters, V. Bakhshi, A. Bowen, C. Cameron, S. Catovsky, D. Crane, S. Cruickshank, S. Dietz, N. Edmonson, S.-L. Garbett, L. Hamid, G. Hoffman, D. Ingram, B. Jones, N. Patmore, H. Radcliffe, R. Sathiyarajah, M. Stock, C. Taylor, T. Vernon, H. Wanjie, and D. Zenghelis (2006), *Stern Review: The Economics of Climate Change*, HM Treasury, London.
- Tol, R.S.J. (1997), 'On the Optimal Control of Carbon Dioxide Emissions: An Application of *FUND*', *Environmental Modeling and Assessment*, **2**, 151-163.
- Tol, R.S.J. (1999), 'Spatial and Temporal Efficiency in Climate Change: Applications of *FUND*', *Environmental and Resource Economics*, **14**, (1), 33-49.
- Tol, R.S.J. (2001), 'Equitable Cost-Benefit Analysis of Climate Change', *Ecological Economics*, **36**, (1), 71-85.
- Tol, R.S.J. (2002), 'Welfare specifications and optimal control of climate change: an application of *fund*', *Energy Economics*, **24**, 367-376.

- Tol, R.S.J. (2005), 'The Marginal Damage Costs of Carbon Dioxide Emissions: An Assessment of the Uncertainties', *Energy Policy*, **33** (16), 2064-2074.
- Tol, R.S.J. (forthcoming), 'Climate, Development and Malaria: An Application of *FUND*', *Climatic Change*.
- Tol, R.S.J. and S. Fankhauser (1998), 'On the Representation of Impact in Integrated Assessment Models of Climate Change', *Environmental Modelling and Assessment*, **3**, 63-74.
- Tol, R.S.J. and G.W. Yohe (2006), 'Of Dangerous Climate Change and Dangerous Emission Reduction' in H.J. Schellnhuber, W. Cramer, N. Nakicenovic, T. Wigley and G. Yohe (eds.), *Avoiding Dangerous Climate Change*, Cambridge University Press, Cambridge, Chapter 30, pp. 291-298.
- van Vuuren, D.P., J.P. Weyant, and F.C. de la Chesnaye (2006), 'Multi-gas Scenarios to Stabilize Radiative Forcing', *Energy Economics*, **28**, 102-120.
- Weyant, J.P. (2004), 'Introduction and overview', *Energy Economics*, **26**, 501-515.
- Yohe, G.W. and R.S.J. Tol (2002), 'Indicators for Social and Economic Coping Capacity – Moving Towards a Working Definition of Adaptive Capacity', *Global Environmental Change*, **12** (1), 25-40.