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. I agree with the Stern Review on a number of things. Firstly, climate change is real, and climate change is a problem. Secondly, climate policy should be guided (but not dictated) by an assessment of the costs and benefits of greenhouse gas emission abatement. Thirdly, climate policy is best implemented with market-based instruments such as taxes and tradable permits.

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 GDP[1] 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 CO_2 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 also 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 – Pearce (2006) adds

[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%.

more detail. 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

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 but stable 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 highlights 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

[2] It is clear from page 162 that this is a certainty-equivalent 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 CO_2 emissions.

[3] It is surprising that the Stern Review overlooked Pielke's work on hurricane damages, as it was presented at the same meeting as Muir-Wood's work, and Pielke alerted Stern to this (Pielke, personal communication, 2006). Pielke's work on hurricanes is referred to in Chapter 1 of the Stern Review.

[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.

against sea level rise. Note that Nicholls and Tol (2005) do report impact measures with adaptation too.[5]

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, 2005) 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 Review interprets the income-loss-equivalent-welfare-losses (market impacts only) with actual income losses – this is a very crude approximation.

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. Firstly, there is less than a 5% probability that the climate change impacts are negative, even in the short run (cf. Mendelsohn *et al.*, 2000). Secondly, the model assumes that vulnerability to climate change is independent of development (cf. 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.

The Stern Review provides too little information to understand what is in the calculations. There appear to be no equity weights in the Stern Review. The report adds otherwise unspecified and unquantified "market impacts" (annuitized at 2.1% of GDP), "non-market impacts" (5.9%) and "catastrophic risk" (2.9%). The reported "mean" is apparently a certainty equivalent, although the "mean" is presented together with a confidence interval. The catastrophic risk apart, the Stern Review also assumes that there is a 0.1% annual probability (10% in a century) of extinction of the human race. The welfare loss of that is added too, apparently in addition to the "catastrophic risk". Together with the certainty equivalent, risk seems to be counted three times.

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 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,

[5] The Stern Review does discuss adaptation. There are 260 pages of text between the discussion of impacts and the discussion of adaptation.

2000; Nordhaus and Yang, 1996; Peck and Teisberg, 1992, 1994; Tol, 1997, 1999, 2001, 2002).

The Stern Review does not include a cost-benefit analysis, apart from a ranking of two projects. 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. 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/tCO_2" but omits that Tol (2005) concludes that "it is unlikely that the marginal damage costs of carbon dioxide emissions exceed \$50/tC [\$14/tCO_2] 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/tCO_2", but it does not provide any more detail – except that this number is preliminary and results from PAGE2002 (Hope, 2006).[6] \$85/tCO_2 equals \$314/tC, and is therefore an outlier in the marginal damage cost literature (Tol, 2005).

Surprisingly, the Stern Review supports a marginal damage cost estimate that is three times as high as the previous estimate of HM Treasury (Clarkson and Deyes, 2002) – but it supports the same target for stabilizing greenhouse gas concentrations. The total climate change impacts of the Stern Review are about 8 times those of the CEC (2005), while Stern's abatement costs estimates are only about 4 times as high – yet, the Stern Review advocates a climate target that is less stringent than does CEC (2005). The Stern Review does not elucidate these discrepancies.

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. In this sense, the Stern Review reminds one of Lomborg (2001). 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 – and may well further polarize the debate.

[6] According to Hope (personal communication, 2006), the marginal damage cost was calculated using a 0.1% rate of pure time preference.

Climate policy is for the long-term. It will only be successful if a broad coalition – of countries and of stakeholders within countries – supports climate policy and continues to support climate policy. To my mind, this calls for a sober analysis, rather than hyperbole.

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