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PERSPECTIVE PAPER

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Global Warming

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Introduction

I find myself in agreement with much of the analysis of Yohe et al. To summarise, I think they have got it broadly right when they say:

- The consequences of climate change are serious, more so for developing countries than for developed ones. Indeed for some time to come climate change may well have benefits in the more temperate zones, where most of the wealthier countries lie.
- The causes of climate change are to be found in the increased emissions of greenhouse gases (GHGs). Reductions in these gases will also reduce likely climatic impacts but mitigation will be expensive and the likely benefits may be small compared to the costs, when the latter are measured using conventional discount rates of 4-5 percent in real terms.
- The benefits of action are enhanced when measures to reduce GHGs are accompanied by support for R&D in low carbon technologies and when action is taken to adapt to climate change, especially by investing in measures to reduce the health impacts of such change.
- The ratio of benefits to costs rises further if mitigation policy is 'flexible', so that reductions are made when they are most effective.
- The same ratio rises a great deal more if we take account of uncertainty, where this uncertainty is measured in terms of the climate sensitivity parameter and the benefits are still measured in terms of expectations – i.e. no account is taken of risk aversion.

In this perspectives paper I would like to make the following points. First, I believe the case for action on climate change is stronger than Yohe et al. have stated. They have gone for a minimalist approach, perhaps on the grounds that if the case can be made on the basis of the least controversial assumptions, it would be made, *a fortiori*, when these additional factors are taken into account. Notwithstanding this, I think the authors could have looked more

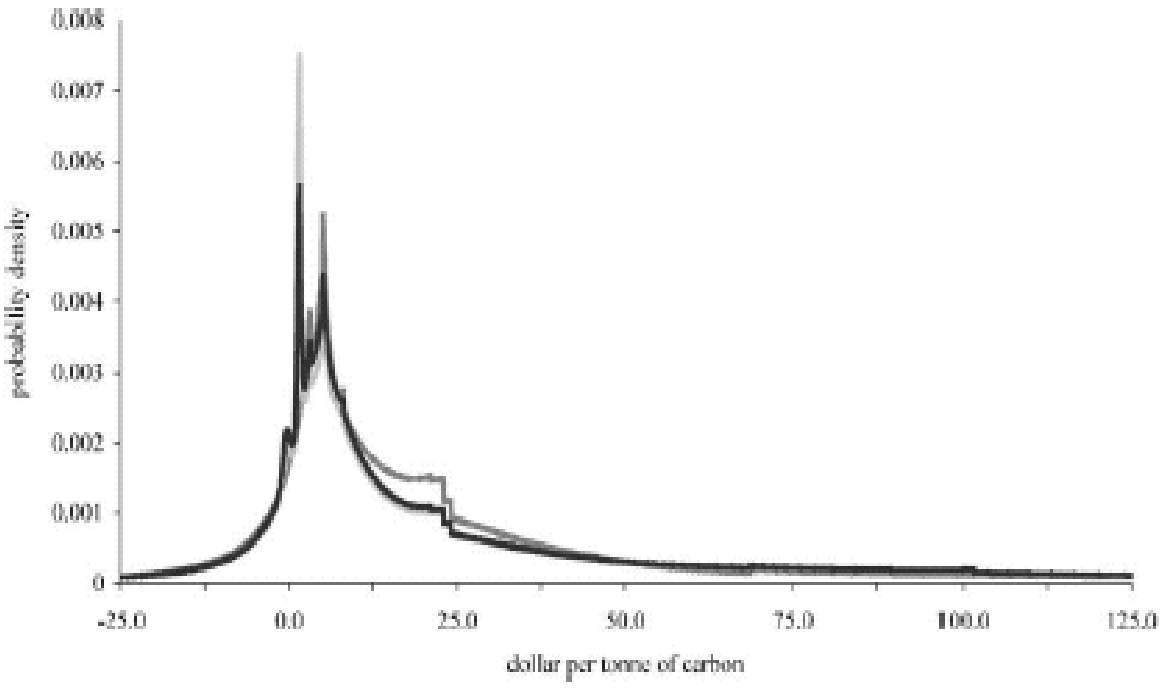
closely at the **maximum potential** for GHG reduction that is justifiable given the parameters they have adopted. If a benefit-cost ratio of up to 7 is estimated for modest actions, a lower but still acceptable ratio may be justified for more severe actions.

Apart from this general point, I consider that four factors need further attention. These are: (a) the estimation of benefits, (b) the issue of distributional effects, (c) the benefits of early action in opening up more options for the future and (d) a deeper treatment of uncertainty. Each of these is considered in turn.

Estimation of Benefits

The benefits estimated by Yohe et al are most likely to be underestimated of the damages of climate change. The FUND model, on which the challenge paper is based is well known for being conservative on the damages compared to many other studies. Figure 1 shows the range of damage from studies as a density function, collected by one of the challenge authors (Tol, 2005). Tol himself is very close to the modal value of this distribution, which is also the result of the FUND model with which he works. But there are others who have much higher estimates and the whole distribution is heavily positively skewed. . Do we simply ignore them? That does not seem reasonable as several other models reported in the peer-reviewed literature are also credible. A mean value across all studies would be higher than that taken in the challenge paper, even if on excluded some of the 'outliers'. Hence one can safely conclude that, based on the existing evidence, the paper is an underestimate of the average damage costs in the literature.

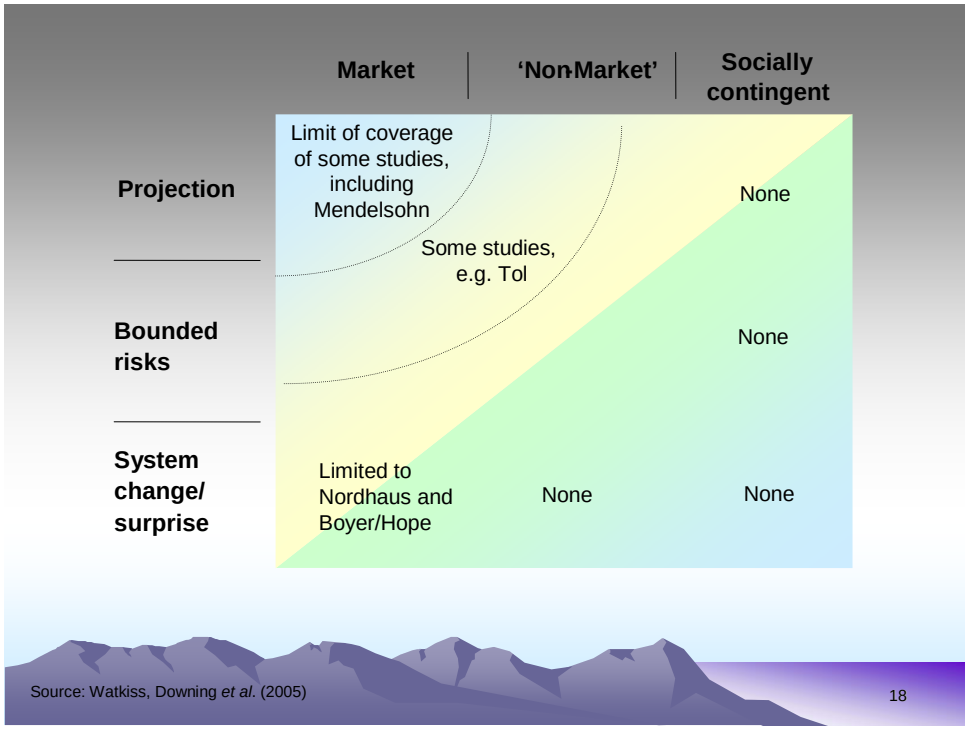
Figure 1: Range of Damage Estimates in Different Studies



Source: Tol, 2005.

The literature itself, however, needs to be recognized as incomplete. Many possible impacts have not been valued, because the nature of the impacts has not been fully characterized. Figure 2 shows the areas where there have been studies and where there have not. The possible consequences of system change and surprise have not been evaluated in the literature. Nor have the 'socially contingent' impacts of climate-induced changes. These include migrations, social conflicts and the like. I accept it is very difficult to include these at this stage, but that cannot be a reason for saying they do not matter for policy purposes. If benefit estimation is unable to make progress in estimating such damages, we need other tools for making decisions in the area of climate change. That is the position taken by several people working the field, who argue that a notion of acceptable risk is a more sound approach in these circumstances.

Figure 2: Range of Studies on Climate Impacts



Distributional Effects

Yohe et al. recognize that there are worrying distributional consequences to climate change but they do not do anything about them in the reported cost-benefit analysis. The benefits are the simple sum of the reduced damages following a reduction in GHG emissions, irrespective of where they occur. Yet no one seriously argues that decisions on investment of public funds between competing uses should be done without taking account of such distributional effects. In the case of climate change these regional differences are particularly egregious. If we look at Figures 5.2 and 5.3 of the challenge paper the combined market and

non-market damages in the less developed countries (excluding China) are positive and significant throughout the period of analysis (to 2300) in the absence of climate change, while in the developed countries they are much smaller and possibly even negative for the next decade or two. China seems to be an exception, with negative damages (i.e. benefits) to about 2075[1]. Nevertheless it is clear that the BAU case implies higher damages to most poor countries and some benefits to the more developed countries.

From this starting point, any action taken generates greater benefits in the less developed countries than it does in the developed (OECD) countries. At least that appears to be the case to 2100. This fact should be reflected in the final data that those who make the decisions look at. Not to do so would be to ignore an important dimension of the problem.

Conversely not taking any action is tantamount to imposing higher costs on the poor than on the rich. Indeed it could even be seen as providing benefits to the rich and imposing costs to the poor. At a discount rate of 5 percent, most of the relevant costs and benefits are those over the next 50 years or so anyway, and, based on Figures 5.2 and 5.3, up to 2050 the OECD countries have no damage costs while developing countries have costs of about 0.3 percent of their GDP. Not acting on climate change therefore is a policy of transferring welfare from the poorer countries to the wealthier countries.

The Benefits of Early Action

The literature on climate change notes that there could benefits to early action. The Stern Report, for example, makes this point on a number of occasions. Others have examined the problem of making decisions with irreversible consequences in other contexts from an options perspective (Dixit and Pindyck, 1996; Mun, 2005).

The issue here is that over time we will learn more about climate change and about the consequences of emissions generated today. If this process reveals that the situation is more benign than we thought, so much to the good. But if it reveals that the situation is more serious than our 'average' view, then it may be too late to take action, if previous action was based on an 'average' view of the seriousness of climate change.

I illustrate the problem with a simple example that captures many of the features of climate policy. Suppose we have three time periods in our horizon, one of which is the present. We can make decisions twice: once now once at the end of the first period, when the true nature of the damages from emissions will be revealed. The costs of action are an increasing function of the level of emissions reductions. To provide a numerical illustration I have assumed that a one percent reduction in emissions increases costs by 1.2 percent. I assume furthermore that in any period the maximum reduction that is possible is ten percent from the BAU scenario. Of course the 'BAU scenario' will change as emissions themselves are altered by reductions in previous periods.

In period 1 we are told the precise nature of the climate change problem. The 'optimistic' scenario is that we discover there is no problem and associated damages are zero. The pessimistic scenario is that we discover the damages are twice the average we assumed in

[1] It is difficult to assess the total damages as the market and non-market damages have not been added up. My comments are based on a visual examination of the two curves.

period 0. I assume that probabilities of each event are equal and that current expected values are correct.

For such an example I consider two actions or programmes. The first is to reduce emissions in period 0 (i.e. today) by 10 percent and then in the second period to either take no action (if it is revealed that there is no problem), or to reduce them by a further 10 percent if the problem is severe. The resulting figures show that the expected benefits from the programme are positive (equal to 2,87 in Table 1), although if we look only at the costs and benefits of the period 0 to period 1 the net figure is zero[2]. Thus on benefit-cost ground the two period decision would be marginal while a full three period analysis is positive.

Table 1: An Example of the Benefits of Early Action

	Period		**0**	**1**	**2**
Data					
	Emissions BAU		0,00	150,00	200,00
	Damages (a)		0,00	0,00	0,00
	Damages (b)		0,00	30,00	40,00
Action 1					
	Controlled Emissions (a)	270,00	0,00	135,00	135,00
	Controlled Emissions (b)	297,00	0,00	135,00	162,00
	Damages (a)	0,00	0,00	0,00	0,00
	Damages (b)	59,40	0,00	27,00	32,40
	Costs (a)	1,50	0,00	1,50	0,00
	Costs (b)	3,37	0,00	1,50	1,87
	Benefits (a)	-1,50	0,00	-1,50	0,00
	Benefits (b)	7,23	0,00	1,50	5,73
	Expected Net Benefits	2,87	0,00	0,00	2,87
	Expected Benefits Period 0-1	0,00			
Action 2					
	Controlled Emissions (a)	255,00	0,00	127,50	127,50
	Controlled Emissions (b)	280,50	0,00	127,50	153,00
	Damages (a)	0,00	0,00	0,00	0,00
	Damages (b)	56,10	0,00	25,50	30,60
	Costs (a)	2,44	0,00	2,44	0,00
	Costs (b)	4,18	0,00	2,44	1,74
	Benefits (a)	-2,44	0,00	-2,44	0,00
	Benefits (b)	9,72	0,00	2,06	7,66
	Expected Net Benefits	3,64	0,00	-0,19	3,83
	Expected Benefits Period 0-1	-0,19			

It is possible, however to think of a government as undertaking a bigger reduction in period 0 in view of the fact that future reductions are constrained and the situation may turn out to be more serious than anticipated. If the decision-maker chooses to make a reduction of 15 percent on this basis instead of the 10 in action 1, the two period net benefits are negative,

[2] For the sake of simplicity I have not introduced any discounting. Doing so does not change the point being made.

but the three period net benefits are both positive and greater than with action 1 (3,64 instead of 2,87).

The example makes two points. First, a short time period analysis is misleading when the costs and benefits are linked over several periods. Second there can be a value to undertaking more emissions reductions today when future options are limited and when future knowledge will reveal information that may make it attractive to keep more options open in the future. In this simple example, the additional reduction of 5 percent in emissions in period 0 can be seen as buying the option of making a bigger overall reduction in emissions in period 1 in case it is discovered that the problem is more serious than was originally envisaged.

The analysis presented by Yohe et al. does not include the benefits of such options because it does not build in sequential learning. Doing so will justify larger reductions today and will generate larger cost benefit ratios for given reductions.

Uncertainty

Uncertainty is at the heart of the climate problem. Although Yohe et al recognize its importance I do not believe they give it as central a role as it deserves.

In most applications of cost benefit analysis uncertainty is treated by replacing a range of possible costs and benefits by their expected values. This is what Yohe et al have done and they show that the expected benefits increase sharply as account is taken of the more extreme outcomes. The result is a reflection of the substantially non-linear and convex damage function, where damages rise sharply and more than proportionally with climate sensitivity.

They could have gone further and added a risk premium to the damages, based on the willingness of people to pay to reduce the uncertainty associated with future developments. Doing so is not difficult, and based on the lognormal distributions they have taken, the reductions in damages would then turn out to be even greater, raising the benefit cost ratio even further beyond the 7 they obtain.

At a deeper level, however, one can question the use of benefit cost analysis in these circumstances. The problem is that we do not know the probability distribution for the key parameters that will determine the seriousness of the climate impacts. Generally the discussion is focussed on the climate sensitivity parameter and a log normal distribution is taken. But the variance of that distribution is not known. Nor is the property of the tail of the distribution that defines the likelihood of extreme events (e.g. temperature increases of more than 6^0 Centigrade with a doubling of emissions, referred to in the literature as the climate sensitivity parameter *S*). All we know is that it is not insignificant. Based on IPCCIV (2007) the probability that $S > 6^0$ is about 5 percent and the probability that it is greater than 8^0 is 2 about percent. These are not insignificant probabilities, and they represent outcomes that would be catastrophic.

As Weitzman (2007) has shown, such extreme events cause problems for decision-making within the cost benefit framework. One cannot base decisions on expected utility

theory, let alone on expected value theory because the relevant functions are unbounded. Moreover knowledge about the parameters of the distribution cannot be learnt from experience in the usual Bayesian sense when the tails are so 'fat' to begin with. This is a dismal result in many respects and Weitzman refers to it as the 'Dismal Theorem'. To quote from his paper he concludes:

> "Perhaps in the end the economist can help most by not presenting a cost-benefit estimate for such situations as if it is accurate and objective, and not even presenting the analysis as if it is an approximation to something that is accurate and objective .but by stressing the fact that such an estimate is arbitrarily inaccurate depending upon what is subjectively assumed about the tails and where they have been cut off. This is unsatisfying and not what economists are used to, but in situations where the Dismal Theorem applies we may be deluding ourselves and others if we think that we are able to deliver anything much more precise than this with even the biggest and most-detailed Integrated Assessment Models."

This poses a more fundamental challenge to the kind of exercise being undertaken under the Copenhagen Consensus, where benefit cost ratios are the *sine qua non* on the basis of which all decisions are made. We have to come to terms with the fact that in some respects they are not, and in the case of climate change we have to include other supplementary or complementary factors in deciding what actions are justified and what are not. One such criteria is to ask what is the level of acceptable risk that we can tolerate and what are we willing to sacrifice to reduce the actual level of risk to that acceptable level. Much of the climate change debate is taking place in such a framework, rather than a benefit cost framework.

Conclusions

This perspectives paper has made the following points:

- Climate change actions are justified on the basis provided in the challenge paper, but thecase can be made stronger if some other factors are taken into account. The challenge paper could go further in seeing how much action is justified – it stops short of the most that can be supported on a cost benefit basis.

- One reason to think that the challenge paper errs on the low side is that benefits of reducing emissions are underestimated. The literature contains some much higher – and credible estimates.

- The second reason for arguing that action is justified is the distribution of the benefits. Climate action benefits most poor countries more than it does the developed countries; conversely not taking action hurts the poor countries more than the rich ones. Normally some weight is given to distributional impacts of government investments when evaluating such investment. In our case such a weight would favour climate action (although it could also favour some of the other proposed actions being considered).

- The third reason for supporting more GHG reduction now is the benefits of early action. These buy the option of undertaking more reductions in the future if climate turns out to be more serious problem than first thought.

- Finally there is the issue of uncertainty. Brining in risk aversion would make the benefits larger than in the challenge paper. But a more fundamental point is that with the kind of uncertainties we face the benefit estimation methods based on expected value and expected utility break down. We need to take account of the possibility of extreme events in a complementary framework, where governments decide on acceptable levels of risk and seek to minimise the costs of achieving those levels.

References

Dixit, A.K. & Pindyck, R.S. 1994. Investment under Uncertainty. Princeton University. Press, Princeton, N.J.

Jonathon, M. 2005. Real Options Analysis: Tools and Techniques for Valuing Strategic Investment and Decisions, 2nd Edition. Wiley Finance.

IPCC4. Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, 2007 (available online at http://www.ipcc.ch).

Stern, N. 2006. Stern Review on the Economics of Climate Change. Cambridge University Press. The Edinburgh Building, Cambridge CB2 8RU, UK. http://www.hmtreasury.gov.uk/independent_reviews/stern_review_economics_climate_change/sternreview_report.cfm.

Weitzman, M. (2007), "The role of uncertainty in the economics of catastrophic climate change", Harvard University Working Paper, Cambridge, MA.