Chapter 11: Reaction to the Panelists: Sir Nicholas Stern

Thank you all very much for the comments. Many of the points I will make, and several others, are made in depth in the respective sections of the Review and in the publications since its release which can be found at www.sternreview.org.uk.

A: The Role of Integrated Assessment Models in Policy Analysis

I'll begin my reply by first explaining at the rather broad level of where these kinds of models take us and then comment briefly on some specifics of the parameter values.

The reason I want to start at the broad level is that I would be very surprised, indeed deeply worried, if a policymaker thinking about these issues decided that everything turned on whether the elasticity of social marginal utility, η, equals 1.1 or 1.7, or on the very close details of pure time discounting. The first thing to do is to step back and ask yourself what kinds of risk reductions you can get for an expenditure of around 1% of GDP per year. Most people would be able to understand that question, and they'd be able to look at the risks in a much more subtle and informed way than is possible in the kind of aggregative models that we build. So the first way to look at the climate change problem is in terms of common sense judgments where you compare costs on the one hand with reduced risks on the other, and where you can be much more subtle about the reduced risks than you could be in the model. I have already emphasized the severe limitations of this type of modeling and economists do the profession and themselves a disservice if they suggest that our whole policy analysis turns on model specifics.

The second thing is to look at what really matters among the statements that come out from the analysis using the model and ask how robust those statements are. The statement that really counts is that the cost of acting strongly now is a lot less than the cost of the damage that is saved or averted; that statement is robust. The particular numbers are of much less significance to the argument.

We did provide sensitivity analysis in the postscript to the Review. (This was published on the Web about three weeks after the report itself, and is also in the bound version of the Review that is published by Cambridge University Press.) That sensitivity

analysis shows that in the context of the model used that key statement is very robust except for extreme forms of pure time discounting. The postscript shows that, if you raise the value of η up to two, or a bit more, most of the model-runs confirm the statement that the cost of the action to avert the damages is a lot less than the damages averted.

B: Ethics

A common misconception is that the Stern Review uses this or that discount rate. In fact, one of the key features of the approach in terms of an expectation of a utility integral is that the discount rate is endogenous. There will be many discount rates depending on the period of time and the path. And for non-marginal changes we must go back to the objective or welfare function. Generally discount rates are derived in the special case of the evaluation of marginal changes. Let me give two examples of the relevance of this endogeneity. Climate change impacts are uncertain. Accordingly, the discount factor (whose rate of fall is the discount rate) used will, for example, be higher for outcomes with limited impacts than it is for projected outcomes that erode consumption more significantly. Second, a higher growth projection will increase in the discount rate but will bring forward in time absolute climate change impacts.

By explicitly stating and quantifying assumptions, the Review has helped clarify the ethics and we welcome the discussion the Review has stimulated. There are, and should be, genuine differences of opinion on ethics and that is why we provided sensitivity analysis. But ethics must be discussed and should not be seen as arbitrary. As already noted, we found no persuasive arguments to discriminate on the basis of birth dates. This would indeed be ethically arbitrary and constitute little more than a failure of the imagination. More importantly, it accords with what most people understand as an ethical system of valuation. By contrast, to use market interest rates to derive ethical values is misplaced. It fails to make for either a 'prescriptive' or even a 'descriptive' account of value judgments. Market rates are derivative of investment, saving and consumption decisions of individual consumers and producers, made primarily with a view of personal gains within expected lifespans. They do not give an indication of broader ethical valuations of communities thinking of how they should treat the interests

of future generations. Market information can be relevant here but it has to be used very carefully and assumptions made explicit.

On eta, the elasticity of social marginal utility, we would accept the possibility that some would suggest an eta greater than 1. Note however that this would accord with a degree of altruism that some would find surprising. Using eta (η) = 1 implies that an increment for someone with five times less resources than someone else will be valued five times more ($u'(c) = 1/c$). Some commentators have suggested that higher values should be used. Using $\eta = 2$ would mean that an extra unit to the person five times poorer would have a value twenty five times higher ($u'(c)$ is the reciprocal of the square of c). However, as Dasgupta has noted, there are arguments relating to 'responsibility' for damages that might imply the use of a higher eta than would be the case if we focused merely on the ethics of 'compassion'. In terms of estimating the value of climate change damages, a higher eta would raise the discount factor but also increase our aversion to risk. The net impact on valuing distant but risky outcomes is ambiguous and this is shown in the sensitivity tables produced after the review. For example, we have shown that for eta higher than 2 and with the possibility of catastrophic scenarios, the estimate of the value of damages will rise with the elasticity of social marginal utility[1].

C: Alternative Strategies and the Structure of Risks

It is important to note that the estimates of the damages climate change are just as sensitive to small but plausible changes to the climate damage sensitivity parameter than they are to discounting assumptions. In so far as we have adopted what may turn out to be a conservative or optimistic view of the damages, the chances are that our damage estimates may prove to be understatements. It is worth restating for the record, that although we have gone further than many previous studies in measuring what counts, there were many aspects of the story that we simply were unable to explicitly value. These include the damage from socially contingent impacts such as conflict and

[1] For example, setting η to 3 has little impact on the numbers due to aversion to the worse case scenarios (see Dietz, S., C. Hope and N. Patmore (forthcoming): 'Some economics of 'dangerous' climate change: reflections on the Stern Review', Global Environmental Change., forthcoming and Stern, N. (2007a): 'The case for action to reduce the risks of climate change'. Paper A of 'After the Stern Review: reflections and responses''. February 12th, 2007. Working draft of paper published on Stern Review website: www.sternreview.org.uk). Essentially because η captures aversion to risk as well as aversion to inequality.

migration, and the treatment of Knightian uncertainty – that is, our aversion to ambiguity when we know we are entering "unchartered territory".

Obviously one way to approach policy is to put the climate change problem to one side: "We'll make these wonderful rates of returns on these investments that we can see, and we'll sort out climate change later on." Would that leave us in a good place? I suspect not. As people become richer and environmental goods become scarcer it seems likely that their relative value will rise rapidly, giving a greater weighting to many of the climate-related damages. And as we all know from the basic theory of discounting in models with many capital goods (following from Malinvaud's famous article in 1953 *Econometrica*) the unit of account that you use has a very striking effect on the discount rate. If you did your accounting in environmental goods, indeed the discount rate would probably be negative. So, if you build models in which you underestimate the rapid rise of the price of environmental goods relative to other goods, then one way of compensating for that mistake is to use a low discount rate[2].

It is important to note that the flow-stock nature of GHG accumulation plus the powerful potential impact of climate change will render many consequences irreversible. Thus exploiting an arbitrage opportunity between ethical discounting and market rates by investing elsewhere and using the resources to compensate any later environmental damage depends on narrow and implausible assumptions and may be very cost-ineffective and highly risky.

D: Social Costs of Carbon and Radical Policy

I'd like to say something about what "radical" means. If you remember the argument this morning, I said go for a stabilization goal on the basis of risk management and the cost of getting there, think of the choice of paths that are consistent with that stabilization goal, use the price mechanism to decarbonize within that framework, and revise from time to time, bearing in mind things like the social cost of carbon. From this point of view, you've

[2] There has been some explicit modeling by Sterner, T. and Persson, U. M., (2007, An even Sterner Review: Introducing relative prices into the discounting debate. Working draft: http://www.hgu.gu.se/files/nationalekonomi/personal/thomas%20sterner/b88.pdf) that shows the powerful effect that this can have on the modelling

got to ask what "radical" means. I don't measure radical in terms of the social cost of carbon, which is very hard to measure and, of course, depends very much on your choice of path. (On the path that we used for stabilization at 550 ppm carbon dioxide equivalent, the social cost of carbon started at $30 per ton of CO_2, though it would have been higher on the business-as-usual path.)

There seems to have been some confusion over the carbon tax level people believe we are advocating. Professor Nordhaus quoted our business as usual level of $85 per ton. However, this is not what we advocated and if adopted would change the business as usual path. Thus the costs would be lower as imposing such a price would drastically reduce emissions and the damages that would result. Professor Cline used our average mitigation costs as our suggested rate. We would not advocate this either. We should note that whilst marginal damage costs are only one relevant aspect of a carbon price, they are important and they are likely to rise over time. The relationship between average and marginal costs of mitigation is discussed in more detail in Chapter 9 of the Review. In Chapter 13 of the Review we justify our policy goal of stabilizing emissions between 450ppm and 550ppm CO2e. In this range we estimate the social cost of carbon to be between $25 per ton (450ppm) and $30 per ton (550ppm) and so policies should be broadly consistent with this range. However, in distorted and uncertain economies any tax should be different from an SCC[3]. Generally the SCC is not a reliable measure of the 'radicalness' of policy.

Instead of discussing particular social costs of carbon I would talk about radicalness in policy in terms of the kinds of targets you set yourself for reducing emissions over 20 and 50 years. I would ask what targets the European Union will set itself for reducing emissions in the third phase of the emissions trading scheme between 2012 and 2020. We're talking in Europe about a 20 %reduction no matter what anybody else does, or maybe 30 %if countries elsewhere move strongly, and we wait in strong anticipation for the United States.

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[3] See the literature on modern public economics (e.g. the Journal of Public Economics) and Section A7 of Stern (2007a): 'The case for action to reduce the risks of climate change'. Paper A of 'After the Stern Review: reflections and responses''. February 12th, 2007. Working draft of paper published on Stern Review website: www.sternreview.org.uk

That's the kind of way I would measure radical. Then the questions are: How difficult is it to reduce emissions? What kind of things would we have to do? Is it easier if we start now? And I actually think that starting now is in some ways less radical than starting later because if you start now, you can spread your action out over a longer period. If you postpone the decision but subsequently decide that the stabilization goal of 550 ppm is wise, then you get yourself into much more trouble later on.

So, I would see radical in terms of the kinds of actions you have to take, the kinds of quantitative goals you have to set, the kinds of R&D you try to do now. That's my notion of radical. And I suspect that if Bill Cline and I looked at radical in those terms, the two of us might come up with similar kinds of ideas, and the policies we would describe would look rather similar.

E: "Political Constraints" and Peer Review

One or two people have mentioned political constraints. They appear to know things about where and how we worked that are totally at variance with the experiences of those of us who were there. The team and myself didn't know what the conclusions would be before we started. I didn't feel under political pressures. Certainly once you're operating in a political environment, there is a limit as to how much you can share, because of the way the argument starts to take place in the newspapers rather than amongst analysts. That's a constraint on the process, but it's not a constraint on what you actually say at the end. So, I didn't feel political constraints. I certainly felt a time constraint. That was painful, and I would like to have continued to take the analysis forward. I look forward to doing that when I return to academic life.

On the point of peer review, the Stern Review was an independent review that was commissioned by and reported to the UK Chancellor and Prime Minister. UK Government does not undertake peer review on commissioned reviews so this was not an option. We did hold a full call for evidence that provided some significant contributions (available on our website). We published papers outlining our approach as it developed several months before publication and gave many presentations around the world that made our emerging thinking clear. Stakeholders were engaged throughout the Review and we drew from the vast wealth of peer-reviewed literature, as the IPCC does in its

own process. In an area such as climate change, a subject in the media spotlight, there are risks of early confused coverage if the Review's contents were somehow leaked.

While the Review did seek to build on the foundations of the academic literature on the economics of climate change, its target audience was not only academics but also policy–makers, business and individuals. This diverse audience means that reviewing the document from only an academic perspective may have reduced the impact on other audiences. One of the things that has pleased me most since the release of the report, is the diverse range of people from around the world that have engaged with the report.

In many ways some peer review has been carried out since the Review's release in the public domain: today has been an important part of this process. The Review has been given the attention of many critiques, many of which we have responded to. I believe throughout this process that our analysis and conclusions have proven to be very robust. Most of the attention has focused on ethical valuations on which reasonable people can differ, but we give powerful arguments for the ranges selected for examination. Many of the other comments are based on misconceptions and false assumptions about what the Review did or failure to read the whole report. So, fortunately, there is nothing significant that I would change if this peer review had been conducted before the release of the Review, other than to include the sensitivity analysis for Chapter 6 (contained in a Postscript and subsequent analysis) in the main body of the Review and to signpost the content of Chapter 13 in Chapter 6 for those that did not have time or inclination to read that far.

F: Additional Points

I think many comments, including those by Gary Yohe and Rob Mendelsohn, ignored the basic sensitivity analysis that we applied. As I mentioned earlier, this showed that you can change the values used in the formulation without changing the key statement of the first half of the Review the costs of action are much smaller than the damages they avert. If you don't like η (elasticity of social marginal utility) equals one and δ (pure time preference) equals 0.1, then increase η to 1.5 or so. You get the kinds of rates of return that you apparently think you see as social rates of return in the market, (although how you appear to know these social rates over hundreds of years puzzles me,

as I revealed earlier) and you reduce the weight of the benefits at the far end that you don't like when η equals one, and you still get the same basic conclusion: that the damages saved are substantially greater than the one %of GDP that it costs to save them.

On comparing GDP and consumption, there is no problem, because we measured the cost in terms of the percentage of GDP, which acts just like a price index that applies to both consumption and GDP. If you're looking at long-run steady states, then there's no difference in percentage changes between GDP and consumption. So, if you're looking at the long run and, eventually, roughly balanced growth, as we were, there is not a problem in comparing these metrics. We did put a paper up on the Review Website (Paper A of 'After the Stern Review: reflections and responses' www.sternreview.org.uk) at the beginning of February in which we looked in detail at the suggestion that there was some kind of inconsistency between those two things, and not surprisingly, we found that there wasn't.

The "now and forever" language in our report is accurate but perhaps it wasn't particularly felicitous, and on reflection, we might have used some other wording. But the point is that we are using a balanced growth equivalent, which is quite a useful tool for comparing percentage damages saved and percentage costs over time as it can capture pathways using a single comparable unit.

On Gary's point on the stabilization target, it was through looking at where we are now and the costs of benefits of stabilization at 550ppm CO2e that we suggest that policy should aim to stabilize between 450ppm and 550ppm CO2e. There is little modeling evidence of lower targets but we were clear that the target should be below 550 ppm not at 550ppm.

Moving now to Rob Mendelsohn's point, unfinished business this certainly is. There would never be any pretense of having the last word. How could there be? And that's not where we try to be.

We have been very open and clear on the analysis undertaken for the Review and will continue to be so. Suggestions of problems of reproducibility are contradicted by the modeling undertaken by members of the panel that uses our parameters in other models and in some cases gets similar results.

Now, what about the charge that we are comparing mitigation policy with no mitigation policy in a fashion similar to comparing education policy based on a world with schools with one with no schools, and that sort of thing? This is dead wrong. I honestly don't think that's the right analogy for what we did. The trouble with writing 700 pages is that people don't always read it all. I apologize for that, but we do in Chapter 13 offer a fairly detailed discussion of the way in which calculations of damages have to be put together. And Chapter 13 is not hidden. It is clearly the concluding chapter to the first half of the Review[4].

Chapter 13 clearly addresses this point and several others Rob made earlier and the strategic argument that we were making using the model was similar to the strategic argument I started off with today: that when we're talking about stabilization levels, we should be thinking of something *at or below* 550 parts of CO_2e per million. We are not saying 550 or nothing. We are saying "Here are very good arguments for coming below 550. Where below 550, we don't know." We heard the discussion this morning that 550 is outrageously high. But 450 is already probably very, very hard to achieve, so the choice is somewhere between 450 and 550. Thus we used both the intuitive risk reduction approach and the modeling approach to say that the target level should be below 550, and we left open where below 550.

The cheapness of mitigation is an area that benefits from a closer look. I'd simply remark that, a month or so after we published our report, the International Energy Agency investigated the technological options in rather greater detail than we were able to do and came out with cost estimates that are below our own.

Rob Mendelsohn said several times that the Review assumes this or that about different technologies. Again dead wrong. Actually we just give examples of the alternative kinds of portfolios that might yield these kinds of cost reduction. The work looking at technological possibilities was led by Dennis Anderson, Professor of Energy Policy at Imperial College. We emphasized very strongly that the portfolio should hinge on a strong price of carbon and strong investments in R&D. That was one method we used. The other was to survey all the various abatement cost estimates in the literature;

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[4] http://www.hm-treasury.gov.uk/media/A/2/Chapter_13_Towards_a_Goal_for_Climate-Change_Policy.pdf

Terry Barker, who did this for us, came up with an estimate of around one %of GDP, though there are a lot of estimates out there.

Briefly on Rob's other points on mitigation costs. The assumptions on learning are modest and well below historical levels. In Dennis' modeling costs are discounted as they will be assessed – using market rates. Constraints are placed on the potential of each technology and estimates of cost do include capital costs. If mitigation reduces the cost of fossil fuels many would see this as a benefit since the main change will be a reduction in their rent which is merely a transfer and not a resource cost. The major problem with our mitigation costs is not in all the ways Rob suggests. Given that they ignore the co-benefits from energy security and local environmental effects, which in some cases may entirely offset mitigation costs, they are likely be too high[5]. There are some cases where climate policy does not work together with these goals but on the whole there are significant gains to be made beyond simply those in terms of avoided climate change.

G: Conclusions

Finally, on "radical" or "dramatic" again: if you start now and spread your action out over time, there is less drama than if you wait, and then get yourself in a difficult situation from which it's very difficult to escape. And I think to "wait and see" and potter on up to 650ppm would put us in an extremely difficult situation. Then action would start to get dramatic. It's much less dramatic if you start now and reduce emissions in a measured way with a target like 550 ppm in mind.

At 550 ppm there is still a small chance of getting near 5 degrees Celsius eventual temperature change relative to pre-industrial. At higher concentrations this chance becomes increasingly likely until about 800 ppm when it becomes the central estimate. Such changes would take us way outside the realm of human experiences and will challenge the fundamentals of life in many regions especially where conditions are already difficult such as Africa. Significant parts of the world will become uninhabitable because of peak temperatures, desertification and drought or eventual sea level rise. The threats of extreme weather events and shifts in the world climate system would become

[5] They do assume that effective policies are put in place. Costs are likely to be higher if the policy considerations in the second half of the report are ignored.

very severe. Those that suggest that the Review's message was radical should be clear what policies they recommend, the concentration levels this would take us to and the risks we face as a consequence. They should be clear, as we were, about what risks have been omitted from their analysis. They should also justify whether they believe that the risks of these levels of temperature change are in fact small or whether they believe that they are large but we simply don't care about them because they are in the future.

Most of the key points in the commentaries on the Stern Review have been discussed today. To conclude below is a bullet-point summary of my response to the main points that have been raised in relation the Review's central conclusions.

1. The costs of stabilizing the stock of GHGs in the range 450-550 ppm CO_2e are considerably less than the costs of delayed action. This conclusion is robust across most reasonable perspectives, including parameter variation within formal modeling.
2. The policies proposed by the Review to stabilize within this range are sound and based on strong economic principles, which move beyond the previous literature in important ways, concerning risks and ethics and constructing an international 'deal'.
3. The Review's foremost argument for strong action is based on a detailed, disaggregated assessment of the risks of business-as-usual (or of delayed action) in various regions and on various dimensions. The types and scale of risks involved were confirmed by the IPCC's *Fourth Assessment Report* a few months after publication of the Review, thus dismissing early claims by some that we exaggerated the risks, and by others that we understated them.
4. The costs of emission reductions to stabilize within the above range were estimated to be around 1% of world GDP, although there is a margin of uncertainty, as emphasized in the Review. Commitment now, clear medium- and long-term objectives, and good economic instruments will control these costs. The Review's cost estimates are consistent with those from the Global Energy Outlook of the International Energy Agency, published subsequent to the Review at the end of 2006 (IEA, 2006), thus countering claims by some that we underestimated the costs of adjustment.

5. The second, and supporting, argument for strong action is based on integrated assessment modeling, which implied high costs of inaction under a range of reasonable variations in assumptions.
6. Critics have focused on the formal modeling in a way that shows naïve understanding of the appropriate use of such models in policy debate. In the very long-term and complex context of climate change, such models cannot be of sufficient plausibility to provide the main argument.
7. Misleading and mistaken criticisms of the Review include a whole range of casual misreadings or simple errors – many examples were given in the Appendix to an article in the journal World Economics[6].
8. Discussion of discounting by some commentators has been confused (with one or two important exceptions) and has shown a weak understanding of the basic theories of cost-benefit analysis and the applied theory of policy:
    a. Discount rates are essentially marginal concepts and climate change is a very different problem involving non-marginal change;
    b. There is no market which reveals the preferences of a community considering responsible action over many generations. Thus whilst we can think about the usefulness of some market information we cannot observe directly the appropriate discount rate;
    c. We have not seen a serious ethical argument for a high rate of pure time preference in this context of planetary risk. Further, there is no contradiction between the application, on the one hand in climate-change policy, of a very low rate of pure time preference to the intergenerational comparison of welfare, and on the other hand in the appraisal of shorter-run and marginal projects, the application of higher rates to account for the possible collapse of the project environment;
    d. An elasticity of the social marginal utility of consumption, η, of 2, looks inconsistent with many distributional judgments in practice, but values around growth 1.5 are indeed plausible

[6] Dietz, S., C. Hope, N. Stern and D. Zenghelis (2007). "Reflections on the Stern Review (1): a robust case for strong action to reduce the risks of climate change." World Economics **8**(1): 121-168. http://www.hm-treasury.gov.uk/media/E/8/World_Economics1.pdf

e. Faster growth gives not only a higher discount rate but also earlier emissions and thus earlier and higher damages;
f. There is no contradiction between the Review's discount rates and current rates of savings once the structure of growth (in particular technical progress) is taken into account.

9. The key arguments and conclusions of the first half of the Review remain strong. The reasons we come to different results from some earlier literature lie in using modern science, and being serious about risk and ethics. From this perspective, some of the earlier literature is now seen to be badly misleading.
10. Those who deny the importance of strong and early action should explicitly propose at least one of three arguments: (i) there are no serious risks; (ii) we can adapt successfully to whatever comes our way, however big the changes; (iii) the future is of little importance. The first is absurd, the second reckless and the third unethical.

Stern Response to Presentations by Panelists Scott Barrett and Jeffrey Sachs

I accept Jeff's point about differences between the various greenhouse gases. It is important to recognize the difference between their impacts and ensure that this is reflected in policy. However, there are potential efficiency savings from ensuring that there are similar price incentives across the gases relative to impacts. Pulling these gases together helps draw attention to the importance of the other greenhouse gases. It also highlights the full temperature change that we risk rather than the smaller changes if we only consider carbon dioxide.

Regarding Scott's discussion on the difficulties on building international agreement, I feel that our analysis in Part VI of the Review on International Collective Action is very pragmatic as well as theoretical. There is a strong focus on the importance of getting international buy-in from China, India and other developing countries. To get action countries must be committed to any targets and believe that this is the best course of action. Countries cannot be forced into compliance and it is difficult to envisage a global institutional architecture that can force countries to act. Fortunately change is now being driven by the will of the domestic population to do the right thing and by visionary leaders. In my discussions with key stakeholders in India, China and elsewhere there is

recognition that they have something to lose and this gives me hope for the future discussions.

I agree that adaptation is a critical part of the response to climate change, not least because the world is already locked into further temperature rises over the coming decades as a consequence of past emission reductions.

However, whilst adaptation is necessary and sensible it is important to recognize that it is not a perfect substitute for mitigation and is likely to become increasingly expensive. Adaptation can only mute the impacts of climate change; there are limits to what it can achieve. Impacts on ecosystems, for instance, may be impossible to avoid. This is particularly true at higher levels of temperature increase, where the impacts will be more severe, and the risks of abrupt irreversible impacts higher. Mitigation is the only way to reduce these risks.

Regarding what Scott said about the importance of acting to support developing countries in their development, including, for example, on malaria. I would be there and have been there, and I agree entirely.

My only other remark here is that we know that whatever we do to reduce climate change will not solve the poverty problem in poor countries: however much we deliver on the aid commitments already made, poor countries will still be much poorer than we are over the next 30, 40, 50 years. Basically, what will pull them out of poverty is their own actions, but there are things that richer countries can do to help. We should act to support developing countries in their plans for development, but this will still leave the problem of inequality pretty severe.