Gurukul Chevening Lecture 2006
The Stern Review on the Economics of Climate Change

Speaker: Sir Nicholas Stern
Chair: Lord Meghnad Desai
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Meghnad Desai
Good evening and welcome to the London School of Economics. My name is Meghnad Desai. I used to teach here. I haven't actually seen Old Theatre so crowded and I'm told New Theatre is also full since the halcyon days in October 1968 when we were passing motion to occupy the LSE and I was the honorary chairman. Anyway, this is a much more exciting occasion I'm sure. This is a new lecture series at the LSE. It is the Gurukul lecture series. And the Gurukul scheme was a gift by the Government of India, sorry the Government of UK to India. Now I don't want to go into colonial history. This is contemporary, by the Government of UK to India on the 50th anniversary of Indian independence. And the scheme selects 12 bright young people, people under 40 who have leadership quality and they're chosen by competitive process across India, men and women, from private sector and public sector and they are finally drawn from a shortlist which is ……..in Delhi. And for the last nine years, they have been coming here and they have been some of the most exciting people to teach. I used to teach on that course in the days when it started. And in a sense, it is a recognition of that that we are supplementing the course which is continuing with this lecture series and we hope that they'll be future lectures. But it's extremely appropriate that the first Gurukul lecture is being given by Professor Sir Nicholas Stern, or Nick as, well it's ……used to calling him because Nick has been a friend of India for many many years. And not just in a, in a usually cliché sense people say but Nick is done which …….. I have never done, he has done and sat in an Indian village and don't fieldwork. He's actually talked to Indian farmers and Indian rural families. And he's done it on a number of ……. has been thoroughly researched by Nick Stern and Christopher Bliss who's at Oxford. And they were really pioneers because economists very rarely go and do such first hand anthropological type research and made a great contribution of our understanding of the economics of rural India. Since then, Nick has done a lot of things. Now I have to say, that I'll give you a factual account of some of this career because the accounts would have been published in the newspapers have been so wrong that only Victoria Beckham has done worse in recent days. Nick graduated from Cambridge and was a lecturer there for seven years. From there he became a Professor at Warwick University but at least after wandering around the world, he came to the London School of Economics where he rightfully belongs. He was a Professor at the London School of Economics and he was director of the Suntory Toyota International Centre for Economics and Related Disciplines, STICERD. And he's, he has since been the chief economist at the European Bank for Reconstruction and Development, EBRD, and he has been the chief economist at the World Bank. The Independent, which is a sort of ……..which gets a lot of climate change in the headline before the report came out saying, US economist warns of, they thought Nick must be

American because he had worked for the World Bank. They were not far wrong because Nick was the first non-American economist to get the job of chief economist at the World Bank and since then, of course, that tradition has been kept up. He is a great expert, he's a real one of the pioneering experts in public economics. He has edited the Journal of Public Economics for many years and in a sense, he comes from a tradition of economics in which very good, sound technical economics is done but with the public purpose always in the forefront of the scholar's mind. And in a sense, the Stern Report, and I like the title, the Stern Report, you know, he's not messing around, the Stern Report is another example and I'm sure Nick will go on to do many more such superb of where a very careful and very thorough analysis has been done. A very tricky problem but it's been done without sounding either alarmist or complacent. There are difficult choices to be made and one of them is that I should stop talking now. And I shall do that and give you Sir, Professor Sir Nicholas Stern.

Nicholas Stern

Thanks very much Meg, most of that was right. It's a great pleasure for me to be back teaching here. The last time I stood up here I think, well I did come here to give a lecture on the Commission for Africa which was what I was writing the year before the one that's just gone. But other than that, I was doing second micro to crowds which were a little less than this but there were still many of you. And I look back to those teaching at the LSE with a great fondness and look forward in hope. The, this is a long review and one of the headlines of course was its length, 600 pages. I am actually going to take you through the whole lot. I'm going to do it pretty fast but I want to do that because half of this is about looking at the risks and the impacts of climate changes and the other half is looking at policy. And both are very important and I do want to try to get to spend some time on the policy story.

This is in large measure about the economics of risk. This is about looking a long way ahead and when we look a long way ahead, we cannot say anything much with certainty. So at the same time, we have to ask ourselves, how do we make policy concerning something which has a very long-term impact? So that is the challenge of looking at the economics of climate change to think clearly and in a structured way, about things which are very uncertain and see what we can say in terms of guidelines for policy. And that's what we tried to do.

Now I did check what the meaning of Gurukul was and the guru in Gurukul is the guru word that you know about. It's a teacher. And a Gurukul is an ancient school. It's a school where the students and teachers live together and mark this current generation of LSE students, where students help teachers with everyday tasks. Now that seems to me a splendid idea and I look forward to the LSE putting it into practice. I've met the Gurukul Chevening students on one occasion in the past and I must say, they're everything that Meghnad said. Very thoughtful, experienced people who have understood what it's like to try to make policy, whether it be in a firm or in a ministry and are thinking long-term, thinking into the future, thinking internationally. So it's a splendid programme and something which is an example of the close ties not just between the UK and India but between the LSE and India. And those ties between the LSE and India are something that mean, means a great deal to me.

Now let me then pick up pace. This is about the economics. It is about the economics of risk so some of you will find some of it a bit tricky. But I will try to, not to dwell too much on those. Those of you who are professional economists I think will want to see those bits and see what's going on but as I said, I won't dwell on them but if the two or three slides in this story, you're finding it a bit tricky, just hang on in there and it'll ease up before it gets tricky again and then eases up again.

So what I want to do is set out the structure of the report in relation to five basic questions which will come on the next slide. But first we have to understand what the science tells us about the economics cause the science shapes the economics. Now firstly, this is something which is an externality in the jargon we use in economics. That means something that you and I do affects the way in which other people can live their lives, the way they consume, the way they produce and so on. That's an externality. It's something that you do and generally speaking, unless some policy comes along, you don't pay for that damage. And that is a market failure. It's a market failure because you are not facing as a consumer, as a producer, the full cost of the thing you buy. You pay for the labour embodied in what you buy normally, you pay something for the capital equipment and so on, you pay something for the variable inputs, but in this case, you do not pay for the damage you cause to other people. That's a market failure. Now we argue in the report that this is the greatest market failure the world has seen. It's actually a fairly obvious statement because everything that any one individual does in terms of actions that generate carbon emissions or more generally greenhouse gas emissions, anything that any one person does affects everybody else. So it is a truly global market failure and there really aren't other market failures of that magnitude.

So it is an externality but it's an externality with a difference. Normally when we think of externalities we think about, you take your car on the road and you cause congestion to other people. Easily recognised and when London traffic slows to talking pace, people think something should be done about it and you get a congestion charge. Smog in London. Um, some of you here will remember what it was like in the 50s when deaths from bronchitis were very high, buses stopped because the smog was so heavy, it was easy to recognise what was doing it, it was the coal and we brought in regulations so avoid coal. So congestion charge, essentially you price to avoid the externality; smog, we used regulations to avoid the externality and that is the kind of policy story that we'll come to.

But what is different about this externality? Well first, I've already said it's global. It's also long-term in the sense that what's causing this externality is the greenhouse gases in the atmosphere, the stock of greenhouse gases in the atmosphere. Those of you who don't know anything about global warning, what happens is the solar energy comes through the atmosphere and then it gets trapped just like it gets trapped in a greenhouse cause it changes to infrared and that infrared energy is trapped, it can't get out. That's the greenhouse effect. And it's shaped by the stock of greenhouse gasses in the atmosphere. Our emissions are a stock, we add each year to that stock. Currently, we're around 430 parts per million, that's how we measure the concentrations or carbon dioxide and the other greenhouse gases in terms of carbon dioxide equivalent. And we're adding about two and a half a year and that two and a half is rising. So that stock of greenhouse gases is going up. And as it builds up over time, and with a lag, it causes the rising temperature and that rising

temperature has all kinds of effects which impact, which affects, influence the way we live and what we can do.

So this is very very long-term process and it's one that's very difficult to turn back. That's why we're forced into long-term policy making and long-term modelling and long-term understanding of impacts because it is a long-term process. What's going to happen to our climate in the next 20 or 30 years is already determined. It's, our actions in the next 20 or 30 years will affect what happens in the decades that come after that. So we're talking about the effects on our actions, of our actions on climate in the second half of this century and of course, into the next century and beyond. And we have to think and beyond because these effects that we're talking about are very difficult to reverse. You can't just find out oh dear, we emitted too much, oh we'll just wind it back in again. We can't do that.

So it's global, it's long-term, it's uncertain as I've already emphasised and they're potentially large and irreversible effects following from what I've just said, you can't turn it back. You're accumulating and adding to this stock. So that's why it's different from any other externality. It's not just like congestion. It's not just like smog although some of the intuition, some of the policies we bring to those problems are indeed relevant to this one. It's a much more complex one than that.

So what do we do when we do the economics of climate change? Well, we ask these give questions. What are the risks and whom do the impacts fall? You've got to talk the language of probability there. What are the options for mitigation? How can we slow this process of build up and what do they cost? And then when we put that together, what do the risks and what do the costs of reducing those risks, what does that together tell us about the kinds of targets for stabilization of greenhouse gases that we should be aiming for?

So that's the first part of the story and the second part of the economics of climate change is that we have to ask the questions, how do we encourage people to reduce the emissions? I've already mentioned the kinds of incentive structures that are used with externalities. I've mentioned taxation and regulation but of course, I'll come to trading in discussing that. I've already said that some change is already on the way. How do we adapt to that change that's already on the way and the change which will come because we can't turn off these emissions overnight. It'll take quite a long time to bring them down. So there's lots of climate change on the way. How do we adapt to that and how is that adaptation financed? Particularly important there for developing countries. And finally, this *is* an international collective action problem. UK is 2% of the emissions, India is 4% of emissions, US is around 20%, a little more of emissions, each part of the world has to play its part in this story. Emissions come from all over the place. Emissions come from deforestation, they come from cars, they come from planes, they come from the generation of power, they come from heating our homes and they come from agriculture. We have to look right across the board. Just as no one country can do, can handle this problem by itself, similarly no one sector can handle the problem by itself. So we have to look across countries, we have to look across sectors. This is par excellence a global collective action problem.

So what is the economics of climate change? For us, the economics of climate change is these questions. And the report goes through, after the introductory part, which you've just heard, the, there are five further parts to the review and that's what they cover. And I'll try to take you through them at a pretty rapid rate.

Now, I've said that concentration of greenhouse gases give you temperature increases. What are the consequences of these different temperature increases? Well, this is a very schematic version of that story and these consequences occur across the whole range of dimensions. It affects food production, through agriculture and thus of course, the incomes of agriculturalists. Water is the most important transmitting factor in all this - floods, droughts, storms, sea level rises. That's the way in which these impacts come more strongly. The environment itself which, to which we should and do attach a value as citizens. How you do that of course is difficult but we do value the environment. That itself has direct, is directly affected by temperature rise in the climate more generally. And as I've already emphasised, you can get to serious problems of abrupt and irreversible changes.

Let me just give you, I can't through all the detail here, but let me just give you an illustration. If we go on under business as usual, we're likely to hit, and I'll explain it in just a moment in a little more detail, something like five degrees C and above. In other words, by the end of this century, if we go on without changing the way we do things, we will have accumulated as much, enough carbon dioxide and other greenhouses gases in the atmosphere, to give us a serious risk of being above five degrees centigrade. 50:50 chance or higher 50:50 chance of being above five degrees centigrade in the next century if we just go until the end of this century before we do anything under business as usual. Five degrees centigrade is a very large increase. The difference between where we are now and where we were in the last Ice Age, 10-12,000 years ago, is five degrees centigrade. Five degrees centigrade transforms the physical geography of the world and thus the human geography of the world, how we live and where we, where we live our lives and how we live our lives. And this is the kind of thing you have to contemplate. It's very hard to think through what the consequences of those things are and what we'll be arguing here is well, you can try to put some numbers on them but the crucial part of the argument is that the risks are very large. So these are the kinds of things that can happen.

Now there are, in looking at the impacts, we look at the impacts generally, we look at the impacts on developed and we look at the impacts on developing countries. And that, for me, is the most telling part of the story of impacts. It's the disaggregated story of what happens to river flows, what happens to forests, what the risks of hurricanes are. Those for me, and how they influence different parts of the world are the most persuasive parts of the story of just how difficult this could get if we let things go on in terms of business as usual.

I mean let me give you very quickly a few examples. A just three degree centigrade, more than one billion people would be suffering from severe water shortages around the world. The whole patterns of river flows and so on and the timings of river flows would be badly disrupted. At three degrees, something like 20 to 50 per cent of the species in the world would face extinction. At three degrees and above, there are major risks of die-backs in the Amazon. In some models, you get a 75% fall in Nile waters by the end of the century under

business as usual. Ten countries in Africa depend on the Nile for their water. These are the kinds of things that could happen. At higher temperatures, three to five degrees, you start to get into serious risks of the collapse of ocean currents and the West Antarctic sheet on top of, of course, the Artic. You run the risks of, many people of course do live in coastal zones for very good reason but at least 200 million of those would be very vulnerable to increases in sea level. They can, of course, move in land but that, of course, is a major disruption. It's a disruption to where people live and how they live their lives.

So this is the kind of risk that we run and I urge you to, those of you who want to get into www.sternreview.org.uk and get into this online, which is, we did a web-based publication for this, I urge you to read those details, disaggregated stories of what could happen because for me, they're the most telling part of the story of why we need to act.

Now I've taken you through very quickly this story of vulnerability and what kind of things could happen. Let me just stress one thing on the disaggregated impacts. That is, that developing countries are the most vulnerable. This is a highly inequitable story. Seventy-five per cent of the greenhouse gases up there now, concentrations that are there already, 75% of that come from the rich countries. It's the poor countries that get hit earliest and hardest. So there's that double inequity there if you like. Inequity in terms of responsibility of where we are now and inequity in terms of impacts. Developing countries are hit hardest really for three reasons. First is that they are actually in the places which are the most vulnerable. They're in the hotter parts of the world and it's the hotter parts of the world that are more vulnerable to increased temperature. Second is they have less diversified economies and therefore, more vulnerable, particularly in agriculture but not just there. And thirdly, they have less resources to protect themselves against the effects of climate change. So developing countries are particularly vulnerable. This is a highly inequitable story and that that inequity should we argue and indeed most of the world does accept that inequity should influence when we come to the story for who pays for mitigation, that inequity should have a powerful influence on policies which look to, more to rich countries to bear at least at the beginning, more of the costs of mitigation. Mitigation in the jargon here is reducing the emissions. Adaptation is adapting to the effects of climate. I'm not sure I like the word mitigation but it's entrenched in the literature. So when we talk about mitigation, it, what we mean is reducing emissions.

So that's, I've laid strong emphasis on the disaggregated side of the story and that for me, is the most important. I'll give you a little bit in just a moment of the more aggregated story in the overall modelling. But let me stress it is aggregated one is the one which for me is the, is particularly convincing.

Now, I linked temperature to consequences and I've already begun to talk about the link between concentrations in the atmosphere and consequences. And that's illustrated on this slide here. Um, what we've done here is to draw the probability intervals, this is the five to 95 per cent interval that you get in terms of temperature increase corresponding to a concentration of gases. So at 400 parts per million, if we did manage to stabilise at that level, I'll argue in just a moment we've missed that boat. But if you did manage to stabilise at that level, your, the bulk of your probability distribution of temperatures would lie between just under one and just one three degrees centigrade. If you go up to 550 parts per million, the

bulk of your probability interval would lie between one and a half degrees centigrade and approaching and four and a half, approaching five degrees centigrade. And we've concentrated on sort of two fairly central models in drawing that red 90% confidence interval. There are some models which actually spread it out further than that.

So what this is doing for us is showing you know, stochastic is the word we use in the jargon, the probabilistic link between concentrations and temperature. And what I want to do is to just say something about that link, to explain why we get to the kind of ranges for stabilisation we would suggest. Now let me use this graph then together with the previous one to say why we suggest stabilising between 450 and 550 parts per million. We are already at 430 parts per million and adding around two and a half a year. So to actually get stabilised at 450, would be tough. We will be at 450 probably in ten years or so and it'll be very hard to pull that back. So 450 is probably the most ambitious you could think of given where we start. Had we started earlier in this story, of course, we'd have had more options but we've been accumulating the greenhouse gases for a long time now and that influence is where we are and we are where we are.

Five hundred and fifty parts per million on the other hand we will argue, and I'll come back to this, could be achieved at relatively small cost. I'll discuss what that means and how we estimated it in a little while. But 550 is possible and it's doable in terms of continuing to grow but just paying a bit more for some of the things that we do so that we can them in a way that emits less carbon. So that is 550 parts per million as a possibility in terms of a target. On the other hand, if you look at 550 parts per million, it is centred around three and at 550 parts per million, we still will run some of the risks, indeed we'll run significant risks associated with the three degrees centigrade I was already speaking about. And of course, 550 parts per million, can take us well above four. Although there's a strong chance that if we stabilise at 550 parts per million, we would be less than four degrees. It's centred around three degrees.

So 550 parts per million is risky but it's far far less risky than these higher concentrations that we show here. If we let it go, if we continued business as usual and we increased the amount we're adding from two and a half a year to three to three and a half to four per year, by the end of this century, we'd about around 850 parts per million. That, if you look at these graphs, involves risk which it's really quite hard to contemplate with any equanimity. But the conclusion that I'll come to and the report comes to, is actually optimistic that you can head off most of those risks by sensible, good policy starting now and getting going over these next few decades quick energetically. So I draw attention to the possibility of the dangers and the extreme dangers of business as usual but our conclusion is much more optimistic than that, that you can head off a lot of these risks with modest but significant investments over these coming years.

So we come to the conclusion in the review, partly looking at it in the disaggregated way I've just described, that we should be between 450 and 550 parts per million but we also build some aggregate models which I'll just take you through rather quickly now.

There's a third method of looking at the objectives, appropriate targets for stabilisation which works much more in terms of prices and social costs of carbon and marginal abatement

costs. I won't dwell on that here but refer you to Chapter 13 of the report where you will enjoy that discussion.

Now, let's turn to the aggregate modelling. Now aggregate modelling out over, thanks very much Meg, aggregate modelling over a couple of hundred years should make you very cautious. It's difficult enough for economists to work out what might happen in the next two or three years, my great friend and former colleague here at the LSE has trouble forecasting inflation and Alex Bowen was with the us from the Bank of England and that's a difficult task. And that's just forecasting inflation. They do a good job but none of us pretend that it's easy. What we're doing is not looking out over two years and fussing about the inflation rate, we're looking out over a couple of centuries and more because you can't stop it at, you can't stop the story at 2200 because these effects go on into the indefinite future. So we're looking out over a very long term. So you have to be very cautious. You have to treat these models as illustrating risk. These are not hard and fast forecasts of the future, they're illustrative of an argument. Now the problem is, and I say this more or less in this sentence in the review, that the problem with numbers coming economic models and economic models themselves, is that non-economists take them too seriously. And actually brackets, I think it says in the report, also and some economists take them too seriously.

That doesn't mean they're irrelevant. They're crucial to think through what the logical consequences of different kinds of actions will be. We have to think ahead in this kind of way and we have to try to do it in a structured and transparent way. But this is about risk. It's about what might happen. It's like illustrating what might happen. I've illustrated that in the disaggregated way which I would attach more weight to but you have to try to aggregate these things and tell a story as well. So this should be seen as run alongside this disaggregated story illustrating the kinds of risks that you run.

Now the model we chose was a model which Chris Hope of the University of Cambridge kindly supplied to us and the reason we chose it was two-fold. One was that it allows the direct modelling of probabilistic phenomenon. Those of you who like this stuff will recognise that it allows you to do Monte Carlo simulations of probabilities. So that's one very important reason why we chose it because we wanted to introduce the economics of risk into a problem that was all about risk but hadn't really been discussed properly in terms of the economics of risk. Sounds like a no-brainer if you're discussing risk you should use the economics of risk but we had to have a model that would allow is to do that explicitly. And the PAGE model was very useful for that. I should also recognise that this was possible because of the advances in the science over the last three or four years that now generates the kind of probabilities I was just discussing. So that's crucial. Earlier model more than say, three or four years ago, couldn't do this because the science wasn't there. So we're, just as it were, coming to grips with building economic models that allow this kind of probabilistic analysis in the economics of risk. So the PAGE model by Chris Hope did allow us to do it. It had a second advantage, which it's designed to span other models. It's designed, as it were, to tell the stories that other models tell. So it does have the complication of the models, but it does it in a simple transparent way that generates the kind of results that they get. So the kinds of results that you get for small temperature increases in this model are very similar and

designed to be similar to the model, to the kinds of model results that you get. But why our results are a bit different from others is basically for two reasons.

One is that we bring in these bigger risks that I've just described of five, six degrees from above from business as usual which we now know are possible. We bring in those risks and we do, we treat the economics of risk in a very direct way. And using these tools, we look a long way out into the future. So that's why we chose the model as we did do and I've warned you that this is illustrative, please don't take it too literally. But do take the story of risk very seriously.

So these are the kinds, if we just now take the basic science as it comes to us with the kind of probabilities associated with temperature increases, associated with different greenhouse gas concentrations in the atmosphere, and we take a very very narrow view of consequences, we just take GDP consequences, that is a very narrow view because as we've told the story, this is about environment, it's about health, it's about dislocation, it's about the kind of things which do not normally get captured in our measures of GDP. But suppose we just took a very narrow view. This is the kind of change that we would see. It would go out, it would build up and as we go into the second half of the next century, you get losses on average of five per cent or so. Now my own view is that the way these models are constructed, they don't actually give as much in terms of consequences as could follow from the high temperature increases we're talking about. But the shaded area is the risk area. So it could be very much, losses could be very much higher than that average. I've stopped the graph at 2200, two thousand two hundred, I've stopped the graph there but actually the analysis goes off, you have to take it off into the indefinite future.

Now that's one case. Let's build up because that's the most optimistic story. If you go on and say, well, if you take into account some of the feedbacks that could happen in the climate, for example, in particular we have in mind the release of methane from the permafrost, that's the kind of result that you could get. That increases as you've seen it there. If you go still further and bring in some of the non-GDP damages, you get to a graph that looks like that. So you can see, as you bring in greater risks, as you bring in a broader view of the damages, the, you build up your estimate of losses and you build up the kind of area covered by the risk here. And remember that this thing goes off into the indefinite future. Actually after 2200, in the modelling we've been quite cautious. We've assumed that the damages that occur by 2200 are then stable. They continue as damages but they don't increase as a proportion of GDP. That actually is slightly, well more than slightly, optimistic.

So this is the kind of modelling that we do. And as I've said, we use a model which tries to span the range of other models. I seem to have a seize-up here. Oh, I'm sorry, that's cause I'm pressing the wrong button. There are two buttons here with arrows on. One is the right one and one is the wrong one. And I have at least a 50:50 chance of choosing. Um, so this is on one graph here the putting all those things together. And you see as you build up the effects, you build up the risks and you build up the mean losses.

Now how do you put a story like that, of losses occurring over time, together? Now you have to do two things here. You have to do two sorts of aggregation. And here, if you forgive me,

I'll just get slightly technical. So if you find the next two or three minutes difficult, then tough. What we have to do is to aggregate over time. We have to take benefits and costs that occur at different points of time. We have to take those together because we're trying to get simple summary measures of the costs of these damages. And you have to treat risk. You have to aggregate across different possible outcomes. Might be here, might be there, we don't know for sure. We've got some take on the probabilities. How do you put that together to give you a simple summary measure for the damages? So there are two kinds of aggregation going on, over time and across possible outcomes.

Now here I'm talking about a key aspect of aggregation over time which is discounting. Now discounting occurs in economics for two reasons. You discount an extra unit of consumption in the future because you believe if you do believe that, that you'll be richer in the future. So a big extra in the future is a bit less than something extra now or one unit extra in the future is worth less than one unit now because you'll be richer then. And you'll value it for a lower amount for that reason. Now that for me is the most important reason for discounting. And of course it means if consumption goes down, you do the opposite of discounting because you'll be poorer in the future if consumption goes up. Now that about marginal changes. It's about a little bit more here and a little bit more there. This isn't just about marginal changes. This is about big changes and for big changes you have to look not simply at what the value of a little bit more and a little bit more there is, one relative to the other, you have to think how do I value this whole path here relative to some other path here? This is, if you can imagine a French geometry lecture where you, this is one path and this is the other path, and you're having to understand how you value one relative to the other. To do that, what you have to do is add up the values of consumption over time along the different paths. We do that using what we charmingly call utility functions which essentially just pick up this idea that an extra unit is worth less as you get richer. So you have the utility function that looks like that.

So you integrate those over time and you add them over possible outcomes and what you do is, when you do that, you say, well, if stuff comes later, if this utility, this consumption is coming later, thinking it as a whole now, not just at marginal elements of it, how much do I value it? How much do I care about this level of consumption for me relative to this level of consumption for those people who will come after? I'm not talking about growing consumption now. I'm putting that issue to one side. I'm talking about, imagine same consumption somebody 50 years from now relative to now, how do I weight that? Do I treat it differently? Well, I'm an advanced age relative to most of you here. If I was talking to something much younger than me, would I be able to say to that person, well, since on average your consumption's going to come 30 or 40 years after mine, or it could be a lot more than that given how old I am, if your, if that consumption is going to come that period after mine, do I give less value? I think the answer to that question should be no. In other words, basically the first approximation for the pure time discount rate which is in the jargon what I'm talking about, should be zero.

Now I'm in good company saying that. Frank Ramsey, Amartya Sen, Bob Solow, Pigou, a lot of people have thought seriously about this issue and suggested that pure time discount rating is, pure time discounting, is not ethically justified. And you cannot here avoid the ethics of the question. How are you going to see the value of what comes later relative to now?

Now what I've got illustrated here is the consequences of two different, not two, of a number of different pure time discount rates. Could I ask you to look at the, just that column that says probably of the human race surviving 100 years? Now if those people that I'm thinking about in the future might not exist because a meteorite might come and wipe out the world, then it would be understandable to take into account that probability. So we take into account the probability of the world surviving beyond 100 years. The pure time discount rate which we do use which is 0.1% says, that well, maybe there's a ten per cent of wipe out in the next hundred years. It's actually a bit pessimistic, yeah? But you can see that if you use much higher discount rates like 1.5 as a pure time discount rate here, that's something like an 80% chance of wipe out and that is very pessimistic, yeah?

So what I've argued is that basically the right approach, ethical approach is not to do pure time discounting except for this probability. Now people differ from, in this, people can argue about this and I've tried to lay out the ethical issues and people do argue about this but it's important to be clear about the assumptions we use.

Now the, what we do when we do that averaging and I won't labour you with this, what we do is we say, think of a path, this of this path which is the green path here, which grows along quite cheerfully but then starts to suffer from the damages of climate change. And we say, how do I express that green path which has change over time, it has all the uncertainty around it, how do I express that in terms of one number? And what we say is that the one number that summarises that path is the definite consumption which if it grew at the basic rate that we're thinking about this model, would give you the same utility integral or if you like, the same expected utility integral as the path being examined. So you can see that that red path averages out the green path. So that red path summarises the green path. The way it summarises in terms of equivalent expected utility integral for those of you who like those things.

So when we talk about the losses associated with climate change from this kind of model. We're talking about the distance between the red path and the black path at the top. And that's what we call the Balance Growth Equivalent. We want to try to summarise in a very simple intuitive way the costs of climate change. So I've given you all that, I've probably spent longer on it than I should have done having told you to suspend your disbelief, you should now reinstate your disbelief and not take all this too literally. But the risks that are embodied in this story are a very serious part of this argument.

So if you look at the annualised losses in the way I've just described, you get essentially a build up that looks as if, as I've set it out here. If you take the very narrow view of consequences, just the GDP story, if you take a fairly standard view of the risks, then you get a mean loss of 5%, a Balance Growth Equivalent loss of 5%. That's an annual loss. And if you go up to the bigger story of more risk and non-market impacts going beyond simply GDP, you get to 14.4%. Now one thing I'm going to put in here which we haven't done the calculations of but we've done some work just to make a judgement is if you bring in income distribution within the generation. I haven't yet got this in the story. And if you bring that in, we speculated bumps your 14-something per cent up to around 20%. So that's an additional

kind of distribution here. So that's the five to 20 per cent you may have read about in the newspapers. Newspapers like simple statements. Disaggregated stories are too complicated and that's why you've seen these headline numbers. So these are the kinds of losses.

Now what happens if you vary the assumptions? Pretty obvious actually. If you increase the pure time discount rates, you will reduce your estimate of losses. Fair enough. I mean well, not fair enough cause it wouldn't be a sensible thing to do but you can do that. and if you put less weight on the future, you will think that there's less justification for investment to avoid the risks of climate change. So that surely will bring down our estimates. It's a very important issue. I had, I suppressed this but there's a relative risk aversion for those of you who know the concept. I'm not going to go into that now. If you increase that, it will, the sum modellings reduce the estimate of losses because it puts less weight on a possibly richer future. On the other hand, it puts more weight on risk. So that can go either way. If you increase the growth rates. We have a fairly modest growth rate in this story. If you increase the growth rates, you'll of course accelerate the emissions under business as usual but you will accentuate discounting because then by assumption, the future generations will be richer. That can go either way then, that one, it depends. And if you allow climate change to continue abated beyond 2200, we've essentially stopped it in its tracks at 2200, not ignored it but held it constant after 2200, that would increase your losses.

So you can actually vary all this and get different results and that's what models are for, to try to help you understand what happens when you use different assumptions. My own judgement on this is that these kinds of models, which were developed for losses associated with two, three and four degrees, actually underestimate losses for the much higher temperatures. That's because the way they were constructed. They weren't looking out to that danger that we now know from the science is a really possibility. So I actually think that the damages that we've got here in the graphs I've showed you, if you think about the disaggregated story, are in fact underestimates.

Now, I've got to go move very rapidly because, can I go on for another 15 minutes Mr Chairman?

Desai; You can, yes, people have come to listen to you.

Stern; Okay. They've come to look at you.

Desai; Yes, it's a Balance Growth Path.

Stern; The, so we've given the argument that the, the damage from business as usual is very high. So what can we do to avoid, well at least avoid most of those risks? I've already begun that discussion when I said, well, we can try and stabilise, we can try and stabilise somewhere between 450 and 550. Let's look a bit more closely at that. I said that 550 avoided some of the more worrying or deeply worrying frightening risks. Of course, it doesn't avoid all the risks. But it takes away a good deal of them. So what happens if you try and stabilise, you try and change the way you do things, you try and stop the deforestation, you try and decarbonise the power sector, you look for alternative ways of powering transport

and so on, and you make a big push for energy efficiency? What, if you do all these things, what kind of path would you have to try to follow if you did try to stabilise at 550? And those are the, the paths which are illustrated here.

We've got the, I won't go into them all in detail but if you look at the yellow path, the yellow path which is the upper of the three paths which go up and then down, that's stabilisation at 550. You see that we have to stop emissions increasing within the next 15 years or 20 years and then we have to decrease, you can't see this directly but it's noted on the graph, then you have to reduce your emissions at one or two and a half per cent per annum thereafter. So that is a path which would stabilise at 550 and I think we know enough now to understand the kinds of things you would have to do and to cost the kind of things you'd have to do. And I'll mention that in just a moment. The more ambitious 450 path which I've already said would be pretty tough to do, you would have to peak very quickly and then come down much faster. So that's the stabilisation story and of course, the later you leave it, the higher your starting point, and therefore the more difficult the task of stabilisation. The top line is the business as usual story.

Now what would be the costs of doing all this? Well I'm not going to go into that in detail. We've looked at that in two ways. The first thing is we trawled the very extensive literature on the cost of mitigation, the cost of reducing. And that very extensive literature is spread out, it depends on your pessimistic you are about the arrival of technology or on how optimistic you are about the arrival of technology. It depends on the quality of policy and so on. And you get quite a broad range. You get, but those ranges on the whole in the literature are centred on, on average, over time, a little bit less at the beginning, a little bit more later, a little bit less after that, but you get an average over time of around one per cent of GDP. That's like a one-off blip upwards in a price index. You do things a bit more expensively because you're doing them carbon-free. So things cost a bit more and they cost a bit more if you take the middle of these ranges by around one per cent.

We did also do our own checks and here we're very grateful to Professor of Energy Policy at Imperial, Dennis Anderson, who's here tonight. What we did was to look technology by technology, what kinds of things you could do to implement these reductions in emissions. So we did our own as it were, bottom up story as well. And it was very much consistent with that broad literature which I've just described. So around one per cent is a central estimate. Like all these things, pluses and minuses around it. So that's the story.

Now let me finish on what I want to say on these, on these models and then I'm going to have to be very quick on the policy story. Strong mitigation is consistent with growth. You pay a bit more and you can carrying on growing. You have to do it wisely, you have to do it well but you pay a bit more for the way you use energy and you can carry on growing. Eventually the costs of business as usual is such that it will really damage growth. You can look how costs occur in different sectors. They'll be higher in sectors which are, higher in sectors which use more carbon currently and they'll be lower in other sectors. So are you move together to implement policy, you have to be careful about how policy is actually done and it's much easier if countries move together. If countries move together, you get less of the problems of competitiveness, less the problems of dumping emissions elsewhere. And we

also note in the review that mitigation policy has actually benefits as well in terms of energy and air quality. Air quality associated with energy has benefits in terms of energy security. You're more diversified, using more renewals except of course, for coal. And there, coal which is quite attractive because of costs and energy security to many countries, is one of the worst polluters, burning coal for electricity. And there, carbon capture and storage, you can catch it, the carbon emissions and put them back under ground is very important. And it, of course, can help with forestry and fighting deforestation, has lots of benefits beyond simply those of climate change.

So there are other benefits and further, there is a real possibility that these investments can generate new technologies which are of real value in terms of generating research ideas. If you like a kind of Schumpeterian burst of growth from innovation.

So that's the story. So what does the story boil down to? It boils down to a judgement about the costs of mitigation and it boils down to a judgement about the damages. They're tutored judgements, they're structured judgements and you can quarrel with them both. We've very deliberately given ranges because this is about uncertainty. But I think the ranges that we've got for the costs are pretty much central to the literature, the costs of reducing emissions. The IPCC, when it gives its fourth assessment report next year, I'm pretty confident will come up with a range for the mitigation costs in which our range of one per cent, plus or minus two or three per cent, fits pretty well. On the damages side, we've come up with damages which are a bit higher than other people but there's a very good reason. Because at low, low percentage increases, the damages look very similar, low temperature increases, the damages look very similar to other models. We've contemplated what the science now tells us is the possibility of higher temperature increases. And we've built in the economics of risk and we've had an ethical approach to pure time discounting. And those are the reasons why we've got higher numbers for the damages those are reasons which I would defend.

So that's the story. Of course, you can also attack all this from the very beginning and deny the science of climate change. Well, that's your privilege. I would refer you to the Royal Societies and their scholarly equivalents in the countries from which you've come and take the argument to them. The science is pretty strong and pretty clear on all this although there are some quite significant deniers of that but as I said, that's their privilege and they should argue it out with the senior science academies in their own countries.

Now very fast canter through policy. But actually the principles of policy are rather straight forward. I've got some water, thanks, Meg. This is an externality. As I said in the beginning, give it a price and you've gone a long way to attacking the problem. Prices can be done through taxes, they can be done through carbon trading, which is a very interesting and important area which is already implemented in the European Union Emissions Trading schemes and other voluntary trading schemes around the world. And you can set standards and regulate and you can regulate on car emissions and efficiency, you can regulate on the efficiency of buildings and there are good reason why you should do that. You can regulate on how power is produced, you can have renewables, incentives and so on. All these things are beginning and actually working in a number of areas. All these for about the price for carbon. You can, in order to motivate and drive policy, to set these prices, to organise the

trading, you've got to have an idea of where you want to go. And the idea of where you want to go is this stabilisation target that I described.

Now there's some fine literature on the economics of risk in this area associated with Martin Whiteman, now at Harvard, where he points out whether you choose quantity constraints or rely only on price signals depends on the structure of risk. And the structure of risk here is that if we overshoot on our stabilisation targets, we cause a lot of damage. So we speak in terms of stabilisation by starting with the kind of quantity targets you eventually want. That's the economics risks pointing to those medium-term stabilisation targets, long-term stabilisation targets which I've been discussing. That will define the corridor in which you want to be. But you want some flexibility in that corridor. And for that, what you want is price guided mechanisms so that you can do your reduction where it's cheapest and you have some flexibility of when you do it and some flexibility in what sector you do it. Where, when and how flexibility is what people talk about and that's what the price mechanism can do for you.

So economics of risk say, have a clear target in quantities in mind over the future, economics of higher cost and price, they keep some flexibility in the short-term. But whatever you do, if you want people to make wise investments, you've got to be credible and clear in where policy is going. Power investments run out over 30, 40, 50 years and you want people to be confident or to have some confidence in the signals that they're going to face. So that's price.

What about technology? Well, if you're a pure Chicago, you say, just check, just sort out the price, sort out the externality, everything else will sort itself out through entrepreneurship and competition and wise investments. Unfortunately, these are sufficiently long-term and the risks are sufficiently high, including the risk of the stability of policy and the urgency of the problem is sufficiently high that we argue that you need technology policy as well. Technology policy on R&D and you need technology policy on deployment. And this illustrates why because experience with different kinds of technologies bring down costs and you learn from what other people do. So if you can move that process along, everybody will learn and you'll save some money along the way. And that's why this is a graph from the International Energy Association about learning. So you need R&D policy as well.

Now you should also go beyond simply pricing and R&D. I've already emphasised regulation. Information is very important. People need to now about emissions. They need to know how they can work to mitigate, how they can work to reduce emissions. So information and sharing of information is very important. But also, and this I do want to emphasise, is that you have also not simply the sticks and carrots which economists love, I do, too, the incentive structures, they are very important, you also need people to understand what this is all about and what responsible behaviour means. So by having public discussion in the good old John Stuart Mills sense of government by discussion, you can actually work to increase people's understanding of responsible behaviour and their behaviour will change for that reason.

So three strands for the policy so far. One is the externality and trying to find a way of pricing it, either tax, trade or implicitly through regulation and standard. Secondly, R&D in

deployment as well and thirdly, removing barriers to taking action and changing public attitudes on climate change.

Public R&D expenditure around the world is roughly half what it was 20 years ago. It's a combination in my view of lower energy prices during that period and the privatisation of much of the power industry which means that the private firms have less incentive as it were to do research than a public institution interested in a broader picture. That can be reversed of course. That's not something which is inevitable and we argue that R&D funding, as soon as is possible around the world now, I'm not talking just about the UK, that R&D funding should roughly double. Get it back quickly at least to where it was 20 years ago. Takes time to build that up and you'll learn along the way. And we also argue strongly for the reasons I've just described to do with the learning process, that deployment incentives should increase strongly, too.

So in the UK for example, we've begun to do a lot of the things that I've already described. In the last budget, the Energy Environment Institute was established. The UK is involved in carbon trading. We tax petrol quite heavily relative to other countries and so on. So all the things that I'm talking about are new things. They're things which should be developed and taken forward.

Now adaptation. I've already argued that adaptation is inevitable because climate change, some more climate change is inevitable. You can't just whistle and hope it goes away. If the climate's changing around you, you're wise to adapt. It's not a substitute for mitigation, you would want to get on with both of them at the same time cause much stronger mitigation means you have to adapt much less further down the track. And as we've argued, if you don't do any mitigation at all, adaptation further down the track is going to be pretty tough given the kinds of consequences that could arise. So that's the story about adaptation and we're already seeing some of the costs of climate change already. Remember that as Ronald Reagan used to say, you ain't seen nothing yet. You've got 0.7 degrees above 1850 now. I've been talking about the possibility, if we're unwise and let business as usual go on, but I've been talking about the possibility of five degrees centigrade and above. And remember that these damages are not just linear, they don't just rise step by step, they're highly non-linear. In the jargon, they're convex, they're increasing marginal damages.

So the story about adaptation is with us and it's something we have to take very seriously and work on. It's much more difficult for developing countries for the reasons I've described. Their economies are less diversified and they have less resources to invest in adaptation. So there is a key role there for international assistance. A moral role if you think about the ability to respond and a moral role if you think about the origin of where we are now.

Development itself of course, is the prime vehicle of adaptation. You become less diversified, you become more able to take defensive measures. So adaptation has to be in the words that people like to use now, mainstreamed into the whole development story and development itself is a strong part of adaptation. Most of that will be done at the country level but there are important things that can be done internationally, international disaster responses, international development of crop varieties and technology and international

forecasting. These are all in our jargon, global public goods which can and should be invested in the global level.

Now last three slides if you've still got the stamina to live through another couple of minutes. It would have been about an hour because Meghnad gave such a long introduction that we didn't start till but it was a lovely introduction. I enjoyed every minute of it.

Desai; Thank you very much.

Stern; So last three slides. International action. This is par excellence a international collective action problem. I emphasised right from the beginning that one country can't handle this on its own but all countries together can. So how do you get to an international collective action problem? Well, the first thing is to understand the kinds of goals that you have in mind. And I've actually said what we argue those should be, somewhere between 450 and 550 parts per million as a long, as a long-term project. So you've got to start with the goals and we've suggested what those goals should be. And you've got to understand the urgency of action cause even those these effects occur far into the future, they are effects which are shaped by what we do now in these coming decades.

What principles should you bring to bear? Well, a shared understanding of why this is important and what you can do about it. A mutual understanding of what others are doing. Actually in some, when the discussion gets heated, some countries accuse other countries of doing nothing. And actually most countries have started. There's so much more they should do but they've started. China, for example, in its 11th Five Year Plan which starts this year, Meghnad used to have parties to celebrate the sugar harvest in the coming in in connection with the Cuban five year plan in the 60s. But the planning actually has become rather more sophisticated and the Chinese 11th Five Year Plan. starting this year, has two headline targets. First headline target, not surprisingly, growth rate. Second headline target is to reduce the energy to output ratio by 20% in five years. Chinese are taking this very seriously. The Indian Five Year Plan which is being prepared now, be finalised in the coming months, looks, if you look at its energy investment framework paper, to be quite ambitious on energy efficiency, too.

United States, which people sometimes knock here in this context, is actually investing quite a lot in R&D. Parts of the United States, California and Northeast United States, are actually investing quite strongly in measures like trading and so on which will help with climate change. In understanding what others are doing, it's very important to be transparent and open and have mutual recognition. That's the foundation of acting together. Of course we should do much more but as we think about what others are doing, we should recognise what they are in fact doing. And we have to think of structures like trading and so on which can sustain and technology-sharing which can sustain cooperation.

So action then. Quantity goals? You need for efficiency, prices of carbon which are as similar as possible over space. You need, have to understand what it means to have an equitable distribution of effort. I haven't dwelt on that but it's been a very important theme in what I've

said and you have to think about cooperation and technology, moving beyond the sticks and carrots.

So last slide, you'll breath a sigh of relief. The, how do you go about financing all this? Well, it's a particularly difficult issue for developing countries. I've said that the financing costs associated or the overall costs associated with mitigation down to 550 and below, are significant but they're manageable. We spoke about one per cent, plus or minus a bit in terms of raising prices. Of course, raising prices of energy-related things by more than that, other prices going up by less than that. But there is a lot of investment to be financed in developing countries which will be happening quickly over the coming years which, if we're to succeed in slowing down emissions, has to be made carbon-clean. And they'll be costs associated with that.

Now the advantage of the trading mechanisms which I mentioned but haven't gone into in any great length, there's a long discussion in the report of trading mechanisms, the advantages of trading mechanisms is that they allow private sector flows to developing countries. They gave incentives for developing countries to cut back on their carbon emissions because there's a reward for so doing, they can trade their emissions reductions and other people looking for emissions reductions can buy it there and they more for their money. You get more a reduction for your money. So those trading schemes plugged into developing countries, moving up in scale, are very important. Of course, investment in energy requires energy markets, power markets particularly, electricity markets which work well. Often they don't work well. Subsidies are $250 billion or so per annum around the world simply on, in energy markets. They're highly distorted markets and it's important that round the world they become less distorted and international financial institutions can play a strong role there. I've already emphasised the technology cooperation story as well.

So finally, let me conclude with adaptation. All countries are going to be hit by climate change. I've argued that we can do a great deal to reduce the risks and should do a great deal to reduce the risks but investment in adaptation will be necessary. It could cost developing countries tens of billions more to build infrastructure which is much more robust against climate change. That means to me, that the obligation to deliver on the overseas aid commitments which were made in Monterrey in 2002 at the UN Conference and in Europe in Gleneagles last year, that those commitments are vital to the adjustments that developing countries need to make. And the moral obligation to deliver on what we've promised is still stronger when you think about climate change.

Let me stop there. I'm sorry I've just overshot my hour but I've tried to take you through 600 pages at pretty rapid speed. Those of you who feel that there is maybe more detail in there than I was able to cover, which I hope is all of you, should go to www.sternreview.org.uk and read it. Thank you.

APPLAUSE

Desai; That was a stunning performance, even by LSE standards where I have heard some great lectures. That was really an outstanding performance. Of course, we all know there isn't such thing as climate change. If it is, it can't be measured. If it's measured, it's cyclical, it's not a trend and if it's a trend, you don't have to anything about that because technology will fix it. And even if somebody had to do it, why has it got to be me? Why can't the Indians and the Chinese do it? And as long as they won't do it, we won't do it and what has the future generation done for me so that I should do anything for the future generation? Now all those questions I do not want. OK? Let's not get that straight in my head. I also would very much like no speeches. In the House of Lords we have very good tradition at question time that every question has to start with does the Minister agree or not agree? Has to be a question. And I know, I know you all have profound differences from Nick Stern and you all know more than him, what it is all about. And you could all write a much better 600 page book than he has done but suspend your disbelief for a while and let us have some searching questions and the shorter the questions you ask, the more equitable it is because then other people can ask questions. I'm going to take about four or five questions to begin with to give Nick a little bit of resting time. Gentleman there.

Q1; Why did you not consider personal carbon allowances in your proposals?

Desai; Good. Is there anybody on this side? Okay, that gentleman there. Who else wants to ask the question?

Q; How about up in the balcony?

Desai; Yeah, it'll all happen.

Q2; The main question on, I am a Gurukul scholar, my question on carbon trading. What will be the impact on developing countries if both developed and developing countries take part in emissions trading?

Desai; Okay. Person up there.

Q3; Scientific evidence suggests feedbacks in the climate system will make stabilisation at the levels you discussed impossible. Are your targets ambitious enough? [APPLAUSE]

Desai; Look, person here. Person here. After that, after that, after him.

Q4; I want to ask about the aviation sector because that's one particular sector where the externalities are enormous and with aviation sector growth from seven or eight per cent of carbon emissions in the UK growing so fast and the potential for developing countries to generate so much more aviation traffic, that's one area is a problem for mitigation.

Desai; Thank you. Gentleman there.

Q5; Thank you. Sir Nicholas, your report favours as the first task of policy, the introduction of market-based mechanisms such as taxes and pricing, greenhouse gases. In the present

situation, with the need to make drastic reduction soon, would it not be better to prioritise introducing regulatory mechanisms so as to directly internalise the actual costs of carbon abatement and to the price of the relevant goods and services.

Desai; Okay, got it, got it. Lady here. Gentleman there, at the back there, yeah. It's on.

Q6; What are your recommendations for the Pre Budget Report?

Desai; Gentleman there, yeah.

Q7; Could you not draw from the same premises in your report, even more of a need for rapid development in the Third World? Sorry, I'm over here.

Desai; The man there, he is ……rapid development in the Third World.

Q; So in other words, if you had a rapid drive to have more nuclear power, more hydroelectric power, more fossil fuels with carbon carbon capture and storage in the Third World, so they had rapid development, they'd be more diversified, they'd have more resources and they could deal with the problem.

Desai; Good ……point. Gentleman there. Gentleman there. He's smart you know, he picks things up very quickly.

Q8; Kate Barker of the Monetary Policy Committee of the Bank of England is just finishing a report into land use planning, looking at the regulatory way of dealing with matters, any immediate bullet point requests of Kate?

Desai; Lady here, second from yeah.

Q; [inaudible]

Desai; Oh God, why does this technology waste so much time? Okay, later, we'll come back to you later. Gentleman there, the man there. Hello? The man there, right, yeah, yeah.

Q9; How far off do you think the ultimate political tipping point before a contraction convergence type model will be adopted globally?

Desai; Okay. Has the mic come on on this side? Not yet. Okay, why don't you answer those questions?

Stern; Can I do just one thing before I do answer those questions and that is that this report's called the Stern Review but it's actually written by a team and I'm going to ask the team to stand up cause most of them are here. Stand up, stand up. [APPLAUSE]

Desai; You see, we packed the audience beforehand.

Stern; Questions. Um, is the mic working? This one? Okay. Now I have to go very fast. Personal carbon allowances, Chapter 15, they do have a discussion. It's important to think through the costs of implementation of those allowances. Are there more effective ways of doing it? Do they right kind of flexibility? On the other hand, they focus people's minds in a very direct way, so in terms of persuading, in terms of people understanding what they can do and the consequences of their actions, they have values. So I think you have to look at them in the round. But you do have to take into account flexibility. You do have to take into account costs of administration. And I think costs of administration wouldn't be small. I think it's the LSE that's been discussing the cost of identity cards as a research for the government. These kinds of things are not cheap to do.

Carbon trading. Well, if, I'm not sure I got the question right. Is it do developing countries become a capital market for the developed? So the reverse flows. I think in this case actually what the rich countries or people in the rich countries or firms in the rich countries will be doing cause it wouldn't be government to government, what would happen would be that they would be helping to finance making certain kinds of investments more carbon clean. And you'd be picking up as you did that for example, quite a lot of co-benefits along with it, for example, on air pollution and so on. So basically in economics, one of the first things we learn is that trade is mutually beneficial and I think this applies here just as it does anywhere else.

Was, there was a question about whether the kinds of targets I was talking about for stabilisation are ambitious enough. That's something which should be debated and discussed. We suggested a region, 450 to 550. I emphasised that it did not remove the risks. Four fifty, which is extremely hard to manage, not impossible but extremely hard to manage given where we start, and you know, we all wish we started earlier, but 450 would involve a roughly 50:50 chance as we now understand the science, of being above two degrees. Four fifty, which would be a touch call, is not risk free. Five fifty involves more risk. Where you go in that range and we suggest you do go in that range, you cannot take all the risks away. But those of you who worry more about the risks, for example, because you worry about systems theory feedbacks and so on, would actually be arguing for going somewhere near the bottom end of the range. And that is something which seems to me, rational discussions should explore and it is something which we hope that the review very much encourages.

Aviation? It's actually quite small in terms of emissions at the moment, a couple of per cent of global emissions but of course, it's rising pretty quickly. Um, there is a discussion in the EU and proposals in the European Union about including aviation in the emissions trading schemes. I think expanding the emissions trading schemes is a good idea. Aviation of course, is not just, the damage it causes is not just the carbon, it goes beyond that in terms of the kinds of disturbances and water vapour it generates. So actually it's more costly than just in terms of the environment than just the carbon. And that would be, should be taken into account in any policy towards aviation. So I believe that the discussion on aviation is already active and will continue and should continue.

The question of market-based mechanisms versus regulation. I tried to be pretty even handed about trading which we were just discussing, taxation and regulation. And I believe

all three have a role to play and we did not want to turn it into a horse race between taxation, trading and regulation. I think that they, all three, have a role to play and in some sectors, regulation will be more important than others. Standards of course, for appliances are part of that regulation story.

I was asked about my recommendations for the pre-budget report. One of the first things you learn in the Treasury, I've been there just three years now, I wasn't a civil servant before that. I'm not genetically made as a civil servant but one thing that I have learnt is that you don't talk about what might be in the pre-budget report.

Desai; Even after it has appeared.

Stern; There's a story about promoting rapid development in developing countries. Most of my professional life has been devoted to just that and that if we could along the way, and I think we should along the way, do two things - help with the whole story of decarbonising of power and eventually decarbonising of transport. Brazil, of course, has gone quite, starts to move quite strongly in decarbonising transport through biofuel. I think we should support that story, sometimes through R&D, sometimes through carbon trading and I think we should support the adaptation story. But above all, we should support the development process itself. And what I wanted to emphasise is, the development process itself is not just consistent with action on global warming, it's actually, if you do it the right way, helps promote action on global warming both on mitigation, and on adaptation.

My answer on Kate Barker who I'm sure is going to produce a very good report on land use planning is the same as on the PBR. I wouldn't dream of telling Kate what to put in her reports, although I'm sure it will be wise.

Now the last question was about a political tipping point and coupled with the idea of contraction and convergence. To those of you who don't know the jargon, you may not know what political tipping point means, it's actually quite deep content. But the, on contraction and convergence, it means that if you're talking, if you go into carbon trading and different nations have different allowances for emissions, the idea of contraction and convergence is that you give everybody the same kind of emissions allowance per capita, regardless of how much they were emitting. So those poor people who emit less can sell some of their allowance to rich countries that emit more. And that's the story of contraction and convergence. And it does have obviously strong ethical attractions to it. It's based on a proposition on rights which is about, a bit tricky to get your head around that we all have the same rights to emit some level or other. And that's a difficult one to understand. I mean you can argue that we have no right to emit. Or you can argue you have some right to emit. And you sort of get into quite difficult conceptual territory. But the motivation behind the question that the story of trading and the story of adaptation and the story of mitigation, should be so structured that rich countries, at least for the beginning period, which might be quite a long period, pay the bulk of the costs is I think sound. We talk about in the report the rich countries paying 80 plus per cent of the costs of mitigation, bearing in mind that rich countries' GDP is 70-75% of world GDP and they bear historic responsibility for the story, that seems to be a fairly modest requirement. But whether you translate your equity concerns specifically just that one way

through contraction and convergence, seems to me to be an open question. But the basic theme of the question I have strong agreement with, that is rich countries pay more. How you implement it I think is open to discussion.

Desai; I think my model predicts that the probability of Nick Stern losing his voice is very high. He has spoken at great length. He has answered lots of questions and I know many more questions are there but I think it would be unkind to impose on him any further than what he already has done. I apologise but I thank you all very much for coming here. And I thank you all and thank Nick Stern very much for what he has done for us. Thank you. [APPLAUSE] Just be kind to the man. This is not the only lecture he has given. This man has been lecturing non-stop for the last two weeks.