

What I am sharing with you now is the early thoughts on how we are going to try to structure the questions that are central to what the Chancellor announced as a major review of the economics of climate change at the end of July 2005. It is a joint activity between the Cabinet Office and the Treasury and I am reporting to the Prime Minister and the Chancellor. In the autumn of 2006 we hope to have a serious statement of what we think are the big issues and how we should respond to them. What follows is an early take on those questions. It would be very interesting for us to get your reactions to it either during the course of the discussion at the end of the lecture or through the website - www.sternreview.org.uk

So this is the first outing, our first day out in explaining what we have in mind here. Now I have been struggling all my adult life with the economics of policy but up until last summer I hadn't really got to grips with climate change itself. I have to say that in reading I have done over these last months and the interactions I have had with various different kinds of people, scientists, and otherwise, I am convinced that this is a really big and fundamental issue. I say that because economists have more than their normal dose of sceptics and cynics and it is important to convince yourself first that this is a big issue. But I have to say that the science does seem to be overwhelming - it is an enormous problem and one that we really have to take very seriously, and economics should be at the heart of any serious discussion of how we proceed. Having argued that economics has to be at heart of what is a very serious story I want to underline that it has to be a very broad range of economics. There is very little economics left out here. There is growth, development, international, institutional, there is information, there is environmental, of course the whole area of public economics which is part of public finance is also a big part of this story. There is nothing left out. I used to joke that monetary economics was the only thing that was left out. But that is not true because we are busy creating lots of very important financial assets, the trading which is charging around the world. So monetary and financial is in there too. This isn't now a part of economics. It is not now pushed into a corner. You have got to bring all the economic tools that are available in trying to analyse this story.

The structure of the argument will be a fair bit about the science of climate change. That's crucial because the science actually shapes the economics. The science of the problem determines what kind of economics you can or should bring to bear. So I will address that explicitly in the implications of science and the structure of economics. The first part is for science, the middle two bits, as it were part two of the story, is the economics. Having established the structure, I will go into some particular issues within that structure and finally I will try to take on some of the challenges of building international action because this has to be serious international action.

Science of Climate Change

Now there just may be one or two people here who, similar to me in August or July of last year, had an idea what the greenhouse effect was but wasn't really sure. Now this is a slide from the Hadley Centre and I should say that we are fortunate in the UK to have the Hadley Centre. It is a jewel in the crown of the scientific establishments in this whole area of understanding how climate change really works, and so quite a few of the slides I have got on science are from the Hadley Centre. The sun sends sunlight

to us and its infra-red goes back the other way after it hits and earth and some of that gets trapped like the greenhouse glass traps, and that is the greenhouse effect. Now that effect is extremely well-known. It dates back to Fourier – some of you have done any mathematics will know about Fourier transforms and Fourier series and all that stuff. It was Fourier who established the existence of this effect in 1827. What he really did was to look at the heat coming in and look at the heat coming out and tried to work out what the temperature of the earth should be and he found out it was a bit warmer than his calculations suggested. So he knew that there was something trapping it and he knew there was a greenhouse effect.

It was a scientist in 1860 who worked out what was doing it. He knew that something was going on but it was Tyndall who worked out what it was that was doing it, and what he showed was that by trying to see what happened when you send heat through air without various things in the air he discovered that it was the carbon dioxide and the water vapour that was actually doing it. Fourier established an effect, Tyndall established what was causing the effect, and a Swedish chemist Arrhenius in the 1890s actually calculated how much the temperature of the earth would go up if you doubled the amount of carbon dioxide in the atmosphere, and his calculations of 5 degrees or so increase in temperature turned out to be remarkably close to the mark. The calculations now might be 4 or 5 [degrees] rather than 5ish, so he was pretty good in 1896.

Now I am emphasising this because this is not some latest scientific wheeze. This is a piece of physical chemistry that has been known for a very long time. Not to me, I only found out last year, but this is a very well established piece of science. And the mental arithmetic that people did very early has stood up very well relative to the much more sophisticated modelling that has taken place subsequently.

Now, so we know that this is an issue. Well, it has been happening. You can see that the temperature has been rising starting around the turn of the 20th century. Early in the 1900s it started going up and it has been shooting up. There are wobbles, of course, because of what human beings are doing is only part of the story. There are changes in the intensity of the solar power emitted by the sun and there are changes in angles of orbits, there are volcanic eruptions and so on. There are all kinds of natural effects going on here. But what you see in the far right [of the slide] is something which cannot be explained, and the scientists have gone into the modelling of this pretty thoroughly. It cannot be explained just by these natural happenstances that occur in the solar system and in the earth. It is important to emphasise that scientists working here are using the basic laws of physics and chemistry. They are not doing time series econometrics. In other words, there is no adjustment in Newton's second law and the laws of thermo-dynamics to fit what is going on, and they predict much more than just the temperature: they predict all kinds of things that would be happening as a result of these physical and chemical and biological phenomena. So they do do a little bit of adjusting of coefficients here and there - I don't want to say it is completely free of any kind of curve fitting or estimation - but basically the underlying story is based on science which is known as I described in the understanding of the 19th century. So the temperature has been going up and the stock of carbon dioxide has been going up and that is the very close link and its not happenstance, its science behind the link between these two curves here.

So I should say while I had temperature in the previous slide starting in the 19th century, if you send that one a long way back as far as we know, if you send it back another 8 or 9 hundred years it would look pretty flat with oscillations around the level. So that's what has been happening to the stock of carbon dioxide and you can see that it is very suggestive in relation to the story of the temperature and of the science. The relation to human activity: this is the stock of carbon dioxide, this is the flow of carbon dioxide simply from the burning of the fossil fuels, so that is the direct link with the human activity. You have to be very careful: it is very easy to get confused with units of the vertical axis: they won't all be the same and the problem is that sometimes people express it in terms of carbon dioxide, sometimes they express it in terms of carbon, sometime they include other greenhouse gases along with the carbon and then they talk about greenhouse gas equivalents and sometimes they don't include all the sources of emissions. For example, sources of emissions from land use are often left out. So don't worry if the vertical axis isn't quite the same in all these graphs. Most important in these stories is the pattern.

Now, where is it all coming from? Well, the blue here – this quadrant covers can produce electricity and heat generation, transport, industry and other energy. The energy quadrant is 61% of the story but land use which is particularly deforestation is 18% and agriculture also is another 14%. It depends on how you till the soil: the soil has got carbon and methane in them and depending on how you till them they release it, depending on the temperature the soil releases greenhouse gases as well. And of course you have a lot of flatulent cows, sheep and so on which is all part of the story. I promised my kids I would put that bit in as they think it is funny!

Up to now we have been talking about the past. Now let's look at these last few slides on the science into the future. You can see the main emissions we have got here but if you are thinking of controlling these emission now you want to look at where the big emitters are now and where are the big sectors which are growing. So the big growth rates are in power and transport. Now, if you look then as to what the effects of this whole story might be, the story of growing emissions, the story of growing emissions for temperature you can see graphs of this kind. This is taken straight from a combination of the Intergovernmental Panel on Climate Change (IPCC) and the Hadley Centre: the Hadley Centre in Exeter took some of the economic scenarios used by the IPCC and they asked what would the implications be for future emissions and then what would the future emissions mean for temperature. So you can see that of course it does depend on what you assume about growth, what you assume about energy efficiency and action on carbon. The line at the top is fairly bullish about future growth and assumes that people don't do very much about energy efficiency and carbon emissions. So you get pretty high carbon emissions, pretty high carbon stock and temperature increases as a result of that. The bottom line, the green one, is much more optimistic about action on climate change. But business-as-usual we should see as something close to that dark line at the top or somewhere between the orange line and the dark line – thinking roughly speaking business-as-usual. So we can see that we are headed for some pretty unpleasant increases in temperature. Those kinds of increases of 4 or 5 degree would take us well outside human experience. Dinosaurs may have experienced something like that but some of these things would take us well outside the area of human experience.

Now don't look too much at the detail of this – we can't look too much at the detail of this because it's quite small. The point of this slide which focuses on water availability and run-off is to emphasise that the effects are going to be very different in different parts of the world. The temperature increase on average on the surface of the earth of 2 degrees or so would be associated with very big changes in temperatures in some parts of the world. And temperature changes over the sea would be quite small. These things vary a great deal. Now, it is probably fairly unpleasant to be dark red or dark blue but red corresponds to a big reduction in water availability. The run-off goes down because the sheer amount of water goes down. Probably a little bit of blue in the middle of Africa isn't much change - from 3 buckets a year to 4 buckets, it's probably not exciting. But the dark blue you can see particularly over the Indian sub-continent and Bangladesh could be associated with much more intense rainfall – much of that associated with floods. And if that is associated with the melting of the Himalayan ice caps and snow caps, as it would the sponges that control the flow of water down the Ganges and the other main rivers in the Gangetic plain would cease to operate in anything like the same kind of way so that precipitation would just charge down off the Himalayas all at one time rather than actually being held during the year by the ice and snow caps in the Himalayas. So there are some fairly frightening consequences that could flow from that story. So the point of the graph is to emphasise variation of experience, the timing of water, and the level of water, up or down, could be a major issue for adaptation.

Now what we have got here is the, I am close to the science that I wanted to point to now, what we have got here is a collection of stories corresponding to different stabilisation levels of carbon dioxide equivalent – that's taking all the greenhouse gases together – in the atmosphere. There are 4 columns which have degree C in them, the first and third are based on 2001 estimates and the second and fourth are more recent estimates based on Hadley Centre subsequent calculations. The first point is that those second set of calculations involve higher temperature increases than had previously been thought in 2001. In other words the science indicates that we should be getting more worried rather than less worried as the evidence builds up. There is a range here of course, and that's another of these points here. There is uncertainty and these are fairly crudely calculated at 90% confidence intervals. Don't press me on the stochastic foundations of the confidence intervals here because I suspect that there's a fair amount of snatching involved. But I do want to emphasise the range and the uncertainty here. But the upper ranges here are all significantly above 2 degrees C. And 2 degrees C is itself quite a worrying level in terms of the kinds of effects that could occur. As you go much above 2 degrees C, it becomes quite possible that significant irreversible effects could occur, for example, the dying back of the Amazon Forest and the thawing of the thermo permafrost across great ranges of Russia and Siberia releasing all sorts of methane as that permafrost thaws. Those two kinds of effects, which could start to kick in at 3 or 4 degrees temperature increases, or perhaps even less than that, would probably be irreversible and would be amplifying effects relative to the story that's expressed here which excludes those effects.

Now where is it all coming from geographically? Well currently you can see this dark red area is where we are now. This dark area, you can see that the big emitters are US and Western Europe; China also quite big. And those are sort of the biggest three of the main blocks of emitting. On the other hand, if you go forward, you can

see that the growth of emissions in China, and this is using World Resource Institute data, the International Energy Agency does a lot of work on this kind of thing as well. But the forecast increases for China are very substantial. They will be also for India as India starts to move forward as well. My rough rule of thumb is that if you look at the cumulative energy emissions over the last 50 years or so, then it's the rich countries that are responsible for 79%. But if you run forward another 20, 25 years, it's likely to be the case that the current developing countries will be responsible for 70%. And in a decade or so the emissions from the developing countries will overtake those from rich countries.

Now the importance of this of course in relation to public discussion is that the developing countries currently don't have targets and there will be a major challenge in bringing them into the whole story of emissions. But as we think about that, we should remember that that was total emissions by country. If you look at it per capita, it's very much higher still in the rich countries than the poor countries. So this is my last slide. I've already emphasised that 550 parts per million involves very significant risks if you think back to slide 11. 550 was the highest one that we presented in this story, and if you look at the bottom right hand entry in this matrix, it involves the possibility of quite high, frighteningly high temperature increases relative to these kinds of irreversible effects that I described. But the 400 is already virtually impossible. We're actually already above 400. Current levels are around 425. So when we think of 550, we shouldn't think of it as some kind of upper band that may or may not happen to us. We are actually, if you go now through to this one, we're actually set for something well above 550 unless we act pretty strongly. So this is, as well as a big issue down the track, it's actually a rather urgent issue for action. If we're to stabilise at 550, already rather worrying as I've argued, you can see that we have the peak around 15 or 20 years from now, and peak at levels significantly below the levels that we are heading for. So to get to something that is rather worrying, and is not hugely ambitious in terms of eliminating risk, but it is pretty ambitious relative to where we are now; to get something like that, strong action has to be taken quite soon. And now "Annex 1" is rich, and "non Annex 1" is not rich, in the jargon of these international agreements. And you can see, as I argued just now in talking about China and India, that the fraction coming from the non annex 1 countries, is pushing up pretty rapidly. So it has to be an international agreement, and it has to involve those countries which don't formally have targets under the Kyoto agreement at the moment.

So that's it on the science. As I said, I've learnt my science from the Hadley Centre and the Chief Scientific Adviser to the Government, but it is important to set it out, because it actually shapes all of the economics that follows. So let's just give up the slides and talk some economics.

Structure of the Economics

But what economics follows from all this stuff? I've five key issues which follow immediately in terms of the structure of the economics.

The first is that this is not a standard externality problem. It is an international collective action problem. Now you've all done the economics of externalities. You know about Pigou and taxing equal to marginal social cost. And you know about

Coase and the allocation of property rights. And trading and bargaining relative to those property rights to get an efficient outcome. You know about wise, all-knowing governments that can always regulate directly. And you probably also know about James Meade and internalising externalities and the apple orchard and the beekeeper getting together and running it all as Apples and Honey inc. Now it's clear that none of these routes is remotely relevant as **the** answer. They **all** probably have something to play as part of the answer, but none of them are singly the answer. Why not? There are a number of reasons why not. The first is this isn't a single jurisdiction. There's no one country selling its policy here. You've got many countries having to try to find some kind of common approach. You've got uncertainty which is pervasive right through this whole story. And you've got all kinds of other interlocking inefficiencies in the system. There's a whole range of reasons why the simple standard theory of externality is a useful observation and a useful insight, but it is not the fundamental, by-itself basic answer to this story. This is an international collective action problem where you have to get people together. Now that will govern everything I think that follows. I've already emphasised that you need all the economics you ever learnt and some more in this story, because all the players in this international collective action problem are going to have to understand the implications for them for their growth, for their mortality rates, and for the survival of species and natural flora and fauna in their country and so on. They're going to have to understand the consequences for them.

And you're going to need all these different branches of economics to help them understand those consequences for them.

We know that this is an area with free riding, and this is the third area that you've got to look at: the game theory and the problems of free riding in this whole story. You can't just conjure international collective action out of the air. You've got a whole series of difficulties in terms of the right ethical perspective, or the appropriate ethical perspective, to bring to bear. This isn't an area where the standard philosophical tool of thinking simply of, well what would this look like in a stripped down version of the problem? That's the standard way we work out how we would proceed in these kinds of ethical problems. We're talking about areas which are potentially right outside the area of human experience, not just modern human experience, human experience period. So it's quite difficult to think about what the right ethical perspectives are in a context like this. You're certainly going to have to think about equity and fairness in the burdens of adjustment. The rich countries are primarily responsible for where we are now. The poor countries are going to be major contributors to future emissions. How do you bring notions of equity and responsibility into that kind of discussion? There are many people who would want to raise issues of sustainability and stewardship; that we as human beings have responsibilities relative to the environment, as well as responsibilities relative to other human beings. The ethics of all this is actually quite difficult and we have to think very hard about that. It is not a simple direct application of welfare economics with Bergson and Samuelson social welfare functions where overall utility W is a function of U indexed by household time and state of nature; and you take the expectation. We use that framework a lot. It's very useful and powerful for lots of problems. But I believe the ethics of this extends beyond that.

Key Issues

And finally, the uncertainty is absolutely pervasive and I'll come back now to some of the specifics of all this. So the science dictates the structure for the economics. What I want to do is to talk very quickly about a few of the key economic issues within that overall framework. Now first let me say something, and I'll focus on areas which in our view have been rather underemphasised in the literature on the economics of climate change hitherto. That literature on the economics of climate change hitherto is very useful, but I think it does focus a bit narrowly relative to the story of the international collective action problem. It traditionally looks at four areas; or hitherto has looked at four areas. The impact of growth on emissions; the availability of technology and the economics of their adoption, second; third it's looked at the social cost of carbon; and fourth it's examined various tax and market structures in shaping the response of the private sector in terms of emissions. So those are broadly the four areas. They're all relevant, they're all important, but I think we have to go much beyond that.

Now first we have to look at the endogeneity of growth. The rate of growth will depend on the environment in which that growth takes place. If you disrupt the monsoon in North India, or the advance of the Sahara is accelerated in Africa, that will have a fairly profound effect on the rate of growth on those countries. There will be impacts in rich countries too. Rising sea levels, changing temperatures. The summer of 2003 will be normal probably in 30, 40, 50 years, and cool if you add 20 or 30 years to that. So there would be a quite profound change in the environment in rich countries too which would affect the opportunities for growth. So there is a fairly clear connection between the environment and growth, and that hasn't been looked at in a particularly systematic way. There is also a potential connection between action to mitigate the emissions, to reduce the emissions. "Mitigate" is used interchangeably with "reduce" in this area. So reducing the carbon emissions also could have quite a strong impact on growth. And I'll say just a little bit in a moment about what kind of impact that could have. So that endogeneity of growth is a serious element in the investigation of the economics. I'll say something, I'll develop the mitigation story in just a minute to a discussion of some of the instruments you might use for mitigation, but let me pause just for a moment to emphasise adaptation.

Adaptation is a word that is used to indicate adaptation. It's a fairly soft word. You could even use it to mean that if Bangladesh becomes submerged and you are forced to swim, then that is adaptation. But of course in other contexts less dramatic than that, there are quite a lot of things that you can do. Like you can build better flood defences. There are quite a lot of things that you can do. But that adaptation story, and I did show it very briefly in the map of the world that was up in the slide, that adaptation story can be very tough for many of the developing countries. It's difficult, this is early stages now, but the calculation of the likely effects, for example on crop yields in Africa, are already looking rather worrying for 20, 30, 40 years ahead. You're talking about figures of reductions of upwards of 10%. It could be more than that. We don't yet know. But if you get crop reductions of that magnitude in sub Saharan Africa, you will have very serious problems which are basically about survival, and adaptation doesn't quite pick up that. Once you've heard about climate change it seems to me the case for overseas development aid is still stronger, and

that's one important part of the adaptation story, and I think it's been underplayed in the literature up to now on climate change.

But let me return to something which has been central to the challenge of climate change, and that is the story of mitigation. Now there is a paper which has already gone up on the Web this morning where further details of what I'm talking about now can be found. I've only got time for very broad brush discussions. But let's just think a little bit about scope for mitigation, scope for carbon reduction and the tools that you might use to mitigate. Now that's where a lot of action in this area is quite rightly focused, and there's lots more detail in the paper that we put up on the Web this morning. So excuse me if I go through this in a fairly fast and fairly broad brush way.

I think it's fairly clear, given the scale of the problem, that if we're going to be effective in reducing carbon emissions, we're going to have to act across a pretty broad area. You saw the pie chart with the various different areas of emissions. We're going to have to try to act across all those areas. You're going to have to try to think about halting deforestation which is a big part of the story. You're going to have to think about carbon free electricity generation. You're going to have to think about adjustments in transport. And other areas; the way in which buildings are constructed and energy efficiency. If you're going to get somewhere in this story, given there are a lot of contributors to it, you're going to have to think of action across a very broad area. And the technologies that will support that vary according to where you look. Carbon free electricity is perfectly possible. It comes with a cost, but it's perfectly possible. You can capture carbon from coal or from gas or from oil in the generation of electricity, and send it back underground. Basically it's a problem if you take the carbon from underground and you stick it up in the air, and it stays there. So you can either not take it out from underground, which means renewables or nuclear, bio fuels and so on. So there are various ways of not taking it from underground; not using fossil fuels. And if you do use fossil fuels, then there's carbon capture and sticking it back underground. So it is possible to examine carbon free electricity generation.

It's possible to imagine stopping deforestation; you can do that too with the right kinds of incentives and institutions and management. Transport is more difficult. On the other hand, if you've got carbon free electricity, you could have your cars, at least in towns, just plugged in overnight to the carbon free electricity and you could use electricity.

So what's possible and how close that technology is varies upon where you look. And it's going to be very important to keep a very open mind about those technologies. So picking technological winners is something that one should do with care in this area. We have to be aware of the technologies in order to think about the right kinds of incentives that you are going to put in place. The incentives you put in place shouldn't be completely free of any understanding of what the technological possibilities are. And there's a governmental challenge in asking itself how much of a role should it itself play, or groups of governments play, in developing technologies. Technologies are ideas; they're public goods. The global atmosphere is a public good, but the technologies to reduce the emissions are also public goods. So there's a challenge there on how far the public sector should play its role in this story too.

So in thinking about technologies and incentive structures and the public sector, we should have a pretty open mind. But I think nevertheless it's fairly clear that most of the action, or the lion's share of the action, in terms of choosing ways of moving forward, choosing how to save energy, choosing how to reduce carbon and so on, those choices will largely be by the private sector. So there's a very serious question of how does a government set the right kind of incentives for the private sector. Now the private sector is actually quite specific on this point. They have a slogan which actually makes a lot of sense: the incentive structure should be loud, long and legal. But the loud, long and legal is actually vulgar for clear, long and credible. There's a difference between loud and clear and there's a difference between legal and credible. But if you're thinking about investments in the kinds of infrastructure and durables that we're talking about, it must be the case that the incentive structure is clear, long term and credible. And putting those kinds of incentive structures together is actually quite difficult. You have to try to bind yourself going forward in a way that governments find it quite difficult to do; a problem the economists have studied right across the board in other areas, including monetary policy, competition and so on. We have to try to put together those kinds of structures. So that's a very important part of the area which we want to analyse. How do you put together in a convincing way those kinds of incentives for the private sector? How do you involve the public sector in the story of discovering not only new technologies, but also the setting of this incentive structure? That's a big challenge. There are lots of people who can help us now helping us with that. Uncertainty will be a big part of that story, but you can see the kind of economics I hope from that statement of the problem that you're going to have to bring to bear in working out what the right kind of public private combination will be in this area of mitigation.

So let me turn now in the last few minutes to the putting together of international collective action, which is where I started when I moved forward from the science to the economics. This is an international collective action problem. So how do you get people together? Well first it seems to me you have to build an understanding of the nature and severity of the problem. People have to agree that it is a problem. They have to agree that the source is human activity. They have to agree that it's a problem they need to act on together. They have to understand that it's very long term. They have to represent future generations much more than they usually do, and so on. So building that common understanding of the nature of the problem is vital. Now when I was writing the report for the Commission for Africa last year, it wasn't hard to convince people that the challenge of Africa demanded our attention. I think most people were already there. I don't think everybody's quite there on climate change. So step 1 is something that has to be built. Of course, in Africa you had to also convince people that the kinds of things you were suggesting might actually help. Could you be effective? Now that of course is another part of this story that we have to build. I've tried to suggest, at a very broad brush level, that there's lots of things that we can do, and the economics of them will be at the heart of the story. But that is again, that second step is something that we have to build. So we have to convince people the nature of the problem and that action is possible and effective.

Moving forward then, we have to convince people that their role in it is acceptable to them, and we can do that only by providing them, or helping to provide them, with the kind of information they'll need to understand the consequences for them. President Bush is concerned with the effect of all this stuff on the growth and way of life in the

United States. And as President of the United States he's right to be concerned. The leaders and people who represent other nations are concerned with those kinds of issues, quite rightly, of the implications for them. So it's our duty, as those who are studying these kinds of issues, to try to put on the table in a systematic way what are these consequences. This isn't about name calling. It's about working out the consequences of different kinds of arrangements.

Now in this case growth is a big issue. The Indians and Chinese will very understandably put that on the table right at the beginning. Their leaders might be expected to say "I take it you're not telling us to grow slower and leave our people in poverty for longer?" And you can understand where they come from. And some people might add: "And further to that, it's all your fault anyway". So you've got to be able to go through in a systematic analytical way what the implications for them are. So in the growth story, you've got to be able to try to understand that if you do carbon capture from the coal which is going to be so important in the generation of electricity in India and China, you have to understand what it's going to cost. It will cost a bit more. How much more? When? What kind of technologies are available? Are they likely to develop and get much more sophisticated and cheaper? And so on. You've got to be able to try at least to give some guidance on those questions.

And in the case of India and China, and the other developing countries, you've got to face up to the question of who pays. And those of you who have been involved in electricity manufacturing, in India, as I and others have for many years, will know the difficulties there. I hope they do eventually solve that problem irrespective of this one. But who pays? And I think there is a growing understanding that the consumers in rich countries should have something to pay through the price of electricity for reducing carbon emissions elsewhere.

Now we have in the Kyoto story something called the Clean Development Mechanism which is organised to do, in principle, exactly that. So as you go into this information story, what does it mean for me and my country, there's quite a lot of things that you can say, but there is a great deal of work to do. It's quite possible in Europe and the United States, where our energy industries are inefficient, that a focus on this area could kick start a reform that could actually save us quite a lot. Now I suppose we could have done it anyway, but if this kick starts it in a strong way then good, and we should put down some of the credit to that. It's quite possible that insisting on carbon free electricity, carbon reduction in transport and right across energy conservation in buildings and so on, it's quite possible that could unleash a wave of innovation which could drive growth. It's also quite possible it could just simply cost more and reduce growth and competitiveness for that reason. These are analytical questions which we have to try to get our hands round if we're to provide the information that people understandably need in order to weigh up their position in these international negotiations.

We also have to think about what kind of mechanisms we're going to bring into those international negotiations. If they're treaties, are treaties monitored and enforced; if they're market mechanisms, what kind of institutional structures do we need to support the market mechanisms? Now market trading mechanisms for carbon are traded in pieces of paper that say I have produced less carbon than I would otherwise have produced. Now in many parts of the world, some might claim if you want a

piece of paper that says I have produced less carbon than I would otherwise have produced, it would be readily available, particularly if you get paid for it. So you need institutional arrangements which can verify the credibility of these kinds of statements. You do it at the level of the farm. When I was in India just about six weeks ago, there was a guy there who had this dietary supplement for cows to reduce their flatulence. Now I thought that was actually a rather interesting idea. How detailed do you go on that? If a town decides that it's going to insist on electric cars from 2020, how do you build that kind of action into the story? You've got to have institutional structures that are going to pick up all these kinds of things. If a country whacks a steaming great tax on carbon emissions, if it does it that way, how are you going to bring that into the story? This isn't impossible. None of this is impossible. And a lot of it's on the way. But it's very important to think through the institutional structures and the incentive structures. So you don't just have to inform people about what's going to happen to them under different arrangements; you have to tell good stories and come up with good examples, and develop actions and practices that are going to give you the support for all these measures. And the institutional challenge is not small. But we are on the way in many cases; we are on the way, but we have to jack it up and move to a still higher plane. And finally of course you have to sustain the story. There will always be the free rider temptation in this area. Much better to persuade other people to do the mitigation and not take on the costs yourself, or promise to do it and then say, well I meant to but it was all too difficult. So you've got to find ways of sustaining those stories. Now this isn't impossible. There's nothing that's going to be watertight here, but it's not impossible. There are lots of things that you can think about doing. Treaty obligations themselves are part of the story. International standards could be part of the story. Helping people into infrastructures that lock in certain kinds of technology could be part of the story as well. There are various things you can do. International negotiations and understandings take place across many dimensions. We've talked to each other about moving the people. We've talked to each other about moving capital. We've talked to each other about trade. We've talked to each other about nuclear proliferation, and terrorism, and drugs. There are a whole load of areas where we talk to each other all the time as international communities. We could make, and should make, climate change a very big part of that story. So the free rider story is not simply just this particular part of the world, or part of the economic activity that produces and adapts to climate change, it's all the other things that come into these international bargains and understandings as well. So there are lots of areas for action that we can think of, and we've got to sustain and try to tie in these agreements as best we can. We have to think along all those dimensions.

And I think there's a dimension which is of particular importance in this long lived story that we've got here, and that is the whole process of education and persuasion. Economists think of, and this is the last thing I'll say because it departs a bit from the way economists currently do things, but I think it's a direction they should go, not just on this area but also on others, they think about incentives and they think about institutions to support those incentives. And they contribute a great deal more to the world than those people who don't know about incentives and don't know about the way in which you design institutions to support incentives. Let's not go away from there but let's add to it the story of persuasion and education and changing preferences. I guess most of you here are upstanding members of the middle classes and socially responsible, but whether or not you are, you probably recycle. Now

nobody pays you to recycle, and nobody fines you if you don't, but you do. You do because we've talked to each other. We've learnt about it and we've changed our understanding of responsible behaviour. People smoke less in public places, not simply because somebody's told them it's bad for them, or the price of cigarettes is high; it's not simply information or incentives. It's also because they've learnt, at least some of them have, to understand what it means for other people and then go a step further to think through what responsible behaviour means. Children who are educated now have learnt much more about climate change at school than some of the older amongst you ever did, and that affects their view of responsible behaviour as well. John Stuart Mill talked a lot about the relationship between democracy and discussion, and he understood very well, as did political philosophers way earlier than that, but the role of public discussion in forming our attitudes and preferences in the process of taking decisions. So I think that in thinking about ways forward, incentives and institutions to support the incentives will be fundamental. All the kind of information and analysis that I've spoken about will be fundamental too. But I think also fundamental will be the process of exchanging ideas and changing preferences and building understanding across nations and across generations.