

ABSTRACT OF THE DISCUSSION

Mr N. G. Silver, F.I.A. (introducing the discussion): The issue of climate change is very controversial. It raises many questions, and those of us who are leading this meeting will admit that we do not know the answers. So, the point of this meeting is to have a discussion and dialogue within the Profession, and to come towards some kind of consensus on the way in which we might move forward.

The meeting takes the form of a short presentation by Professor Smith on the state of climate models, and then a discussion, led by Mr Fulcher, Mr Lette and Mr Robins, on the possible implications for the three areas where many of us practice, that is pensions, investments and non-life insurance.

What has climate change to do with us as actuaries? Our politicians say: "It is the greatest challenge facing mankind", and other issues of the day now are compared routinely to climate change. There are long-term implications, which, realistically, are not going to occur during our lifetime. In the short term, there are certain impacts, which could, potentially, affect the work which we do.

I have divided them into three. First, there is the local impact, the effect of extreme weather events. These are predicted to increase, both in magnitude and in frequency, in the near future. We have seen, recently, that, while you cannot attribute individual events to climate change, they will have obvious implications for things like property insurance. Next, there is the more global view, whereby large areas of the world, for example Africa, Asia and the Middle East, are predicted to have changes in their rainfall patterns which may, in turn, affect food production. We live in an increasingly globalised world, where the impact on those countries will have a knock-on effect on us and on our economy. Then there is society's reaction to the problem. We are currently seeing a large switch, from where we are mostly powered by hydrocarbons, to, at some time in the future, being predominantly fuelled by something else. This will produce a massive shift in the resource allocation, and will have obvious effects on large asset holders, like pension funds, for example.

So, what do we do about it? What conclusions might we come to in this meeting? There are many possible reactions:

- (1) We could choose to do nothing at all. This might be a reasonable reaction in certain circumstances.
- (2) We could monitor the situation, and tweak our models. For example, catastrophe models might require a trend set in them.
- (3) We could rethink the way in which we model risk.
- (4) We could consider that climate change and the emerging carbon markets will give rise to massive opportunities in which we could use our skills as actuaries in exciting new areas. For example, I have recently been involved in insurance around the emerging carbon market. I have been asked to look at how insurance could be used as a tool for driving adaptation behaviour in countries which are highly vulnerable to climate change. Then there is the whole issue of the policy debate, for example, the recent Stern Review on the Economics of Climate Change (Stern, 2007), which, controversially, used a discount rate of 0%. We, as actuaries, are perfectly qualified to comment and to debate the merits of that.

I now introduce Professor Smith, who is the perfect person to lead us through the morass. He is the Director of the Centre for the Analysis of Time Series. Since 1992 he has been a Senior Research Fellow at Pembroke College, Oxford. He also became a Professor of Statistics at the London School of Economics in October 2004. In 2003 he was awarded the Fitzroy Prize by the Royal Meteorological Society.

REFERENCE

- STERN, N. (2007). *The Stern review report on the economics of climate change*. HM Treasury and Cambridge University Press.

Professor L. A. Smith (a visitor; introducing the implications of the Intergovernmental Panel on Climate Change (IPCC) Report for the Profession): My interests go beyond just climate change. The Centre for the Analysis of Time Series is interested in forecasting anything which changes, and, if something has not changed yet, well that is just a special case. We are really interested in the predictability of a wide variety of things, more than simply climate. I preface my talk with some figures, which show the results from a survey of actuaries on climate which was carried out and which received over a thousand replies. [For more details of the questionnaire, see the ‘Questionnaire Analysis’ immediately before this discussion.] I will then talk about my interpretation of some of the survey, especially on the replies which actuaries have given to questions as to whether or not, during their careers, climate change will have any effect on their work. Only about 5% said ‘no’, and that it was a media myth. No scientist whom I know believes that climate change is a media myth. There is a lot of uncertainty about how significant the impacts will be, but there is no belief that there is not a serious issue, a real phenomenon at which we are looking. The answers to question 1 of the questionnaire are shown in Figure D.1. Climate change will definitely have an impact the work of actuaries, through climate policy if nothing else, and so I disagree with the 25% of actuaries who replied that climate change was real, but would have no impact on their work. Certainly, unless they are involved in life insurance with a very long lead time, or with companies involved in large infrastructure projects, it is arguable whether or not they will see the environmental impacts from climate change in the next year or three years. However, questions of policy can have a huge effect, even if you, personally, are agnostic on the actual size of the climate change impact.

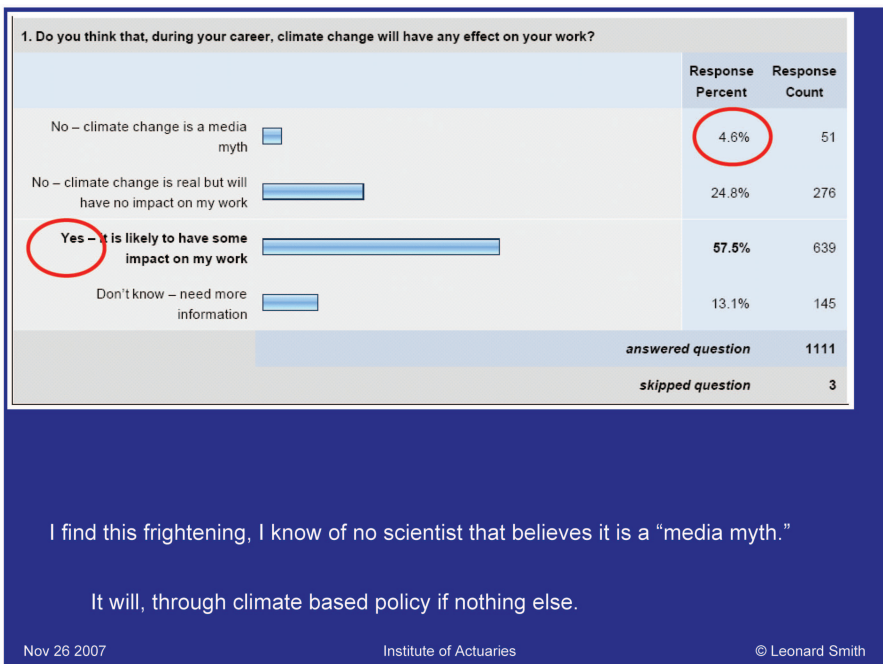


Figure D.1. Climate change questionnaire — question 1

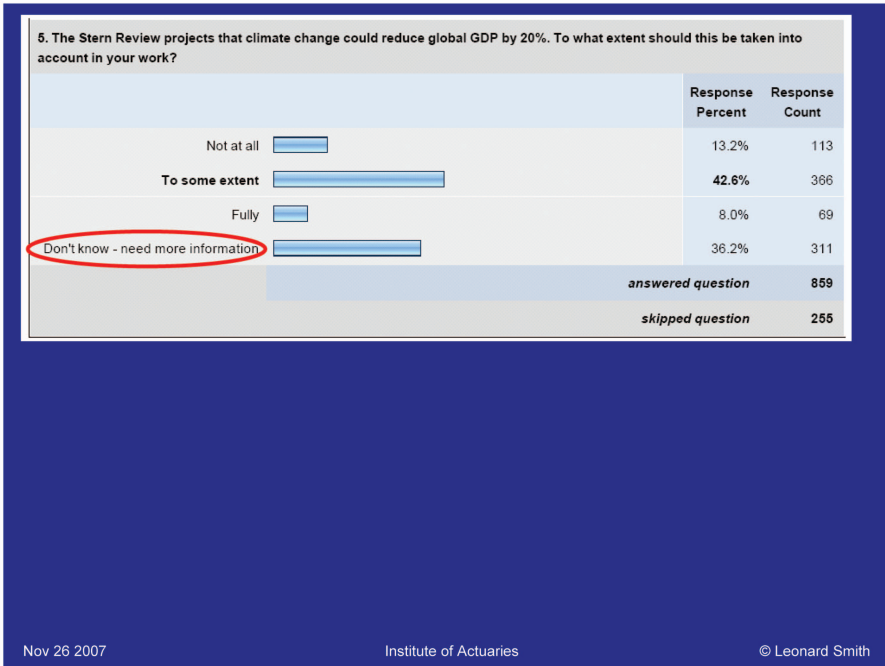


Figure D.2. Climate change questionnaire — question 5

Question 5 (shown in Figure D.2) considered the Stern Review, specifically the extent to which it should be taken into account in an actuary’s work. In many cases, details will depend on what actuaries do and what their time horizons are. There is a real need for getting more information, a need which over one third of you expressed in the survey.

The last point which I consider in the questionnaire is the reply to question 7 (shown in Figure D.3), on whether climate change will lead to increased natural catastrophes, heat waves and more extended extreme weather. It is clear that over 85 % of actuaries have not considered them. I would argue that it is time to start to consider the impacts of climate change, and, certainly, policies which will be adapted, even while the extent of the impacts are still uncertain.

I now give you a very brief introduction to the IPCC Summary for Policymakers (SPM), from this year’s WG1 Fourth Assessment Report. Climate models and historical observations provide overwhelming evidence for global warming. These models are now reaching a level of sophistication which allows informed decision support, although the details of exactly how much information you can get out of our year 2007 models is still in question.

In the transition from asking: “What has happened?” to asking: “What will happen next?”, climate science will benefit a great deal from an increased involvement of decision makers, the people who have an interest in using the output of our models. When you are trying to base decisions and policy on model output and on science, you have a very different view than someone who is trying to do the science itself.

Science never provides proof. If you hear someone arguing that something in climate science

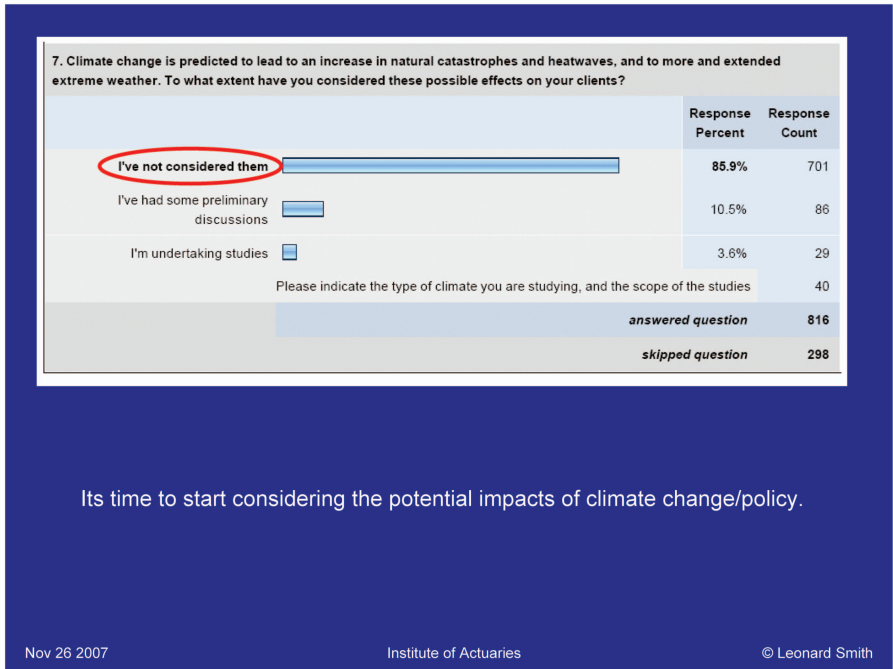


Figure D.3. Climate change questionnaire — question 7

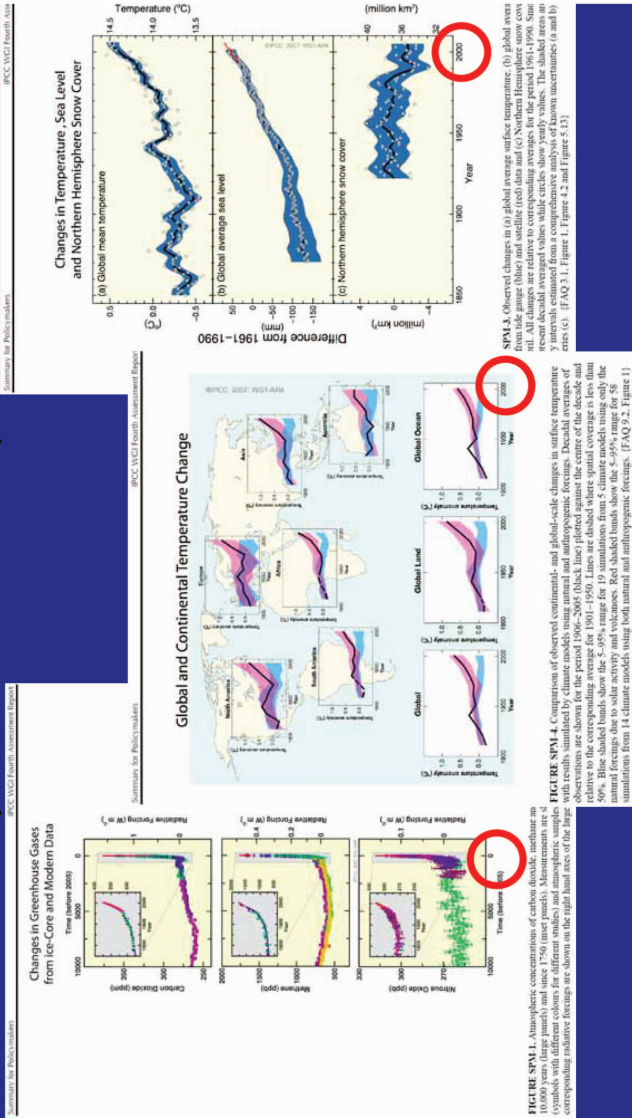
is not proven, remind them that this is true for all science. Figure D.4 shows three figures from the IPCC Summary for Policymakers [SPM, Figures SPM-1, SPM-3 and SPM-4]. What they reflect in each case are historical data, time series which run up to zero, which is 'now', and series which run up to 2000, which is also 'now'. Sometimes they go a little bit past the year 2000.

In each case we can see how things have changed. In Figure D.5 this is from 1815 up to 2000. Here we see increases in temperature along with the sea level and decreases in northern hemisphere snow cover. The blue bands which you can see in Figure D.5 reflect measurement uncertainties, due to sampling uncertainty and other data issues. This type of uncertainty is analogous to our uncertainty in what all actuaries think about climate change, based on the answers of those actuaries who responded to the questionnaire which I have just considered.

It is easy to see that these blue bars are very small compared to the kinds of change over the last century. You might argue that the relative uncertainties are not so small in terms of snow cover, but they are very small in the cases of global average temperature and sea level. The basic global warming result is really not seriously in question.

In Figure D.6 you can see the changes in temperature from 1900 to 2000, the temperature time series over the individual continents. You can see them globally: over the land; and over the ocean. In each of these graphs, the solid line again represents the observations. In this case, however, the uncertainty bands are rather different things; the blue bands and the pink bands represent variations in the output in and across various models. The immediate visual suggestion of the model output is to say that our models could only reproduce the observed warming if we include the anthropogenic forces (that is 'us'). The pink band is for model runs which include these anthropogenic forces; the blue bands represent models which do not, and the blue bands

The first three figures of the IPCC Summary for Policy Makers reflect analysis of historical data. These figures aim to convey to overwhelming evidence for global warming, and relatively small level of our uncertainty.



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Figure D.4. Figures SPM-1, SPM-3 and SPM-4 of the IPCC Summary for Policymakers

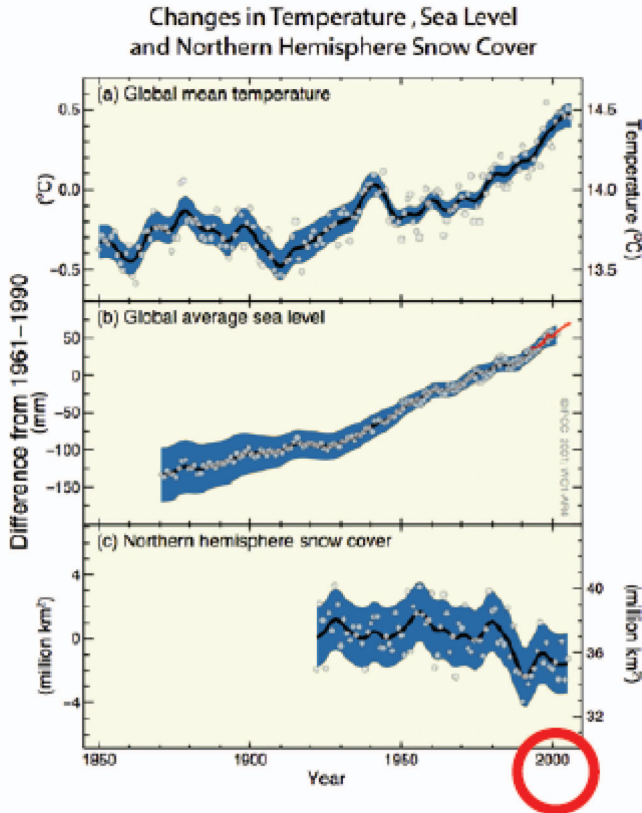


Figure D.5. Figure SPM-3 of the IPCC Summary for Policymakers

with only natural forcings are always too cool. However, that is a very different kind of uncertainty than the measurement uncertainty due to noisy thermometer readings or the sampling uncertainty from taking a survey of actuaries. The blue and pink bands reflect a range of ‘uncertainty’, based on running an ensemble of models. Ensembles are a group of models available to us today. They will play a crucial role in working out what the impacts are going to be in the future, even though we have no clear methodology yet for doing this.

The last three figures from the IPCC Summary for Policymakers have projections going into the future [Figures SPM-5, SPM-6 and SPM-7], and these are shown in Figure D.7. Here we have projections going out into the future to 2100 or 2099. The question of how you interpret this information from extrapolation with models is very different from how you interpret information based on the past, due to the uncertainty of observations.

The basic question for using these kinds of results is how probabilities based on ensembles of climate models should be interpreted. Should you interpret this information like a probability that a driver will have an accident if you know only his/her age and gender? You could get pretty good statistical accuracy based on that, and I would be happy to treat that as a probability; or, should you treat climate model-based ‘probability’ like the probability that some government will

Global and Continental Temperature Change

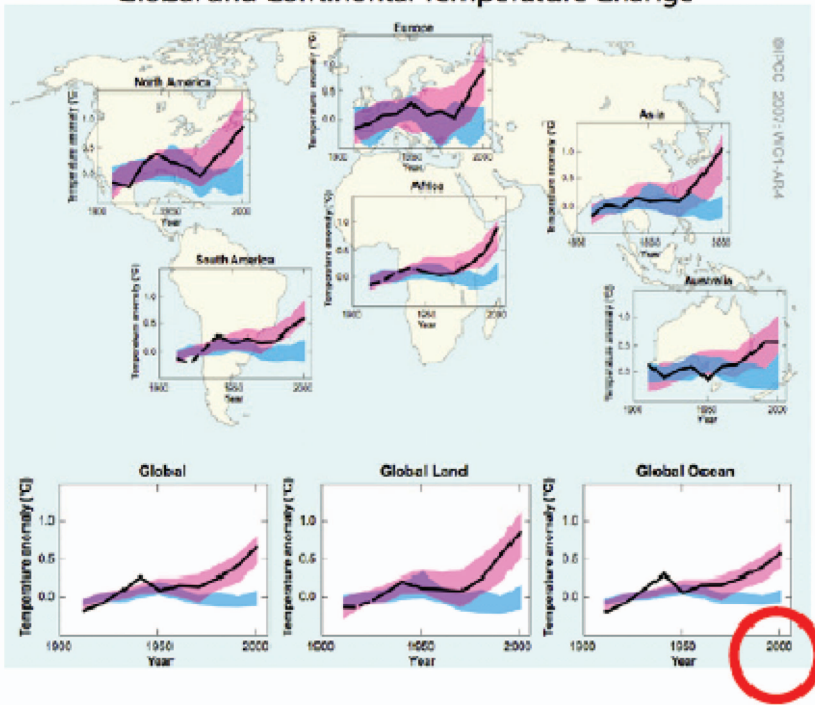


Figure D.6. Figure SPM-4 of the IPCC Summary for Policymakers

decide that nuclear power is green? If you are trying to make decisions about wind farms, that could have a huge impact, but few try to put hard numbers on it.

So, how should you treat climate information? The first case integrates out the uncertainty. In the second case, we have to think more carefully on how to mitigate risk. The information which we have in hand is of a different kind, and it is not clear that fancy mathematics on probability distributions will help. I expect that information on climate change falls in between these two.

I now tell you a story about three statisticians. We have three non-Floridian statisticians. It is important that they are non-Floridian, because it will prove to be important that they cannot swim. They come to a river, and they want to know if they can cross it safely. They each have a forecast for the depth of the river. Each forecast indicates that they will drown. However, they have multiple models for the depth of the river. So, since they have an ensemble, they decide to average their forecasts and base their decision upon the average, as shown in Figure D.8.

The question is: "Is this a good idea?" The answer of course, is: 'No'. The ensembles of model simulations contain a great deal of the information, and we need to be careful not to destroy, or to discard, that information when we are trying to do a decision support analysis.

Figure SPM-6 from the 'IPCC Summary for Policymakers' is given as Figure D.9, and it shows the multi-model ensemble averaged for the world for various scenarios. If you are trying to get a general picture of what is happening, this indicates that, in the last ten years of this

The last three figures report model projections, some as probabilities.

It is less clear how to use this information for decision-support, but the evidence for significant impacts is clear.

Summary for Policymakers IPCC WGI Fourth Assessment Report

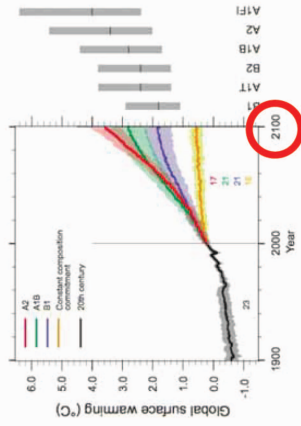
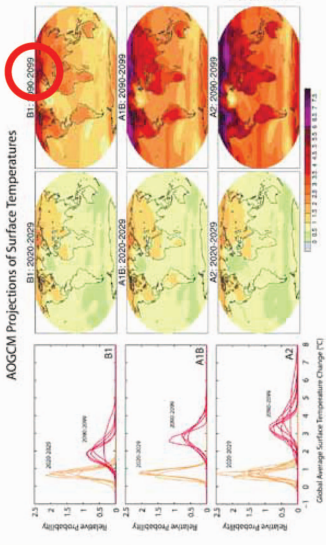


Figure SPM-7: Solid lines are multi-model global averages of surface warming (relative to 1990-99) for the scenarios A2, A1B and B1, shown as continuations of the 20th century simulations. Shading denotes the plus-minus one standard deviation range of individual model annual means. The number of AOGCM runs for a given time experiment where concentrations were held constant at year 2000 values. The gray bars at right indicate the best estimate (solid line within each bar) and the likely range assessed for the six SRES marker scenarios. The figure, as well as results from a hierarchy of independent models and observational constraints (Figs. 10.4 and 10.29)

[To be changed] from current comparisons to year 2000 (current concentration). Colour central bar in gray bars and lettering to match A2, A1B, B1 curves as appropriate. Drop model numbers and more to caption)

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We will return to these also, insit



Summary for Policymakers IPCC WGI Fourth Assessment Report

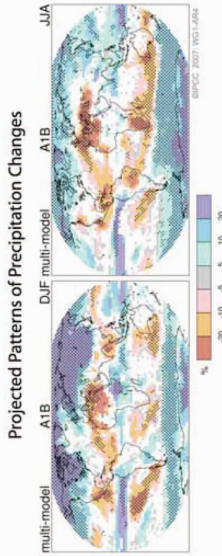


Figure SPM-6: Relative changes in precipitation (in percent) for the period 2000-2099 relative to 1980-1999. Values are multi-modeled averages based on the SRES A1B scenario. White areas (left) and line to August (right). White areas are where less than 66% of the models agree in the sign of the change and stippled areas are where more than 90% of the models agree in the sign of the change.

Figure D.7. Figures SPM-6 and SPM-7 of the IPCC Summary for Policymakers



Figure D.8. The three non-Floridian statisticians and the river

century, the earth will be warmer. That is straightforward to interpret. However, remember, from a decision support view, that all climate is local, and trying to interpret details of the effects and the impacts which these will have in terms of life insurance, or in terms of the impacts on buildings, that information is not in this kind of statistic. Its limitations are quite close to that faced by our three statisticians and their ‘ensemble average’ depth forecast.

On the left side of Figure D.9 are ‘relative probability’ distributions of the global average change. There is a huge range in each study, a large ‘uncertainty’ between studies, of these model probabilities of what the global average temperature change is going to be. It is not really clear how to interpret this kind of multi-model average for decision support coherently, given that sort of baseline uncertainty in global mean temperature. This does not cast doubt on the conclusion that it is going to warm, but the details and the variations critical for policy making are, in fact, suppressed in this averaging process. We understand a lot of the big picture, but many of the details are still very uncertain. A crucial question is: “What physical details matter in the model?” Another is: “Are you willing to mitigate in the face of that uncertainty, or not?” In the past, climate scientists have aimed to communicate what was robust. There has been a big push, first, just to establish clearly whether or not the climate was warming. That is very good science. Decision support, however, would benefit from things which are more useful, such as local information; but how robust is our current knowledge of those useful elements? High resolution information, say five kilometre hourly forecasts, may look valuable, but, if we expect that high resolution details will change beyond recognition as our models improve in a few years, we can hardly suggest that decision makers pay attention to those meaningless fine details, they are but model noise.

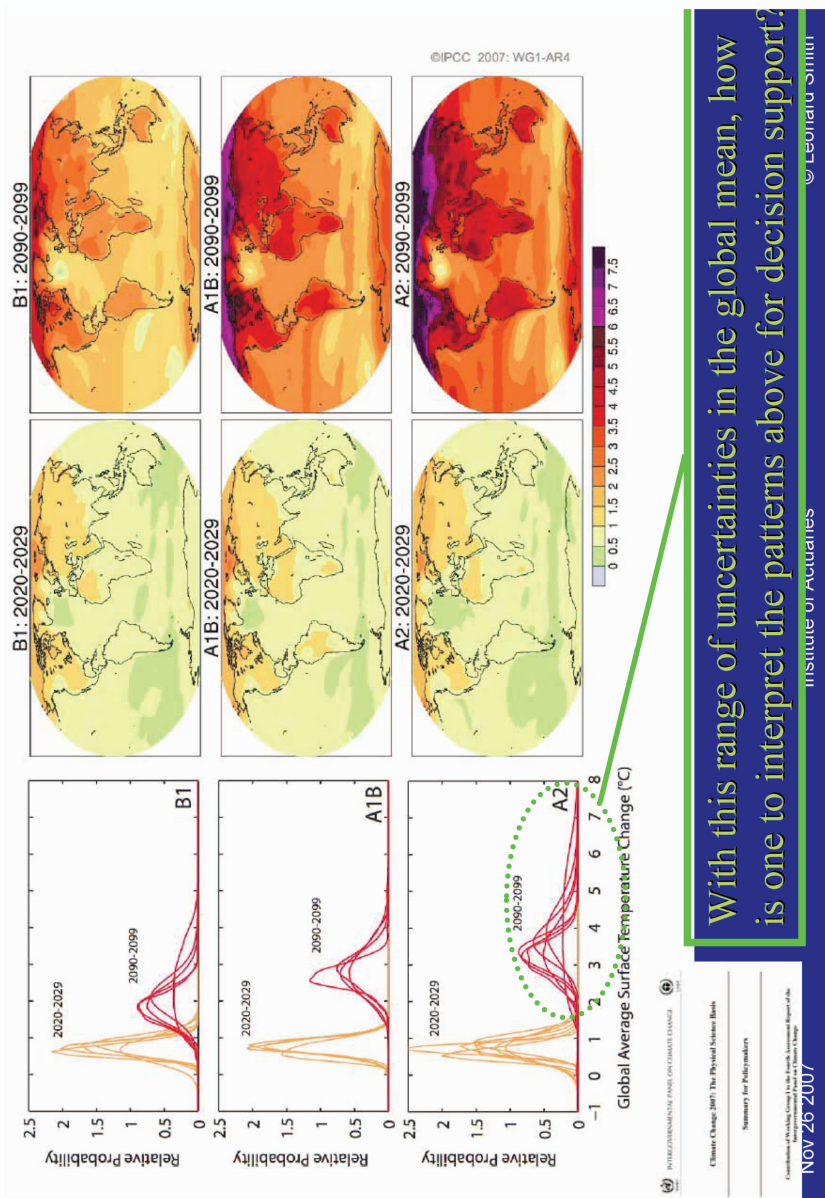


Figure D.9. AOGCM projections of surface temperatures

I would argue that climate science can best aid decision making when its strengths and its weaknesses, relevant to the decisions, are communicated clearly. The ensemble idea is not so foreign, as was given in an article in *The Times* of 17 November 2007, 'Home Owners Brace Themselves for Cold Front on the Property Market'. This is actually an ensemble forecast for the change in house prices across the United Kingdom. You can see in Figure D.10 that there are three different forecasts for how house prices are going to change, broken down spatially around the country. The format of these ensemble forecasts is not so different from that of climate forecasts, although we have many more IPCC models. Obviously, in the case of housing prices, it is useful to see more than just the ensemble mean.

Looking more closely at the housing forecast, we see that in Scotland all the forecasts are positive. In London, none of the forecasts is negative. In Northern Ireland, one of the forecasts is positive. The other regions are all mixed, some positive and some negative.

Clearly, how you interpret this kind of information is going to depend on what you think of the different models — modellers, in this case, are financial institutions — and what decisions you are trying to make. Each of these issues is mirrored in climate modelling, including the fact that the forecasts are not really independent. All our models are running on 2007 computer hardware. They all suffer from some of the same difficulties. They each have left out those things about which nobody knows. Those unknown unknowns, along with the known unknowns, give rise to what is called model inadequacy. Nevertheless, our models can be extremely useful for decision making, if we refrain from over-interpreting the model noise!

So, why are these scientific forecasts more reliable than economic forecasts? Figure D.11 shows Figure SPM2 in the 'IPCC Summary for Policymakers'. I shall not explain this in detail, but let us focus our interest only on the last column, the one labelled LOSU (level of scientific understanding). This table looks at different physical effects, asking how important each is, and how well we understand that effect. Models of climate, like models of weather forecasting and many kinds of physical models, differ from economic models, in that some parameters in the physical models really do mean something. Figure D.11 shows that there are certain things which we know that we know, and we model them extremely well; and that, as far as we know, we understand the important things in terms of modelling the global mean temperature. This lays a firmer foundation for the physical models.

The last column is our current level of scientific understanding. We see that the very high impact phenomena are well understood. This allows decision-relevant relevance to our forecasts. We can look for consistency between our models, (Given the uncertainty in each, do they give the same distribution?) I tend to question the relevance of today's (year 2007) models more than many other climate scientists, but we all agree the basic framework. Almost universal is the remarkable degree of agreement among the basic ideas of what the initial global impacts will look like.

On the question of whether or not we can believe the models, there was an article in the *Sunday Times* of 25 November 2007, about the new climate change exhibit which is coming soon to the Science Museum. In it is this quotation: "Some critics say children are being indoctrinated with a theory that is not proven in all its details." Nothing which I learnt in physics before I went to university had been proven in all of its detail. Newton's laws are not proven in detail. In fact, we know that they fail in detail, but we know that they are useful. We know that we can use them for some things and not for others. The real question to resolve in climate change is: "What information in our current models is likely to be robust and useful: local scales or continental; on daily events; or only on seasonal averages?"

The basic mechanisms responsible for global warming are better understood than the connections between smoking and lung cancer. We can actually use that information once we better understand what the questions being asked in policy and decision support are.

There is one issue about which we have to be aware, and that is unknown unknowns. These will also impact our non-Floridian statisticians in Figure D.8. As it turns out, the river which they wish to cross is shallow. Nevertheless, our models often have very important, common shortcomings. There may be something else — like an alligator in the river — which causes problems. The decision-relevant question is: "Can they cross the river?" Climate, itself, is going

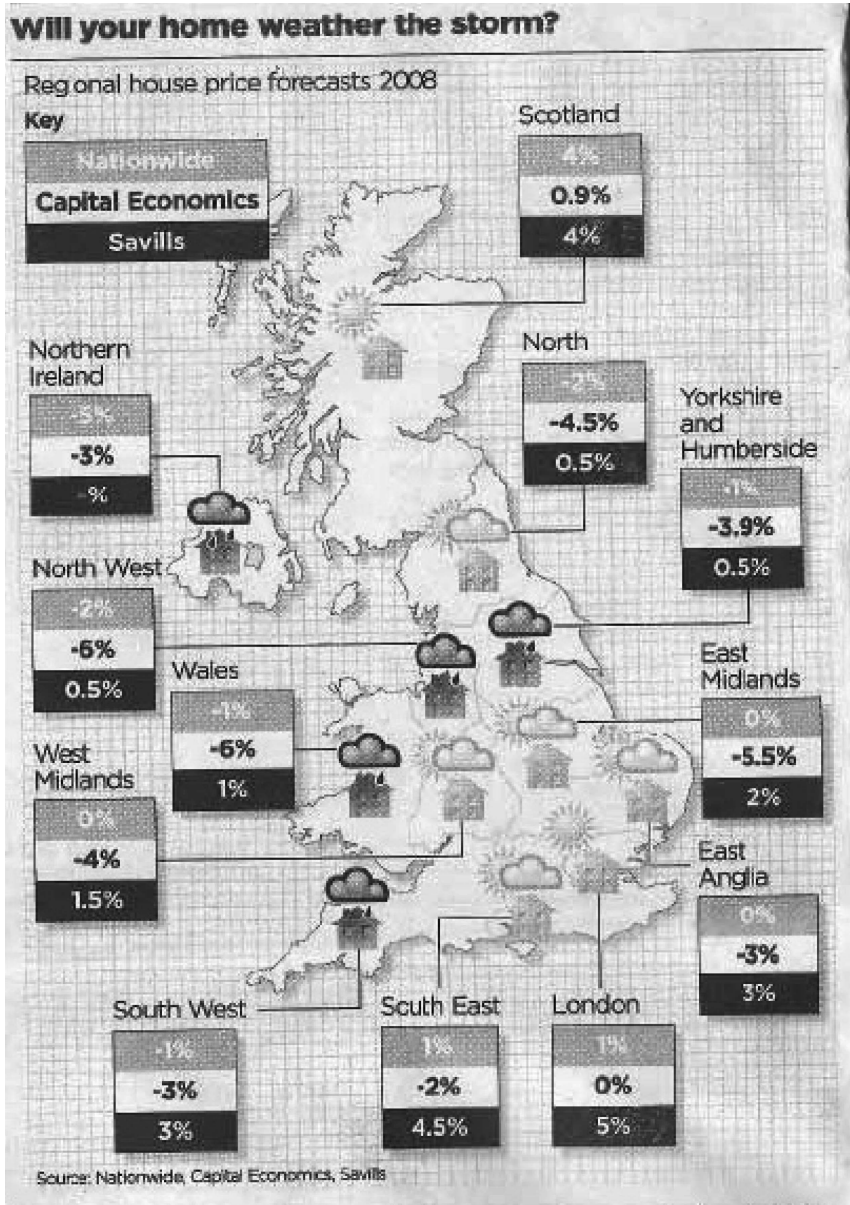


Figure D.10. Forecast changes in house prices across the U.K.

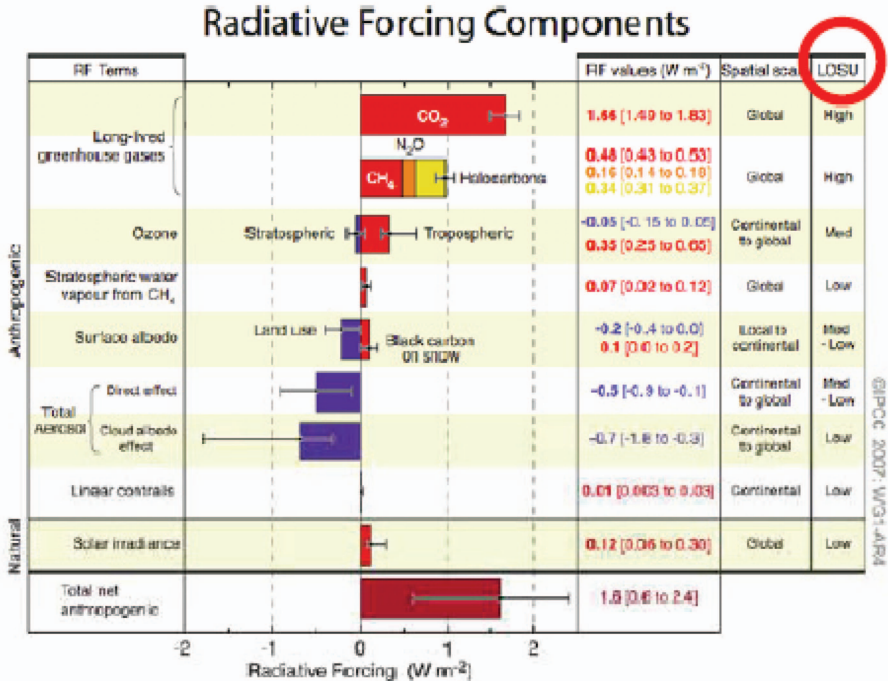


Figure D.11. Figure SPM-2 of the IPCC Summary for Policymakers

to be only one component in that question, and we need to respect the limitations of models to use them effectively.

The question for you will be how you plan to track developments in climate science, to see what model-based information is relevant now, and to see how more things, more details, become relevant as time passes. Ideally, you can help to guide developments in climate science, this is well-recognised. Figure D.12 is the Espoo statement from a United Nations WMO meeting, which was held in Finland in 2006. If you Google 'Living with Climate', you can easily find more details. This statement, which is trying to pull more decision makers, especially numerate decision makers, into the climate science project, is trying to get a better idea of how climate science can develop in a way which is more relevant to actual decision makers. The membership of the Institute of Actuaries provides one of the most obvious, most valuable, groups for contributing to this kind of project, because of the fact that actuaries can discuss things at a mathematically sophisticated level. I hope that many of you will help us to improve the information on climate. Your questionnaire indicates that you want to help already.

REFERENCES

IPCC (2007). Summary for policymakers. In *Climate change 2007: the physical science basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press.

Three Statisticians. www.lse.ac.uk/threeStatisticians

Espoo. http://www.livingwithclimate.fi/en/en_18.html



Figure D.12. Living with climate variability and change — Espoo statement

Mr Silver: The next stage for discussion is what this means for us. I now introduce Mr Fulcher, the Chief Actuary of Ace European Group. He chaired the 2006 GIRO Working Party on CAT models, and is a member of the Institute Climate Change Working Party. He is the ideal person to tell us about the impacts upon the issues about which Professor Smith has talked on the non-life model.

Mr G. Fulcher, F.I.A. (introducing the implications for general insurers): In talking about the effects of climate change on non-life insurance, I take a strategy-based approach, adopting two fairly common strategy models. One is the SWOT (strengths, weaknesses, opportunities and threats) analysis, and the other one is an environmental analysis, called a PESTL analysis.

I start with the SWOT analysis, and, in particular, I consider the threats and the opportunities which climate change poses to non-life insurance companies, particularly in the medium to long term, although I will come back to the short-term view as well. I start with the threats, which are considerable over that time period.

The recent IPCC Report — which Professor Smith has summarised for us — identifies that climate change already has affected and, particularly over the next century, will have much greater effects on the incidence of natural catastrophes, such as: tropical cyclones; winter storms; wild fires; and floods. All of these can be expected to lead directly to increased property claims. In some ways, that is the obvious impact of climate change on non-life insurers and on their liabilities. In addition, the huge economic and social impact of climate change, identified by the Stern Report (Stern, 2007), will lead, inevitably, to accusations, claims and lawsuits over the attribution of the causation of climate change, and, inevitably, insurance companies will get increased liability claims.

Even if a company is initially unaffected either by increased property claims or by liability claims, regulators and rating agencies can, and, in fact, already are, required by non-life insurers to make allowances in their capital assessments for the scientific consensus that extreme climate-related events, in particular, will become more common in future, because of the impact of climate change.

Another adverse impact is to the reputation of our industry. The events in Florida after the 2004 and 2005 hurricanes showed the issues which insurance companies can face, as they tried to increase insurance prices to what they believed were economic levels. The recent press reaction and governmental and political reaction after the 2007 U.K. floods, has highlighted the sensitivity of insurers even hinting that they may need to withdraw cover from certain high risk areas.

As non-life actuaries, we can often take too much comfort from believing that non-life insurance is a one-year business, where: we can review our risk; we can alter our prices; we can rewrite the terms and conditions; and we can even remove coverage in a one-year timescale. That may be *our* view. Our customers and politically motivated regulators, particularly in personal lines, may have a different view altogether.

I see these as four threats: increased property claims; increased liability claims; increased capital requirements; and potential increased reputational risk. That is not to mention the impact on our investments.

As for opportunities, climate change is clearly going to alter the risk landscape significantly. This gives a very large opportunity to non-life insurers. Our core competencies, and, in fact, our product offerings, are the understanding, quantification and management of risk. So, as risk changes, opportunities arise.

There are two particular areas of opportunity, corresponding to the two main ways of responding to climate change. The first is known as mitigation, which means the attempts to slow or to reverse the process of climate change, by lowering the level of greenhouse gases in the atmosphere, although more extreme possibilities have also been discussed. Just to give one example, a key form of mitigation is new, clean energy technology. Non-life insurers have an opportunity to insure that technology.

The second response is adaptation, which is simply, even if climate change is not mitigated, to develop ways to reduce vulnerability to the impact of climate change, particularly human vulnerabilities. Again, insurance can be key here. In fact, one key form of adaptation is simply the offering of commercially priced insurance, which acts as a signal of risk, and offers protection to the unfortunate and to the unlucky.

So, there are both threats and opportunities, and some of these may be more in the medium to long term.

A second angle is to consider the environment in which we operate. For this, I want to use a PESTL model. For those who do not know, a PESTL model is a fairly common strategy tool where you look at the environment in which a company operates under various headings: the political environment; the economic environment; the socio/cultural environment; the technological environment; and the legal environment.

To give some very brief examples, politically, we have the Climate Change Bill on the statute book or close to being on the statute book in the U.K., and recently there was the first election in a major western country where climate change played a key role — in Australia. Economically, we have the prospect of carbon taxes and carbon trading. Also, the socio/cultural aspect is interesting. Companies, including insurance companies, are falling over themselves to prove their green credentials. However, we are going to be held to account for what we claim. Last week I received a copy of a consumer magazine, which ranked motor and household insurers on their policy on climate change, under the strapline of ‘Investigating the insurance industry’s ethics and whether it is partly to blame for the crises it has to pay out on’. That is already out there as an issue.

Under the technological heading, I have already mentioned green energy, and, under the legal heading, we are already seeing changes to the law, both in the U.K. and in the United States of America.

John Browne, moving British Petroleum away from its contrarian anti-climate-change viewpoint to a ‘Beyond Petroleum’ strapline, ten years ago, following the 1997 IPCC report, said: “The time to consider the policy dimensions of climate change is not when the link between greenhouse gases and climate change is conclusively proven, but when the possibility cannot be discounted and is taken seriously by the society of which we are part.” Ten years on, the time has indisputably passed, and non-life insurance companies now need to factor the implications of climate change and the changing environment in which we operate into our strategies.

I now conclude with some general thoughts on the role of actuaries in this process. I take my inspiration from the motto of various actuarial societies. Our own Profession says that we ‘Make Financial Sense of the Future’. The American Academy of Actuaries’ motto is to: ‘Build Such Work As Our Descendants Will Thank Us For’, and the Canadian Institute of Actuaries’ motto says: ‘We Care About The Future’. Under all these straplines, by our advertising of what we do, we are clearly one of the best placed professions to help our employers and our clients to understand the risks and the opportunities of climate change.

However, this is not something which we should do in isolation. The Penrose Report criticised actuaries for trying to second guess other disciplines. In that case it was the legal profession. The Morris Report built on those conclusions, and encouraged actuaries to engage more openly with other disciplines and with other areas of expertise, particularly academia.

Our role in advising our clients and companies on the effect of climate change is not to try to second-guess the scientists, but, instead, actively to engage with them. This is something which has been a key for the Climate Change Working Party, of which many of us on the panel, including Professor Smith, are members.

My involvement with scientists has made me understand that the risks of climate change are much greater than I had believed before joining the Working Party (when I was of a sceptical viewpoint), but has also allowed me to be better informed about the uncertainties and nuances of the scientific debate, and about the potentially profound implications for the non-life insurance industry.

Mr Silver: I have a question. Mr Fulcher mentioned potential liability claims. Does he know of any?

Mr Fulcher: There are certainly liability claims out there, although none has actually come to a settlement. There have been lawsuits launched against some of the car manufacturers by the State of California. There have been one or two other examples as well.

Mr D. M. Hart, F.I.A.: That may have been overtaken by events. The claims to which you refer have been thrown out, not on the basis that they do not exist, but on the basis that they are indeterminate within the particular company which has manufactured the automobile.

Mr T. J. Maynard, F.I.A.: The same was true of cigarettes and pointing the finger at any one

cigarette or manufacturer. That did not stop a huge settlement. So, we should not count our chickens.

Mr Fulcher: And similarly in relation to asbestos.

Mr C. J. W. Czapiewski, F.I.A.: To follow on from there, in April 2006 some plaintiffs in America, representing a class of house owners in Mississippi, filed a complaint against 40 oil and gas energy companies, claiming that they helped to cause Hurricane Katrina by global warming.

Mr Silver: I now introduce Mr Lette, who is a worldwide partner of Mercers. He transferred to the London office in 2007, following 15 years' service in the Australian investment consulting business. He works with the firm's global director of consulting and the directors of consulting from other regional businesses in addressing strategic research issues of cross-regional interest. He will be looking at how pension schemes might be impacted by climate change.

Mr G. Lette (a visitor; introducing the implications for pensions): As has been mentioned, I am from Australia. I voted in the election to which Mr Fulcher referred. We have two Houses of Parliament in Australia. The Upper House, the Senate, is, effectively, the house of review. Voting takes place on a state basis, and the election is decided on proportional representation lines. This approach encourages the participation of smaller parties, which do not really have a chance of winning seats in the Lower House. For the first time which I can recall, there were two special-interest climate change parties, and, of course, there were the Greens, who have been a significant force in Australia for quite a while, plus the two mainstream major parties, both of which recognise the importance of the environmental vote. Certainly climate change was an issue well to the fore. The former Prime Minister, who not only lost his position as PM, but who is in grave danger of losing his seat, remained a climate change sceptic until quite recently, whereas our new Prime Minister has promised to be much more 'modern' on this issue.

Regarding the implications of climate change for pensions, the big picture issue for pensions is that it is an issue which, at least, needs to be put on the agenda. In the vast majority of cases, climate change is not even on the agenda at this time.

I first speak about what I see as the current 'state of play' in the industry. The broad conclusion is that, although there are pockets of activity among pension plans, in the vast majority of cases plans are devoting little, if any, attention to the issue. Until the issue reaches the agenda of more funds, progress will be slower than it could be.

I now consider the reasons for the lack of activity, and then about one area of change which has been quite sudden, and quite positive, in the last three or four years. This is the view of the legitimacy of an issue, such as climate change, from a fiduciary perspective. I then talk briefly about a couple of the more specific financial aspects.

It is clear that there are some pension funds which are seeing climate change as an opportunity. There is money going into clean technology, such as renewable energy. Not much of this investment is from the U.K., but from Europe and the U.S.A. Although there are many vehicles being raised by hopeful managers, as a proportion of the total assets of pension plans the sums being invested are insignificant.

There are other funds which are addressing the issue from a risk management perspective rather than from an investment opportunity perspective. These funds are moving to assure themselves that their investment managers are equipped to analyse climate change issues, and to ensure that, where stocks are vulnerable, then this view or information is reflected in their portfolio. The sort of things which are happening are as follows. When making a new manager appointment, some funds are including, as one of their selection criteria, the ability of the contenders to analyse climate change issues. Also, when they are talking to their existing managers, they will try to ascertain the extent to which the managers are familiar with, and are capable of analysing, these issues. Further, climate change is being seen as part of a much

broader range of environmental, social and governance issues, so, the attention is not really focused on climate change.

None of this changes the fact that funds doing anything, either from an investment opportunity or from a risk management perspective, are a minority. The vast majority of pension plans in this country, or in any other countries with which I am familiar, are doing nothing. The issue is not even on the agenda for the majority of funds. As an illustration of that, you may be aware of a group called the Institutional Investors Group on Climate Change (IIGCC), which was established about five years ago. It has an educational and an awareness objective and focus, and has done some very useful things. At the moment it has 13 U.K. pension fund members. I am not too sure how many pension funds there are in this country, but, clearly, 13 represents a tiny fraction of the total number of plans. So, the first implication for pension plans in respect of climate change issues is that the issue needs to be put on their agendas.

Trustees' agendas are crowded. In relation to the demands on trustees' time, Her Majesty's Treasury's Report on the progress of the implementation of the Myners principles (DWP, 2004) made an interesting point. In particular, it noted that the average trustee was spending 11 hours in board meetings a year. Fewer than four of those hours were being spent on investment issues. If these figures are wrong by a factor of two or three, they still suggest that the amount of time which has been devoted to investment issues is pretty small. Also, trustees have had to cope with a broad range of issues in the investment field over that time, such as deficits, liability-driven investment, derivatives, alternatives, hedge funds, swaps, long/short, and so on. Although climate change is of massive importance, it is only natural that it hardly gets a hearing when the agendas are that crowded, and all the focus, naturally, is on more immediate issues.

The second factor restraining attention being paid to climate change within the pensions industry is that it has been seen as part of a broader set of environmental, social and governance considerations. It has been difficult for trustees to select an individual issue from within the broader classification, and focus on that particular issue.

As Professor Smith has illustrated, this is a complex issue. It is hard to understand the implications with any precision, or to know what the policy responses might be over the next decade or so, which will change the outcomes. There is also confusion regarding the actions which an individual group of trustees can take which are both practical and meaningful.

There has been a sea change in one particular area in the past few years. A majority of trustees regarded climate change as an environmental/ethical issue. Therefore, it was seen as not the sort of thing with which a fiduciary could, or should, get involved. This attitude has changed. Now individual trustees view climate change as being about risk and return (as well as being an environmental issue), and, therefore, definitely a fiduciary issue.

This change in thinking has emerged with the increased prominence, generally, of the issue and of the reports which have been issued by Stern (2007), the IPCC, and many others. However, the change in thinking was confirmed by a report by a global legal firm by the name of Freshfields, which was commissioned by the United Nations in 2005 to look at some of the barriers faced by fiduciaries in addressing environmental, social and governance (ESG) issues. Although not focussed particularly on climate change, Freshfields came to the view that it was/is acceptable practice for fiduciaries to take into consideration a wide range of ESG issues. In fact, it was stated that it is arguably the case that trustees must do so in order to fulfil their fiduciary duties properly.

I now consider the three areas where climate change has implications for pensions — investments, liabilities and the sponsor covenant, although Mr Robins will be speaking more on the investment side later. It is hard to think of any long-term part of an investment portfolio which is not potentially affected by climate change: equities, fixed income, property, and /or various alternatives. These implications will be both at the broad market level and at the individual stock or asset level. The regional impacts of climate change will be very different, so that it is also a country and a regional issue for funds which have global portfolios, and that is virtually all funds.

The Stern Review (Stern, 2007) painted a scenario where the economic impact would be of

the same order of magnitude as the impact of the World Wars and the Great Depression in the 20th century, and that that is going to have an impact on overall investment returns and the relative returns across asset classes.

On the liabilities side, the IPCC report highlighted implications for mortality patterns arising from increases in temperatures, which now seem virtually inevitable. These included reductions in cold-related deaths at higher latitudes and increases in heat-related deaths at low latitudes. There is a Doomsday scenario which involves much higher increases in temperatures as a result of climate change, and correspondingly greater impacts on longevity and on other health issues. Also, as climate change has economy-wide implications, it has the potential to influence the discount rate used in valuing pension liabilities.

Concerning the sponsor covenant, this is an area which may have received less attention, but, potentially, at least from the perspective of an individual trustee group, it may be the area where the impact will be felt most directly and most immediately. It is clear that climate change has the potential to render business models and technologies less competitive, and, in some cases, obsolete. A trustee of a plan where the sponsor's business is vulnerable to climate change should be thinking about this issue. Trustees need to address their sponsor's ability to adapt to the changing investment landscape. They may need to seek extra comfort from their sponsor that they will be able to continue to fund contributions. If there are doubts in this area, then they may need to reduce their investment risk.

Individual trustee groups may be able to avoid specific action in relation to their investment portfolios by, effectively, leaving it to their investment managers, underlying investment companies and their peers to take appropriate actions to address the implications of climate change. However, the onus will be very clearly on the individual group of trustees to take appropriate action where doubts arise as to their sponsor covenant.

REFERENCE

DWP (2004). The Myners principles and occupational pension schemes. Research report no. 213.

Mr Silver: We now have our last speaker, Mr Robins, who is going to talk about investment management. He is the head of HSBC climate change centre of excellence, and was previously a fund manager at Henderson's.

Mr N. Robins (a visitor; introducing the implications for investment): I enjoyed Mr Fulcher's reference to the mottos and missions of the various actuarial societies. One of the first big environmental strategies came out of the Netherlands in the late 1980s, entitled '*Zoorgen voor Morgen*', or, in other words, 'Care for Tomorrow', which we could, perhaps, use as our theme for this meeting.

To understand climate change, it is helpful to understand it as a very-long-term journey, starting back in 1990, when the IPCC first reported, and when negotiations first started for the Climate Change Convention, which was signed in 1992. The scientists and politicians are telling us that, by 2050 (60 years on), we, as a world, will have had to reduce our emissions by a minimum of 50% at a time of hugely rising population and growth. So, we are just over a quarter of the way into a 60-year transformation.

Since 1990, as the IPCC has told us, global emissions have gone up by almost a quarter. We have had much discussion, some negotiation, but very little action. As a result, the global economy is re-carbonising, that is increasing absolute emissions, and also becoming more carbon intensive per unit of output.

As we look ahead, climate change poses a dual challenge for long-term investments, particularly for pension funds. First, there will be a huge reallocation of capital if we are to achieve the reductions in emissions which we need in order to have a secure and safe climate. Secondly, we are moving into a climate system, in terms of temperature and greenhouse gas concentrations in the atmosphere, about which we, as a civilisation, have very little experience

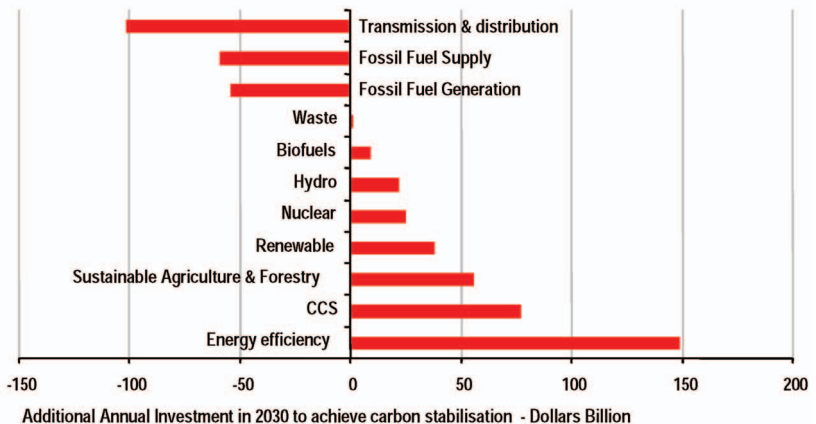
and understanding. Past patterns of climate are no longer a useful guide to the future, which has significant implications for your profession and your work.

Mr Silver said that we will see these impacts far into the future. However, they are already with us. We have seen an 0.7 degree C rise in global average temperature over the past 100 years. Already leading political and scientific figures in China are linking the current surge in food price inflation with climate change, notably the increase in the number of droughts. We are committed, because of past emissions, to another 0.6 degree C. Obviously, if we do not curb emissions, the temperature rise could be much greater, bringing potentially catastrophic consequences.

What is the scale of the investment challenge before us? One of the more interesting studies which came out in August 2007 was an assessment by the U.N. Framework Convention on Climate Change (UNFCCC) Secretariat. This looked at the shifts in investments needed to return emissions in 2030 to today's levels, getting us onto a path of climate stabilisation. According to 'business as usual' projections, the International Energy Agency projects that emissions could rise by almost 60%. What the UNFCCC does is to highlight the changes needed if we are to avoid this path of intensifying emissions. These are shown in Figure D.13.

By 2030, an extra £150 billion will be invested annually in energy efficiency in buildings, industry and transport. Interestingly, within the energy sector as a whole, there will be less capital expenditure and less spending, as the world will be consuming 15% less energy. Therefore, a low carbon future will be a cheaper future.

Over \$200 billion required to return emissions to current levels



Source: UNFCCC, *Investment & Financial Flows, 2007*

Half of additional investments in emerging markets

Figure D.13. Financing the low carbon shift

The second area of investment is, perhaps, more concerning. It is in the area of carbon capture storage (CCS). We have no operational plants, at the moment, which can capture the emissions from power plants and bury them securely underground. In just over two decades, it is projected that we could be investing over £80 billion a year in the technology for these UNFCCC projects. Clearly, much needs to be done to test whether CCS is viable — and, if not, accentuate other low carbon options.

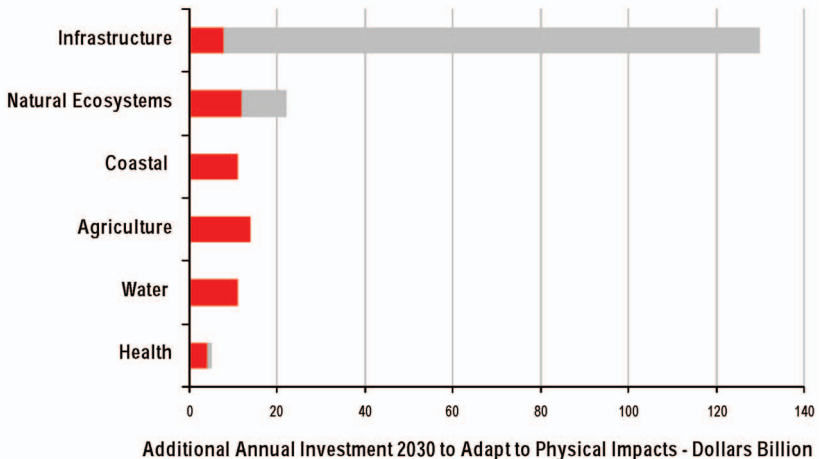
The third area is in agriculture and in forestry, which, together, are responsible for over 30% of global emissions. Here, the UNFCCC estimates that over \$50 billion a year will be invested in initiatives which cut emissions from tropical deforestation, reduce methane from livestock and drive down emissions from fertiliser use.

After this, we move to more familiar territory, renewable energy, nuclear, and then, right down at the bottom, there is something which gets a lot of coverage, but which is not seen to be a huge investment opportunity, and that is biofuels.

The flip side of these increases in investment will be a cut in capital flows to carbon intensive sectors. The UNFCCC study projects about £100 billion a year less in transmission and distribution; if you use less energy, you do not need to transmit and distribute as much. In addition, there will be £100 billion less in fossil fuel extraction and burning. We need to start thinking about to what extent are we going to see stranded assets, assets which make perfect financial sense now, but which become obsolete and unprofitable in a world where carbon costs get included in market prices.

The UNFCCC also examined the investments required to address our second challenge — that of adaptation, and this is shown in Figure D.14. Here we have much less certainty about the

Up to \$190 billion in adaptation investments



Source: UNFCCC, Investment & Financial Flows, 2007

Huge range of uncertainty remains

Figure D.14. Financing climate proofing

investment implications. For example, extra annual investment could range from £8 billion to £130 billion. This uncertainty chimes with the analysis of the climate scientists. For example, the Meteorological Office's report, which went into today's CBI strategy paper, concluded that: "Every detailed study to date has cited the lack of clear economic information needed for the business case for adaptation." Clearly, there is a huge amount of work which needs to be done, particularly for investors to understand what they need to do to adapt to climate change.

Overall, investors will need to grapple with five main shocks, and to integrate these into their strategies and their models. Number one is the macro economic implications, in terms of growth and the changing price of key goods and services, as carbon is internalised and impacts intensify. Another area, where many investors gain or lose their clients' money, is in geographical asset allocation. How is the challenge of climate change going to render different geographies more competitive or less competitive, more at risk or less at risk? Next, there are clearly huge areas of low carbon opportunities. Many people are pointing to energy efficiency, which seems to be the area of the greatest opportunity. However, then there are areas of carbon exposure, huge industries which are key parts of all current portfolios, which are going to be increasingly exposed, as we include a carbon price into our models. How many current investments would be attractive as investments if we put Sir Nicholas Stern's \$85 a tonne of damage for carbon into our valuation models?

The final challenge is for investors themselves. Investors have been leading the way with initiatives, such as the Carbon Disclosure Project, to improve corporate reporting on climate change. Increasingly, there will be more onus on investors to put their own acts in order, to demonstrate investor responsibility, and, perhaps, to disclose to themselves the carbon intensity of their portfolios, and to communicate that with customers.

Mr Silver: I have a question. In talking about the potential implications for the investment industry, realistically, how widespread is it within the investment management community? If the ideas are not widespread, why not?

Mr Robins: The first impact is on investment strategy, particularly in the pensions community, where climate change is now becoming a very important part of the overall strategy for the big funds in the U.S.A., in Europe, and also in Australia. That is stimulating a response from fund managers, such as the Deutsche Bank. The second impact is in terms of specialist funds, where there is a surge of new clean technology and carbon funds coming to market, signalling the size of the opportunity. Increasingly, climate change is becoming a normal investment issue. However, we still have a long way to go to root it into actual models.

Mr P. Dickinson (a visitor; Chief Executive, Carbon Disclosure Project): I was interested in the comments of Professor Smith about providing information for decision makers. They might be slightly mythical characters.

My fear is that there is a simple model which says that scientists tell governments that they must take action; governments prepare proposals; industry groups say that you cannot implement the proposals; and then nothing happens. This problem is exacerbated, because national governments are in dispute with one another about what sort of limitations to make on each country's emissions.

The Stern Review (Stern, 2007) characterised climate change as the greatest market failure, but is it not more realistic to call it the greatest political failure? In the context of political failure, certainly what drew my interest to this great profession was a comment by a previous President, who stated in the press that the Government was not competent to set the retirement age. I thought that there was a profession with a great deal of confidence in reality.

My question for pension fund trustees or actuarial advisers, is: "How can the Actuarial Profession bring its intelligence and its weight to bear to break this log jam?"

Mr B. P. Ridsdale, F.F.A.: I shall be asking whether there are three areas where actuaries can apply their principles in the climate change arena to the benefit of their clients; but first, we must

put things into context. We are dealing with a problem which has no local solution. The solution has to be global. Actuaries need to be involved in solutions, so it would be a good idea to agree on the problem.

Would it not be nice if actuaries could be concerned with the projections, quoted in the Stern review (2007), of the hundreds of millions of people in the world who will be affected by climate change over the coming years. It is a bit difficult to imagine that. Let us be cynical, and look at money. If we are trying to get the 'decision-relevant' question, perhaps we should express the problem in terms of 'the effect of climate change on global economic development'. Stern, using the results from formal economic models, said that, if we do not act, the overall costs and risks of climate change will be equivalent to losing at least 5% of global GDP each year, now and for ever. If a wider range of risks and impacts is taken into account, the estimates of damage could rise to 20% of GDP or more.

When it came to the reconstruction of Europe after the First World War, it was realised, clearly, that you had to have a Europe-wide solution to a Europe-wide problem. So, the Treaty of Versailles was agreed. It was forced on the German people, and there were going to be reparations to be paid for 70 years. Economists, such as Keynes, argued that the price could not be afforded. Historians have argued since then that the cost to the German people was one of the causes of World War II. The Europe-wide solution had ignored the Germans.

If we need a solution to 'the effect of climate change on global economic development', we need a global solution. Unilateral carbon reduction targets are good, and the development of carbon markets sets standards for the future, but they are not going to be enough to achieve the aim of holding the temperature rise below 2%. Caps on reduction targets for the developed world are not going to be enough. There are going to have to be targets for the developing world. Yet, the imposition of world-wide per capita targets could, arguably, place the developed world in a position of trying to force a 'Treaty of Versailles' solution on the developing world.

The current carbon market model envisages permits allocated to countries on the basis of an equitable model, with a notional per capita allocation based on current consumption. What we know is that polluting has a cost, falling, in practice, mainly on the poorest and the most vulnerable. We see this in floods and in desertification, on declining crop yields and on ocean acidification, but, more insidiously, in constraints on future economic development.

Emerging countries will be reluctant to take the necessary steps to cut carbon, for fear that they will be denied a chance of future prosperity. Nations which have grown rich in the past, based on polluting without paying the costs, must now repay their carbon debt to the developing world. That principle was accepted by a number of areas, including the E.U., at a U.N. meeting in Bonn in 2001, and already the promises made then are being broken.

Sir Nicholas Stern's Review (Stern, 2007) suggested that 1% of gross world product must be spent on cutting carbon emissions and on building defences against climate change. Others might say that the cost could be moving on to 2%. However, compared with the 5% of year-on-year reductions in gross world product, that would be a bargain. A greenhouse development rights framework would allow the global costs of cutting emissions and dealing with climate change to be divided up according to the 'polluter pays' principle.

I said that I would ask whether there are three areas where actuaries could apply their principles for the benefit of their clients in the climate change arena.

First, can we use our expertise in investment and risk management to assist the flow of investment into quality, low carbon development paths? Secondly, the under-represented party in climate change negotiations is always going to be the developing nations. They will need support. Can we build on the *Actuaires sans Frontières* concept to help? Thirdly, and personally most difficult, there is a need for opinion formers to find ways of demonstrating, personally, and in our companies and our organisations, a real commitment to reducing our own carbon footprint. Can we do that?

Mr L. J. Martin, C.B.E., F.I.A.: I should like to draw together, briefly, the strands of three sets of predictions which have been made recently, each of which relates to the work of the Actuarial Profession: the subject of climate change, which we are discussing; the future growth of world

population and its geographical distribution; and the extent of the long-term sustainability of the human population by our world, with its finite resources.

As I understand it, the predictions of climate change indicate that the CO₂ already in the atmosphere will inevitably increase global mean temperature, whatever the reasonable extent of future CO₂ emissions, by more than three degrees centigrade by the end of the century. That is not a very long time hence. We know that this will affect sea levels. We know that it will affect the weather, agriculture, wildlife and migrations, not only of wildlife, but also, I suggest, of our own species.

Then, coupled with this, we have the projections of future world population, which has tripled in my own lifetime. I believe that it has doubled since I joined the Profession to the present figure of 6.7 billions. This will increase to 8 billions by 2050, even if dramatic reductions are achieved in fertility rates. These are U.N. figures. These projections also show that, if fertility rates continue as at present, the figure may be as much as 12 billions soon after 2050. These are startling figures.

What will the world population be by the end of the century? The figures which I have quoted are only for 2050. That is in your own children's lifetimes, and the world will be at least three degrees centigrade hotter. This huge population will also have longer expectations of life. People will be striving to be more affluent, and they will be better educated. The growth in numbers will also be predominantly in Asia and in the presently less developed countries.

The third factor is: "What world population can the resources of our finite world actually support in the long run?" A recent paper in the *Journal of the Royal Statistical Society* suggests that this might be as little as only 3 billions, even after allowing for advances in technology. The figure is a balance between population size, affluence and technology. The paper suggests, very strongly, as do others, that the present population already exceeds what the world will actually be able to sustain in the long run.

As actuaries, we should be considering, not only climate change, but the combined effects of these three factors. When one does so, it becomes vividly clear that there are huge and probably dangerous social, economic and political problems which lie ahead in the not too distant future.

Our Profession should take steps to bring together a small group of specialists to consider the overall scene. The problems of climate change alone, when compared with those of the overall scene, may seem relatively straightforward.

Mr I. J. Kenna, A.I.A.: In a recent issue of *Beijing Review*, an official publication of the People's Republic of China (10 May 2007, p18), the National Bureau of Statistics of China points out that the middle class in China will expand from 5% of the working population in 2005 to 45% by 2020. This is not a target, or an aim, it is a statement of fact.

What has happened here while we have improved our prosperity over the past few years? Generally, we are tending to use more aviation, more high-speed trains, more energy generally, and more personal motor transport. Personal motor transport has now become built in. I cannot see the Chinese settling for anything less. In fact, China is now becoming a relatively developed country, though not a high wage country yet. Low pay production is gradually moving to Vietnam and to India, and it will not stop there. The Chinese will move to our standard of living, and gradually our standard of living will move out to these other places. No one knows who is going to suffer a lower standard of living as a result. There are no volunteers for that position.

As for peak oil, as the demand creeps up, as it will, the oil will be found. It will just be a lot dearer, and we shall be forced back on relatively cheap coal, which, again, will bring with it its problems of being rather worse, even than oil, even with clean coal technology. We have already passed the point of no return on this.

The only market solution is indicated by general insurance colleagues (in the response to Question 9 of the questionnaire). We are not yet at the high level of global warming about which everybody else has been speaking, but general insurance actuaries say that we should not insure any more those places which are no longer insurable. That appears to be going a bit far, but solidarity should be out as regards general insurance. Mutuality should be in. In other words, if people insist on living in these places which, on any realistic basis whatsoever, are going to be

flooded, they should go without insurance or pay the appropriate premiums. I can see no alternative, except pious wishes about cutting global warming, which are given the lie every time when a new runway is proposed for Heathrow.

Mr A. Dlugolecki (a visitor; Director, Carbon Disclosure Project and Visiting Research Fellow at the Climatic Research Unit, University of East Anglia); Although I am not an actuary, I was responsible for actuarial best practice in what is now the Aviva Group, through its General Accident arm. I built regression models as far back as the 1970s, showing that motor claims related very much to weather. I have been involved with climate change since 1988, so I know something about insurance and something about climate change.

What I want to raise now is about what actuaries should do about this issue. I have been involved with your Environmental Research Group for something like three years, coming as an outside member, and I have been rather dismayed, up until today, at the attitude of actuaries in other parts of the profession. The actuaries on asset management committees have had a complete disinterest. Those on the general side have even gone further than that to express, on one occasion, complete disbelief that climate change is an issue which exists at all. As was said earlier, 5% of your responding members still think that it is a media hype.

I have two broad points. One relates to the general side and the science side, about which Professor Smith and Mr Fulcher were speaking. Concerning general insurance, there is a fallacy that, because general insurance is a one-year deal, we are all right, we will always be able to pull out of it. I think that Mr Fulcher made the point that you may not be allowed to, as has happened in the U.S.A.

My point is a little different, and is that the probabilities of extreme events about which you should be very worried, in terms of solvency, pricing and profitability, are changing very rapidly. It is hard to see that in the statistics of storms, because there are so few storms that it is hard to create a meaningful population, and the observations in previous centuries are not so good. However, for temperature we have amazingly good statistics in the U.K. We can see how the probabilities are changing very rapidly. Therefore, it is unrealistic to suggest that, if the probabilities of different temperatures are changing very rapidly and, apparently, levels of rainfall as well, why would storms not be doing the same? So, for example, a one in 100 years temperature probability, as a monthly average about 100 years ago, is now once every 12.5 years.

You can do the extrapolations with normal curves, and you can see that that means, for a normal curve, that the one in 1,000 years event is now one in 83 years. These are amazing changes. These mean that things which you would have thought of as being an AA credit rating are now probably only a B rating. That is on the general side.

I now come to the investment side and to the pensions side. Two of us ran a seminar on investment managers and climate change in 2001. We tried and we strove, and we got just one actuary to come to that meeting. There were many investment people there, so you would have thought that actuaries, too, would have been interested to come, but they were not. The point which was made over and over again was the obsession with the short term in the investment world. Many people were wringing their hands and saying: "Can actuaries not do something about this? Can they not introduce the possibility of a best practice, which is not looking three months, six months or nine months ahead, but is looking much further ahead?" To look at it another way, the price/earnings ratio of companies on the Stock Exchange is something like 18. Given the profit rate at which companies are run, that means that a great deal of value is being put on earnings in those companies a long way down the road, and yet most cash flow projections which you see only look one, two or three years ahead. You do not see anything about the bulk of the money, which is going to be made after three years ahead, and which has so much effect on the price. We should do something more determinedly, to bring in something in terms of the mandate which the fund managers are given by the investment companies and the pension fund trustees to run their funds. That is where the weak link is.

People put a great deal of reliance on the professional who is advising them. The flavour which I have got from speakers here is that best practice now means that climate change should

be part of the mandate given to fund managers, and should be part of the way of measuring their performance.

Mr Fulcher: I agree with the point which was made by Mr Dlugolecki about extreme events. It is clear, already, that there does seem to be a trend in extreme events. Perhaps it was not exactly the example which you were giving, but the one which worries most is Atlantic hurricanes. It is not inarguable, and therefore it has not made it as an inarguable fact into the IPCC's research, but there certainly seems to be a weighted opinion regarding the frequency of categories 3, 4 and 5 hurricanes increasing, even though, perhaps, the overall frequency of tropical storms may be decreasing. Unfortunately, from an insurance point of view, it is the most extreme events about which we are worried. Even if the evidence on these is slightly ambiguous, and the frequency is so low that it is hard to see it in the statistics, certainly companies should be allowing for that in their capital assessments. I know that Lloyd's, with which Mr Maynard has been involved in some of its guidance, requires that companies reflect this in their individual capital assessments.

Mr Robins: I think that it is very important to consider the historical context. Useful analogies can be drawn with the post-war Marshall Plan. France's President, Nicolas Sarkozy, announced, at the results of the Grenelle de l'Environnement, that the Marshall plan cost 2% of GDP at that time. So, Sir Nicholas Stern's proposal of allocating 1% of global GDP is a positive bargain for the climate.

Just to pick up on the short-term point, just before the Big Bang, shares were held by investors, on average, about eight to nine years. Now it is fewer than 11 months, suggesting that the average investor is not even concerned with the annual report and accounts. This shortening of the time horizon is clearly at odds with the long-term view needed to tackle climate change. In this area, there is the work of the Marathon Club, which is trying to develop best practice around long termism, including sustainability. That might be something on which the profession could draw.

Professor Smith: First, I consider the issue of the science/government/industry linear procedure. This needs to be replaced by more of a web joining the science and the various industries together. My own experience came through looking at long-range weather forecasts.

There is always a question of whether there is information in those forecasts or not. Once it was demonstrated that there was information in those forecasts, their use slowly spread throughout the sector. In that case you have the science connected directly to the industry, because there is clear proof of value. The real challenge of climate change is that you will not have that same proof of value, even though the impact might be even larger.

What you could try to do is to identify the risks, to neutralise them, where possible, and to keep quantifying them, so that you know to which you are most vulnerable. Also, identify triggers; what things you would expect to happen in order to get an early warning, and then watch for those triggers, so that you know exactly where you are most vulnerable.

I also very much liked the comment that we should not insure any more places which are not insurable. This is not really very well known. I was recently in Florida, talking to members who still live very near my high school. They are on the city council and they sell insurance, but they do not have a good concept for what would happen. They do not understand that these questions are being debated seriously. If it was more well known, that there really is an issue of whether or not insurance or reinsurance is going to be available, that would, again, raise the profile and the discussion, and would improve the level of discussion.

There was also the comment that climate change should become part of the mandate. That is exactly the right way forward. By increasing the level of discussion, by asking better questions, and by trying to pick apart exactly what we know and what we do not know, and how to learn more, that can really advance the applications and the understanding of what vulnerabilities we will face.

Mr P. G. Meins, F.I.A.: One implication of climate change is that pensions are going to be

lower in the future than we thought that they might have been a few years ago. GDP growth is going to be lower. There is going to be an impact on the resources available. That will be quite considerable over a period of time, and it does not seem to have been factored in, particularly when one is looking at a national scheme, designed to provide core income.

On the investments side, I was hoping that someone was going to discuss why, in the Stern Review (Stern, 2007) the discounting was at 0.1% plus the growth in GDP per annum, which I gather is used in other studies, but is obviously very different from the approach which actuaries adopt, and which private sector companies, or any organisations, adopt as regards their own investment projects.

Taking an example, like a project for carbon capture or for flood prevention, the benefits could be wide ranging, but possibly somewhat difficult to quantify. However, those who are actually building these things are going to want quite an adequate return for shareholders, which means that the cost is going to be greater than it would be if a lower discount rate is used. I wonder how that was built into the Stern projections.

Dr N. Patmore (a visitor; Senior Climate Analyst, Risk Management Solutions): I will answer the question on the Stern Review, as an ex-Stern Review analyst. However, note that I am a climate scientist, not an economist. The discount rate used had two components, as was picked up. This is looking at the impact now. A completely different discount rate was used in analysing the mitigation cost part of the Stern Review. When we analysed the impacts to get the 5% to 20% range, the discount rate used tried to take into account the fact that, because what Stern would call ‘non-marginals’, because it was not a small change in the damage, because it was so big, you could not discount it in the way in which you normally would.

So, the time preference was 0.1%. When you take into account things which happen today compared to what happens in the future, and because what could happen in the future is so big, you cannot say just: “Because it is in the future, I will forget about it”, because the future may not be there, effectively.

The other component of the discount rate was a fairly standard discount rate, which takes into account the fact that you are richer in the future. I hope that this has answered the question.

The point which I want to make is on adaptation. At Risk Management Solutions, we have been doing a lot of work looking at climate change, the benefits which could be seen through adaptation, and the increases in risk which one gets through the socio-economic changes as well. What we have seen is that, over time, the socio-economic choices which you make can have a bigger influence on your risk than climate change, itself, can. The study, which is about to be published, shows that it could be double if you follow a business-as-usual socio-economic prediction. The effect of this could be double that from climate change itself. However, when you put adaptation into those models, you find that you reduce your risk to less than it is today. So, adaptation is incredibly valuable.

The questions which I wish to pose to the panel are: “How can insurers take adaptation into account? How can they incentivise adaptation through their products? Is it something which needs to be done at an individual level through incentivising individual policyholders, or is it incentivising the Government to take action?”

Mr R. Street (a visitor; Technical Director, U.K. Climate Impacts Programme): I have a couple of points with respect to the IPCC. One of the significant reports, which is included within the IPCC, is the one on impacts, vulnerability and adaptation.

Some of the most provocative statements which could come out of the IPCC are actually contained in that report. This is that impacts are with us now, and they are with us for the long term. Also, adaptation is occurring now, but there needs to be a much more informed process on adaptation in moving forward. We are seeing impacts of a changing climate in the U.K. We have a growing season which is 30 to 40 days longer than it was at the start of the previous century. We have changes in our precipitation. We no longer have a predominance of those very light drizzles. We are having, essentially, many more extreme rainfall events occurring.

People are adapting to this. If you look at investments, which are occurring in the agricultural industry and in the forestry industry, they are already starting to reflect this. In London, the Mayor, Ken Livingstone, is making decisions on adaptation strategies and is addressing the anxieties with respect to the viability of London as a continuing financial centre within the world under climate change. There are contingency plans for many global financial services to deal with the impacts of extreme events, including those projected under climate change, to move out of the City of London, maybe for only a short period.

People are making decisions in the face of changing climate. We have people from France starting to invest in land for vineyards in England. There are farmers moving from East Anglia into other parts of the country where water will not be a problem. There are water disadvantaged areas now and projected for the future, such as in southern Europe. Those industries which will be affected by increased water stress are another source of potential migration, and companies are starting to address that risk. They are looking to migrate to water advantaged areas. They may be moving into England, into other parts of the U.K., or into northern Europe. That is another form of migration and change in investment patterns which is going to be of concern, and these need to be addressed in the adaptation strategies of communities and regions.

The U.K. Climate Impacts Programme continues to work with a number of organisations in the U.K. We are trying to understand, with them, the impacts which are occurring with companies, local authorities, etc. It is surprising to note that some local authorities are starting to awaken to the fact that they are vulnerable now to the impacts which they are seeing with some of the increased warming. For example, I know that Oxfordshire County Council realised recently that it spent over £4 million on resurfacing its roads as a result of the heat in 2006. The nature of these costs, and realising that it is reliant upon emergency revenue sources for meeting them, raised concerns about the extent of this risk. Climate changes are going to change investment patterns within local authorities.

In the U.K. Climate Impacts Programme, adaptation is one side of the response coin, with the other side being mitigation. Mitigation is essential. If we want to continue to be able to adapt, then we need to ensure that we adapt appropriately.

Adaptation is very much part of our future.

Mr Maynard (closing the discussion): The point in the Stern Review about discounting is that it was deliberate. The members of his team did not just forget to discount, they thought very deeply about it. In fact, they discounted at the growth in GDP plus something. The fact that they added on something which was close to zero is because that extra bit at which you discount is whether you care about future generations. If you believe that they are going to be richer, and that there is going to be new technology, and that they will sort it out, because they always have in the past, which has been true, in fairness, and that is why economists discount with a positive add-on, then you can discount at a higher rate. If you are not willing to assume that, then you set that extra component to zero. That is what Sir Nicholas Stern did, so far as I am aware. So, it is actually a well thought through and eminently sensible thing to have done.

With regard to risk management solutions, I would characterise them as scientists speaking the language of finance, and I should like to see us actuaries, financiers, speaking the language of science a bit as well, rather than letting them do it for us all the time.

I now ask for a show of hands. How many actuaries are in the room?

A large proportion, which is great. It is good to see that there are many non-actuaries present as well.

Please put your hand up if you work in the field of pensions. That is very good.

Life assurance? A few.

General insurance? Very good.

Investment and pensions? That is great.

That is excellent news. It is good to see how well represented the other disciplines are, and it is fantastic to see life and pensions actuaries here. Earlier, Mr Martin spoke about thinking about combined effects. I completely agree with that. We should not be thinking just about climate

change; we should be thinking about population growth; we should be thinking about peak oil, etc. It is wrong to focus just on one thing.

Unfortunately, the possible three degrees centigrade rise as a maximum by the end of the century is too low. It could be as much as nine degrees centigrade if the worst happens, and that is the end of humanity, unfortunately.

Many of you in this room are already convinced of the urgency of the problem of climate change. For those of you who were not when you arrived, I hope that our speakers have helped to convince you.

Professor Smith showed us that, whilst climate models agree on the urgency of the problem, they do not agree on the fine details. He made it clear to us that he believes that the models conclude, accurately, that climate change is one of the most urgent problems facing humanity; that mankind is partly to blame, and that climate scientists 'agree completely on the basic framework' of their science. However, he stressed that we must not be overconfident in the model's granularity.

As actuaries, we are used to this phenomenon. For example, a capital assessment model can be perfectly appropriate for an overall capital calculation; yet, when you drill down into the detail, inconsistencies and inaccuracies emerge. I am sure that we have all been in front of a board of directors, trying to explain why that is all right.

Actuaries also understand that models built for one purpose are not necessarily appropriate for another. Global climate models were not built to illustrate the kind of extreme values which can arise from either the climate or the weather. They were calibrated to the mean of their distribution; and this is likely to lead to an understatement of the risks of extreme outcomes. Insurers and long-term investors, like pension funds, are very interested in such events; so we need to take care when interpreting climate model output. They do not pick up extreme outcomes as much as they should.

Worse still, some of the procedures used (for example, averaging across simulations), as in Professor Smith's example of an 'on average shallow river bed' which leads to the occasional drowning, is not a valid statistical approach. I agree with him that we must not throw away information from simulations. Actuaries have learned this lesson, for example by under-reserving guaranteed annuity options, because they were also, on average, out-of-the-money. We can help to make this point to politicians and to other stakeholders, struggling to make sense of the future. We have experience of explaining this. So, I should like to thank Professor Smith for a thought-provoking presentation.

Mr Lette told us that, in his view, the large majority of pension fund trustees are doing nothing about climate change. He said that the issue was felt by many to be too complex, and that they are too busy. There has been a raft of pension-related issues over the past 15 years, leading to ever-more regulation and work for them. However, they must not forget about the really big issues; they must not let the trees obscure the wood. Climate change is the future, and, as long-term investors, they must surely consider both: how they should adapt to the risk; and, as responsible shareholders, how they should act to mitigate its effects.

As actuaries, we have a clear role, to present the key facts of climate change to them, and to urge them to take action. Some might argue that this is not within our narrowly defined remit to advise on funding rates, etc. Yet, surely, an issue of this potential magnitude should affect our advice. If we do not take it into account, might we be negligent here?

Mr Lette raised the issue of sponsor health, too. If, as we expect, climate change will damage the economy generally, then ongoing contributions may be at risk. Some industries will, no doubt, be affected sooner and to a greater extent than others. Should actuaries be pointing this out?

Mr Fulcher started with a SWOT analysis. He noted that climate change is already affecting our financial results. He raised the possibility of legal liability as well as direct property damage. To this I would add that rising sea levels, worsening crop yields and general economic effects may lead to migration and political tension. This will surely affect insurance coverage for terrorism and political risk; and some of these contracts are written over multiple years, locking them into out-of-date assumptions.

Mr Lette mentioned that our companies' reputations may be damaged. We may want to start the process of communication now, so that our policyholders are clear where our promises begin and end. He pointed out that many actuarial societies have mottos with the word 'future' in them. I would argue that any valid model of the future must contain the ever more damaging impacts of climate change. Actuaries must seek to understand this risk; it is in their job description!

Mr Lette also stressed that we should not work in isolation. I am delighted to say that many scientists have contributed to the Climate Change Working Party. It just shows that they are keen to speak to us; in turn we should listen to them.

Mr Robins told us that we were part way through a 60-year transformation. As such, we should expect massive investment flows (for example, into renewable energies), some positive, some negative, arising because of the mitigation effort. Likewise, we can expect large flows as society attempts to adapt to the change. I think that he was saying \$190 billion of cost. That seems a little low; this is only \$30 per head of population. Perhaps we can get some clarity on that. Not all the population will be materially affected, but just \$30 per person seems quite cheap to adapt to climate change. He stressed that there will be impacts on investment sectors and geographical effects. People are starting to think about how stock selection will be affected. This too should be drawn to the attention of trustees and boards of directors of insurance companies.

Mr Dickinson asked the question: "Where are the decision makers?" That is a very good question. I would add to that: "Where are the owners?" It seems that there is a big hot potato which is climate change, which is being thrown around. Actuaries say: "I cannot tell anyone anything. I just advise trustees." Trustees say: "I am a lay person. It is my investment manager." Investment managers say: "It is not in the mandate, so I cannot talk about it." So, where are the decision makers and where are the owners? We need to get to grips with that point.

I should like to make some closing remarks from the Environmental Research Group. It was very interesting to me that many of the responses to our questionnaire were along the lines of "the Profession should ...". It strikes me that this is an odd comment. Surely we, the members, are the Profession. Apart from certain limited issues, for which the Profession is well suited, most of the innovation, research, communication and change will come from individuals working together. So, I hope to see many working parties springing up over the next few years: the pensions and climate change working party; the mortality and climate change working party; the impact on asset values due to climate change working party.

The Profession has a direct role, too, and I call on the Profession in the following areas:

- It should become a carbon neutral organisation; all conferences should include the cost of offsetting their footprints. We were delighted to hear that GIRO, the general insurance conference, has decided to do this this year and in future, and I hope that others will follow suit.
- It should consider whether to encourage the Board for Actuarial Standards to produce guidance to actuaries on the appropriate response to climate change. The future includes climate change, and, apparently, we will make financial sense of it. This, I fear, leaves us open to legal challenge, and guidance will help members defend their actions. What really is foreseeable at present, and what is not? Society has a wonderful hindsight, which has been used against our Profession before; let us draw lines in the sand now to avoid this in future.
- It should take a public position on climate change, not least because we claim to be financial risk managers, and our silence, as a Profession, is odd.

The President (Mr N. J. Dumbreck, F.I.A.): Thank you very much indeed, Mr Maynard. We have had an excellent discussion and plenty of suggestions for further work in this area. This may have been the first Institute sessional meeting on climate change, but I do not think it will be the last.

I should like to thank Mr Silver for organising the discussion, our four panellists, Mr Maynard for closing the discussion, and all those who have contributed to it.