

Chapter 8: Robert Mendelsohn, Yale University

I recognize that as an official document of the British government, the Report and the process of writing the Report was under political constraints. Writing the Report was made only the more difficult by the fact that the Report was due in such a short time. This Yale critical review of the Report is in fact the first public peer review of the Report and as such is quite important. Unfortunately, it is too late to amend the Report. I understand that there is not to be a Stern Review II. However, this critical review is nonetheless useful to place the Report in context with respect to both the existing literature and existing policy.

My personal belief is that the Stern Review makes a serious effort in the right direction, but it is not a finished analysis. I was hoping that there would be a Stern Review II that would complete many of the analyses which are partially completed in this Report.

When I listened to Sir Nicholas this morning and when I read the Report, my initial impression is that there has been a tremendous analysis that has led conclusively to an unquestionable finding that society must initiate a crash program to control greenhouse gases. Not only do we need controls, but we need severe controls on greenhouse gas emissions that involve immense near term expenditures on carbon mitigation. It was a very awe inspiring presentation complete with thunder and lightening.

Unfortunately, my job today is to take the role of Toto in the Wizard of Oz. Just how powerful is this wizard and what is his command of the truth? Is the Stern Review a complete revision of the economics of climate change or is it merely smoke and mirrors? Is the Review substantive and authoritative or is it mostly hand waving? As my role indicates, I think the Report largely is the latter.

If the Report were substantive, it would show that the preferred policy (stabilizing greenhouse gas concentrations at 550ppm) minimizes the sum of mitigation costs and climate damages. That is, of all the possible strategies to control greenhouse gases, this strategy is the least cost alternative for society. The report would show that its preferred policy balances marginal abatement cost against the present value of marginal damages.

All alternative policies would be shown to be inferior. The Stern Review never makes this analysis.

The Stern Review begins with the conclusion that stabilizing greenhouse gas concentrations at 550 ppm is best and then merely compares the mitigation cost of this policy against doing nothing at all for 200 years. This comparison is not an economic analysis nor is it a reasonable policy analysis. Comparing the cost of a single policy against doing nothing at all does not prove that the policy is the best alternative.

Imagine if we were talking about education policy and I argued “I have a great policy for educating children and look it is better than closing all schools.” Presumably, you would not be convinced this is necessarily the best educational policy. You would want my policy compared against other possible ways to educate children. Similarly, I could argue “I have a great health policy and look it is better than having no doctors, nurses, or medicine”. Again, you should not be impressed. You should demand that my preferred policy be compared against other plausible health policies that could be implemented.

To prove a policy is optimal, it must be compared against other possible policies. The Stern Review does not do this. It does not examine the efficacy of stabilizing concentrations at 550 ppm versus 650ppm or 750ppm. The Stern Review is not an economic analysis. It may present mitigation costs and impacts measured in dollars, but it is not an economic analysis. The Stern Review does not present an economic analysis showing that that stabilizing concentrations at 550 ppm is best. The Stern Review merely asserts that this is the best policy.

One of the difficulties of writing a Report of this magnitude in such a short time is that it is difficult to keep the entire effort integrated. The Report reads as if there was a team of experts that studied the mitigation costs of stabilizing concentrations at 550 ppm and another team of experts that just studied the impacts of doing no abatement at all. The two teams were never integrated. They did not make the same assumptions about the discount rate, GDP growth, population growth, and energy growth. The Report did not use a single integrated model to look at both abatement costs and benefits.

One of the beauties of having an integrated model is that it forces you to make consistent assumptions. It is very difficult to manage a project of this magnitude without

having a central model that combines the results of all the relevant experts. Further, with an integrated economic model of climate change, it would have been easy for them to have conducted the economic analysis that was supposed to be the heart of this effort.

The Stern Review places little weight on the conclusions reached by earlier studies of climate change. The economic literature tends to favor slowing not stopping climate change in the near term (Nordhaus 1991; Nordhaus 1994; Manne et al. 1995; Plambeck et al. 1997; Nordhaus and Boyer 2000). These preferred policies stabilize concentrations at much higher levels than 550 ppm. Stabilization targets of 650ppm, 750ppm, or higher are consistent with most of the economics literature. The reason the higher targets are preferred is two fold. First, carbon mitigation is expensive. In order to reach a 550 ppm target, society will have to begin aggressive near term mitigation that will cost hundreds of billions of dollars in the next few decades. With a 650 or 750 ppm target, near term mitigation can be modest, postponing substantial mitigation costs until the second half of the century. This dramatically reduces the present value of the cost of mitigation. The second reason that economic studies argue that stabilization targets should be lower is that the impacts of climate change are not very large until much higher concentrations are reached. So the cost of mitigation to hold concentrations at 550 ppm rather than 650 ppm are much larger than the additional climate damages associated with going from 550 ppm to 650 ppm. The economic analyses suggest that a 650ppm alternative or higher is a better choice for society than the 550ppm alternative.

The Stern Review does not directly refute the results from the economic literature because the Review does not show any analysis. However, the Stern Review does suggest that there may be assumptions in the earlier analyses that have led them to underestimate the impacts of climate change and overestimate the costs of mitigation. The Stern Review argues that the literature has made numerous errors by failing to make the correct assumptions for climate change. The Report argues that if the literature only made the assumptions in the Report, the literature would reach the same conclusions. Looked at from a different perspective, the Stern Report provides a list of the assumptions that are necessary to argue that aggressive near term mitigation is efficient. If these assumptions cannot be justified, then the conclusions of the Report are invalid as well.

Probably the most controversial and important assumption made by the Stern Review is that the discount rate should be 1.4%. This, of course, is the focus of several other commentaries on the Stern Review so that I will cover this assumption only briefly (Nordhaus 2007, Dasgupta 2007). By choosing such a low discount rate, far future impacts matter today. The Stern Review can therefore look far into the future (for example by 2200) and argue that future impacts bear some consequence to what we ought to be doing about climate change this decade. At a 1.4% discount rate, \$1650 of damage in 2200 has a present value of \$100. However, at a 4% discount rate, \$1650 of damage in 2200 has a present value of only \$0.55.

The Stern Review argues that choosing this very low discount rate is morally correct because it effectively does not discount the future. They argue it is the only fair approach to future generations. However, by choosing a very low discount rate, each generation must save a vast fraction of their income for capital for future generations. The Stern Review argues we owe this to future generations. However, a low discount rate makes every generation indebted to future generations. In pursuit of equity, every generation is made worse off. Clearly this is not a morally superior outcome.

Further, if the impact analysis assumes that the discount rate is 1.4%, then the mitigation cost analysis must also make that same assumption. However, investment dollars devoted to the market economy still earn the market rate of interest. Consequently, every \$1 of investment taken from the economy and spent on climate change has an opportunity cost equal to the market rate of interest discounted at 1.4%. That is, the opportunity cost of a dollar invested in climate mitigation is $.04/.014$ or 2.9. The mitigation costs cited by Stern need to be increased by a factor of 2.9 in order to take into account the low discount rate assumed in the damage analysis.

Another important assumption made by the Stern Review is that the damages from climate change would have an expected value of 5% of GDP. The current literature suggests that the damages from a climate warming of about 5°C are close to 3% of current world GDP or about \$600 billion/year (Mendelsohn and Williams 2004; 2007; Tol 2002a; 2002b). However, the Stern Review makes the mistake of assuming that market damages would be close to 5% of the world's future GDP or about \$60 trillion/year. Although one can make any assumption one pleases, there is no empirical evidence that

supports the Stern assumption. The impacts that are anticipated in all the climate sensitive market sectors add up to 1/100th of this amount. The Stern Review overestimates market damages by two orders of magnitude.

The Stern Review also assumes that nonmarket damages will be equal to 5% of future GDP. It is quite clear that there will be nonmarket damages associated with climate change. Tundra will shrink and therefore polar bear habitat will shrink as well. Infectious diseases will spread from their current domain and so there will be additional pressure to extend appropriate public health responses. Some secondary air pollutants will form at a faster rate forcing additional abatement. Ecosystems will shift poleward forcing conservationists and homeowners to change how they manage land across the planet. However, there is no evidence that these changes amount to more than the \$600 billion/year damages associated with market impacts. There is no empirical support for the assumption in the Stern Review that nonmarket damages will be \$60 trillion/year. Again, it is likely that the Stern Review has overestimated damages by two orders of magnitude.

A third assumption the Stern Review makes in the impact analysis is that extreme events, such as hurricanes and tornadoes, caused by climate change will cause \$60 trillion dollars of damage per year by 2200. The current level of damages caused by storms is about \$140 billion/year. In order for the damages from storms to reach \$60 trillion/year, the damages of storms due to climate change alone would have to increase by over 400 times. Scientists have just been able to show that climate change has a detectable effect on storms in North America (International Panel Climate Change 2007). This is a long way from indicating that damages will increase by 400 times. Again, it is likely that the Stern Review has overestimated damages by two orders of magnitude.

The Stern Review also wants to inflate damages because they are largely born by poor people from the low latitudes. It has long been suspected that low latitude countries are more vulnerable to climate change than mid to high latitude countries (Pearce 1996). However, more recent research indicates that low latitude countries may well bear the brunt of climate change absorbing most of the damages (Mendelsohn et al. 2006). The Stern Review is correct in raising this inequity to the public's attention. However, if the problem is equity, the solution is not to spend more money on abatement. If one is

concerned about the impacts on poor people, the appropriate policy is to engage in direct compensation. Poor countries should be given assistance to help with adaptation and to help with development. Adaptation funds can reduce the damages that each country must endure. Development funds can help countries move away from climate sensitive economic sectors such as agriculture and into economic sectors that will not be affected by climate change. Using funds that could be used for compensation to fund mitigation instead not only earns a low return but it makes poor victims worse off.

In addition to making very strong assumptions to overestimate damages, the Stern Review also makes a number of assumptions that likely underestimate abatement costs. The Review assumes that the mitigation program will be global and efficient. This is a likely outcome if the program starts slowly and learns from its mistakes. However, crash programs that start abruptly with mandates to move forward at all costs are rarely efficient. The idea that an expensive program of mitigation could be organized by 2050 across the entire world is ambitious indeed.

The Stern Review argues that their 550ppm stabilization policy requires that carbon emissions be reduced by 60% by 2050. If such a program were instituted with today's technology, the average abatement cost would be \$400/ton of carbon (Anderson 2006). Multiplying this average cost by the 40 billion tons removed yields a total cost of abatement of \$1.6 trillion/year. However, the Stern Review argues that technical change will reduce abatement costs by 3% a year. Consequently, they argue that the program would only cost \$357 billion a year by 2050. The cost would be less than \$100 per ton. Sir Nicholas argues that such high rates of technical change make sense because carbon mitigation is a new field. It is easy to point to many successful technologies that have achieved rapid rates of cost reductions. However, it should also be remembered that there are many technologies that proved to be very expensive in the long run and have since disappeared. The Stern Review is probably correct that future mitigation technologies will be cheaper than what is available today. It is yet another argument why it makes sense not to spend too many abatement dollars too soon. However, it is debatable that technical change will proceed as rapidly as the Review predicts.

The Review argues that it can reduce the emissions from land use by halting deforestation. It estimates that the cost of reducing deforestation is quite low because it is

cheap to protect remaining standing forests. There are two problems with this argument. First, most of the world's forests that are economical to harvest have already been cut, so that there are not large gains to be earned from "better" conservation programs. Second, it is hard to prevent local people from cutting forests that are profitable to harvest. Stopping local harvesting requires a local police force that is not in the interest of local and often national interests. The cost to the international community to stop this harvesting may be higher than the Review anticipates.

However, the critical carbon emissions to stop concern the energy sector. The Review places great hope that a method will be found that can take the carbon out of smokestacks so that the remaining fossil fuels can still be burned. Currently, such technology is known but it is not clear how expensive it will be. More importantly, it is not clear where to put the stripped carbon dioxide or how it is removed from the smokestack. One plan is to place it in the deep oceans. However, scientists are concerned such plans may cause biological damage in the deep oceans and the carbon dioxide may eventually circulate back to the surface. It has also been suggested that the carbon dioxide can be pumped into natural gas wells. Carbon dioxide infusion is currently used as a method of pressuring natural gas out of these wells. However, it is not clear how quickly the carbon dioxide will escape these storage areas or how much storage volume is conveniently located near emission sites. If a solution to this storage problem is not found, the whole idea of stripping carbon must be abandoned.

The Review fails to take into account the effect that a strong abatement policy will have on the value of fossil fuels. The Review assumes that the value of fossil fuels will remain unaffected by their carbon policies. However, the stabilization plan advocated by the Review is very likely to depress the value of fossil fuels, especially coal. In fact, if the abatement program cannot find an effective way to strip carbon from smokestacks, it is very likely that coal simply cannot be used at all. It will have to be left in the ground. This lost value is not currently measured in the Review.

The remaining alternative to reducing carbon is to find renewable energy sources. Although there are many renewable energy sources, the scale of renewable energy required is daunting. For example, one plan mentioned in the Review suggests a combination of two million windmills, a doubling of nuclear power plants, 10 million

hectares of solar cells, and 500 million hectares of biofuel. The plan assumes that the scale of these activities will only lower the cost. However, it will be difficult to site this many facilities which may increase the costs substantially. Further, the price of arable land will certainly increase if such a vast fraction of land is suddenly devoted to energy crops. In fact, taking away 500 million hectares of cropland for renewable energy is very likely to have a much larger impact on agriculture than climate change.

Finally, the Stern Review ignores the environmental damages associated with its renewable energy program. It is very likely that citizens will find doubling nuclear power plants to be a very dangerous idea. It is not apparent whether the risks of nuclear energy are smaller or larger than global warming. Citizens are also likely to balk at any increases in dams for hydropower. Most attempts by developing countries to harness their own hydropower have met with stiff resistance from the international environmental community (e.g. Three Gorges Dam). Perhaps the most dangerous plan of all is to store carbon in temporary quarters. If this carbon is later released it will result in the catastrophic climate outcomes that the mitigation effort was intended to prevent.

Examining this long list of assumptions, it is clear why past economic studies have not reached the same conclusion as the Stern Review. In fact, one can look at the Stern Review as a fairly complete argument why aggressive near term abatement does not make sense. The assumptions required to argue for aggressive near term abatement are long and unlikely. The prudent path is to begin with a modest abatement program that turns global as quickly as possible. The program should at first focus on being efficient and global in coverage. As time progresses, the targets of the program should be gradually tightened so that there is significant abatement planned for the second half of this century. This will give countries plenty of time to negotiate a world treaty. This will give companies and citizens plenty of time to prepare for future abatement. This will delay abatement expenditures into the next half century when costs should be much lower. Yet, this plan would protect the planet from dangerous levels of carbon dioxide accumulating in the atmosphere.

In the end, however, we must thank Sir Nicholas for his contribution and move forward. It is up to all of us to take the next steps. We must all share this burden of analyzing climate change and determining optimal policies.

What research needs to go on? I believe that we've spent a tremendous amount on natural science linking greenhouse gases and climate change. We have spent very little money, however, on either the costs of mitigation or the link between climate changes and damages. We need to better understand both of these issues if we are to make sensible policy in the future.

Of course, we have spent considerable resources understanding impacts in the United States. However, when you start looking around the world, we know much less. We need to study what is going to happen around the world. In fact, the places that are probably the most important to understand are the low latitudes where the damages are expected to be the greatest and the high latitudes where the climate changes are likely to be the greatest. Without grasping what is going to happen in these two critical regions of the world, we will get a distorted view of the importance of climate change.

We also must understand mitigation costs. I'm amused to hear Dr. Jeffrey Sachs promote at this conference an engineering solution to climate change led by Columbia University. Economists used to be attacked as too optimistic but I guess engineers have us beat. If Dr. Sachs is correct that there is a very inexpensive technological solution that can strip carbon from smokestacks and store it safely, I would agree that it will take care of the problem. Carbon could be safely removed at a reasonable cost and we would simply have to implement the technology universally. But engineers once promised us that nuclear power would produce energy that was "too cheap to meter". This did not turn out to be the case as the technology was more complicated and more dangerous than anyone first realized. I think we definitely need to research new technologies and invest in R&D. Learning how expensive these technologies will be is an important part of the puzzle. That includes estimating environmental costs. The Stern Review is concerned about low probability- high consequence events associated with climate change. The same concerns should be applied to alternative policies. Would placing 500 million hectares of cropland into energy crops lead to world wide hunger? What are the costs of damming the remaining wild rivers? How will the planet store extensive nuclear material safely for thousands of years?

One policy that was not emphasized in today's discussion is emergency plans. What can we do if we are mistaken about climate change and it turns out to be more

dangerous than we expected? What actions can we take to immediately cool the planet if we are faced with runaway higher temperatures? Some scientists have discussed the possibility of bioengineering, placing dust particles in the upper atmosphere to cool the planet. This is likely to have unforeseen negative repercussions so that it should not be done lightly. However, if we faced a situation that was considered catastrophic, we should be willing to take reasonable counter measures. I think developing emergency plans that would be implemented only if needed is an appropriate precautionary measure. We should develop the research required to make it possible to implement such plans quickly in case the need arises.

Another point I think that everyone agrees upon is that the planet will warm no matter what mitigation policy we adopt. Clearly, one aspect of climate policy must be adaptation. We must be prepared for the climate changes that are coming. This is going to be especially important for the low latitude countries that are otherwise going to have large immediate damages and the high latitude countries which are likely to see rapid warming. The private sector must be left free to adapt to climate change. The public sector must try to make sure that it keeps up with climate change as well. Changes in dams, coastal protection, water allocation, energy infrastructure are all changes with substantial government input. The government must adapt as needed where it is needed.

Finally, one of the issues raised in the Stern Review is that the damages of climate change will fall most heavily on poor low latitude countries. This raises serious equity concerns that require compensation. The people and firms who emit carbon, who are often wealthy, need to provide compensation to the victims of climate change, who are often quite poor. Specifically, mid and high latitude countries should provide assistance to low latitude countries who are likely to be the primary victims of climate change. Specifically, wealthier carbon emitting countries could provide assistance for adaptation and for development in low latitude countries. The adaptation funds could help lessen the damages in climate sensitive sectors such as agriculture. The development funds could help move the economies away from agriculture and towards sectors that are less dependent on climate and increase standards of living.

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