Global Climate Change: A Challenge to Policy

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Last fall, the United Kingdom issued a major government report on global climate change directed by Sir Nicholas Stern, a top-flight economist. The Stern Report amounts to a call to action: it argues that huge future costs of global warming can be avoided by incurring relatively modest cost today.

Critics of the Stern Report don't think serious action to limit carbon dioxide (CO_2) emissions is justified because there remains substantial uncertainty about the extent of the costs of global climate change and because these costs will be incurred far in the future. They think that Stern improperly fails to discount for either uncertainty or futurity.

I agree that both futurity and uncertainty require significant discounting. However, even with that, I believe the fundamental conclusion of Stern is justified: we are much better off to act to reduce CO_2 emissions substantially than to suffer and risk the consequences of failing to meet this challenge. As I explain here, this conclusion holds true even if, unlike Stern, one heavily discounts the future.

A PERSONAL INTRODUCTION TO GLOBAL WARMING

I first heard of the effect of industrialization on global temperatures long before the present concerns became significant: in the fall of 1942, to be precise. I was being trained as a weather officer. One course, called "dynamic meteorology," taught by Dr. Hans Panofsky at New York University, dealt with the basic physics of weather systems (pressure variations, the laws determining the strength of winds, the causes and effects of precipitation, and similar matters). One of the first things to understand was what determined the general level of temperature. The source of terrestrial temperature is, of course, solar radiation. But heating of the Earth from the Sun's rays causes the Earth to emit radiation at frequencies appropriate to its temperature, that is, in the infra-red low-frequency portion of the electromagnetic spectrum. Since the Earth radiates into empty space, where the temperature approximates absolute zero, it would appear that in equilibrium the Earth should come to that temperature also, as is indeed the case with the Moon.

What makes the difference is the Earth's atmosphere. The vast bulk of the atmosphere is

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made up of nitrogen and oxygen, transparent to both the visible radiation coming from the Sun and the infrared radiation emitted by the Earth, and hence without effect on the equilibrium temperature. However, the atmosphere also contains, we learned, a considerable variety of other gases in small quantities. These "trace gases" include most notably water vapor, carbon dioxide, and methane, though there are many others. These trace gases have the property of being transparent to radiation in the visible part of the spectrum but absorbent at lower frequencies, such as infrared. Hence, the effect of these gases is to retain the outgoing radiation and so raise the temperature of the Earth to the point in which life can flourish. The effect is strictly parallel to the use of glass in greenhouses, also transparent to visible radiation but not to infrared; hence, the widespread term, "greenhouse effect."

Where do these trace gases come from? The water vapor comes from the passage of air over the large expanses of water in the Earth's surface, particularly when the water is warmer than the air. The carbon dioxide and methane have come from some non-biological sources, such as volcanic eruptions, but also from the respiration of animals and from organic wastes. (Vegetation, on the contrary, absorbs CO_2.)

Our instructor then added one more observation. CO_2 is a by-product of combustion. There are fires due to volcanoes and lightning, and mankind has lit fires for 500,000 years, but the pace of combustion has vastly increased since the Industrial Revolution. So, concluded Dr. Panofsky, we can expect the world temperature to rise steadily as CO_2 continues to accumulate and at an increasing rate with the growth of industry. This was not presented as a jeremiad or as controversial. Indeed, we were clearly being told this rather to vivify the somewhat arid set of facts we had to learn than to move us to action.

As any economist accustomed to general equilibrium theory might guess, the implications of a given increase in greenhouse gases for the weather are mediated through a very complex interactive system with both positive and negative feedbacks. Elaborate climate models have been developed, each admittedly falling short of catching some significant aspect. (Economists will understand.) Nevertheless, serious studies have lead to a considerable consensus, although with a wide range of uncertainty. I will draw upon the most recent report, prepared by a team directed by Sir Nicholas Stern for the United Kingdom Prime Minister and Chancellor of the Exchequer. The mean levels of different magnitudes in this report are comparable to those in earlier work, but the Stern Review is more explicit about ranges of uncertainty.

The current level of CO_2 (plus other greenhouse gases, in CO_2 equivalents) is today about 430 parts per million (ppm), compared with 280 ppm before the Industrial Revolution. With the present and growing rate of emissions, the level could reach 550 ppm by 2035. This is almost twice the pre-industrial level, and a level that has not been reached for several million years.

POTENTIAL CLIMATE CHANGE AND ITS IMPACTS

Most climate change models predict that a concentration of 550 ppm would be associated with a rise in temperature of at least two degrees Centigrade. A continuation of "business as usual" trends will likely lead to a trebling of CO_2 by the end of the century, with a 50% chance of exceeding a rise of five degrees Centigrade, about the same as the increase from the last ice age to the present.

The full consequences of such rises are not well known. Some of the direct effects are obvious: implications for agriculture (not all bad; productivity in Canada and northern Russia will rise, but negative effects predominate where moisture is the limiting factor and especially in the heavily populated tropical regions), and a rise in sea-level, which will wipe out the small island countries (e.g., the Maldives or Tonga) and encroach considerably on all countries. Bangladesh will lose much of its land area; Manhattan could be under water. This rise might be catastrophic rather than gradual if the Greenland and West Antarctic ice sheets melt and collapse. In addition, temperature changes can change the nature of the world's weather system. A reversing of the Gulf Stream, which could cause climate in Europe to resemble that of Greenland, is a distinct possibility. There is good reason to believe that tropical storms will become more severe, since the energy which fuels them comes from the rising temperature of the oceans. Glaciers will disappear, indeed have been disappearing, rapidly, and with them, valuable water supplies.

ARE THE BENEFITS FROM REDUCING CLIMATE CHANGE WORTH THE COSTS?

The available policies essentially are ways of preventing the greenhouse gases from entering the atmosphere, or at least reducing their magnitude. Today the source of 65% of the gases is the use of energy; the remainder arises from waste, agriculture, and land use. A number of behavioral changes would mitigate this problem: (1) shifting to fuels which have higher ratio of useful energy to CO_2 emissions (e.g., from coal to oil or oil to natural gas); (2) developing technologies which use less energy per unit output; (3) shifting demand to products with lower energy intensity; (4) planting trees and reducing deforestation, since trees absorb CO_2; or, (5) pursuing an unproven but apparently feasible policy of sequestering the CO_2 by pumping it directly into underground reservoirs. We can go further and simply restrict output.

Two factors deserve emphasis, factors that differentiate global climate change from other environmental problems. First, emissions of CO_2 and other trace gases are almost irreversible; more precisely, their residence time in the atmosphere is measured in centuries. Most environmental insults are mitigated promptly or in fairly short order when the source is cleaned up, as with water pollution, acid rain, or sulfur dioxide emissions. Here, reducing emissions today is very valuable to humanity in the distant future. Second, the scale of the externality is truly global; greenhouse gases travel around the world in a few days. This means that the nation-state and its subsidiaries, the typical loci for internalization of externalities, are limited in their remedial ability. (To be sure, there are other transboundary environmental externalities, as with water pollution in the Rhine Valley or acid rain, but none nearly so far-flung as climate change.) However, since the United States contributes about 25% of the world's CO_2 emissions, its own policy could make a large difference.

Thus, global climate change is a public good (bad) *par excellence*. Benefit-cost analysis is a principal tool for deciding whether altering this public good through mitigation policy is warranted. Economic analysis can also help identify the most efficient policy instruments for mitigation, but I leave that to other essays in this issue.

Two aspects of the benefit-cost calculation are critical. One is allowance for uncertainty (and related behavioral effects reflecting risk aversion). To explain economic choices such as insurance or the holding of inventories, it has to be assumed that individuals prefer to avoid risk. That is, an uncertain outcome is worth less than the average of the outcomes. As has already been indicated, the possible outcomes of global warming in the absence of mitigation are very uncertain, though surely bad; the uncertain losses should be evaluated as being equivalent to a single loss greater than the expected loss.

The other critical aspect is how one treats future outcomes relative to current ones. The issue of futurity has aroused much attention among philosophers as well as economists. At what rate should future impacts—in particular, losses of future consumption—be discounted to the present. The consumption discount rate, δ, can be expressed by the following simple formula:

$$\delta = \rho + g\eta$$

where ρ is the social rate of time preference, g is the projected growth rate of average consumption, and η is the elasticity of the social weight attributed to a change in consumption.

The parameter η in the second term accounts for the possibility that, as consumption grows, the marginal unit of consumption may be considered as having less social value. It is analogous to the idea of diminishing marginal private utility of private consumption. This component of the consumption rate of discount is relatively uncontroversial, although researchers disagree on its magnitude. The appropriate value to assign to η is disputed, but a value of 2 or 3 seems reasonable (the Stern Review uses 1, but this level does not seem compatible with other evidence).

Greater disagreement surrounds the appropriate value for ρ, the social rate of time preference. This parameter allows for discounting the future simply because it is the future, even if future generations were no better off than we are. The Stern Review follows a considerable tradition among British economists and many philosophers against discounting for pure futurity. Most economists take pure time preference as obvious. Tjalling Koopmans pointed out in effect that the savings rates implied by zero time preference are very much higher than those we observe. (I am myself convinced by this argument.)

Many have complained about the Stern Review adopting a value of zero for ρ , the social rate of time preference. However, I find that the case for intervention to keep CO_2 levels within bounds (say, aiming to stabilize them at about 550 ppm) is sufficiently strong as to be insensitive to the arguments about ρ . To establish this point, I draw on some numbers from the Stern Review concerning future benefits from keeping greenhouse gas concentrations from exceeding 550 ppm, as well as the costs of accomplishing this.

The benefits from mitigation of greenhouse gases are the avoided damages. The Review provides a comprehensive view of these damages, including both market damages as well as non-market damages that account for health impacts and various ecological impacts. The damages are presented in several scenarios, but I consider the so-called High-climate scenario to be the best-based. Figure 6-5c of the Review shows the increasing damages of climate change on a "business as usual" policy. By the year 2200, the losses in GNP have an expected value of 13.8% of what GNP would be otherwise, with a .05 percentile of about 3% and a .95 percentile of about 34%. With this degree of uncertainty, the loss should be equivalent to a certain loss of about 20%. The base rate of growth of the economy (before calculating the climate change effect) was taken to be 1.3% per year; a loss of 20% in the year 2200 amounts to reducing the growth rate to 1.2% per year. In other words, the benefit from mitigating greenhouse gas emissions can be represented as the increase in the growth rate from today to 2200 from 1.2 % per year to 1.3% per year.

We have to compare this benefit with the cost of stabilization. Estimates given in Table 10.1 of the Stern Review range from 3.4% down to -3.9% of GNP. (Since energy-saving reduces energy costs, this last estimate is not as startling as it sounds.) Let me assume then that costs to prevent additional accumulation of CO_2 (and equivalents) come to 1% of GNP every year forever.

Finally, I assume, in accordance with a fair amount of empirical evidence, that η, the component of the discount rate attributable to the declining marginal utility of consumption, is equal to 2. I then examine whether the present value of benefits (from the increase in the GDP growth rate from 1.2% to 1.3%) exceeds the present value of the costs (from the 1% permanent reduction in the level of the GDP time profile). A straightforward calculation shows that mitigation is better than business as usual—that is, the present value of the benefits exceeds the present value of the costs—for any social rate of time preference (ρ) less than 8.5%. No estimate for the pure rate of time preference even by those who believe in relatively strong discounting of the future has ever approached 8.5%.

These calculations indicate that, even with higher discounting, the Stern Review's estimates of future benefits and costs imply that current mitigation passes a benefit-cost test. Note that these calculations rely on the Stern Review's projected time profiles for benefits and its estimate of annual costs. Much disagreement surrounds these estimates, and further sensitivity analysis is called for. Still, I believe there can be little serious argument over the importance of a policy of avoiding major further increases in combustion by-products.

Letters commenting on this piece or others may be submitted at http://www.bepress.com/cgi/submit.cgi?context=ev.

REFERENCES AND FURTHER READING

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