ECONOMICS

Climate Change: Risk, Ethics, and the Stern Review

An optimal economic response to climate change requires consideration of discounting and value judgments.

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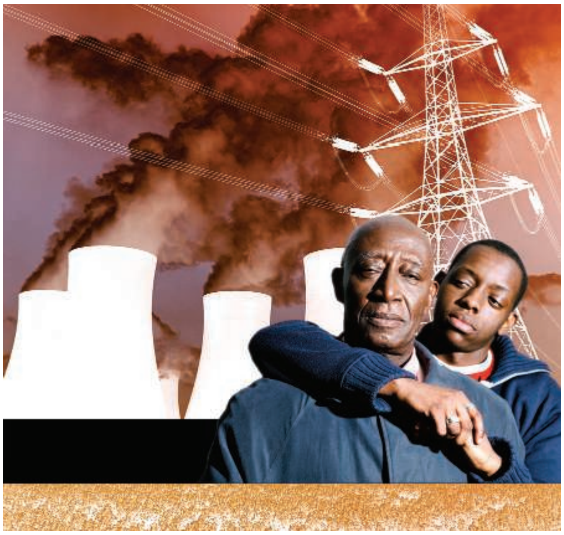
Any thorough analysis of policy on climate change must examine scientific, economic, and political issues and many other relationships and structures and must have ethics at its heart. In a Policy Forum in this issue of *Science*, Nordhaus (*1*) suggests that our results as described in the Stern Review (*2*) stem almost entirely from ethical judgments. This is not correct. In addition to revisiting the ethics, we also incorporated the latest science, which tells us that, for a given change in atmospheric concentration, the worst impacts now appear more likely. Further, the science also now gives us a better understanding of probabilities, so we could incorporate explicit risk analysis, largely overlooked in previous studies. It is risk plus ethics that drive our results.



The most direct way to look at the problem of constructing an economic response to climate change is to look at the individual impacts of climate change alongside the cost of reducing emissions and then to ask whether it is worth paying for mitigation. However, we do not have the kind of information that would enable formally attaching numbers to all consequences, weighting them, and adding them all up with any plausibility. Thus, economists attempt aggregations of impacts and costs using very simplified aggregate modeling and, in the process, throw away much that is of fundamental importance to a balanced judgment.

The central estimate of mitigation costs for stabilizing emissions below 550 ppm CO_2 equivalent is 1% of gross domestic product (GDP) per annum (*2*). The basic question is thus whether it is worth paying 1% of GDP to avoid the additional risks of higher emissions. The modeling in the Stern Review is valuable in identifying some key drivers of costs and benefits in terms of economic modeling approaches, scientific variables, and ethical considerations. However, excessive focus on the narrow aspects of these simplistic models distorts and often exaggerates their role in policy decisions. They cannot substitute for the detailed risk and cost analysis of key effects.

Our sensitivity analysis shows that our main conclusions—that the costs of strong action are less than the costs of the damage avoided by that action—are robust to a range of assumptions. These assumptions concern (i) model structure and inputs (including population, structure of the damage function, aversion to irreversible consequences, future conditions, and the rise in price of environmental goods relative to consumption goods) and (ii) value judgments (attitudes to risk and inequality, the extent to which future generations matter, and intragenerational income distribution and/or regional equity weighting).

Some credible assumptions about the rate at which climate change will result in damage would lead to cost estimates that are much higher; our modeling approach has been cautious. Some modelers are very optimistic about economic growth and social rates of return for the next centuries. However, they appear to overlook that such rapid growth is likely to lead to greater emissions and, hence, the more rapid onset of climate change.

The ethical approach adopted in our analysis focuses on the ethics of allocation between richer and poorer people and between those born at different times. Ramsey (*3*) developed the standard social welfare discounting formula $r = \eta g + \rho$, where r is the consumption discount rate, η is the elasticity of the social benefits attained (also called the social marginal utility), g is per-capita consumption growth rate, and ρ is the time discount rate (also called the pure rate of time preference). The equation arises from comparing the social value of a bit of consumption in the future with a unit now and asking how it falls over time, the definition of a discount rate.

Traditionally, the discount rate has been applied to policies and projects involving small changes with direct benefits and costs over less than one generation (say a few decades at most), which means that people are feeling the impact of their decisions in their own lives. However, climate change is an intergenerational policy issue, and thus, we must see ρ as a parameter capturing discrimination by date of birth. For example, applying a 2% pure time discounting rate ($\rho = 2$) gives half the ethical weight to someone born in 2008 relative to someone born in 1973. Surely, many would find this difficult to justify.

In addition, the discounting formula described above depends on the path of future growth in consumption. Climate change involves potentially very large changes and can reduce future growth in consumption, so the discount rate applied in a world with climate change will be less than that in a world without, all else being equal. Moreover, this logic can be extended so that the uncertainty around climate impacts is taken into account. For every possible scenario of future climate change, there will be a specific average discount rate, depending on the growth rate of consumption in that scenario (*4*). Thus, to speak of "the discount rate" is misguided.

Using $\eta = 1$ implies that a given social benefit will be valued more highly by a factor of five for someone with one-fifth the resources of someone else. Some commentators have suggested that higher values should be used. Using $\eta = 2$ would mean that an extra benefit to the person who is poorer by a factor of five would have a value 25 times that to a richer person. In a transfer from the richer

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individual to the poorer one, how much would you be prepared to lose in the process and still regard it as a beneficial transfer? In the case of $\eta = 2$, as long as less than 96% is lost, it would be seen as beneficial and, for $\eta = 1$, less than 80%. Although it is a tenable ethical position, those who argue for η as high as 2 should be advocating very strong redistribution policies.

In the case of $\eta = 3$ in Nordhaus' example, over 99% could be lost and a transfer would still be beneficial. Does he advocate huge increases in transfers from rich to poor in the current generation?

A value of unity for η is quite commonly invoked, but higher values of ρ are sometimes used in cost-benefit analysis. Indeed, there are a number of reasons why a smaller-scale project such as a new road or railway may not be as valuable—or relevant at all—in several years time as circumstances change. However, avoiding the impacts of climate change (the value of a stable climate, human life, and ecosystems) is likely to continue to be relevant as long as the planet and its people exist.

Further, as people become richer and environmental goods become scarcer, it seems likely that, rather than fall, their value will rise very rapidly, which was an issue raised in chapter 2 of our review and has been investigated in later analyses (*5*). And the flow-stock nature of greenhouse gas accumulation, plus the powerful impact of climate change, will render many consequences irreversible. Thus, investing elsewhere and using the resources to compensate for any later environmental damage may be very cost-ineffective.

Many of the comments on the review have suggested that the ethical side of the modeling should be consistent with observable market behavior. As discussed by Hepburn (*6*), there are many reasons for thinking that market rates and other approaches that illustrate observable market behavior cannot be seen as reflections of an ethical response to the issues at hand. There is no real economic market that reveals our ethical decisions on how we should act together on environmental issues in the very long term.

Most long-term capital markets are very thin and imperfect. Choices that reflect current individual personal allocations of resource may be different from collective values and from what individuals may prefer in their capacity as citizens. Individuals will have a different attitude to risk because they have a higher probability of demise in that year than society. Those who do not feature in the market place (future generations) have no say in the calculus, and those who feature in the market less prominently (the young and the poor) have less influence on the behaviors that are being observed.

The issue of ethics should be tackled directly and explicitly through discussion (*7*). No discussion of the appropriateness of particular value judgments can be decisive. Alternative ethical approaches should be explored: Within the narrow confines of the modeling, sensitivity analysis does this. There is also scope for further work attempting to disentangle the roles of risk aversion and inequality aversion that are conflated (via η) in this modeling. Furthermore, we should go beyond the narrow framework of social welfare functions to consider other ethical approaches, including those involving rights and sustainability.

We note briefly that Nordhaus misrepresents the Stern Review on the subject of taxes. He argues that we propose a tax of \$85 per ton of carbon dioxide, which equates to \$312 per ton of carbon. This was our estimate of the marginal environmental cost of each extra carbon emission (the "social cost of carbon," hereafter SCC) under business-as-usual, with no policies to reduce emissions. To identify this with a recommended tax makes two mistakes. First, any estimate of the SCC is path-dependent. In chapter 13 of the Stern Review, we justify our proposed policy goal of stabilizing emissions between 450 and 550 ppm CO_2 equivalent. In this range, we estimate the social cost of carbon to be between \$25 per ton of carbon dioxide (450 ppm) and \$30 per ton (550 ppm), and so the proposed package of policies should be broadly consistent with this range. Second, in distorted and uncertain economies, any tax should be different from an SCC (*8*). Stabilization between 450 and 550 ppm is equivalent to reductions of around 25 to 70% in 2050. Nordhaus claims erroneously that the review suggests reductions on this scale over the next two decades. The Stern Review is also clear that prices should increase over time, although perhaps not as sharply as Nordhaus suggests.

The ethical approach in Nordhaus' modeling helps drive the initial low level of action and the steepness of his policy ramp. As future generations have a lower weight they are expected to shoulder the burden of greater mitigation costs. This could be a source of dynamic inconsistency, because future generations will be faced with the same challenge and, if they take the same approach, will also seek to minimize short-term costs but expect greater reductions in the future as they place a larger weight on consumption now over the effects on future generations (thus perpetuating the delay for significant reductions).

We have argued strongly for an assessment of policy on climate change to be based on a disaggregated approach to consequences—looking at different dimensions, places, and times—and a broad ethical approach. Nevertheless, our modeling sensitivity analysis demonstrates that the treatment of risk and uncertainty and the extent to which the model responds to progress in the scientific literature, are of roughly similar importance in shaping damage estimates as our approach to ethics and discounting. It is these three factors that explain higher damage estimates than those in the previous literature.

Given the centrality of risk, scientific advance, and ethics, in our view, the question should really be why, with some important exemptions, did the previous literature pay inadequate attention to these issues?

There was much structural caution in our approach. We left out many risks that are likely to be important, for example, the possibility of strong disruption of carbon cycles by changes to oceans and forests. It is possible that risks and damages are higher than we estimated. But one thing is clear: however unpleasant the damages from climate change are likely to appear in the future, any disregard for the future, simply because it is in the future, will suppress action to address climate change.

References and Notes

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