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WILLIAM R. CLINE[1]

1 Meeting the Challenge of Global Warming

Introduction

This chapter compares the costs and benefits of three alternative policy strategies to reduce mankind's emissions of greenhouse gases and limit damage due to global warming.

It is particularly difficult to analyze the economics of policies to limit such emissions because expected benefits to be generated from such policy actions will materialize only in the distant future, whereas many of the costs will be incurred much sooner. Therefore the way in which future benefits are discounted to give a present value is crucial: How much is the prospect of $100 earned in 50 or 100 years worth to us today? This is discussed below in more detail before the model used for evaluating the three policy options is described.

[1] Center for Global Development and Institute for International Economics.

The state of global warming science and policy

The Intergovernmental Panel on Climate Change (IPCC) provides a framework for scientists from across the world to share and evaluate the data generated by a range of computer models projecting future changes to atmospheric composition, average temperatures, and climate patterns. The IPCC periodically reviews this situation, most recently in the Third Assessment Report (TAR) published in 2001. This report compiles a vast amount of detailed scientific information, which is distilled into a "Summary for Policymakers" agreed to by all participating governments. This summary is the basis for planning future action.

The TAR projects an increase in average temperatures by 2100 in the range 1.4–5.8°C (above the 1990 baseline). It is also estimated that global average surface temperature rose by 0.6°C from 1861 to 2000, and the panel concluded that "most of the observed warming over the last 50 years is likely to have been due to the increase in greenhouse gas concentrations." Of the six recognized greenhouse gases, carbon dioxide (CO_2) plays the greatest role because it is emitted in the greatest quantities and persists for long periods in the atmosphere.

When projecting future temperature rises, the climate models use a range of six benchmark scenarios, which give rise to very different patterns of man-made carbon dioxide emissions. It is implicitly assumed in the TAR that all these scenarios have equal weight, and therefore that the future temperature rise is equally likely to be anywhere within the projected range. However, the analysis in this

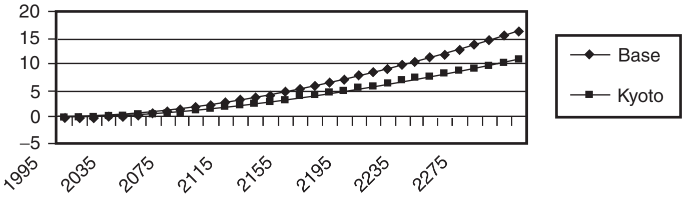

Figure 1.1. Climate damage as percent of GWP, baseline, and Kyoto Protocol

chapter assumes that some scenarios that predict low emissions are extremely unlikely without economic incentives, which means that future temperature rise would be towards the upper end of the range.

International policy on mitigation of climate change is focused on the Kyoto Protocol negotiated in 1997. This treaty sets limits on emissions of carbon dioxide allowed from industrialized and transition economies without making any demands on the developing world. This agreement was seen as the first, relatively small, step by the international community in a more ambitious, long-term program of emissions reduction. However, there now seems little chance of the Kyoto Protocol coming into force globally. The USA has made clear that it will not ratify the treaty, both because of the economic harm it would cause and the uncertainty surrounding climate science. Russia seems unlikely to ratify, for similar reasons.

The Protocol must be ratified by industrialized and transition countries, accounting for at least 55% of total emissions, to come into force. Without Russia's ratification, this cannot be achieved. Although some signatories, particularly

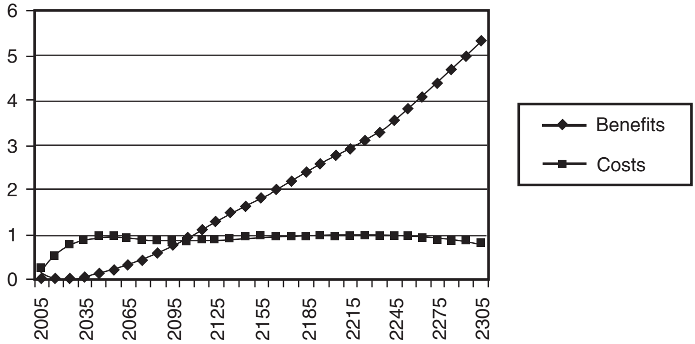

Figure 1.2. Benefits and costs of Kyoto Protocol abatement (% world product)

EU countries, have their own programs to limit emissions, few are meeting their self-imposed targets.

The Kyoto Protocol is discussed further below as one of the policy options. However, it is now doubtful that the Protocol is still relevant because of lack of support from key players. A more likely option is the re-opening of international negotiations to arrive at a new agreement to be supported by the United States, Russia, and developing countries.

Core analytical issues

For most projects, the economic analysis on which decisions are based covers a period of, at most, a few decades. However, global warming takes place on a much longer timescale. IPCC projections cover at least the period up to 2100. But arguably, the proper time horizon is in fact 300 years, because it would take that long for carbon dioxide to be mixed into the deep ocean and so start to reverse its build-up in the atmosphere.

Conventional discounting, even with low discount rates, makes present day values of benefits to be received far in the future vanishingly small. The reason why we discount the value of expected future benefits is that people tend to prefer consumption sooner rather than later. If asked to choose between getting $100 today or $100 in a year's time, most people would prefer $100 now. When people save money, they forestall consumption today. Generally, they are only willing to do that because the savings can be invested to yield an interest premium that ensures future consumption will be larger. (Taking account of the large costs involved in the short term, a conventional economic analysis would nearly always strongly suggest that no action be taken. And yet, potentially severe climate damage can only be limited by taking costly actions now. How can we establish an economic case for such actions?)

As an alternative to the conventional method, a system of "utility-based discounting" is proposed. This approach is used in the economics literature on social cost-benefit analysis. In this case, the discount rate for "pure time preference" (explicit preference for consumption today over consumption tomorrow) is set at zero. However, future consumption is still discounted on the basis that per capita consumption will increase, so the marginal benefit of extra consumption will fall (for example, buying a car has an enormous benefit compared to not having one at all; buying a second car for convenience has a smaller additional benefit). In this case, the discount rate applied is called the

Social Rate of Time Preference (SRTP). Because the long-term per capita growth rate is about 1%, and because extra utility from extra consumption is estimated to decline by 1.5% when consumption per capita rises by 1%, the effective total discount rate is about 1.5%. This equals zero for the component of "pure" time preference (or "impatience") and 1.5% for the component reflecting falling "marginal utility."

Although there has been considerable work on the costs of mitigating global warming, calculations of the benefits (the climate-induced damage avoided) are far more difficult to make. Based on figures available in the early 1990s, the potential damage calculated for a doubling of atmospheric CO_2 would amount to some 1% GDP annually, with one-quarter of this related to agriculture. Other authors have come to similar conclusions, with rates of damage skewed toward developing countries because of their reduced scope for adaptation.

Some economists have also tried to include an allowance for potential catastrophic change in their assessments. A number of possible catastrophes have been postulated, including the widely publicized shut-down of the so-called thermohaline circulation in the Atlantic Ocean.

It has been suggested that the present "conveyor belt," in which cold water sinking in the Arctic induces upwelling of warm water in the southern Atlantic, could stop as melting polar ice makes Arctic waters less salty. In Northwestern Europe, this circulation pattern manifests itself as the Gulf Stream, a phenomenon believed to have a significant moderating effect on the regional climate. It has been calculated that the economic loss for Europe of such a catastrophic shutdown could be over 40% of GDP. The probability of such an occurrence rises steeply with the extent of global temperature rise, leading to the conclusion that, in the case of a 6°C rise, the potential costs would warrant Europe sacrificing 10% of GDP to avoid the catastrophe.

Previous cost–benefit analyses

In earlier work by the present author, it was assumed that, in the absence of policy changes, emissions of greenhouse gasses would continue to rise to a maximum of 50 GtC (gigatonnes, or million million tons of carbon) in the latter part of the 23rd century, from a baseline of 6.9 GtC in 2000. This was based on the assumption that the large known reserves of coal would increasingly be exploited as oil and gas reserves are depleted.

A central value of 10°C for temperature rise by 2300 was estimated, giving an annual cost of 16% of global GDP. Abatement costs are also difficult to estimate, but making reasonable assumptions about the availability of alternative energy sources and the application of today's best technology, it would cost around 2% of the global economic product to cut world emissions in half by 2050. Because of the development of further technological alternatives, this same cost could produce a net emission reduction of 80% by the end of the 21st century.

An alternative model (DICE) has been used for the past two decades by William Nordhaus to estimate optimal carbon abatement. His most recent studies have indicated an optimum of rather modest reductions in carbon emissions

(5% at present, 11% by 2100), mediated by a carbon tax of $9 per tons by 2005, rising to $67 per tons by the end of the century. The result would be a reduction in warming of less than 0.1°C.

It is not the abatement costs as such that lead to such limited results: In fact, figures generated for 2045 suggest that it would cost only 0.03% of global GDP to reduce emissions by 10% (double what the model identifies as optimal) and less than 1% to halve them. The results are driven by the calculated low present value of the benefit, in turn determined by conventional assumptions about time discounting.

The proposals in this chapter are therefore based on an adapted version of this model – considered a good one for showing the effects of policies over time – but using the preferred Social Rate of Time Preference (SRTP) discounting approach.

Adapting the DICE99 model

The main changes made to this model (called DICE99CL in its modified form) are:

- Setting pure time preference (the conventional discount rate) at zero.
- Discounting future consumption using the SRTP approach. This implies a falling marginal value of consumption with growth.
- Shadow-pricing capital. The social cost–benefit approach converts capital into consumption equivalents, taking account of the fact that a proportion of the

abatement costs would come from investment rather than consumption.

- Increasing baseline carbon emissions. In Nordhaus' recent use of the DICE model, he assumes a significant reduction in carbon intensity (tons of carbon per unit of GDP) by the end of the century because of large increases in extraction costs for fossil fuels. This is not consistent with other analysts' views on future emission scenarios, so the adapted model reflects what the present author considers to be the more realistic of the IPCC scenarios.

The net effect of these and other changes is to raise the warming baseline, although it is still somewhat more optimistic than several of the IPCC scenarios. In the adapted model, warming reaches 3.3°C by 2100, 5.5°C by 2200, and 7.3°C by 2300.

Alternative policy strategies

The adapted model examined above is applied to the analysis of the following three policy options. Note that adaptation to climate change is not considered to be a credible separate option. Rather, it is assumed that for all three policies feasible adaptations are already undertaken as part of the baseline case.

Option 1: Optimal carbon tax

This policy is for an internationally agreed and coordinated tax to be levied by national governments. Each country would use the proceeds for its own purposes.

Optimal emission cuts (based on 1990 emissions as the baseline) would start at around the 40% mark, rise to nearly 50% by the end of the century, and peak at 63% in 2200 before declining to around 15% in 2300. Carbon taxes to achieve this would be similarly aggressive: $170 per ton in 2005, $600 in 2100, peaking at $1,300 in 2200, and tapering off.

The net effect is a gradual widening of the gap between projected warming from "business as usual" and the optimized carbon tax approach: By 2300, the temperature rise is limited to 5.4°C compared to the 7.3°C baseline. The discounted present value of the abatement costs is $128 trillion, but the value of benefits from avoiding damage is $271 trillion: a benefit-cost ratio of 2.1. Although this is what the model defines as optimal, there is still considerable scope to implement an even more aggressive tax policy and further reduce warming while still producing a benefit-cost ratio of more than one.

Option 2: The Kyoto Protocol

This option would commit the industrialized and transition economies to cutting emissions by 5% below 1990 levels and maintaining them at that level, with no constraints on developing economies. Such an approach would reduce global emissions far less than the Option 1.

Although the effect on temperature rise is modest – a reduction from 7.3° to 6.1° by 2300 – damage to the world economy is reduced from 15.4% to 10.3%. Over the same period, the benefits rise steadily after a lag period, becoming greater than costs around 2100, and reaching more than 5%

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