

Executive Summary

Climate Risks and Carbon Prices: Revising the Social Cost of Carbon

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Revising the Social Cost of Carbon

How much economic damage is done by one ton of carbon dioxide emissions? That number, called the "social cost of carbon," or SCC, provides one measure of the urgency of the problem of climate change. It has been estimated by a federal government working group at a mere \$21 as of 2010 – the equivalent of just \$0.21 for every gallon of gasoline.

This is not a large number. It seems to suggest that we don't need to do much about climate change: if a proposed climate policy would cost more than \$21 per ton of reductions in carbon dioxide emissions, then, according to this calculation, it's not worth doing.

The government's calculation of the \$21 SCC, however, omits many of the biggest risks associated with climate change, and downplays the impact of our current emissions on future generations. Our re-analysis, including those factors, shows that the SCC could be much higher. In our worst case, it could be almost \$900 in 2010, rising to \$1,500 in

It is unequivocally less expensive to reduce greenhouse gas emissions than to suffer climate damages.

2050. If the damages per ton of carbon dioxide are that high, then almost anything that reduces emissions is worth doing.

For our re-analysis of the SCC, we used the DICE model, the best-known of the models used by the government working group. We repeated the working group analysis, changing it only where needed to represent four big uncertainties.

First, scientists remain uncertain about how rapidly global warming will progress as we fill the atmosphere with greenhouse gases. "Climate sensitivity," defined as the global average warming that results from doubling the carbon

dioxide concentration in the atmosphere, is most commonly estimated to be 3.0°C (5.4°F) – but there is a significant risk that it is larger, and we won't know for certain until it is too late to do anything about it. In this case, the working group analysis does a careful job of addressing uncertainty, estimating that there's a 1-in-20 chance (95^{th} percentile) that climate sensitivity is 7.1°C (12.8°F) or higher; they calculate, but do not emphasize, SCC estimates based on this higher value of climate sensitivity. We followed their method without change, calculating the SCC both for average and for 95^{th} percentile climate sensitivity.

Second, economists are uncertain about the severity of the damages that will result from the early stages of warming. The DICE model, developed by William Nordhaus, estimates that 2.5°C (4.5°F) of warming will cause a loss of only 1.8 percent of world GDP. Another economist, Michael Hanemann, has done a detailed review of the DICE damage estimate as it applies to the United States, and concluded that it should be four times as large. We ran the DICE model both with the Nordhaus (original) estimate and the Hanemann estimate of damages at 2.5°C.

Third, economists have very little information about damages at the much higher temperatures that will eventually result from unchecked climate change. DICE simply extrapolates from its low-temperature estimate, implying that only when 19°C (34°F) of warming has occurred do damages reach one half of world GDP. Martin Weitzman argues that this is a drastic understatement of high-temperature damages and suggests an estimate more in keeping with recent climate science: losses due to global warming could reach half of world GDP at 6°C (11°F), and 99 percent of world GDP at 12°C (22°F). This dire forecast may seem more plausible in light of a recent study showing that at 12°C average warming, large parts of the world will, at least once a year, reach temperatures that human beings cannot survive. We ran the DICE model both with the Nordhaus (original) method of extrapolation to high temperatures, and with the Weitzman guesses for high-temperature damages.

Finally, there is no consensus in the longstanding controversy on the appropriate way in which to value the future costs and benefits of climate change. (A lower discount rate gives greater importance to the future; a higher rate, less importance.) The working group analysis prefers a constant 3 percent discount rate, and does not examine any rates below 2.5 percent. The prestigious Stern Review, among others, argued for much lower discount rates, in order to reflect the damage that climate change could do to future generations. As an alternative to the 3 percent rate, we also ran the SCC analysis at a 1.5 percent discount rate, approximating the Stern rate.

Our estimates for the SCC in 2010, using all combinations of these four factors, are shown in Figure ES-1. They range from \$28 (the working group estimate from DICE alone) up to \$893.

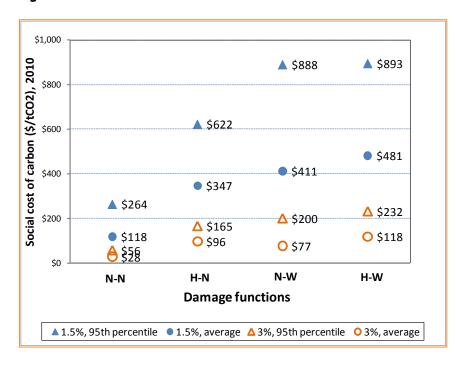


Figure ES-1: Alternative SCC values for 2010

Source: Authors' calculations.

The four damage functions, from left to right, are:

- The original DICE version (i.e., Nordhaus estimates at both low and high temperatures)
- Hanemann's alternative at low temperatures, no change at high temperatures
- Nordhaus' estimate at low temperatures, Weitzman's at high temperatures
- Hanemann's estimate at low temperatures, Weitzman's at high temperatures.

Circles represent average climate sensitivity; triangles are 95th percentile. Solid blue shapes are estimates at a 1.5 percent discount rate; orange outlines are at a 3 percent discount rate.

While many of these values are quite high, they are not the end of the story. The SCC is projected to rise over time, since emissions that occur later will do more damage – because they will come at a time when the concentration of greenhouse gases in the atmosphere is already higher. Our SCC estimates for 2050 are shown in Figure ES-2.

\$1,600 **\$1,550** Social cost of carbon (\$/tcO2), 2050 **\$1,430 \$910** \$817 \$761 \$150 - \$500 \$558 ▲ \$534 **\$509 \$418 △** \$315 O \$275 O \$225 O \$202 \$0 N-N H-N N-W H-W **Damage functions** ▲ 1.5%, 95th percentile ● 1.5%, average △ 3%, 95th percentile O 3%, average

Figure ES-2: Alternative SCC values for 2050

Source: Authors' calculations.

Under some of the assumptions explored in our analysis, the SCC could be as high as \$1,500 per ton – equivalent to \$15 per gallon of gas and more than 70 times as high as the working group's estimate of \$21. How should such extraordinarily high estimates be interpreted?

As long as there is a credible risk that the SCC [social cost of carbon], or damages from a ton of emissions, could be above the cost of maximum feasible abatement, then it is worth doing everything we can to reduce emissions.

In recent years, a number of researchers have explored ambitious scenarios for eliminating carbon dioxide emissions as rapidly as seems technologically feasible; most of these scenarios reach zero or negative net global emissions by the end of this century. While details vary from one study to another, they typically require spending up to \$150 to \$500 per ton of reductions in carbon dioxide emissions by 2050 – the gray band shown in Figure ES-2. Most of our SCC estimates for 2050 are at or above this level, some far above it.

That is, under many of the assumptions we explored, the damages from a ton of carbon dioxide emissions in 2050 could equal or exceed the cost of reducing emissions at the maximum technically feasible rate. In other words, it is unequivocally less expensive to

reduce greenhouse gas emissions than to suffer climate damages. Once this is the case, the exact value of the SCC no longer matters, and cost-benefit analysis of proposals for emission reduction conveys no additional information. All that is needed is a cost-effectiveness analysis of the least-cost strategy for eliminating carbon emissions as rapidly as possible.

In a controversial theoretical analysis, Martin Weitzman argued that under certain plausible assumptions the marginal damages from a ton of emissions, or marginal benefits from reducing emissions, could be infinite. Our estimates are not literally infinite, but they may be close enough to infinity for all practical purposes. As long as there is a credible risk that the SCC, or damages from a ton of emissions, could be above the cost of maximum feasible abatement, then it is worth doing everything we can to reduce emissions. Cost-benefit analysis under such conditions coincides with a precautionary approach that calls for taking immediate, large-scale action to phase out carbon emissions and protect the Earth's climate.