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# How Do We Price an Unknowable Risk?

Devised by economists and set by bureaucrats, the social cost of carbon has a powerful moral implication: the sacrifice society is willing to make for posterity.

**T**he social cost of carbon (SCC) has been described as the most important number most people have never heard of. The greenhouse gases emitted by human activity may remain in the atmosphere for decades or centuries, contributing to higher temperatures, more intense storms, rising sea levels, more acidic oceans, and a host of other ecological, health, and societal harms. Expressed in dollars per ton of carbon emissions, the SCC provides a monetary estimate of the economic costs of such harms. Ideally, it should tell policymakers which policies are worth implementing to control climate change and which are too expensive to be justified.

The SCC is an odd amalgam, though. It's not a number you can look up alongside daily stock prices. Set by bureaucrats who are advised by economists, it nonetheless has a powerful moral implication: whatever benefits arise from reductions in greenhouse gas emissions today will largely accrue not to people living now, but to our children and grandchildren and *their* children. The SCC quantifies the sacrifice today's society is willing to make for posterity.

As the Biden administration undertakes revisions to the valuation most recently adopted for the SCC—\$51 per ton of carbon dioxide-equivalent emissions—researchers are trying to better integrate the calculation of the SCC with social values. These efforts stem from the contributions of many people, but probably none was more important than the late economist Martin Weitzman. Weitzman initially held an optimistic view, common among economists, that humans would respond to climate change as we have to other challenges, by innovating and adapting. He later came to question that view. As scholars revisit the SCC, and as society

tries to determine what level of sacrifice it's willing to make, experts are returning to Weitzman's questions, along with what he characterized as a "dismal theorem": that it might be impossible to calculate the SCC with any precision.

## **Necessary "for planning purposes"**

Nobel laureate economist Kenneth Arrow used to tell a story about his military service in the Second World War. Assigned to prepare weather forecasts for the US Army Air Forces, he came to doubt that they were accurate enough to be useful. He communicated these concerns up his chain of command. "The commanding general is well aware that the forecasts are no good," the reply came back. "However, he needs them for planning purposes."

The social cost of carbon came into being because it, too, is needed for planning purposes. In 1981, President Reagan issued Executive Order 12291, requiring that significant federal regulations be subjected to benefit-cost analysis. Subsequent presidents have reaffirmed the order several times. The SCC became a component of benefit-cost analysis after a 2007 decision of the US Court of Appeals for the Ninth Circuit in a case brought by the nonprofit Center for Biological Diversity. The center had sued the George W. Bush administration, arguing that the National Highway Traffic Safety Administration failed to account for climate damages from vehicle exhaust when making regulatory decisions. The court held that although putting a price on global warming would be difficult, a federal agency could not implicitly suppose that damages are zero by failing to quantify them.

So in 2009, the Interagency Working Group on Social Cost of Carbon was formed, issuing its first SCC estimates in

2010. While the working group acknowledged the formidable uncertainties, they employed what were arguably the best—and perhaps only—methods available to them. They averaged the projections of what are called integrated assessment models, developed by economists including William Nordhaus, who would be awarded the Nobel Prize in 2018 for his work on climate economics. These models predict how total economic output—gross domestic product, or GDP—will vary over time and incorporate feedback effects; this is what makes them *integrated* assessment models. Higher GDP growth is accomplished by emitting more greenhouse gases, but higher emissions reduce future GDP growth. The social cost of carbon is, therefore, expressed as the amount by which emissions at one point in time reduce GDP in all future years.

The calculated value of the SCC is critically dependent on another number: the discount rate. The discount rate is the number of pennies we would subtract from a dollar that is promised to us one year in the future to determine that dollar-in-a-year's-time value now. For example, if I am indifferent between having 95 cents now and getting a dollar a year from now, the nickel difference is my discount rate: 5%. By concatenating such calculations over 2, 5, 10, or 100 years, a “discounted present value” may be calculated over any time frame. The lower the discount rate, the higher the SCC.

The US Office of Management and Budget (OMB) specifies that discount rates of 3 and 7% be used for project analysis, but suggests lower rates might be employed to consider the present value of costs or benefits that accrue in the distant future. The OMB advice reflects a dichotomy that appears in the Interagency Working Group report between adopting a “descriptive” discount rate, based on historical returns on investment, or a “prescriptive” one, based on projected future consumption. The working group largely adopted a descriptive approach.

Although the first SCC figures were developed during the Obama presidency, work by Robert Hahn and Robert Ritz suggests that the SCC may have had little impact on that administration's rule making: few economic impact analyses, even those focused specifically on the regulation of carbon dioxide, seem to have hinged on the SCC. The metric had even less impact during the Trump administration, when it was largely eviscerated by confining the analysis only to the impacts of climate change on Americans, rather than also including its effects on those who live in other countries—more than 95% of the world's population.

However, interest in the SCC continued to grow, perhaps in anticipation of more ambitious climate policies being adopted under a subsequent Democratic administration. According to Google Scholar, fewer than 500 academic papers on the SCC were published in 2010, when the SCC first began to be applied in regulatory decisions. This tripled to 1,500 in 2018, even though the SCC was out of vogue in government at the time.

On Inauguration Day 2021, President Biden signed an executive order reconvening the Interagency Working Group, which had been disbanded by the previous administration, to study the social cost of carbon. A month later, the SCC was restored to \$51 per ton, roughly its level during the Obama administration, and the new working group is expected to recommend a revised figure in early 2022. Until then, when a federal agency such as the Environmental Protection Agency contemplates a regulation that will affect the amount of carbon dioxide emissions from power generation or transportation, it will value any resulting changes in emissions at \$51 per ton.

### A number between 14 and 152

How did regulators arrive at \$51? The figure arises from applying a 3% annual discount rate to central projections of temperature change and economic growth. But the working group could have assigned a price of \$14 a ton. Or \$76. Or \$152. \$14 comes from applying a 5% discount rate, \$76 from applying a 2.5% discount rate. And \$152 comes from using a 3% discount rate but supposing a more extreme increase in temperatures.

This range of estimates arises in large part because estimating the economic consequences of climate change is *really* complicated. The integrated assessment models used to develop the SCC typically combine different modules: a socioeconomic module to project population, economic, and emissions growth; a climate module incorporating projections of the relationship between emissions and temperature change; a damages module relating temperature changes to economic losses; and a discounting module showing how damages at different points in time should be weighted. The output of each module is unavoidably speculative and uncertain, and whatever prediction errors one introduces may be compounded by interaction with the others.

The source of uncertainty that has received the most attention is the discount rate. At a discount rate of 2.5%, \$100 to be received 100 years from now would be worth \$8.46 today; at 5%, the same \$100 would be worth only about 76 cents today. The economist Nicholas Stern, in his 2007 report for the UK government, *The Economics of Climate Change*, sometimes used a discount rate of 1.4%. At that rate, in a century, \$100 would be worth \$24.90. Because many of the effects the SCC attempts to measure are predicted to occur far in the future, differences in the discount rate used to calculate the SCC translate into large swings in its estimated value.

Such sensitivity to fundamental parameters has motivated critical commentaries on the integrated assessment models that drive the calculation of SCC. Massachusetts Institute of Technology economist Robert Pindyck asked in the title of a 2013 paper, “What Do the Models Tell Us?” He answers his own question: “Very little.” Among his criticisms, Pindyck identifies extreme sensitivity to basic parameters like the discount rate. The assessment models, he said, create “a

perception of knowledge and precision, but that perception is illusory and misleading.” In particular, the models don’t tell us about “the most important driver of the SCC, the possibility of a catastrophic climate outcome.” Economists have been working on the concerns Pindyck raised, but they have not been resolved.

If we can’t say with any precision what the discount rate is, can we know with any precision what the SCC is? When economics professors lecture on discount rates, we emphasize that they are not fixed parameters; rather, their value depends on other variables within the model. The discount rate is a *price* and, like any other price, it is determined by relative scarcity. It reflects the scarcity of a very broad aggregate: future consumption. If future consumption is expected to be high, its price in terms of current consumption will be low. If future consumption is expected to be low, people ought to be willing to pay a higher price in terms of forgone current consumption to help their descendants.

Although it’s well known that the SCC depends on the discount rate, what is sometimes less appreciated is that the discount rate may also depend on the SCC. If the discount

set up, Weitzman had been working for more than a decade on the critical factor that Pindyck noted: discounting in the presence of potentially catastrophic risks.

Weitzman’s views on discounting evolved over time. In the mid-1990s he shared the confidence of many economists that human ingenuity would continue to compensate for resource depletion and environmental degradation. When he spoke at a 1996 conference on “Discounting and Intergenerational Equity” at Resources for the Future, where I was then a senior fellow, his contribution was titled “Just Keep Discounting.” As he put it at the time, “I don’t see any fundamental reason why we should not keep on discounting the deep future at today’s best estimates of the return to capital.” He advocated a descriptive approach, in which discount rates would be based on the historical experience of rates of return that had hovered in the general neighborhood of 5% for a century or more.

However, when his paper was published a few years later in the conference volume, Weitzman had expanded its title by a word: “Just Keep Discounting, But ...” In a coda to his original paper, Weitzman noted that his opinions were shifting.

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rate reflects the price of future material benefits relative to present ones, then it will be determined by whether our children and grandchildren will be wealthier than we are. And that, in turn, may well depend on whether we constrain our greenhouse gas emissions now by adopting a high SCC.

So, when we are making judgments as to the appropriate discount rate to use in setting climate policy, we need to be careful not to assume our conclusion. If we assume that consumption will be plentiful in the future relative to the present, that will imply a high discount rate (and a correspondingly low SCC). Whatever effects climate change may have in a generation or a century or a millennium would then be of little consequence. So, then, how should we value carbon if the accumulation of carbon and associated climate change would substantially detract from our descendants’ ability to produce and, consequently, consume goods in the future?

### **The dismal theorem**

This question vexed Martin Weitzman. Earlier in his career, the economist made seminal contributions to the interpretation of national income and welfare, the treatment of uncertainty in policymaking, and a host of other topics. At the time the Interagency Working Group on the SCC was

“Something was gnawing at me,” he wrote, about uncertainty in the rate of return: it could have a profound effect on how we should treat the far-distant future.

By 1998, Weitzman had begun to experience what he described as an “uneasy intuitive feeling that something is wrong,” and he argued that we should apply lower discount rates to more distant events. In a series of papers over the next decade, he developed a more radical view on discounting.

Weitzman’s key insight was that a low discount rate should be applied to the valuation of future well-being—not because we know for sure that our descendants will suffer because of our choices but because we don’t know the effects of our actions with any certainty. Even relatively low probabilities of extreme climate outcomes might become salient in planning for the future. If there is a not-entirely-negligible chance of extreme climate change, this may mean that there is a corresponding not-entirely-negligible chance that our descendants will have radically diminished consumption possibilities. If consumption were to fall to subsistence levels, our descendants’ “marginal utility of consumption”—the value they would assign to having just a few more necessities—could be astronomical. So, Weitzman argued, there may be a small probability that our descendants will place a huge value on future consumption.

How do we assign probabilities to events that have not occurred in recorded human history and for which we can only draw limited analogies from the geological record? As the ecologist E. O. Wilson famously said, “One planet, one experiment.” These considerations led Weitzman to what he characterized as a “dismal theorem,” the prospect that it might prove impossible to estimate a social cost of carbon. While the probability of a truly catastrophic climate outcome might be very low, the consequence might be very, *very* dire. This raises the prospect of straying into mathematically forbidden territory: multiplying a small but non-zero probability by an infinite loss.

Many leading economists, including Pindyck and Nordhaus, think Weitzman took this argument too far. It requires extreme assumptions to find that the SCC is literally incalculable. Still, Weitzman was onto something important. A 2017 National Academies of Sciences, Engineering, and Medicine report went some way toward reconciling descriptive and prescriptive approaches to long-term discounting, but found that the 2010 working group did not incorporate the connection between discounting and consumption growth that Weitzman’s work had emphasized. The report suggested that subsequent work employ a “conceptually sound framework for modeling the relationship between economic growth and discounting uncertainty.” Weitzman died in the fall of 2019, but the issues he raised are increasingly being incorporated into integrated assessments. It remains to be seen how much they will, as Weitzman warned, render an already speculative analysis even less precise.

### **“No one ever made a decision because of a number”**

Psychologist Daniel Kahneman, who was awarded the 2002 Nobel Prize in economics, has said, “No one ever made a decision because of a number. They need a story.” If the United States and other major greenhouse gas emitters ever address climate change effectively, it will probably not be because a study has determined that a ton of carbon dioxide emissions causes damages valued at \$51, or \$14, or \$152, or any other price tag. It will more likely be because we adopt a narrative in which we are no longer willing to risk bequeathing a damaged planet to our descendants.

Nonetheless, a new SCC will soon be announced to comply with the requirement that it be employed in regulatory impact analyses. A cynic might claim that this is an exercise in “policy-based evidence-making”: producing figures contrived to reflect the ambitions that are feasible in our political moment. But it would not necessarily be misguided to reverse-engineer the SCC from a consideration of the costs required to achieve a particular atmospheric concentration or temperature change objective, as Nicholas Stern and Joseph Stiglitz, another

Nobel laureate in economics, have recently suggested. Even if we can’t say with any precision what preventing climate change is worth to us, having a better sense of what it will cost may help us frame whether we think it’s worth doing.

In a sense, the SCC plants a dollar-based flagpole around which we can develop a story, one that helps citizens and policymakers to make decisions that are both practical and moral. And perhaps the takeaway message from Weitzman’s work is that we simply can’t know with any real precision what effect greenhouse gas emissions will have on future well-being. I find myself increasingly convinced by the view that many in the natural sciences have long held: the unknown and unknowable risks of climate change argue for caution.

Yet this is an uncomfortable position: we economists are all about the necessity of making decisions, given limited resources, between competing wants and needs. Increased fossil fuel use now increases the risk of climate change in the future, but decreased fossil fuel use now also has consequences. It would be pretty to think that choosing an SCC would accomplish such “win-wins” as dissuading frivolous bitcoin miners from squandering massive amounts of energy. But raising the cost of fossil fuels today is not all “win;” it will also inflict real pain on people who can’t afford it. A higher SCC may make it more expensive for poor people to drive the old cars they cannot afford to replace or heat the poorly insulated homes they cannot afford to move out of. How do we tell deserving users who lack the money to pay the extra charges imposed under the SCC that they must curtail consumption in the interests of future generations?

Economic theory is grounded in the presumption that people make choices to maximize their well-being. Policymakers must have a compelling reason to *not* respect those choices. For example, pollution is a “market failure” that justifies an intervention, and economists can prescribe solutions when real costs of dirty air and water are not reflected in prices. But in these cases, rather than tell people what their preferences should be, economists try to infer the public’s preferences and reflect back an estimate, or range of estimates. In this manner, decisionmakers and the public can better understand the consequences of their choices, and, in theory, choose wisely. Yet, what the saga of the social cost of carbon is telling citizens is that we economists simply cannot provide them very precise guidance concerning the value they should place on climate change.

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