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THE SOCIAL COST OF CARBON IN TAXES AND SUBSIDIES

PART 2: ALTERNATIVES TO THE US GOVERNMENT SC-CO_2 ESTIMATES

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Part 1 of this series described the development and various uses of US government estimates of the social cost of carbon, including concerns with their recent use in taxes and subsidies.

Carbon taxes and clean energy subsidies are implemented for a range of reasons, and many different approaches are used to set tax and subsidy rates. One approach gaining momentum in the United States is to set these rates based on the US government's Central estimates of the social cost of carbon (SC-CO_2),[1] which is often referred to as the best estimate of climate damages from one ton of carbon dioxide (CO_2) emissions.[2] Prominent examples include federal carbon tax proposals in the US Senate and House of Representatives[3] and nuclear energy subsidies in New York and Illinois.

The use of the SC-CO_2 in taxes and subsidies rests on two premises:

1. Balancing the benefits and costs of emissions reductions, which is the intent of the SC-CO_2 in this context, is a valid approach for putting a price on CO_2 emissions.
2. The US government's Central SC-CO_2s are the best available CO_2 prices that balance the benefits and costs of emissions reductions.

This paper takes the first premise as a given and focuses on the second. Five approaches for setting CO_2 prices based on the benefits and costs of reducing CO_2 emissions are introduced and compared across three desired attributes for such a metric. Three of these approaches involve detailed monetary estimates of climate damages—that is, they estimate a social cost of carbon. The last two approaches estimate the CO_2 prices needed to achieve emissions targets at the lowest possible cost. The US government SC-CO_2 estimates have none of the three desired attributes, whereas alternative approaches have up to two.

The purpose of this paper is not to recommend an approach for setting carbon tax or clean energy subsidy rates and certainly not to tell countries how to develop their overall climate policy strategies. After all, the right policies for a given jurisdiction may depend on a host of factors that are outside the scope of current SC-CO_2 estimates, such as local air pollution, energy security, interactions with existing policies, the expected actions of other jurisdictions, and perhaps most importantly, political viability.

However, SC-CO_2 estimates are being used to set tax and subsidy rates, which indicates an appetite on the part of some policy makers for setting CO_2 prices based on the global benefits and costs of reducing CO_2 emissions. Part 1 of this series described a host of problems (summarized later) with using the US government's Central SC-CO_2 estimates for this purpose. If less-problematic metrics can accomplish the same goal, policy makers should be aware of these alternatives.

Desired Attributes

The SC-CO_2s or alternative CO_2 prices used to set tax or subsidy rates would ideally have the three attributes described below. Consistent with the scope of the SC-CO_2, these attributes relate only to the benefits and costs of greenhouse gas (GHG) emissions reductions, disregarding many other important factors that may influence the desired tax or subsidy rate.

Attribute 1

The approach identifies the CO_2 prices that equalize the marginal benefits and costs of emissions reductions—that is, it is designed to produce optimal CO_2 prices. Near-zero carbon prices are an insufficient response to climate risks, and carbon prices of thousands of dollars per ton would cause excessive economic harm. In theory, the CO_2 prices that perfectly balance the benefits and costs of emissions reductions are somewhere in the middle. Economists assume that, at any given time, as the level of emissions reductions grows, the costs of each additional ("marginal") ton increases, while the benefits from reducing emissions by an additional ton is relatively flat or decreasing.[4] Under these assumptions, there is a level of emissions reductions whereby the cost to society of an additional ton of reductions is equal to the benefits. Ignoring truly heroic practical challenges, the approach should be designed to identify these optimal CO_2 prices that balance benefits and costs. Economists call these Pigouvian tax levels.[5]

Attribute 2

The CO_2 prices are consistent with a successful global response to climate risks—that is, the approach produces defensible outcomes. The promise of Pigouvian taxes is that when CO_2 prices are set at levels that balance the benefits and costs to society, market behavior will change in ways that produce optimal emissions outcomes. While there is little agreement on precisely what future global emissions outcomes should look like, as a sanity check, the global emissions and climate outcomes associated with the CO_2 prices should not be clearly outside the range of what the policy makers proposing these CO_2 prices would support.

Of course, this is complicated by the fact that any individual climate policy will have only indirect and limited impacts on global emissions and climate outcomes. Still, the use of the SC-CO_2 to set tax and subsidy rates rests on the assumption that jurisdictions should act as if the rest of the world acts accordingly, so the same standard is applied to all approaches considered in this paper.[6]

Attribute 3

An objective and transparent analysis can identify a range of CO_2 prices that is sufficiently narrow to be useful for setting tax and subsidy rates—that is, the approach produces a

useful range of estimates. In some contexts, an approach that produces a wide range of CO_2 prices can be useful to policy makers. For example, air quality regulations are often informed by benefit-cost analyses, and regulators can make use of a large range of potential benefits from avoided GHG emissions in deciding where to set an air quality standard.

In contrast, for policy makers setting tax and subsidy rates solely on the basis of the benefits and costs of GHG emissions reductions, single dollar-per-ton values are needed. No approach produces CO_2 prices that are devoid of uncertainty, but, for example, an approach that produces a range from $20 to $30 per ton is far more useful to policy makers than a range from $20 to $200 per ton. Put another way, if the approach can be used to justify policies of dramatically different stringency levels (e.g., weak or strong climate policies), it does not produce a range of CO_2 prices that is useful to policy makers setting tax and subsidy rates.

Evaluation of the US Government SC-CO_2 and Four Alternatives for Use in Taxes and Subsidies

Five approaches for estimating CO_2 prices are identified, described, and evaluated across the three attributes introduced in the previous section. Characterizing whether a global emissions trajectory is "defensible" or a range of CO_2 prices is "useful" requires subjective assessments. Readers may disagree with the characterizations made in this section and therefore draw different policy conclusions.

Approach 1: US Government SC-CO_2s

The recently proposed carbon taxes and clean energy subsidies with rates based on the SC-CO_2 rely on estimates produced by the US government under President Obama (USG SC-CO_2s). The US government approach involves a combination of the following:

- socioeconomic projections of global population levels, macroeconomic outcomes, and GHG emissions for centuries into the future;
- climate models that translate the future GHG emissions trajectory into temperature changes and other impacts on the climate;
- "damage functions" that provide monetary estimates of the impacts of climate change on the economy and human welfare; and
- economic methods that aggregate centuries of impacts into a single value representing the benefits of emissions reductions.[7]

When the US government last updated its estimates in 2016, it produced four sets of USG SC-CO_2 estimates that span a range from about $15 to $150 per metric ton of CO_2 emissions in 2020 and increase gradually over time.[8] The interagency group that developed these estimates did not point to a single "best estimate," instead emphasizing the importance of using the full range of USG SC-CO_2 estimates in policy applications.[9] Indeed, the full range of USG SC-CO_2 estimates has been used by federal agencies to evaluate the benefits of CO_2 reductions caused by proposed regulations.[10]

Attribute 1

Is the US government SC-CO_2 approach designed to produce optimal CO_2 prices? **No.**

The US government's approach starts with a projection of future emissions[11] and then estimates the climate damages caused by an additional ton of CO_2 emissions. It does not explicitly consider the costs of emissions reductions. This is a theoretically sound approach for the purpose the USG SC-CO_2s were developed: estimating the benefits of emissions reductions from a policy that is not expected to significantly change future global emissions outcomes.[12]

But the US government approach would produce different climate damage estimates (and thus different SC-CO_2 estimates) with different assumptions about future emissions. To understand why, consider two scenarios: in one, the world has warmed by 5°C by 2100; in the second, the world has warmed by just 2°C by 2100. Because CO_2 remains in the atmosphere for centuries, the benefit of CO_2 reductions today is larger in the 5°C scenario, because far more future climate damages are avoided when future warming is higher.

In contrast, and as explained further below, optimal/Pigouvian CO_2 prices are based on the (theoretical) single global emissions pathway that balances the benefits and costs of achieving emissions reductions.[13]

Attribute 2

Does the US government SC-CO_2 approach produce defensible outcomes? **Unclear.**

Because the USG SC-CO_2s reflect an estimate of climate damages associated with an assumed emissions pathway, the US government's approach is unique among the five considered in this paper in not involving an estimate of the emissions pathway associated with the implementation of these CO_2 prices. That makes this categorization tricky.

Models of the economy and energy system can be used to estimate the emissions outcomes associated with CO_2 prices, but such models cannot be relied upon to forecast emissions levels decades or centuries into the future, because we cannot forecast influential variables like innovation and economic growth over these time periods. In other words, if the USG SC-CO_2 were adopted as a global CO_2 price for the remainder of the century, global emissions would undoubtedly fall, but we do not have a good grasp on how much.

Attribute 3

Does the US government SC-CO_2 approach produce a useful range of estimates? **No.**

Federal government agencies have used the wide range of USG SC-CO_2 estimates as input to cost-benefit analyses for major regulations. In contrast, setting tax and subsidy rates requires single annual dollar-per-ton values. When policy makers set tax and subsidy rates based on the USG SC-CO_2s, they have used the US government's Central SC-CO_2 estimates (about $50 per ton of CO_2 emitted in 2020), despite the US government's recommendation to use its full range rather than any single estimate.

As part 1 of this series explained in some detail, the US government's Central SC-CO_2s are not meaningful single estimates of the benefits of emissions reductions. Various categories of climate change impacts are extraordinarily difficult to estimate in monetary terms, and some, like ocean acidification or the potential for natural resource–related conflicts among nations, are omitted altogether from USG SC-CO_2 estimates. Some omitted impacts would push the SC-CO_2 higher, and others would push it lower, and there is no reason to suspect these omitted positive and negative impacts are either small or would cancel each other out.

In addition, the USG SC-CO_2 estimates are heavily influenced by moral judgments for which the tools of science, economics, and statistics are incapable of providing a "best" or single value. Consider one example: the benefits of avoiding civilization-threatening risks to future generations. Since we care about their welfare, avoiding possible harm to our descendants clearly provides us with some benefit, but how much? For "normal" risks, economists may estimate these benefits using data from insurance or other markets. But no market data tells us the value of avoiding catastrophic intergenerational risks. Instead, the academics/analysts that produce SC-CO_2 estimates commonly select a single assumption for "societal risk aversion" and argue for its reasonableness in the face of uncertainty (the US government chose the rather extreme assumption of zero societal risk aversion, or "risk neutrality"[14]). But different "reasonable" assumptions can produce SC-CO_2 estimates that differ by hundreds of dollars per ton.[15]

In theory, for every moral judgment that influences the SC-CO_2 (the discount rate, aversion to risk, aversion to inequality, etc.), policy makers could provide transparent guidance to analysts so that SC-CO_2 estimates would reflect the combination of these various judgments.[16] But this has not happened in practice. Instead, the analysts/academics that produce the SC-CO_2 estimates are making the moral judgments that determine the stringency of climate policies. Even worse, policy makers may be influencing these modeling decisions and producing SC-CO_2 estimates that reflect predetermined policy stringencies.

Approach 2: Optimal SC-CO_2s

Academic economists have produced estimates of the SC-CO_2 with a different methodology than the US government used to produce the USG SC-CO_2s.[17] Instead of starting with an assumed pathway of future emissions, this approach involves estimating an "optimal emissions pathway" that balances the cost and benefits of emissions reductions and the CO_2 prices consistent with this emissions pathway ("Optimal SC-CO_2s").

Otherwise, this approach is identical to the US government's, relying on climate models that translate emissions into climate outcomes, damage functions that translate climate outcomes to economic outcomes, and a method of translating centuries of economic impacts into a single value representing the net benefits of emissions reductions. A recent study by the Electric Power Research Institute (EPRI) shows that when identical assumptions and models are used to estimate both USG SC-CO_2s and Optimal SC-CO_2s, the estimates are similar in the near term (within $10 per ton), but Optimal SC-CO_2s can be significantly lower in future years.[18]

Attribute 1

Is the Optimal SC-CO_2 approach designed to produce optimal CO_2 prices? **Yes, by definition.**

Attribute 2

Does the Optimal SC-CO_2 approach produce defensible outcomes? **No.**

Like the previous approach, we do not know the future emissions levels that would result from implementing global CO^2 prices at the level of the Optimal SC-CO^2s. But, unlike the USG SC-CO_2s, the Optimal SC-CO^2s are explicitly tied to future emissions levels in the models that produce them in other words, the optimal prices and optimal emissions levels are a package deal.

The future emissions levels produced by the Optimal SC-CO_2 approach are not in the ballpark of the emissions outcomes supported by most policy makers and experts concerned with climate change. For example, a recent study by Yale economist William Nordhaus, who developed the most prominent model that produces Optimal SC-CO_2s (called DICE), shows global emissions increasing until around 2050 and not falling near zero until well after 2100. Nordhaus' model shows global average temperatures of 3.5°C above preindustrial levels by 2100 and continuing to rise after that.[19] This degree of warming would be catastrophic to some island nations and other vulnerable regions of the world, and it is roughly double the international community's target of well below 2°C.

What accounts for this divergence between real-world targets and the outcomes associated with Optimal SC-CO_2s? The most obvious explanation is that SC-CO_2 estimates omit many important benefits of limiting climate change,[20] so they are naturally associated with relatively weak emissions targets. Another possible explanation is that the international community is not properly balancing the benefits and costs of emissions reductions in setting targets. However, unless and until more comprehensive SC-CO_2 estimates can be credibly produced, experts and policy makers concerned with climate change are unlikely to take these estimated "optimal" emissions levels seriously.

Attribute 3

Does the Optimal SC-CO_2 approach produce a useful range of estimates? **No.**

For the same reasons as the previous approach, the Optimal SC-CO_2 approach does not produce a range of CO_2 price estimates that is useful to policy makers setting taxes or subsidy rates. In fact, the need to estimate the optimal global emissions pathway that balances marginal benefits and costs may add significant additional challenges and uncertainties.

Approach 3: Best Conceivable Future Optimal SC-CO_2s

In 2017, the National Academy of Sciences, Engineering, and Medicine (NAS) completed a multiyear effort to analyze the methodology used to produce the USG SC-CO_2s and provided extensive recommendations for how this approach can be improved.[21] While the Trump administration has abolished the interagency group that developed the USG SC-CO_2s,[22] experts from nongovernment organizations and academia have taken up the mantle in implementing the recommendations of the NAS.[23]

Along with the broader work of the scientific community, such efforts will undoubtedly lead to improvements in SC-CO_2 estimates. It is therefore worth considering how the evaluation of the Optimal SC-CO_2 approach might change in the future, assuming efforts to improve these models are highly successful (thus producing highly speculative "Best Conceivable Future Optimal SC-CO_2s").

Attribute 1

Is the Future Optimal SC-CO_2 approach designed to produce optimal CO_2 prices? **Yes, by definition.**

Attribute 2

Will the Future Optimal SC-CO_2 approach produce defensible outcomes? **Maybe.**

Improvements to scientific data and statistical methods could enable this approach to produce emissions pathways that policy makers and experts consider defensible. Implementing the NAS recommendations for improvements to the SC-CO_2 is an important step in this direction. For example, the NAS provided detailed recommendations for developing a "surface ocean pH component within the climate module" that would be an important (though not nearly final) step toward developing credible estimates of the damages from ocean acidification caused by climate change, currently omitted from USG SC-CO_2 estimates.[24] Some climate impacts will always be extremely difficult to put into credible monetary terms, and it is impossible to know what progress will be made. In a "best conceivable" future, perhaps human ingenuity should be given the benefit of the doubt.

Attribute 3

Will the Future Optimal SC-CO_2 approach produce a useful range of estimates? **Unlikely.**

Human ingenuity has its limits. The uncertainties associated with monetary estimates of climate damages and the moral judgments on how to value those damages are massive. It is difficult to imagine an objective and transparent analysis identifying a range of CO_2 prices that is sufficiently narrow to be useful for setting tax and subsidy rates. Realistically, a wide range of SC-CO_2 estimates is the best we can do.

None of the three approaches described thus far received perfect grades, which means the use of the social cost of carbon in tax and subsidies requires policy makers to compromise on at least one desirable attribute for such a metric. Other approaches that require compromises are worth considering as well.

The following two approaches make a compromise at the outset: while they are informed by the benefits of limiting climate change, they make no attempt to estimate these benefits in monetary terms and therefore no attempt to identify an optimal CO_2 price.

Approach 4: CO_2 Prices to Achieve a Net Zero Emissions Target

Everyone reading this is likely aware of the international community's climate change mitigation goals: holding the increase in the global average temperature to well below 2°C above preindustrial levels, pursuing efforts to limit the temperature increase to 1.5°C above preindustrial levels, and achieving net zero GHG emissions in the second half of this century.[25]

National and subnational climate change goals often come in the form of emissions targets that are arguably consistent with these global goals. For example, the Obama administration put forth a US emissions target for 2025 and described a long-term emissions pathway to 2050.[26]

Despite the focus of the international climate community on emissions targets, the drawback of emissions targets is that they are typically influenced as much by politics as by the best science and economics.

But it does not have to be so. An emissions target can be chosen based solely on the benefits and costs of GHG reductions. For policy makers who wish to set taxes and subsidies based on the benefits and costs of GHG reductions, an alternative to using estimates of the SC-CO_2 is to set an emissions target that is informed by the benefits and costs of reducing GHGs and then to estimate the CO_2 prices needed to achieve that target at the lowest possible cost.[27]

Detailed models of economic and energy systems can be used for this purpose.[28] These models translate CO_2 prices into changes in market prices across the economy. Then, they forecast the extent to which producers and consumers will shift to less carbon-intensive actions due to the price changes.

In this context, a net zero CO_2 emissions target is particularly attractive. After all, limiting warming to any level requires the world to achieve net zero CO_2 emissions,[29] which means, on average, every jurisdiction needs to achieve net zero emissions. Like estimating a social cost of carbon for use in taxes and subsidies, choosing a net zero date requires various moral judgments, including the responsibility of one generation to the next.

After evaluating this and the following approach across the same three attributes, we can weigh their pros and cons against the use of the social cost of carbon in taxes and subsidies.

Attribute 1

Is the Net Zero Emissions Target approach designed to produce optimal CO_2 prices? **No.**

A net zero emissions target can be informed by the benefits of emissions reductions, but the approach makes no attempt to balance the marginal benefits and costs of emissions reductions (in a sense, it is the opposite of the US government's approach to estimating SC-CO_2s, which focuses on benefits and considers costs only indirectly).

Attribute 2:

Does the Net Zero Emissions Target approach produce defensible outcomes? **Yes.**

While experts and policy makers disagree on the needed pace of decarbonization, virtually everyone concerned about climate change agrees that global temperatures eventually need to be stabilized (i.e., warming needs to stop), or else future generations will be condemned to intolerable risks. That means achieving net zero CO_2 emissions.

Still, whether this approach leads to a defensible emissions/climate outcome depends on the date that is chosen to achieve net zero. Under the Paris agreement, the international community agreed to achieve net zero GHG emissions before 2100, and the estimated consequences of various global net zero dates are widely published by experts (e.g., recent modeling suggests that global net zero emissions by 2060 is needed to keep the world on a most likely pathway of 1.75°C of warming[30]). Defensible net zero target dates will differ by jurisdiction, consistent with the broadly accepted principle of "common but differentiated responsibilities" to address the risks of climate change.

If policy makers choose emissions targets that are consistent with these global targets and equity principles, the CO_2 prices developed using this approach will be associated with defensible emissions outcomes.

Attribute 3:

Does the Net Zero Emissions Target approach produce a useful range of estimates? **No.**

The range of uncertainty associated with the CO_2 prices needed to achieve net zero is narrower than the range associated with SC-CO_2 estimates. After all, modeling the economy of one jurisdiction over a handful of decades is inherently easier than modeling the climate and economy of the world over centuries.

Still, for an emissions target that is many decades into the future or more, models of the current energy system and economy are of limited use, because their results are too heavily influenced by factors like consumer preferences and technological progress that are impossible to predict decades in advance. As a recent Stanford Energy Model Forum exercise concluded, "[2050 CO_2 prices] likely say more about the difficulties the models have achieving these targets than the actual prices that will be needed."[31]

Consider one future world with technological breakthroughs that dramatically reduce the costs of clean energy by midcentury, and an alternative future with breakthroughs in fossil fuel extraction technologies over that period. Far lower CO_2 prices would be needed in the former world compared to the latter. An objective analysis would therefore produce a wide range of CO_2 prices that span dramatically different policy stringency levels.

Approach 5: CO2 Prices to Achieve a Near-Term Trajectory to Net Zero

Like the prior approach, this involves setting a date to achieve an emissions target that is informed by the benefits and costs of reducing GHGs: preferably a net zero CO_2 emissions target. Then, instead of attempting to estimate the CO_2 prices needed to get all the way to net zero, the "Near-Term to Net Zero" approach involves selecting a near-term emissions target (i.e., a decade or less) on the pathway to the net zero goal.

Energy/economic models can be used to estimate the CO_2 prices that are needed to achieve this near-term target at the lowest possible cost. Importantly, despite the focus on the near-term, producers and consumers across the economy would be cognizant of the long-term emissions target and its potential implications for future policy (both in the real-world and in the modeling exercise).

Then, every few years, the jurisdiction can undertake the same process again. The CO_2 price pathway would be revised and extended, capturing the most up-to-date information available.

Consider one example, in which the United States sets a net zero date for 2060 and a near-term target of 28 percent below 2005 emissions levels by 2025. A model of the US economy and energy system can be used to estimate the minimum economy-wide carbon prices between 2020 and 2025 that achieve this near-term target.

The Near-Term to Net Zero approach has not been used to set carbon tax or clean energy subsidy levels. For example, the United Kingdom has a long-run emissions reduction target of 80 percent by 2050 and implements policies to achieve carbon budgets over five-year periods.[32] California also has a target of 80 percent emissions reductions by 2050, and it has implemented a cap-and-trade program and other policies designed to achieve 40 percent reductions by 2030.[33]

Attribute 1

Is the Near-Term to Net Zero approach designed to produce optimal CO_2 prices? **No.**

Attribute 2

Does the Near-Term to Net Zero approach produce defensible outcomes? **Yes.**

As noted earlier, a net zero target is highly defensible if the net zero date is consistent with global targets and equity principles. The near-term target is also defensible if policy makers can credibly argue that it puts the jurisdiction on a pathway to achieving its net zero target.

The example given above contemplates a roughly straight-line pathway of annual CO_2 emissions for the United States from current emissions levels to the net zero target, which is perhaps the most straightforward approach. For various reasons, jurisdictions may prefer an emissions pathway with a different shape. However, near-term targets that contemplate a less ambitious emissions pathway compared to the straight-line pathway would be more difficult for policy makers to defend, because they would have the appearance of a weak target for political convenience.

Attribute 3

Does the Near-Term to Net Zero approach produce a useful range of estimates? **Yes.**

Energy and economic systems are far more stable over a handful of years than over decades or centuries. After all, while new energy technologies are continuously being developed, energy transitions are notoriously slow, and the responses of producers and consumers to the carbon tax can be approximated by their historical responses to similar price changes.[34] Models of the energy system and economy can therefore provide an indication of the likely effects of CO_2 prices on emissions over short time frames.

This does not mean the uncertainty associated with near-term energy/economic modeling is negligible or even small—indeed, the projections of most widely used energy/economic models in the United States have missed the mark by wide margins in recent decades due to the unexpected and rapid progress of technologies like solar and shale oil and gas.

Still, using best-in-class modeling tools and forecasts, this approach can arguably produce a range of CO2 price estimates that is sufficiently narrow to be useful to policy makers setting tax and subsidy rates. At a minimum, the uncertainty is small relative to the previous four approaches.

Summing Up: Advantages of Near-Term to Net Zero

Part 1 of this series described a host of concerns with setting tax and subsidy rates based on the US government's Central estimates of the social cost of carbon, including the vulnerability of these policies. It concluded with the question posed in the title of this essay: Can we do better?

The table below summarizes the characterizations of five approaches for estimating CO_2 prices across three desirable attributes. The US government Central SC-CO_2 estimates have none of the three desired attributes, while alternatives have one or more.

In particular, the Near-Term to Net Zero approach offers important advantages over current SC-CO_2 estimates (produced by the US government or otherwise). First, policy makers implementing these CO^2 prices can credibly argue that covering all global emissions with the same approach would lead to a successful global response to climate risks, which is about the best an individual policy maker can do. In contrast, the emissions outcomes associated with the US government's approach are unclear, and other current SC-CO_2 estimates are associated with global emissions pathways that are far outside the range of defensible outcomes.

Second, using the Near-Term to Net Zero approach, only a few transparently selected dates (a near-term target and net zero date) are needed to produce a relatively narrow range of CO_2 prices that can inform policy makers setting tax and subsidy policies. In contrast, we cannot produce a useful range of SC-CO_2 estimates without significant improvements in our ability to quantify the benefits and costs of limiting climate change—and without making numerous moral judgments as inputs to the analysis.

	Approaches for Estimating CO_2 Prices[1]				
	US Gov't SC-CO_2s	Optimal SC-CO_2s	Future Optimal SC-CO_2s	Net Zero Targets	Near-Term to Net Zero
Is the approach designed to produce optimal CO_2 prices?	No	Yes	Yes	No	No
Does the approach produce defensible outcomes?	Unclear	No	Maybe	Yes	Yes
Does the approach produce a useful range of estimates?	No	No	Unlikely	No	Yes

[1] These approaches are limited in scope to factors that contribute to estimates of the social cost of carbon—i.e., the benefits and costs of reducing GHG emissions.

All five approaches have drawbacks—including the omission of political considerations and many other important factors that influence the appropriate CO_2 prices for a given jurisdiction—and the Near-Term to Net Zero approach is no exception. It does not identify an "optimal" emissions pathway, and, unlike the social cost of carbon, it does not estimate CO_2 prices that reflect all available information about long-term benefits and costs of emissions reductions.

In defense of this more limited scope, responding to climate change is not like fixing a broken car, with a mechanic that understands each step of the process and how the final product should look.[35] Instead, climate policies involve highly complex, uncertain, and dynamic systems. The presumption that today's CO_2 prices should reflect a start-to-finish solution to the climate problem may give disproportionate influence to the most uncertain aspects of the climate problem. Instead, like the doctor who tells her patient to take two pills and call her in the morning, a humbler approach to developing CO_2 prices could enable a focus on the aspects of the problem that we understand well and a willingness to adjust our strategies as we learn more.

In Defense of Policy Makers Using US Government SC-CO2s in Taxes and Subsidies

Despite the potential advantages of alternative approaches, policy makers are increasingly using the USG SC-CO_2s in taxes and subsidies, and it is easy to see why. The US government estimates were produced by renowned experts,[36] they have been widely used in regulatory analyses and academic studies, and they have survived challenges in federal courts (albeit in a different context).[37]

For the other approaches described in this paper, no off-the-shelf estimates exist with the gravitas of the US government SC-CO_2s.[38] Instead, to produce CO_2 prices using these other approaches, policy makers would need to do the analysis themselves or select a study from the literature to rely upon. I am unaware of any estimates of CO_2 prices using the Near-Term to Net Zero approach.

Simply put, the US government SC-CO_2s may not be the best possible estimate of CO_2 prices that balance the benefits and costs of emissions reductions, but they may be the best available estimate. The next installment of this series will attempt to change that, by providing initial empirical estimates and guidance for setting tax and subsidy rates using the Near-Term to Net Zero approach.

About the Author

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Notes

1. The US government SC-CO_2 estimates referred to in this essay are those produced by the Obama administration. The Trump administration has used different SC-CO_2 estimates in rulemakings for federal regulations, but the recent use of SC-CO_2s in taxes and subsidies have all involved the Obama administration estimates.

2. Revesz et al. 2017. "Best cost estimate of greenhouse gases." Science Letters. Vol. 357, Issue 6352, pp. 655; DOI: 10.1126/science.aao4322.

3. The US Senate proposal is the American Opportunity Carbon Fee Act, cosponsored by Senators Whitehouse and Schatz; the most recent version, released in February 2018, was also sponsored by Congressmen Earl Blumenauer (D-OR) and David Cicilline (D-RI). The US House of Representatives proposal is the America Wins Act, introduced by Representative Larson (CT) in late 2017 and cosponsored by 16 Democrats.

4. To understand why marginal benefits may decrease as emissions reductions increase, it is helpful to consider extreme scenarios. When future emissions levels are very high, climate outcomes are very bad, so emissions reductions produce relatively large benefits. Alternatively, if future emissions levels are near zero, climate outcomes are not as bad, so an additional ton of avoided emissions produces relatively lower benefits.

5. Named after Arthur Cecil Pigou, the economist credited with introducing the concept of taxing activities that involve negative externalities so that producers and consumers properly account for the full social costs of these activities.

6. More precisely, this is the assumption underlying the use of a "global" SC-CO_2 estimate. Some have proposed alternative SC-CO_2s that do not account (or fully account) for the benefits that accrue outside of a given jurisdiction. However, the SC-CO_2 estimates that are the focus of this paper (i.e., the SC-CO_2s produced by the Obama administration that are being used to set tax and subsidy rates) are global SC-CO_2 estimates.

7. For further information about these models, see National Academies of Sciences, Engineering, and Medicine, Valuing Climate Damages: Updating Estimation of the Social Cost of Carbon Dioxide (Washington, DC: the National Academies Press, 2017): doi: https://doi.org/10.17226/24651.

8. These values have been adjusted to today's dollars. The annual increase is about 2 percent in real terms (not accounting for inflation). The differences among the four sets of estimates come from changes in the discount rate (between 2.5 and 5 percent), as well as one scenario that considers much higher than expected damage levels.

9. Interagency Working Group on Social Cost of Carbon, "Technical Support Document: Social Cost of Carbon for Regulatory Impact Analysis under Executive Order 12866," US Government, February 2010, page 3.

10. "Applying the Social Cost of Carbon: Technical Considerations." Electric Power Research Institute. July 2016. https://www.epri.com/#/pages/product/3002004659/.

11. The US government essentially assumes global CO_2 emissions double between 2010 and 2100. Taking an average of the five emissions scenarios used by the US government, CO_2 emissions from fossil and industrial sources increase from 31.1 Gt/year in 2010 to 62.8 Gt/year in 2100. For details, see Interagency Working Group on Social Cost of Carbon, "Technical Support Document," 16.

12. In its 2010 report, the interagency working group that produced the USG SC-CO_2s noted, "The purpose of the 'social cost of carbon' estimates presented here is to allow agencies to incorporate the social benefits of reducing carbon dioxide emissions into cost-benefit analyses of regulatory actions that have small, or 'marginal,' impacts on cumulative global emissions."

13. For a more detailed explanation, see S. Rose, "Carbon Pricing and the Social Cost of Carbon," Electric Power Research Institute, Discussion Paper 3002011391, December 2017.

14. The US government's highest of its four SC-CO_2 estimates (the SC-CO_2 calculated at the 95th percentile of damage estimates) was developed in part due to the need to incorporate aversion to severe downside risks in its range of SC-CO_2 estimates. However, the US government's highest SC-CO_2 scenario has not been used to inform tax or subsidy rates. Instead, only the Central USG SC-CO_2 has been used, which assumes risk neutrality.

15. Kaufman, "The Bias of Integrated Assessment Models That Ignore Climate Catastrophes," Climatic Change 110 (2012): 575, https://doi.org/10.1007/s10584-011-0140-7.

16. The US government has provided guidance on discount rates to use in policy analysis, in documents like the OMB Circular A-4 and EPA's Guidelines for Economic Analysis. However, notably, the guidance has been for a relatively wide range of discount rates, and the interagency working group that produced the USG SC-CO_2 relied on a range of social discount rates (between 2.5 to 5 percent) that produces a wide range of SC-CO_2 estimates.

17. Academic economists that have produced SC-CO_2 estimates include William Nordhaus of Yale University, Richard Tol of the University of Sussex, Chris Hope of the University of Cambridge, and David Anthoff of the University of California, Berkeley, among many others.

18. Future Optimal SC-CO_2s are lower because the economically efficient emissions trajectory falls well below a "business-as-usual" trajectory, and the benefits of reducing GHG emissions are larger when emissions are higher, because that means the avoided climate damages are higher too. This divergence in future emissions levels affects current SC-CO_2 estimates as well, and if lower discount rate were used by EPRI (so that future damages are more highly valued today), current Optimal SC-CO_2 may have been significantly below current USG-CO_2s as well. For more, see Rose, "Carbon Pricing and the Social Cost of Carbon."

19. Nordhaus, William D. "Projections and Uncertainties About Climate Change in an Era of Minimal Climate Policies." NBER Working Paper No. 22933. September 2017. http://www.nber.org/papers/w22933

20. See part 1 of this series for details.

21. National Academies of Sciences, Engineering, and Medicine, Valuing Climate Damages.

22. "Presidential Executive Order on Promoting Energy Independence and Economic Growth." March 28, 2017. https://www.whitehouse.gov/presidential-actions/presidential-executive-order-promoting-energy-independence-economic-growth/.

23. See RFF's Social Cost of Carbon Initiative at http://www.rff.org/research/collection/rffs-social-cost-carbon-initiative.

24. National Academies of Sciences, Engineering, and Medicine, *Valuing Climate Damages*.

25. These goals are outlined in the 2015 Paris agreement signed by all major countries. Regarding "net zero GHG emissions," the actual language from the agreement is this: "A balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases in the second half of this century, on the basis of equity, and in the context of sustainable development and efforts to eradicate poverty" (article 4).

26. For 2025, in its Intended National Determined Contribution, the Obama administration put forth an economy-wide target of reducing its greenhouse gas emissions by 26–28 percent below its 2005 level. See http://www4.unfccc.int/ndcregistry/PublishedDocuments/United%20States%20of%20America%20First/U.S.A.%20First%20NDC%20Submission.pdf. The long-term pathway to 80 percent reductions or more below 2005 levels was outlined in the United States Mid-Century Strategy for Deep Decarbonization. See https://unfccc.int/files/focus/long-term_strategies/application/pdf/us_mid_century_strategy.pdf.

27. The target could be set in terms of annual emissions in a given future year, which aligns with most existing national and sub-national emissions goals. An alternative would be to set a cumulative emissions target, in which net CO_2 emissions fall to zero by a given year and total emissions between now and then are constrained to a given level. A cumulative emissions target is arguably a better match for the cumulative impact CO_2 emissions have on climate change.

28. Computable general equilibrium (CGE) models are perhaps most commonly used. But some partial equilibrium models, such as the National Energy Modeling System developed by the US Energy Information Administration, can also be used for this purpose.

29. "Can Paris pledges avert severe climate change?" Fawcett et al. Science. Volume 350, Issue 6265. December 2015. https://www.indstate.edu/cas/sites/arts.indstate.edu/files/Economics/Science-ParisClimateConf2015.pdf.

30. "IEA: World can reach 'net zero' emissions by 2060 to meet Paris climate goals." Simon Evans. Carbon Brief. June 6, 2017. https://www.carbonbrief.org/iea-world-can-reach-net-

zero-emissions-by-2060-meet-paris-climate-goals.

31. Barron et al. 2018. "Policy Insights from the EMF 32 Study on US Carbon Tax Scenarios." Climate Change Economics, Vol. 9, No. 1. https://www.worldscientific.com/doi/pdf/10.1142/S2010007818400031.

32. Information about the UK emissions targets and carbon budgets can be found at: https://www.theccc.org.uk/tackling-climate-change/reducing-carbon-emissions/carbon-budgets-and-targets/.

33. Information about California climate change policy can be found at: https://www.arb.ca.gov/cc/scopingplan/scopingplan.htm.

34. In some cases, the response to carbon taxes is likely be significantly different from the responses to price changes caused by other factors. For example, consumers of gasoline in British Columbia have been roughly three times more responsive to the price changes caused by the carbon tax than to everyday price changes. However, analysts can improve models to take such differential responses into account. See: Lawley, Chad and Vincent Thivierge. "Refining the Evidence: British Columbia's Carbon Tax and Household Gasoline Consumption." April 2018 The Energy Journal 39(2):35-61.

35. This analogy was inspired by the Econtalk podcast with Russ Roberts and Vincent Rajkuma, available here: http://www.econtalk.org/archives/2018/04/vincent_rajkuma.html.

36. The original group was led Michael Greenstone, then the chief economist for President Obama's Council of Economic Advisers, and included numerous experts from government and academia.

37. See part 1 for details.

38. The World Bank's High Level Commission on Carbon Prices identified a range of global CO_2 prices needed to achieve a two-degree trajectory: $40–80 per ton of CO2 by 2020 and $50–100 per ton by 2030. See https://static1.squarespace.com/static/54ff9c5ce4b0a53decccfb4c/t/59b7f2409f8dce5316811916/1505227332748/CarbonPricing_FullReport.pdf. Chen and Hafstead (2017) develops carbon tax estimates for the United States to achieve its international emissions pledges. See http://www.rff.org/files/document/file/RFF-DP-16-48.pdf.

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