Does the Social Cost of Carbon Matter?: Evidence from U.S. Policy

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Abstract

We evaluate a recent U.S. initiative to include the social cost of carbon (SCC) in regulatory decisions. To our knowledge, this paper provides the first systematic analysis of the extent to which applying the SCC has affected national policy. We examine all economically significant federal regulations since 2008, and obtain an unexpected result: putting a value on changes in carbon dioxide emissions does not generally affect the ranking of the preferred policy compared with the status quo. Overall, we find little evidence that using the social cost of carbon has mattered for the actual choice of policy in the U.S. This is true even for policies explicitly aimed at reducing carbon dioxide emissions. We offer some possible explanations for the patterns observed in the data.

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1. Introduction

Economists have long supported policies that incentivize individuals and organizations to consider the full costs of their actions on society (Coase, 1960). This is particularly true where there may be large divergences between private and social costs, as is the case with many environmental problems. Almost a century ago, Pigou (1920) argued that one way to appropriately incentivize economic agents to consider the full costs of their actions is to impose taxes on activities that fully reflect their marginal damages to society.

In the case of climate change, a growing number of economists have argued for introducing market-based mechanisms, such as taxes or cap-and-trade systems, as ways of limiting greenhouse gas emissions (Anthoff *et al*., 2011b; Metcalf and Weisbach, 2009; and Stavins, 2007). These mechanisms have been tried in various places, notably Europe, with varying degrees of success (Ellerman and Buchner, 2007).

Absent an economy-wide incentive scheme, governments can account for greenhouse gas emissions by adding a measure of the marginal damages from climate change in benefit-cost analyses. Economists have argued that such environmental damages should be explicitly included in benefit-cost analysis to the extent that they can be quantified (Arrow et al., 1996). For example, a government might consider a regulation to increase fuel economy standards for automobiles, and include the reduction in carbon dioxide (CO_2) emissions as an additional benefit that has a monetary value.

To perform such an analysis, that government would need to attach a value to a ton of CO_2 reductions. One such value is the "social cost of carbon", or SCC, which measures the monetized damages associated with emitting a specified quantity of carbon dioxide emissions into the atmosphere (*e.g.*, Nordhaus and Boyer, 2000). There has been much work on the appropriate value of the social cost of carbon (Tol, 2009, Anthoff *et al.*, 2011a, Greenstone, Kopits, and Wolverton, 2013). For example, Greenstone, Kopits, and Wolverton (2013) note that the U.S. government used a central estimate of $21 per metric ton (in 2007$) for global damages from CO_2 emissions in 2010.[1]

[1] A more recent update by the U.S. Government argues that the social cost of carbon in regulatory analysis should be at least 50 percent higher than initial estimates (Interagency Working Group, 2013). These new values for the SCC are used in analyses of regulations beginning in 2013.

While there has been much debate on the appropriate *value* of the social cost of carbon, there has been much less work on the actual *use* of the social cost of carbon in the design of policy. Watkiss and Downing (2008) examine the social cost of carbon in UK policy while Watkiss and Hope (2011) examine more broadly how the social cost of carbon is used in regulatory deliberations. Watkiss and Hope (2011) note that several countries use a "global" social cost of carbon, which incorporates damages for global carbon emissions for different regulatory activities; examples include the United States, the United Kingdom, the Netherlands, Finland, and Italy.[2] They offer a number of interesting insights on the SCC including: how its value has changed over time; the importance of SCC values in different sectors; trade-offs in using ranges and point estimates for the SCC; and examples where use of the SCC appears to have changed the results of a particular benefit-cost analysis. Kopp and Mignone (2012) examine several U.S. rules with energy efficiency standards, and offer suggestions on how the application of the SCC to regulatory policy could be improved. The analysis to date has been largely based on examples, rather than an exhaustive review of all regulations or policies. Existing studies are not designed to test the overall impact of using the SCC on a nation's policy choices. Our paper seeks to fill this gap in the literature.

The question this paper will examine is what role the social cost of carbon has played in U.S. federal regulatory policy. To our knowledge, this paper provides the first systematic analysis of the extent to which applying the social cost of carbon has affected national policy. Our sample includes the entire set of significant federal regulations that consider the social cost of carbon in the United States, beginning in 2008 – when this policy was first implemented. These regulations typically have an annual economic impact of at least $100 million.[3]

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[2] Whether or not countries *should* use a global SCC is an open question. With the exception of climate policy, most U.S. regulatory policy focuses on the impact on U.S. citizens. Perhaps this is because most U.S. regulations primarily affect its citizens. Still, other policy arenas in the U.S. that affect the welfare of citizens in other countries—such as defense, trade, and monetary policy—appear to be guided primarily by an assessment of the costs and benefits on U.S. citizens. Thus, it is not obvious why climate change should be treated differently. See Gayer and Viscusi (2014) for a recent analysis of this issue in the context of U.S. climate policy. For a formal economic model of why using the global cost of carbon is almost never optimal, see Hahn and Ritz (2013). For an ethical defense that is sympathetic to its use, see Broome (2012).

[3] We use the term "economically significant federal regulation" to denote a "significant regulatory action" as defined by Executive Order 12866. These include actions that may result in a rule that has "an annual effect on the economy of $100 million or more or adversely affect in a material way the economy, a sector of the economy, productivity, competition, jobs, the environment, public health or safety, or State, local, or tribal governments or communities" (3 C.F.R. 638).

To assess how outcomes were affected, we examine net benefit estimates provided by the U.S. government for all significant federal regulatory policies from 2008 through 2013. We consider 53 regulatory policies, with and without including estimates of the benefits associated with changes in carbon dioxide emissions. Over half of the policies we consider set energy conservation standards for commercial or residential items such as electric motors or dishwashers. Most of the remaining policies set limits on hazardous pollutants from large entities, such as petroleum refineries or electric utilities.

We examine whether inclusion of the benefits from carbon dioxide emissions changes the sign of the net benefits for each regulatory policy. We find that the social cost of carbon was used in many rulemakings. We also find that, for some rulemakings, the benefits from reducing carbon dioxide represent a significant fraction of total net benefits for the policy that was selected. However, we find the impact of including the social cost carbon on regulatory policy appears to have been limited. This finding holds for a wide range of regulations, including those rules that were explicitly motivated by climate change considerations.

Specifically, we obtain the result that including the benefits from estimated changes in carbon dioxide emissions does not generally change the sign of quantified net benefits relative to the status quo. Put differently, in almost all cases, government estimates of net benefits are positive both with and without the social cost of carbon. This finding provides support for the view that the SCC has not had a big effect on actual U.S. policy to date.

We then consider whether the SCC changes the *ranking* of different policy alternatives within a given regulatory policy based on their expected net benefits. In other words, has the SCC led to changes in the details of a regulatory policy? We find some evidence that it does change economic rankings of alternatives in a small number of cases. Whether this led to a change in the actual regulatory decision is less clear because, as we discuss below, there are many factors that go into such a decision, not simply the expected net benefits of the policy.

Based on this evidence and analysis, we argue that the SCC does not appear to have had a substantial impact on U.S. policy between 2008, when it was first used, and the beginning of 2013. We consider explanations for our finding related to the political economy of regulation. We also suggest how the government's approach to benefit-cost analysis could be modified to increase the expected net benefits associated with regulation.

The paper proceeds as follows: Section 2 presents the analytical approach, and Section 3 presents the main results. Section 4 concludes and suggests areas for future research.

2. Empirical methodology

We begin by discussing the different ways in which incorporating the social cost of carbon could affect regulatory decision-making, and the extent to which these can be measured empirically. In general, the introduction of the SCC could affect (i) the regulations that are considered, (ii) the set of alternatives that are considered in designing a regulation, (iii) the ranking of those alternatives based on estimates of net benefits (*i.e.*, the difference between benefits and costs), and (iv) the choice of a particular regulatory policy by the agency.

We cannot observe the regulations under consideration, but do not believe that introducing the SCC has had much, if any, impact on these regulations. The reason is that the regulations under consideration are generally determined by laws or court decisions that require agencies to take a regulatory action. We also cannot observe whether the specific policy alternatives considered in a regulation were affected by introduction of the SCC, but we were unable to find discussions in regulations suggesting that this factor was prominent.

However, we can observe how the SCC affected the ranking of alternatives based on net benefits for a number of regulatory policies, and we can also observe the choice of a particular regulatory policy. We discuss our approach to obtaining and analyzing this data in detail below.

Our methodological approach for assessing the impact of the SCC relies on benefit-cost analyses prepared by regulatory agencies in the United States (Hahn and Tetlock, 2008). The United States requires selected regulatory agencies to assess benefits and costs for all significant federal regulations, and to the extent possible, "propose or adopt a regulation only upon a reasoned determination that the benefits of the intended regulation justify its costs" (3 C.F.R. 638).

The search algorithm for identifying specific benefit-cost analyses involved three steps. First, we identified the set of rules in our main sample by searching for rules that included a discussion of the social cost of carbon. Second, we identified benefit-cost analyses within those rules that permitted a comparison of the policy choice made by the government with the status quo. Third, we identified benefit-cost analyses within those rules that allowed us to examine whether the relative ranking of policy alternatives changes with the inclusion of benefits from CO_2**.**

To identify rules in the main sample, we searched the U.S. *Federal Register* (which lists all regulations) for rules containing the phrase "social cost of carbon" or "social cost of

CO_2." We searched for proposed and final rules.[4] We then searched regulations.gov (which contains all supporting material for regulations) for supporting documents containing the same phrases. When we found documents that corresponded to rules not found in the *Federal Register*, we added the rules associated with these documents to our sample.

We included proposed rules in our main sample only where final rules had not been issued, because proposed rules are usually very similar to final rules. We found rules from three regulatory agencies: the Environmental Protection Agency (EPA), the Department of Energy (DOE), and the Department of Transportation (DOT).

We searched all rules for complete benefit-cost information, with and without the economic benefits of changes in CO_2 emissions included. We found 23 proposed and 29 final rules between May 2008 and April 2013 that provided an estimate of quantified benefits and costs for the policy selected by the agency.[5] Sixteen proposed rules were associated with final rules. We did not include the analyses from these proposed rules in our main sample because in most cases they were very similar to the analyses in the final rule. This left a total of 36 rules (29 plus 23 less 16) in our main sample. While we did not include the matching proposed rules in this sample, we did check these proposed rules to see that they are consistent with the findings presented below. We report these results in a sensitivity analysis.

Our main analysis compared net benefits of the policy actually selected with the status quo. Since rules often contained multiple benefit-cost estimates for a given policy, we developed a procedure for choosing between them. We have retained a fuller record of our work in an Excel spreadsheet, available upon request. The spreadsheet contains a complete list of the rules we reviewed along with explanations of our judgments about what to include.

We identified benefit-cost analyses at the *highest* level of aggregation for which the agency provided sufficient information on net benefits. We chose the highest level of aggregation to be conservative on the size of the sample. For example, we recorded

[4] A proposed rule is a regulation that that the government has proposed, but has not received final approval from the executive branch. A final rule is a regulation that the government has finalized and is scheduled to be implemented.

[5] We found one rule with no net benefits. EPA asserted that owners of electricity generating units would meet certain greenhouse-gas emissions standards even in the rule's absence, so the rule would not affect their behavior. We did not include this rule in our sample. We also found five final rules that provided incomplete information on costs and benefits. In one case, DOT was unable to estimate net benefits; in two others, DOE chose not to estimate net benefits for the policy it selected because it had eliminated all other legally permissible alternatives. In the final two cases, EPA and DOT did not discount net benefits at 3%.

fuel economy standards for heavy-duty vehicles as a single observation rather than recording separate observations for pickup trucks and vans, vocational vehicles, and tractors. This approach yielded a total of 53 benefit-cost analyses, which are summarized in Table A1 in the online appendix.

The next step in our analysis was to compare the net benefits of selected and rejected policy alternatives with one another to assess the impact of including CO_2 benefits on the ranking of policy alternatives. We first identified regulatory policies that quantified net benefits for at least two policy alternatives. In choosing particular benefit-cost analyses, we continued to follow the procedures described above. For example, we chose the benefit-cost analyses at the highest level of aggregation provided by the agency. This approach yielded a total of 202 policy alternatives for 43 policies.

We took all the information on benefits and costs in the rules as given. The only change we made to the benefit and cost estimates was to adjust all values to 2011 dollars by using the GDP Deflators published by the U.S. Bureau of Economic Analysis (2013). Rules generally used real discount rates of 3% and 7%, and we recorded both.

Values for the social cost of carbon have changed over time. We recorded the value that was used in the benefit-cost analysis. The SCC was first used in regulatory analysis in 2008. In 2009, the government assembled an interagency working group to estimate values for the social cost of carbon and help bring consistency to values used by regulatory agencies. This group issued a report in 2010. Agencies then used these SCC values to estimate the benefits from reducing CO_2 emissions for selected regulatory activities (Greenstone, Kopits, and Wolverton, 2013).

The interagency report directs agencies to use a *global* social cost of carbon, which considers the global benefits accruing to all countries combined from reducing a ton of carbon dioxide. The central value specified by the report is $21 (in 2007$) per metric ton of CO_2 emissions reduction in 2010. It increases over time to reflect the greater marginal damages of global temperature changes associated with higher temperature levels. The discount rate used for determining the central value of the social cost of carbon is 3% (Interagency Working Group, 2010).

From August 2009 until the release of the first interagency report, all agencies used a central value of $19 (in 2007$) per metric ton of CO_2 emissions reduction in 2007. Before this, each agency chose its own SCC estimates. For example, EPA once used central estimates of $68 and $40 (2006$) for a ton of emissions in 2007. DOE once used a central estimate of $33 (2007$) for a ton of emissions in 2007.

In some cases, an agency used both a global and a domestic SCC for valuation. Unlike the global SCC value, the domestic value incorporates only benefits to the U.S., and is generally much lower than the global value. In those cases where a domestic value was presented, we continued to record data on the benefits and costs for global values of the SCC. This choice is supported by the interagency report, which provides an estimate for the domestic SCC, but recommends that agencies use the global SCC in their central estimates (Interagency Working Group, 2010).

Prior to the issuance of this report, however, DOE sometimes failed to draw a clear distinction between global and domestic values for the SCC. The agency provided a range that included both, but stated that domestic values were likely to fall near the lower bound. Several rules used a range of $0 to $20. This approach made it impossible for us to separate the global estimates from the domestic ones, so we used the midpoint of the full range for our primary analysis. We also ran a sensitivity analysis in which we used the upper and lower bounds of the range.

3. Results

The quantitative analysis first examines whether use of the SCC has had an impact on the net benefits of the selected alternative compared with the status quo. It then examines whether use of the SCC has changed the relative ranking of policy alternatives, and whether this could have impacted policy.

A. Comparing the selected alternative with the status quo

A key result is that using the SCC in the regulatory analyses did not generally change the sign of the benefit-cost analysis for the selected alternative. This result is shown graphically in Figure 1, which shows the net benefits on a log scale at a 3% discount rate for the 50 benefit-cost analyses in the data set with positive net benefits (of a total of 53 analyses). The observations are ranked in terms of increasing net benefits. Regulatory policies are only reported here if they provided a net benefit calculation and if they valued CO_2 emissions changes in that calculation. In cases where a range of net benefits was presented at a 3% discount rate, we report the mid-point of those net benefits. The use of the mid-point does not affect our qualitative conclusions.

The three benefit-cost analyses we found for which net benefits were negative are not reported in this figure or Figure 2 (see below). The policies set limits on the emissions of hazardous air pollutants from commercial and institutional boilers and steam electric power generators.[6] Net benefits remained negative even after including the value of CO_2 benefits, consistent with the finding in Figure 1. EPA appears to have approved these policies because the Clean Air Act and Clean Water Act require it to establish specific types of emissions standards for sources of hazardous pollutants. These

[6] Two of these policies are from the same regulation: they define effluent limitation standards for new and existing steam electric power generators. All three policies are starred in Table A1 in the online appendix.

regulatory decisions by EPA are consistent with regulatory executive orders that require agencies to select alternatives where benefits justify costs to the extent permitted by law.

In addition to showing that the sign of the benefit-cost analysis does not change with the inclusion of CO_2 benefits, Figure 1 reveals that the SCC has to date been applied to a very wide range of regulatory policies, for which net benefits vary over several orders of magnitude. The lowest net benefit for a regulatory policy was on the order of \$10 million while a few regulatory policies had net benefits that approached \$500 billion.

Figure 2 takes the same regulatory policies shown in Figure 1, and computes CO_2 benefits as a percentage of total net benefits (but on an arithmetic scale). The CO_2 benefits average about 14% across all regulatory policies with a range of -2 to 70%. The cases for which the CO_2 net benefits are negative, but for which overall net benefits are positive, reflect a small increase in CO_2 emissions from greater energy usage. For example, the "National Emission Standards for Hazardous Air Pollutants for Major Sources" cause a slight increase in CO_2 emissions because boilers that meet the standards use slightly more energy than boilers that do not.

Instead of asking whether including CO_2 benefits changes the sign of net benefits for a particular policy, we can explore the incremental impact of including CO_2 benefits for particular policies. From the data in Figure 1, we found that CO_2 benefits account for 30% or more of total benefits in 10% of the cases (5 out of 50); and CO_2 benefits account for 20% or more of total benefits in 22% of the cases (11 out of 50). In this sense, the incremental contribution of estimated monetary CO_2 benefits is a non-trivial portion of net benefits for some policies.

We tried to explain the variation in CO_2 benefits as a percentage of total net benefits across regulatory policies. We examined whether this difference might be explained by two factors – the agency proposing the regulatory policy and the major source of benefits from that policy. The major sources of benefits for regulatory policy were broken down into three categories: health benefits from reduced exposure to pollutants, fuel savings for vehicles and planes, and energy savings for equipment other than vehicles. We found that neither of these factors is important in explaining the variation in percentages across regulatory policies.[7]

[7] We also investigated a possible relationship between total net benefits and CO_2 benefits as a percentage of net benefits. We did not find strong evidence of a relationship between net benefits and CO_2 benefits as a percentage of net benefits. For example, we regressed the percentage on levels and logarithms of total net benefits. The slope coefficient was negative and significant in the logarithmic regression, indicating that a 1% increase in total net benefits is associated (on average) with a 2%

The results for Figures 1 and 2 consider all rules that use the social cost of carbon. There are 3 rules that were explicitly motivated by climate change considerations. All are greenhouse gas emission standards for vehicles. Since each of these rules is estimated to yield substantial benefits from fuel savings for vehicle owners, each has positive net benefits before the addition of CO_2 benefits. Consequently, restricting the analysis to these rules does not change our conclusions.

We then considered the robustness of our conclusions in various dimensions, including changes in the discount rate; the level at which benefits and costs were aggregated; the use of different values for the SCC; and changes in the benefits associated with estimated fuel savings, which may be overstated.

Changes in the discount rate generally did not affect the qualitative results. We did find one class of equipment for which introducing CO_2 benefits at a 3% discount rate changed the sign of net benefits when costs and non-CO_2 benefits were evaluated at a 7% discount rate: Class B beverage vending machines. Net benefits were relatively small in both cases, however; they went from -$3 million to $9 million with the inclusion of CO_2 benefits in the calculation.

We considered whether the results shown in Figures 1 and 2 apply to policies that are evaluated at a lower level of aggregation. For example, we checked whether CO_2 benefits changed the sign of net benefits of fuel economy standards for several *subcategories* of heavy-duty vehicles. We performed the same exercise on 72 distinct disaggregated policies in the rules in our sample. In 70 of these cases, we found that the addition of CO_2 benefits did not change the sign of net benefits at a 3% or a 7% discount rate. The exceptions were vending machines and commercial air conditioning and heating equipment.

We considered what would happen if there were changes in the value of the SCC employed. In this analysis, the answer is very little because most benefit-cost analyses we examined already pass a benefit-cost analysis without the addition of CO_2 benefits, and in most cases, the CO_2 benefits were positive.

As a final sensitivity check, we considered one particular adjustment to the data regarding fuel savings, but did so using a bounding analysis. Fuel savings are a major benefit category in seven separate benefit-cost analyses included in five rules that we examined. However, there is some controversy over the correct way to account for fuel savings in certain purchases. Greenstone et al. (2013, p. 43) exclude private fuel

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reduction in CO_2 benefits as a percentage of net benefits. Alternative specifications that we tried were not statistically significant.

savings because “many consider the question of how consumers account for fuel savings in their purchase decisions an unsettled empirical question.”

Frequently, the value of fuel savings, and energy savings more generally, are based on engineering analysis. That may not be the right way to value such savings. For example, a consumer may value fuel savings from a new technology in an automobile, but she may also value other vehicle attributes, such as safety or lower emissions (Lave, 1984). If these other attributes are not taken into account in the benefit-cost analysis, then the rule may overstate the benefits by focusing on fuel savings alone.

To address the issue that the estimated benefits from fuel savings may overstate actual benefits, we performed a sensitivity analysis on our data. We assumed the benefits from fuel savings were zero, which is likely to be an extreme assumption. We examined 7 benefit-cost analyses by EPA and DOT that included fuel savings.

These analyses covered greenhouse gas emissions standards and fuel economy standards for vehicles of different weights and model years. Each cited fuel savings as the greatest benefit of the standards in question. We found only 1 analysis in which CO_2 benefits played a decisive role (once fuel savings were omitted). This analysis covered greenhouse gas emissions standards for light-duty vehicles sold in model years 2017-2025.

Another interesting issue arises with EPA greenhouse gas standards for vehicles. When issuing these standards, EPA always performed a sensitivity analysis on its own data. It assumed that the standards would be extended indefinitely and measured the net benefits through 2050. In all 3 cases, large fuel savings benefits ensured that the standards had positive net benefits before the addition of CO_2 benefits. When we excluded fuel savings benefits, however, we found that the addition of CO_2 benefits always changed the sign of net benefits. While we think this analysis is useful as a bounding exercise, we think the assumption that the same standards will be in place for such a long time period is unrealistic, and may lead to an overstatement of the benefits of those standards.

The preceding examples suggest that with a different, and perhaps more realistic, set of economic analyses, the SCC could have made a more pronounced difference in the selection of particular policies. In our conclusion below, we suggest a way of shedding light on this issue by doing independent analyses of all rulemakings.

B. The SCC and the relative ranking of policy alternatives

The analysis in Figures 1 and 2 focused on the impact of including CO_2 benefits on the policy alternative that was actually selected within each regulation. As noted above, it is possible that the inclusion of CO_2 benefits affected the relative ranking of policy alternatives that the government considered, and this change in ranking led to a change in the selection of a particular policy alternative.

We addressed this issue in two ways. First, we searched the regulatory analyses for a discussion of net benefits that would suggest that the inclusion of CO_2 benefits was an important or decisive factor in selecting the final policy. We found no such discussion in our search, which does not lend support to the notion that use of the SCC was a critical factor in decision-making. Keywords and phrases used in our search included: social cost of carbon, CO_2 emissions, and CO_2 benefits.

We also tried a quantitative approach to this problem. We searched for policy analyses of rules, and parts of rules, that provided benefit and cost information on both the selected alternative and at least one rejected alternative.[8] This exercise revealed that there is widespread *variation* across regulatory agencies in the extent to which they quantify the benefits of changes in the value of carbon dioxide emissions.

We encountered two difficulties in this exercise. First, EPA rarely provided estimates of net benefits for alternatives, and DOT rarely provided estimates of CO_2 benefits for alternatives. Even after checking regulatory impact analyses and technical support documents, we found sufficient information in only one-third of the rules issued by EPA or DOT. We found sufficient information in all of the rules issued by DOE. Consequently, our data set for this exercise was heavily biased toward rules issued by DOE.[9]

Second, agencies that did provide information on rejected alternatives often used a lower level of aggregation than they used in their presentation of selected alternatives. For example, DOE conducted three separate cost-benefit analyses for three different types of distribution transformers. Although the agency combined the three to obtain a net benefit estimate for the standards it selected, it did not do the same for standards it rejected. We addressed this problem by using the highest level of aggregation provided by the agency (*i.e.*, the level of aggregation at which the agency actually made its

[8] In many cases, these regulatory alternatives differed in terms of the stringency of the standard. For example, the four alternatives to DOE's energy conservation standards for residential clothes washers were simply more and less stringent versions of the final standards. The standards were defined in terms of energy savings and water savings targets that could be met with existing technologies that were on the market.

[9] We checked whether proposed rules contained more information on rejected alternatives than final rules did. In general, they did not. We found 38 proposed policies (36 of which were rules issued by DOE) that provided sufficient information on net benefits of rejected alternatives. We analyzed these policies, and found that they support our main qualitative findings.

decisions among various alternatives). If we had aggregated the data further, we would have lost useful information about decisions that considered a range of alternatives.

Our final data set for this exercise contained 43 policies that provided benefit and cost information on at least one rejected alternative other than the status quo and the preferred policy. Of those 43, we found 12 policies for which the inclusion of CO_2 benefits actually changed the alternative that maximized quantitative net benefits. We also found 20 of 43 policies where the inclusion of CO_2 benefits changed the relative ranking of at least 2 alternatives. This change in ranking suggests that the SCC has had some effect on the economic analysis.

Determining whether the change in ranking had an impact on the actual policy choice is more difficult. For 6 of the 12 policies where including CO_2 benefits actually changed the alternative that maximized net benefits, the alternative with the highest quantified net benefits was actually selected. On the surface, this finding might appear to lend some support for the hypothesis that CO_2 benefits were important in the final policy decision for a small, but non-trivial group of policies.

There is a problem with this conclusion, however. There is no requirement in the presidential executive order governing regulations that says the policy with the *maximum* quantifiable net benefits must be selected. Furthermore, sometimes statutes limit the scope for actually selecting the alternative that maximizes net benefits. In the case of energy conservation standards, for example, the DOE uses seven statutory factors to determine whether the benefits of an energy conservation standard exceed its burdens. Those factors are (1) the economic impact on manufacturers and consumers, (2) operating cost savings, (3) energy and water savings, (4) reduction in product utility or performance, (5) reduction in competition, (6) need of the nation to conserve energy and water, and (7) other factors deemed relevant by the Secretary of Energy (42 U.S.C. 6295(o)(2)(B)(i)). DOE can use these factors to justify a decision even if it has not included that factor in the relevant net benefit estimates. That is, it can conclude that the costs of a policy exceed its benefits even though its estimated net benefits are large and positive.

To obtain an estimate, admittedly crude, of the proportion of cases in which the addition of CO_2 benefits affects regulatory decisions, we used the following equation:

(1) % of cases in which including CO_2 benefits changes the decision) =

(Increase in the likelihood that a policy alternative is chosen from being ranked in the first position) x

(% of cases in which including CO_2 benefits moves a policy alternative to the first position)

We assume for simplicity that: the two terms on the right hand side of equation (1) are independent; that each regulation considers the same number of policy alternatives; and that all alternatives below the first position are equally likely to be chosen. The last assumption allows us to focus only on those cases where the SCC changes the top-ranked alternative.[10] Intuitively, we are trying to estimate the impact of the SCC in terms of the frequency with which using the SCC shifts a policy alternative to being ranked first, together with the "value" of being ranked first (in terms of making it more likely to be chosen by the agency).

To compute the first term on the right hand side of equation (1), note that regulators selected the top ranked alternative in 58% of all cases (25 of 43). The average number of alternatives considered in in the 53 rules was 4.7. Assuming the remaining alternatives were equally likely to be chosen means that they each were selected 11% of the time.[11] Taking the difference between 58% and 11% gives 47%, which provides a best estimate of the first term on the right hand side of equation (1). Our estimate of the second term is 12 of 43, or 28%. Multiplying these two percentages yields an estimate that the SCC may have changed decisions in about 13% of the cases.[12] We conclude from this exercise that introduction of the SCC may have impacted the final decision in roughly 1 out of 8 cases.

The preceding analysis is based on a stylized model that makes many assumptions. An alternative model that we constructed had the counterfactual consist of policies that were randomly selected. In that model, the impact of the SCC on decisions would generally be smaller than estimated here. Our goal here is simply to provide some novel estimates of the impact of the SCC. While recognizing that several different approaches exist, we do not pretend to be able to offer a precise final answer.

4. Conclusion and areas for future research

We evaluated a recent innovation in U.S. regulatory policy: the use of the social cost of carbon to value changes in emissions of carbon dioxide, a greenhouse gas. To assess whether outcomes were affected, we considered net benefits for 53 regulatory policies from 2008 through 2013, with and without estimates of the benefits associated with

[10] If the SCC does not move a policy's rank to the first position, it does not change the "probability" that it is selected, so the SCC is assumed to have no impact on the likely choice of particular decisions. This allows us to focus only on those cases where the SCC moves a policy alternative to the first position.
[11] (1-.58) divided by 4.7.
[12] We examined the sensitivity of our results to the average number of alternatives. If there were 4 alternatives per rule, our formula for the impact of the SCC would yield 12.3% instead of 13.1%. If there were 5 alternatives per rule, it would yield 13.3%.

changes in carbon dioxide emissions. We find that including the benefits from expected changes in carbon dioxide emissions does not typically affect the ranking of the preferred policy compared with the status quo. This is true even for policies explicitly aimed at reducing carbon dioxide emissions.

In some cases, including benefits from reductions in emissions does change the relative ranking of different policy alternatives. We considered how changes in ranking were affected by the introduction of the SCC and found that including CO_2 benefits may matter in roughly 1 of 8 cases.

A general limitation of our quantitative analysis is that we take the regulatory benefits and costs calculated by the agency as given. We do not know the biases that exist in these data; and there is relatively little work that provides a definitive assessment on the nature of these biases (Hahn and Tetlock, 2008). One way of addressing the bias issue would be to do independent analyses of the economic benefits and costs of these rulemakings (Harrington, Morgenstern and Nelson, 2000). Such analyses are labor-intensive, but could help furnish insights into the underlying political economy.[13]

There are at least three key issues that are raised by this analysis, all of which deserve further scrutiny. One is the question of how the pattern in the data can be explained. The absence of a marked impact may be explained, in part, because U.S. regulators have succeeded in selecting the “low-hanging fruit,” where the net benefits of a policy that reduces carbon dioxide are positive. Another possible explanation was that the SCC was so small that it will never make a difference. We view this as highly unlikely in light of the findings presented above. CO_2 benefits average roughly 15% of the net benefits for the data considered here. A further explanation, which we also rejected, is that our sample only considers economically significant regulations (e.g., regulations whose impact exceeds $100 million), which are likely to pass a benefit-cost test; otherwise, the argument is that they would not be proposed. We reject this argument based on the work of several regulatory scholars, which finds that many economically significant regulations do not pass a benefit-cost test even when using the government’s own numbers (Morrall, 1986; Hahn, 2000).

A second critical issue is why the U.S. chose to implement the social cost of carbon, given that it appears to have made little actual difference for policy to date. One possible explanation is that regulators may have thought it was appropriate to value carbon in federal regulatory decisions related to climate, taking into account global damages. The Interagency Working Group reports support this view. An alternative

[13] We also conjecture that such an analysis could lead to a larger number of cases in which inclusion of the SCC changed the sign of net benefits of the policy from negative to positive. This is because some benefits that the agencies count may not be appropriate to count, or may be overstated.

explanation, not necessarily inconsistent with the former one, is that the SCC may have been attractive for the executive branch to pursue because it gave the appearance of doing something on climate policy (an issue that President Obama put high on his agenda). At the same time, Congress may have found this acceptable because it probably had little real impact on policy, at least so far. Finally, there may have been an expectation that estimates of the SCC may increase over time, and thus have a more pronounced impact on regulatory decisions (see, *e.g.*, Moyer et al., 2014, forthcoming).

A third issue relates to whether agencies are selecting policies that maximize expected net benefits. Frequently, an agency does not present sufficient information in the benefit-cost analysis to allow a reader to ascertain whether or not the outcome selected maximizes net benefits (Hahn and Tetlock, 2008). We know from the benefit-cost analyses reviewed here that agencies are generally selecting policies that have positive net benefits relative to the status quo. We do not know, whether the selected policy actually maximizes net benefits compared with other alternatives. We do know, however, from an earlier discussion that regulators selected the top ranked alternative in 58% of cases examined, meaning they did not do so in 42% of the cases. The selection of an economic alternative with lower quantified net benefits may have been made for several reasons, such as consideration for non-quantifiable benefits, concerns with equity, or politics.

Regulatory agencies could address this issue by being clearer about the nature of the particular net benefit function they are trying to maximize (for example, specifying which externalities are included). They could also quantify the benefits and costs associated with a larger number of alternatives, so that the interested independent analyst could compare net benefits for different alternatives (Arrow et al, 1996). This is especially important to do for *marginal* net benefits. In the case of the SCC, we would conjecture that introduction of the SCC would likely make a difference for the optimal policy choice, much in the same way a Pigouvian tax makes a difference, by lowering the optimal level of pollution.

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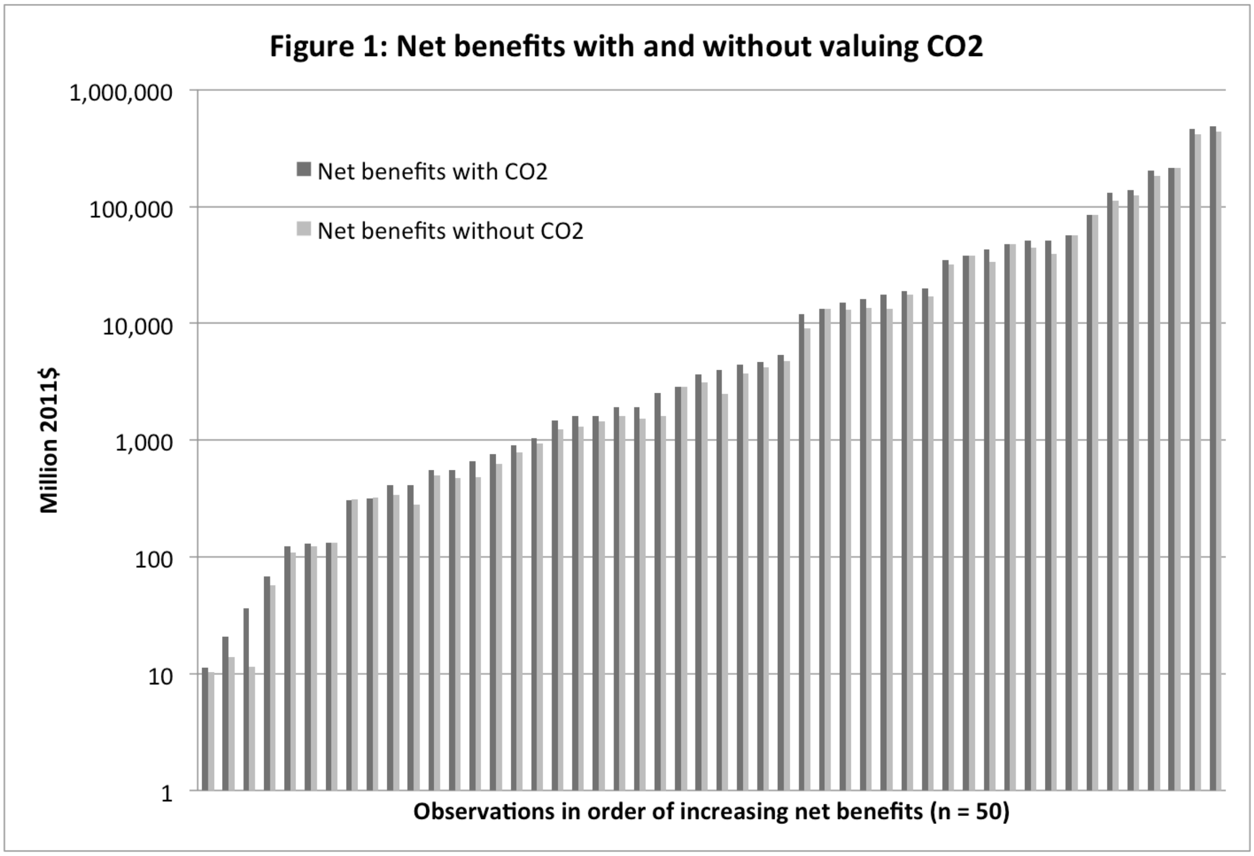
Figure 1: Net benefits with and without valuing CO2
1,000,000
100,000
10,000
1,000
100
10
1
Million 2011$
Net benefits with CO2
Net benefits without CO2
Observations in order of increasing net benefits (n = 50)

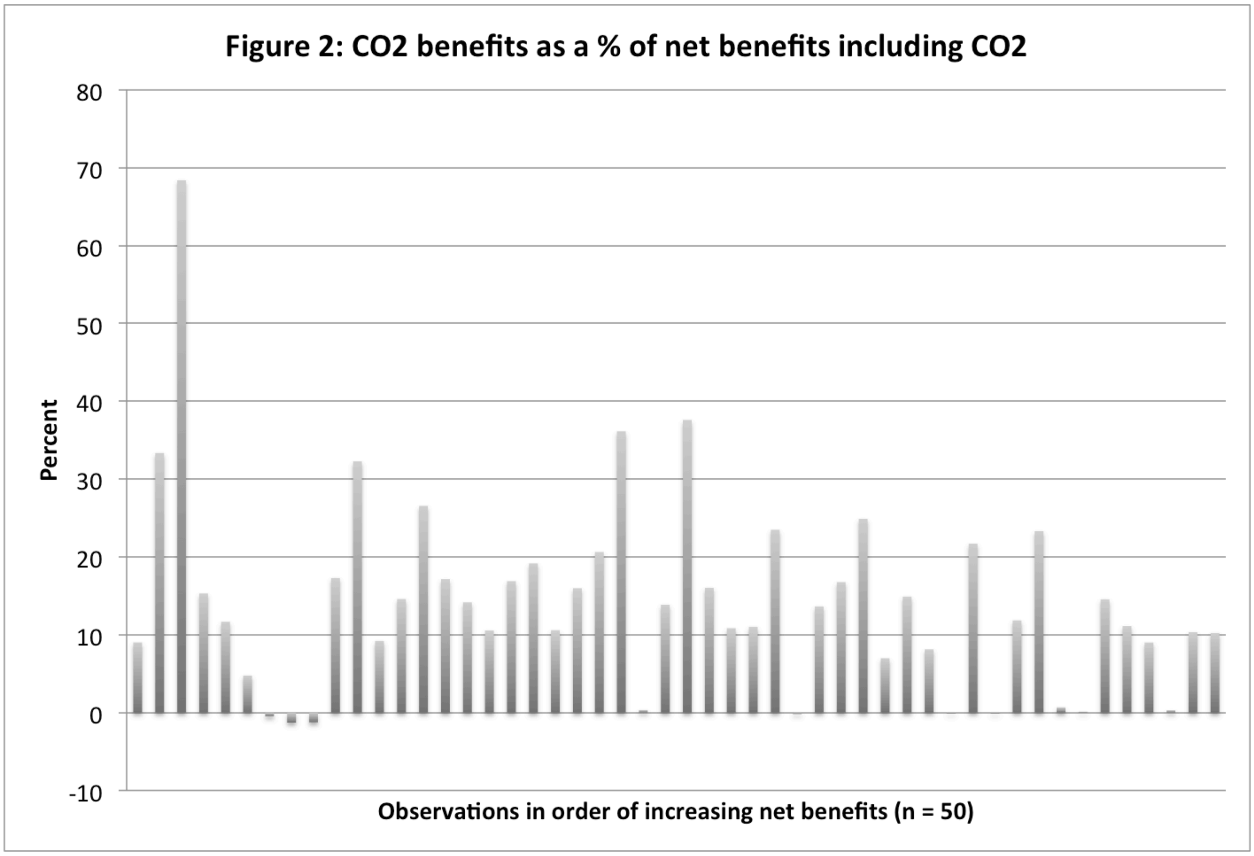

Figure 2: CO2 benefits as a % of net benefits including CO2
80
70
60
50
40
30
20
10
0
-10
Percent
Observations in order of increasing net benefits (n = 50)

Appendix - Table A1
Summary of Benefit-Cost Analyses

Agency / Year[a]	Rule ID Number	Subject[b]	Net Benefits including CO_2 (Billions 2011$)[c]	Net Benefits not including CO_2 (Billions 2011$)
Final Rules				
DOE / 2013	1904–AC04	ECS[d] for Distribution Transformers	18	13
EPA / 2013	2060–AR13	NESHAP for Boilers and Process Heaters	47	47
EPA / 2012	2060–AQ54	GHG Emissions Standards for Light-Duty Vehicles	460	410
DOT / 2012	2127–AK79	CAFE Standards for Light-Duty Vehicles	490	440
EPA / 2012	2060–AN72	Standards of Performance for Petroleum Refineries	0.55	0.50
DOE / 2012	1904–AB90	ECS for Residential Clothes Washers	35	32
DOE / 2012	1904–AC64	ECS for Residential Dishwashers	0.56	0.47
EPA / 2012	2060–AP52; 2060–AR31	NESHAP for Steam Generating Units	57	57
DOE / 2011	1904–AB50	ECS for Fluorescent Lamp Ballasts	19	18
DOE / 2011	1904–AB79	ECS for Residential Refrigeration Products	43	34
EPA, DOT / 2011	2060–AP61; 2127–AK74	GHG and Fuel Efficiency Standards for Medium- and Heavy-Duty Vehicles	51	45
EPA / 2011	2060–AP50	Interstate Transport of Particulate Matter and Ozone	210	210
DOE / 2011	1904–AC06	Energy Efficiency Standards for Residential Furnaces, A/C, and Heat Pumps Standards for Standby/Off Mode for Residential Furnaces, A/C, and Heat Pumps	20 1.5	17 1.2
DOE / 2011	1904–AA89	ECS for Residential Clothes Dryers ECS for Residential A/C	3.7 1.9	3.2 1.5
EPA / 2011	2060–AO12	Standards of Performance and Emission Guidelines for Waste Incinerators	0.32	0.32
EPA / 2011	2060–AQ25	NESHAP for Major Sources	38	38
EPA / 2011	2060–AM44	NESHAP for Area Sources*	-0.13	-0.13
EPA, DOT / 2010	2127–AK50; 2060–AP58	CAFE Standards for Light-Duty Vehicles GHG Emissions Standards for Light-Duty Vehicles	140 200	120 180
DOE / 2010	1904–AA90	ECS for Residential Water Heaters ECS for Direct Heating Equipment ECS for Pool Heaters	12 1.6 0.12	9.1 1.4 0.11

EPA / 2010	2060–AO38	Control of Emissions from New Marine Compression-Ignition Engines	85	85
DOT / 2010	2120–AI92	ADS-B Out Performance Requirements to Support Air Traffic Control Service	0.41	0.28
DOE / 2009	1904–AB58	ECS for Class A Beverage Vending Machines ECS for Class B Beverage Vending Machines	0.66 0.036	0.49 0.011
DOE / 2009	1904–AA92	ECS for General Service Fluorescent Lamps ECS for Incandescent Reflector Lamps	51 16	39 13
DOE / 2009	1904–AB49	ECS for Conventional Cooking Products	0.91	0.78
DOE / 2009	1904–AB59	ECS for Commercial Refrigeration Products	4.7	4.2
DOE / 2009	1904–AB74	ECS for Certain Consumer Products and Commercial and Industrial Equipment	130	110
DOE / 2008	1904–AB44	Packaged Terminal A/C and Heat Pump ECS	0.068	0.058
Proposed Rules *with no Final Rules in this data set*				
DOE / 2013	1904–AC00	ECS for Metal Halide Lamp Fixtures	4.0	2.5
EPA / 2013	2040–AF14	Effluent Limitations Standards for new Steam Electric Power Generators* Effluent Limitations Standards for existing Steam Electric Power Generators*	-0.79 -0.27	-0.89 -0.30
DOE / 2012	1904–AB57	ECS for Class B,C,D,E External Power Supplies ECS for Class X External Power Supplies ECS for Class H External Power Supplies ECS for Class 1 Battery Chargers ECS for Class 2,3,4 Battery Chargers ECS for Class 5,6 Battery Chargers ECS for Class 7 Battery Chargers ECS for Class 8 Battery Chargers ECS for Class 10 Battery Chargers	2.5 0.41 0.011 0.76 1.6 5.4 0.13 2.8 1.9	1.6 0.34 0.010 0.63 1.3 4.8 0.12 2.8 1.6
DOE / 2012	1904–AC07	ECS for Microwave Ovens	4.4	3.7
EPA / 2011	2060–AR15; 2050–AG44	Solid Waste Incinerators: Reconsideration and Proposed Amendments	0.31	0.31
EPA / 2011	2060–AN99	NESHAP for Mercury Cell Chlor-Alkali Plants	0.021	0.014
EPA / 2010	2060–AP90	Standards of Performance and Emission Guidelines for Sewage Sludge Incinerators	0.13	0.13

* These rules are not shown in the figures because they have negative net benefits with and without valuing CO_2.
[a] Year of publication in the *Federal Register*.
[b] For rules that contained a single central cost-benefit analysis, we report the subject of the rule. Otherwise, we report the subject of the relevant subpart.
[c] All estimates are rounded to two significant digits, and use a 3% discount rate.
[d] ECS: Energy Conservation Standards; NESHAP: National Emission Standards for Hazardous Air Pollutants; CAFE: Corporate Average Fuel Economy; and

NSPS: New Source Performance Standards.