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Does the Social Cost of Carbon Matter?: An Assessment of U.S. Policy

EPRG Working Paper 1323

Cambridge Working Paper in Economics 1346

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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 test of the extent to which applying the SCC has affected national policy. We examine all economically significant federal regulations since 2008, and obtain a surprising 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 use of the SCC has affected U.S. policy choices to date. We offer an explanation related to the political economy of regulation.

Keywords Cost-Benefit Analysis ; Social Cost of Carbon ; Climate Policy ; Regulatory Innovation

JEL Classifications H43 (Project Evaluation) ; K32 (Environmental Law) ; Q51 (Valuation of Environmental Effects) ; Q58 (Environmental Policy)

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Publication October 2013

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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; Pizer, 2002;, 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., Hope, 2006; 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, Sunstein, 2013). For example, Greenstone, Kopits, and Wolverton (2013) note that the U.S. government used a central estimate of $21 per metric ton for global damages from CO_2 emissions in 2010 (2007$).[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

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 for different regulatory activities; examples include the United States, the United Kingdom, the Netherlands, Finland, and Italy. 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. However, their analysis is based primarily 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.

We provide a detailed analysis of how the use of the social cost of carbon has affected the economic analysis of U.S. regulations. To our knowledge, this paper provides the first systematic test 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.[2]

To assess how outcomes were affected, we examine net benefits of 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. Using this measure, we obtain the

(Interagency Working Group, 2013). These new values for the SCC are used in analyses of regulations beginning in 2013.

[2] 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).

surprising 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, estimated 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 significant impact on U.S. policy between 2008, when it was first used, and the beginning of 2013. We offer an explanation for the finding related to the underlying political economy of regulation in the U.S.

The paper proceeds as follows: Section 2 presents the analytical approach, and Section 3 presents the main results. Section 4 discusses some potential limitations of the results and the approach taken. Finally, Section 5 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 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. In particular, we searched our sample of rules for explanations of why an agency selected a particular alternative. We found explanations for many rules, none of which made reference to CO_2 emissions or the

SCC. Because some rules did not contain complete discussions of alternatives, however, we cannot categorically rule out that the SCC was a prominent factor in explaining a particular policy choice.

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, which are summarized in the flowchart in Figure 1. 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.

[FIGURE 1 ABOUT HERE]

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.[3] 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).

[3] 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.

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.[4] 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 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.

Some rules presented a benefit-cost analysis for two different time frames. We reported the analysis that covered the lifetime of the products subject to the rule. However, we checked that our conclusions held under alternative estimates of net benefits that were provided in the rule.

On occasion, an agency conducted two benefit-cost analyses for the same product over the same period, but using different assumptions. For example, DOT sometimes provided one analysis that accounted for vehicle manufacturers' voluntary adoption of

[4] 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%.

advanced technologies and one analysis that did not. In these cases we deferred to the agency's judgment: we recorded the benefit and cost data that the agency used to summarize the economic impact of the rule.

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 global benefits 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 had an impact on 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 2, which shows the net benefits at a 3% discount rate for the 50 benefit-cost analyses in the data set with positive net benefits. 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 the figure. The policies set limits on the emissions of hazardous air pollutants from commercial and institutional boilers and steam electric power generators.[5] Net benefits remained negative even after including the value of CO_2 benefits, consistent with the finding in Figure 2. 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 regulatory

[5] 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.

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.

[FIGURE 2 ABOUT HERE]

In addition to showing that the sign of the benefit-cost analysis does not change with the inclusion of CO_2 benefits, Figure 2 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 3 takes the same regulatory policies shown in Figure 2, and computes CO_2 benefits as a percentage of total net benefits. The CO_2 benefits average about 14% percent across all regulatory policies with a range of -1 to 70 percent. The few cases for which the CO_2 net benefits are negative 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.

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.

[FIGURE 3 ABOUT HERE]

The results for Figures 2 and 3 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 reported the results in Figures 2 and 3 using a 3% discount rate, but also considered what would happen using a 7% discount rate for conventional costs and benefits and a 3% discount rate applied to CO_2 benefits.[6] Since the regulations we considered had costs that were concentrated at the beginning, and benefits that were spread across a longer period of time, we found that net benefits at a 3% discount rate always exceeded net benefits at a 7% discount rate. We also found that CO_2 benefits expressed as a percentage of net benefits were generally greater under a 7% discount rate than a 3% discount rate. This happened because the government typically calculated CO_2 benefits using a 3% discount rate, so the change from 3% to 7% reduced total net benefits, but did not affect CO_2 benefits.

We did find one class of equipment for which CO_2 benefits changed the sign of net benefits when 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 addition of CO_2 benefits.

We considered whether the results shown in Figures 2 and 3 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 SCC. 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.

Suppose, for example, the U.S. used a domestic SCC that was lower than a global SCC, but still a positive number, reflecting the assumption that the U.S. would get some domestic benefits from reducing a ton of CO_2. Using a domestic SCC might be warranted if, for example, the U.S. wanted to focus solely on domestic net benefits, instead of including global benefits from CO_2.

[6] Calculations for a 7% discount rate for CO_2 benefits were not done in the most of the government analyses of regulations, so this is why we did not consider an analysis with a consistent discount rate across all benefits and costs. We also did not explicitly consider changes in uncertainty over the discount rate (Weitzman, 1995) because those data were not available.

For this analysis, use of a domestic SCC would not change our basic conclusion. It would simply reduce the value of CO_2 benefits. Since these benefits did not generally change the sign of the net benefits of a regulatory policy, making the SCC value lower, but still positive, would have no effect on the sign of the benefit-cost results. Thus, considering the lower bound on the SCC estimate also would not affect the results.[7]

As a final sensitivity, 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 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.

Greenstone et al. (2013, p. 43) draw attention to this benefit-cost analysis, which they view as an example of “the impact that the SCC can have on regulatory decisions.” We draw a slightly different conclusion. Excluding fuel savings reveals that changes in the benefit-cost analysis are plausible under assumptions not used by the agency to

[7] Similar reasoning applies to using the upper bound of the SCC range. Because most of the regulatory policies had positive net benefits without including CO_2 benefits, using a higher value for the SCC would not change the qualitative results.

determine its policy choice.[8]

B. The SCC and the relative ranking of policy alternatives

The analysis in Figures 2 and 3 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 using 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.[9] 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. For example, EPA did not provide net benefit estimates for alternative greenhouse gas emission standards for the same vehicles. DOT did not publish CO_2 benefit estimates for alternative fuel economy standards for light-duty vehicles in model

[8] Another interesting case 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.

[9] 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.

years 2012-2016. 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 towards rules issued by DOE.[10]

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 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 had 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

[10] 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.

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 provide a benchmark for our comparison, we examined the 31 policies for which CO_2 benefits did *not* change the alternative that maximized quantified net benefits. Regulators only selected the alternative that maximized quantified net benefits in 19 of these cases. This benchmark helps us interpret the results of our exercise because it shows that the maximization of quantified net benefits is not necessary for selecting a particular alternative. Even though an agency sometimes chose the alternative that maximized net benefits with CO_2 over the alternative that maximized net benefits without, there is little evidence that the addition of CO_2 benefits affected its decision. It is possible that the agency would have selected the same alternative even if it had never considered CO_2 benefits. This makes it difficult to interpret the impact of the SCC on the choice between regulatory alternatives.

4. Discussion

There are several issues related to the use of a global SCC. Here we address four: whether the use of a global benefit function in U.S. regulatory policy increases global welfare; the appropriate global welfare function; two adjustments to a global SCC that may be needed to improve benefit-cost analysis; and explaining the emergence of this policy innovation.

One rationale for using a global SCC is that it could increase global welfare.[11] We think that this argument could be true, if, for example, it is assumed that other countries do not change their behavior as a result of the U.S. policy. Alternatively, if the U.S. policy change encouraged other countries to follow suit, this might be a welfare-enhancing outcome both for the U.S. and the world.

There is anecdotal evidence that Canada followed the lead of the U.S. in selecting a value for the SCC for in its analysis of heavy-duty vehicle and engine emission regulations. The *Canada Gazette* (2013) notes, "The values used by Environment Canada are based on the extensive work of the U.S. Interagency Working Group on the

[11] Using a global value would also apply, in principle, to other greenhouse gases, but research is only beginning to emerge on how to value such gases (Marten and Newbold, 2012).

Social Cost of Carbon.” If the U.S. is, indeed, influencing other countries’ decisions on the value of an SCC that they use, then the U.S. may want to take this into account in its policy choices, whether it choose to try to maximize domestic welfare or a measure of global welfare.

A second issue concerns whether the use of the global social cost of carbon in regulatory benefit-cost analysis is appropriate for maximizing global economic welfare, as measured by the sum of producer and consumer surplus across countries. Even if one accepts that global welfare is the appropriate objective for U.S. policy, there is one important point that seems to have escaped the notice of analysts and regulators. Applying a global social cost of carbon helps address the environmental externality that the U.S. is imposing on other countries. There is a second “externality” that has not been considered, which is how U.S. actions could affect the cost of abatement in other countries, or more broadly, the cost of doing business in other countries. If the aim is indeed to maximize global welfare, a more complete analysis should consider costs as well as benefits for other countries. Perhaps, the U.S. decided these were second order or too hard to estimate, but we think such spillovers are worth considering.

A third issue relates to how one might apply the SCC in benefit-cost analyses. Here, we address two concerns: the possibility that emissions may not decrease by the full amount typically assumed, and the impact of an imperfectly competitive market on the design of an optimal emissions tax.

In some cases, use of a global SCC as the implicit global carbon price could, in principle, raise the cost of doing business in the U.S. relative to other countries, thus potentially leading to the export of some CO_2-related pollution in trade-exposed sectors. Several scholars have noted the possibility of such “carbon leakage” and what might be done about it (Ritz, 2009; Helm, Hepburn and Ruta, 2012). The point we wish to make here is that this leakage may need to be taken into account in calculations of the appropriate price for CO_2 in the U.S. and elsewhere. The leakage argument would tend to support a price that is less than the global SCC on gross emission reductions, depending on the estimate of the actual leakage rate. An alternative, equivalent way, of thinking about the problem is that the SCC should only be applied to the *net* reduction in emissions, after taking account of leakage. Up to this point, the SCC has been applied to gross emissions, and we think this could be problematic in that it over-estimates the actual carbon-reduction benefits of regulatory policy.

Leakage could be a significant issue for some of the rules in our data set because they are likely to increase the costs of doing business in the United States. Possible examples include standards for heavy-duty vehicles, incinerators, refineries, and hazardous air pollutants. Interestingly, however, very few of the regulatory policies we reviewed considered the leakage issue, and the Interagency Working Group document on the SCC does not mention the word “leakage” (Interagency Working Group, 2010). We examined all of the proposed and final regulations to see how they treated the leakage issue. Four rules mentioned leakage as a potential problem. One rule mentioned leakage as a result of the higher cost of doing business in the U.S. Three mentioned leakage as a result of a decrease in the U.S. demand for petroleum, which causes the global price of petroleum to fall and the foreign demand for petroleum to rise. None of the CO_2 benefit calculations were adjusted in response, but the three most recent rules were accompanied by an Environmental Impact Statement that contained a rough estimate. Each rule concluded that “the leakage effect is likely to offset only a modest fraction” of projected CO_2 benefits (2017 and Later Model Year Light Duty Vehicle GHG and CAFE Standards, 2012, 63060).

Like leakage, the issue of market structure poses important challenges for the application of an SCC in benefit-cost analysis that appear to have been largely neglected. A classic result due to Buchanan (1969) shows that the optimal emissions tax on a monopolist is lower than the social marginal damage--and in some cases may even be zero or negative (see also Barnett, 1980). The reason is that there are two market failures: the price put on emissions takes on the dual role of addressing both the environmental externality and the social losses from monopoly underproduction. Although things become more complicated, the same basic issue also arises with more realistic oligopolistic market structures (Katsoulacos and Xepapadeas, 1996).

It may be appropriate for regulatory policy to ignore this additional market failure. Of course, the extent to which it matters will vary across different industries, and other policy instruments may be available that can address distortions due to market power more directly. But there is recent empirical evidence that Buchanan's argument may play an important role in the environmental regulation of U.S. industry. Davis and Muehlegger (2010), for example, find large price markups in U.S. natural gas distribution markets (both commercial and residential) across all 50 states. They suggest that these price schedules are "an important preexisting distortion which should be taken into account when evaluating carbon taxes and other policies aimed at addressing external costs."

We also note that the market-structure point is likely to become more salient in the future, insofar as the values employed for the SCC, and emissions-pricing more generally, are likely to increase. Then, in addition to the static market-power effect identified by Buchanan, carbon regulation could affect U.S. industry dynamics, that is, firm entry and exit. Incorporating these kinds of effects is no doubt challenging but may also be important for achieving regulatory outcomes that increase expected net benefits. We therefore suggest that further policy on using the SCC might try to take market-structure issues into account. It could, for example, be desirable to use different values of the SCC for different sectors, depending on differences in price-cost margins and other considerations.

A fourth 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. A complete analysis of the underlying political economy of this regulatory innovation is beyond the scope of this paper; however, we think there are various possible explanations as to why the executive branch unilaterally decided to value changes in emissions in CO2 using the approach outlined above. From a normative perspective, 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 explanation, not necessarily inconsistent with the former motivation, 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. At the same time, Congress may have found this acceptable because it probably had little real impact on policy, at least so far. If analyses using the SCC were to have a significant impact on policy, then Congress would be more likely to act if executive branch actions were not consistent with its preferences (McCubbins, Noll and Weingast, 1987).

A related question is why we observe the emergence of an interagency group to address the SCC issue. Here, we think the answer is more straightforward. There were inconsistencies in the values different regulatory agencies were using for the SCC, and the interagency group provided a solution to this problem. Furthermore, the group is in a good position to update values for the SCC as new information becomes available.

5. <u>Conclusion and areas for future research</u>

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 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. In some cases, including these benefits does change the relative ranking of different policy alternatives that the government considered.

Overall, we do not find much evidence that using the social cost of carbon has mattered for the actual choice of policy in the U.S. The absence of a discernible 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. In the future, the SCC could play a more important role in affecting policy choices. This situation could arise, for example, if U.S. regulators found that the benefits from fuel or energy savings overstated actual benefits or the SCC were to increase in value.

A general limitation of our quantitative analysis is that we take the regulatory benefits and costs as performed 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 (*e.g.*, Hahn and Tetlock, 2008). Thus, while we are confident arguing that adding in the SCC benefits has not made a difference to the sign of most benefit-cost analyses, that argument is conditional on taking the U.S. government's analysis as given.

We suggest two areas for future research. First, we think insights from the political economy of regulation could be fruitfully applied to the use of this regulatory innovation across countries (Joskow and Noll, 1981). If the SCC has made a difference in selected sectors or locations, what is it about the politics that might help explain these outcomes? And what might help explain decisions that have been largely delegated to civil servants?

A second research question is whether U.S. policy makers should be trying to maximize domestic or global net benefits, and how these two strategies would differ in terms of their impact on domestic or global welfare. With the exception of the 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. The fact that climate change may be closer to a pure global public good than some of these other examples may not, by itself, provide an adequate justification for treating it differently from a U.S. perspective. However, there may be ethical justifications for doing so (Broome, 2012).

Use of the social cost of carbon in regulatory analysis is an important innovation that countries are implementing more widely. There is anecdotal evidence that the SCC has made an economic difference in some examples, but we would like to see more careful analysis of this issue in different sectors and countries. In particular, we conjecture that use of this mechanism would be more likely to make a difference in the regulation of carbon-intensive industries, such as the coal industry. Furthermore, if estimates of the SCC were higher relative to energy prices, including these costs could result in policies that promote more energy conservation. Given the apparent reluctance of politicians in many countries to introduce an explicit price on carbon dioxide emissions, we think that researchers and policy makers should pay more attention to the role this tool could play in designing more efficient policies for addressing climate change.

References

"2017 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emissions and Corporate Average Fuel Economy Standards; Final Rule," 77 *Federal Register* 199 (15 October 2012), 62623–63200.

Anthoff, David et al. 2011a. "Regional and Sectoral Estimates of the Social Cost of Carbon: An Application of FUND." Kiel Institute for the World Economy Economics Discussion Paper 2011-18.

Anthoff, David et al. 2011b. "Thinking Through the Climate Change Challenge." *VoxEU.org*. http://www.voxeu.org/article/thinking-through-climate-change-challenge.

Arrow, Kenneth J. et al. 1996. "Is There a Role for Benefit-cost Analysis in Environmental, Health, and Safety Regulation?" *Science* 272 (5259): 221–222.

Barnett, Andrew H. 1980. "The Pigouvian Tax Rule under Monopoly." *American Economic Review* 70 (5): 1037–1041.

Broome, John. 2012. *Climate Matters: Ethics in a Warming World*. W. W. Norton & Company.

Buchanan, James M. 1969. "External Diseconomies, Corrective Taxes, and Market Structure." *American Economic Review* 59 (1): 174–177.

Bureau of Economic Analysis. 2005-2012. "Table 1.1.9. Implicit Price Deflators for Gross Domestic Product." United States Department of Commerce. http://www.bea.gov/iTable/iTable.cfm?ReqID=9&step=1#reqid=9&step=3&isuri=1&903=13 (accessed May 5, 2013).

Coase, Ronald H. 1960. "The Problem of Social Cost." *Journal of Law & Economics* 3: 1–44.

Davis, Lucas W., and Erich Muehlegger. 2010. "Do Americans Consume Too Little Natural Gas? An Empirical Test of Marginal Cost Pricing." *The RAND Journal of Economics* 41 (4): 791–810.

Ellerman, A. Denny, and Barbara K. Buchner. 2007. "The European Union Emissions Trading Scheme: Origins, Allocation, and Early Results." *Review of Environmental Economics and Policy* 1 (1) (January 1): 66–87. doi:10.1093/reep/rem003.

"Energy Conservation Standards," Title 42 *U.S. Code*, Sec. 6295. 2006 ed. Supp. IV, 2010. http://www.gpo.gov/fdsys/pkg/USCODE-2010-title42/pdf/USCODE-2010-title42-chap77-subchapIII-partA-sec6295.pdf.

Greenstone, Michael, Elizabeth Kopits, and Ann Wolverton. 2013. "Developing a Social Cost of Carbon for US Regulatory Analysis: A Methodology and Interpretation." *Review of Environmental Economics and Policy* 7 (1) (January 22): 23–46. doi:10.1093/reep/res015.

Hahn, Robert W., and Paul C. Tetlock. 2008. "Has Economic Analysis Improved Regulatory Decisions?" *Journal of Economic Perspectives* 22 (1) (March): 67–84. doi:10.1257/jep.22.1.67.

"Heavy-duty Vehicle and Engine Greenhouse Gas Emission Regulations." 2013. 147 *Canada Gazette* 6 (March 13, 2013). (SOR/2013-24).

Helm, Dieter, Cameron Hepburn, and Giovanni Ruta. 2012. "Trade, Climate Change, and the Political Game Theory of Border Carbon Adjustments." *Oxford Review of Economic Policy* 28 (2) (June 20): 368–394. doi:10.1093/oxrep/grs013.

Hope, Chris. 2006. "The Marginal Impact of CO2 from PAGE2002: An Integrated Assessment Model Incorporating the IPCC's Five Reasons for Concern." *Integrated Assessment* 6 (1) (January 31). http://journals.sfu.ca/int_assess/index.php/iaj/article/view/227.

Interagency Working Group on Social Cost of Carbon. 2010. *Social Cost of Carbon for Regulatory Impact Analysis under Executive Order 12866*. February. United States Government. http://www.epa.gov/otaq/climate/regulations/scc-tsd.pdf.

Interagency Working Group on Social Cost of Carbon. 2013. *Technical Update of Social Cost of Carbon for Regulatory Impact Analysis under Executive Order 12866.* United States Government. http://www.whitehouse.gov/sites/default/files/omb/inforeg/social_cost_of_carbon_for_ria_2013_update.pdf.

Joskow, Paul L., and Roger G. Noll. 1981. "Regulation in Theory and Practice: An Overview." In *Studies in Public Regulation*, edited by Fromm, Gary, 1–78. MIT Press.

Katsoulacos, Yiannis, and Anastasios Xepapadeas. 1996. "Emission Taxes and Market Structure." In *Environmental Policy and Market Structure*, edited by Carlo Carraro, Yiannis Katsoulacos, and Anastasios Xepapadeas, 3–22. Economics, Energy and Environment 4. Springer Netherlands. http://link.springer.com/chapter/10.1007/978-94-015-8642-9_1.

Lave, Lester B. 1984. "Controlling Contradictions Among Regulations." *The American Economic Review* 74 (3): 471–475.

Marten, Alex L., and Stephen C. Newbold. 2012. "Estimating the Social Cost of non-CO2 GHG Emissions: Methane and Nitrous Oxide." *Energy Policy* 51 (December): 957–972. doi:10.1016/j.enpol.2012.09.073.

McCubbins, Mathew D., Roger G. Noll, and Barry R. Weingast. 1987. "Administrative procedures as instruments of political control." *Journal of Law, Economics, & Organization* 3(2): 243-277.

Metcalf, Gilbert, and David Weisbach. 2009. "The Design of a Carbon Tax." *Harvard Environmental Law Review* 33: 499-556.

Nordhaus, William D., and Joseph Boyer. 2000. *Warming the World: Economic Models of Global Warming*. MIT Press.

Pigou, Arthur C. 1924. *The Economics of Welfare*. MacMillan.

Pizer, William A. 2002. “Combining Price and Quantity Controls to Mitigate Global Climate Change.” *Journal of Public Economics* 85 (3) (September): 409–434. doi:10.1016/S0047-2727(01)00118-9.

“Regulatory Planning and Review,” Title 3 *Code of Federal Regulations* (C.F.R), Pt. 638. 2013 ed.

Ritz, Robert A. 2009. “Carbon Leakage under Incomplete Environmental Regulation: An Industry-Level Approach.” University of Oxford Economics Series Working Paper 461.

Stavins, Robert. 2007. “A US Cap-and-trade System to Address Global Climate Change.” Brookings Institution Hamilton Project Discussion Paper 2007-13.

Sunstein, Cass R. 2013. “The Real World Of Cost-Benefit Analysis: Thirty-Six Questions (And Almost As Many Answers).” http://isites.harvard.edu/fs/docs/icb.topic1133008.files/February%2019--Cass%20Sunstein/SunsteinCasstheRealWorldOfCost_Benefit.pdf.

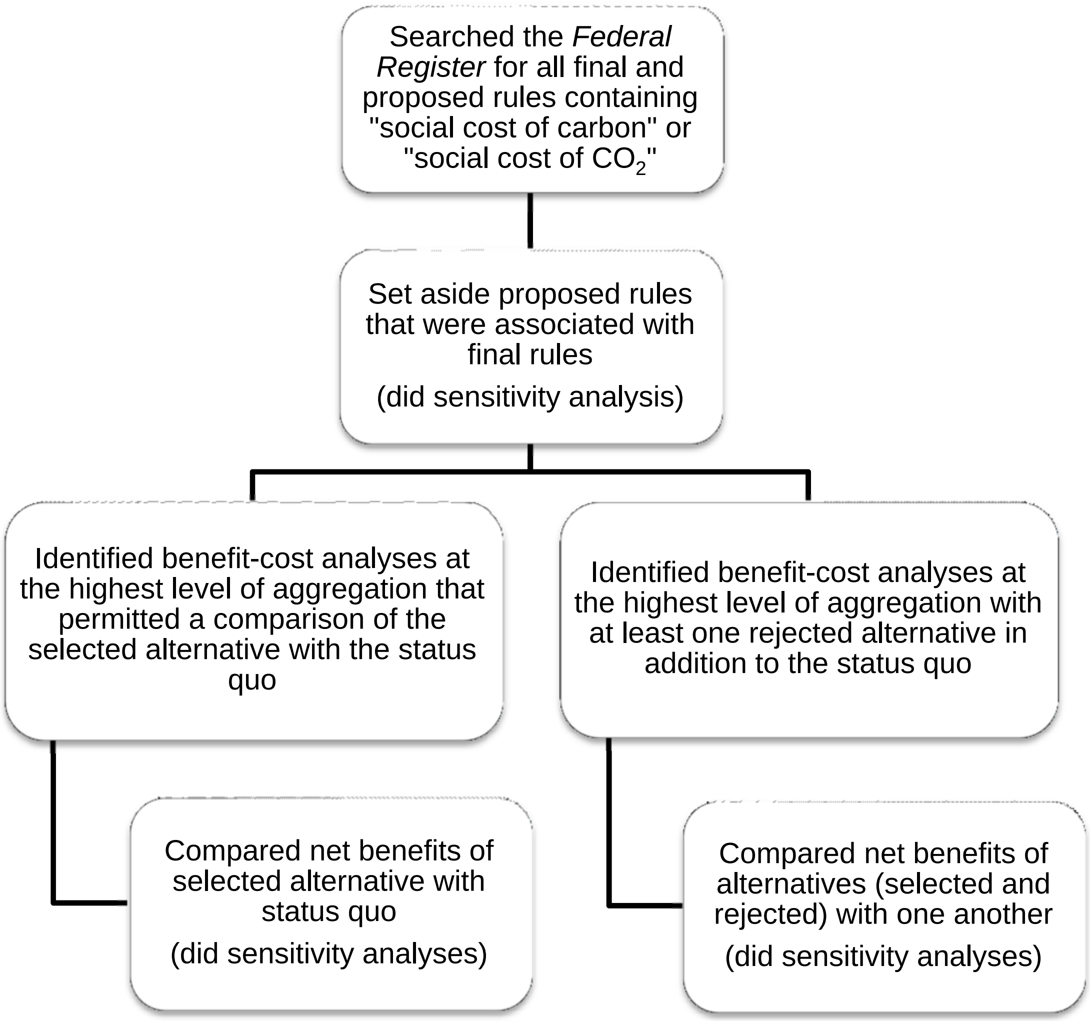
Tol, Richard S. J. 2009. “The Economic Effects of Climate Change.” *Journal of Economic Perspectives* 23 (2) (April): 29–51. doi:10.1257/jep.23.2.29.

Watkiss, Paul, and Chris Hope. 2011. “Using the Social Cost of Carbon in Regulatory Deliberations.” *Wiley Interdisciplinary Reviews: Climate Change* 2 (6): 886–901. doi:10.1002/wcc.140.

Watkiss, Paul, and Thomas Downing. 2008. “The Social Cost of Carbon: Valuation Estimates and Their Use in UK Policy.” *Integrated Assessment* 8 (1) (February 6). http://journals.sfu.ca/int_assess/index.php/iaj/article/view/272.

Weitzman, Martin. 1998. “Why the Far-Distant Future Should Be Discounted at Its Lowest Possible Rate.” *Journal of Environmental Economics and Management* 36 (3): 201-208.

Figure 1: Identification of benefit-cost analyses in the sample



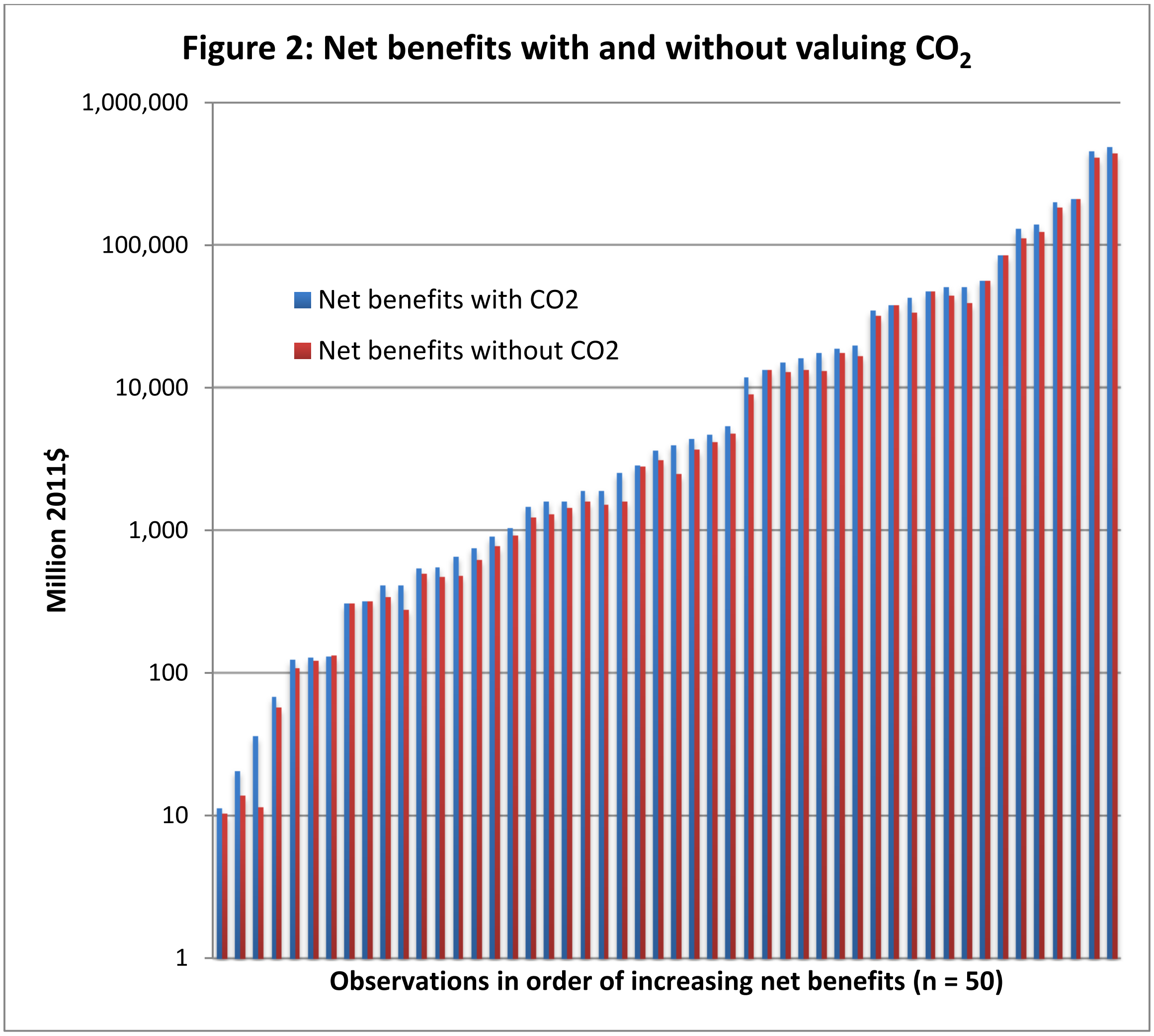


Figure 2: Net benefits with and without valuing CO_2
1,000,000
100,000
10,000
1,000
100
10
1
Million 2011$
Net benefits with CO2
Net benefits without CO2
Observations in order of increasing net benefits (n = 50)

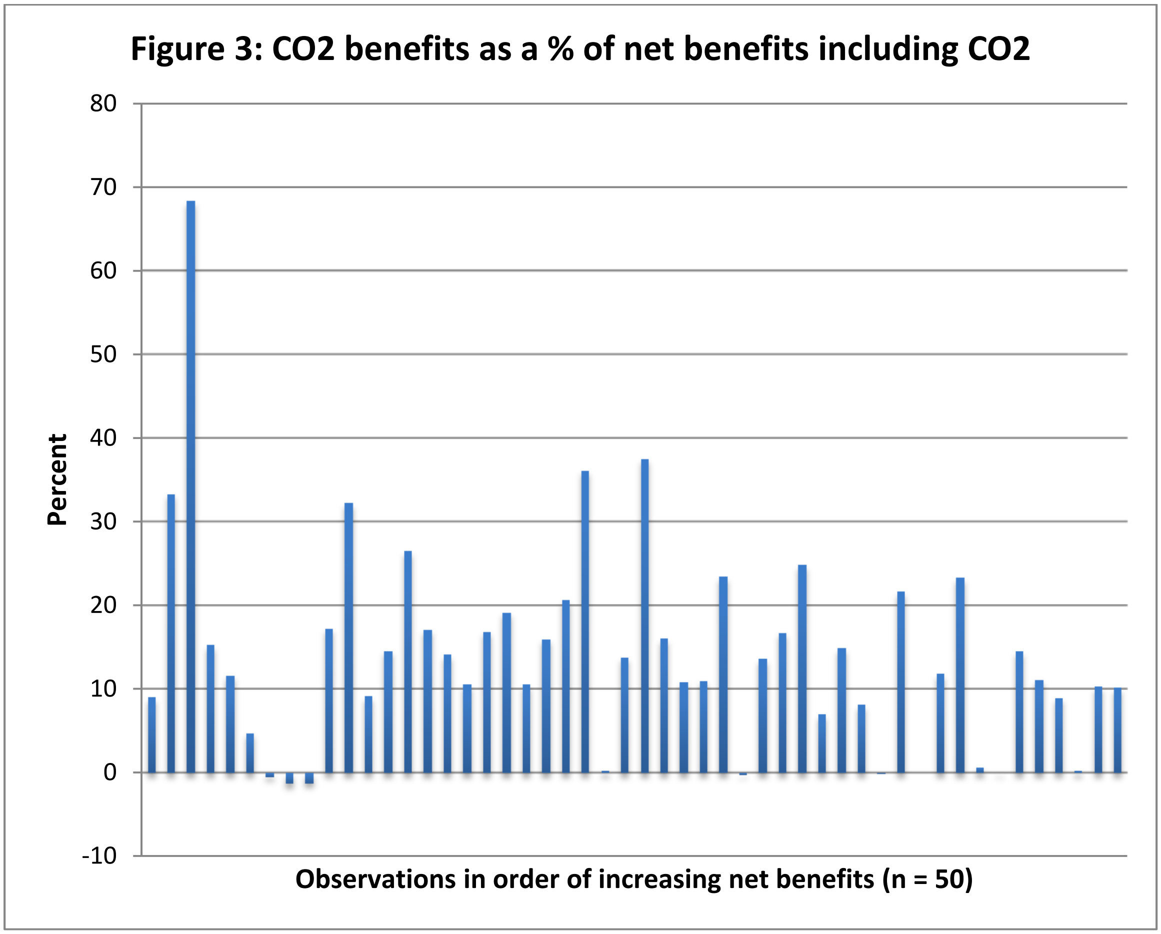


Figure 3: CO2 benefits as a % of net benefits including CO2
Percent
80
70
60
50
40
30
20
10
0
-10
Observations in order of increasing net benefits (n = 50)

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
DOE / 2010	1904–AB70	ECS for Small Electric Motors	15	13
DOE / 2010	1904–AB93	ECS for Commercial Clothes Washers	1.0	0.93
EPA / 2010	2060–AO15, 2060–AO42	NESHAP and NSPS for Portland Cement Plants	13	13

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
		ECS for Class A Beverage Vending Machines	0.66	0.49
DOE / 2009	1904–AB58	ECS for Class B Beverage Vending Machines	0.036	0.011
		ECS for General Service Fluorescent Lamps	51	39
DOE / 2009	1904–AA92	ECS for Incandescent Reflector Lamps	16	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
		Effluent Limitations Standards for new Steam Electric Power Generators*	-0.79	-0.89
EPA / 2013	2040–AF14	Effluent Limitations Standards for existing Steam Electric Power Generators*	-0.27	-0.30
		ECS for Class B,C,D,E External Power Supplies	2.5	1.6
		ECS for Class X External Power Supplies	0.41	0.34
		ECS for Class H External Power Supplies	0.011	0.010
		ECS for Class 1 Battery Chargers	0.76	0.63
		ECS for Class 2,3,4 Battery Chargers	1.6	1.3
		ECS for Class 5,6 Battery Chargers	5.4	4.8
		ECS for Class 7 Battery Chargers	0.13	0.12
		ECS for Class 8 Battery Chargers	2.8	2.8
DOE / 2012	1904–AB57	ECS for Class 10 Battery Chargers	1.9	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.