The Social Cost of Carbon: A Primer and Overview of the U.S. Government's SCC Estimates

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Outline

- What the Social Cost of Carbon Is and Is Not
- Overview of U.S Government's (USG) SCC Estimates
  - 2009-2010 Process
  - 2013 Update
- Discussion

What is the Social Cost of Carbon?

- The SCC provides a measure of the marginal damage from CO_2 emissions – and thus the *marginal benefit of abatement*
  - The SCC is the theoretically consistent value to compare with the marginal cost of abatement in benefit cost analysis
- Specifically, the SCC is the monetized value of future worldwide economic damages associated with a one-ton increase in CO_2 emissions in a particular year discounted to the present.
  - This is identical to the avoided damages associated with a one-ton decrease.
- It is intended to be a comprehensive measure of climate change damages, including (but not limited to):
  - changes in net agricultural productivity
  - net energy demand
  - human health
  - property damages from increased flood risk
  - the value of ecosystem services

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What the Social Cost of Carbon is Not

- The SCC is not the carbon shadow price derived from various policies (e.g., cap-and-trade program, performance standards)
- The carbon price associated with a policy that specifies an environmental target provides a measure of the *marginal cost of abatement.*
  - This is useful in evaluating policy cost-effectiveness
  - It is NOT an alternative way to value damages from CO_2 emissions
  - It does implicitly require a valuation of damages when setting the constraint
    - E.g., a target set to keep temperature increases to a certain amount to avoid "far too risky" outcomes implies a valuation of damages.
- The marginal cost of abatement and the marginal benefit of abatement (i.e., the true value of the SCC) are equal only when the emissions target is set at the economically efficient level

Overview of USG SCC Estimates

How is the SCC Used to Evaluate the Effects of U.S. Regulation?

- Executive Order 12866 directs federal agencies "to assess both the costs and benefits of the intended regulation…."
  - The SCC is an estimate of the benefits of reducing emissions of CO_2, which allows those benefits to be considered in benefit-cost analysis.
  - Without a SCC, the benefit to society of reducing CO_2 emissions would be treated as zero – effectively ignoring climate change damages
- In 2009, the Obama Administration launched an interagency process to promote consistency in the SCC values used by agencies
  - Prior to 2008, reductions CO_2 emissions impacts were not valued
  - From 2008 to 2009, SCC estimates varied substantially among agencies
  - In 2009, "interim" USG SCC estimates were issued based on literature review
  - The 2010 USG SCC estimates have been used in 30+ regulations to date (EPA, DOT, DOE)

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Overview of USG SCC Analytic Process

- Used 3 "integrated assessment models" (IAMs) that combine climate processes, economic growth, and feedbacks between the two in a single modeling framework
  - PAGE, DICE, and FUND models, each given equal weight
  - IAMs are highly simplified representations of the potential economic damages from climate change and limited by the current state of research
  - Despite their inherent uncertainties and limitations, they are the best tools currently available for estimating the SCC
- Applied a common set of assumptions in each model for: reference socioeconomic and emissions trajectories, climate sensitivity, and discount rates
- All other features of the IAMs were left unchanged
- It was decided that the value should reflect global damages from CO_2 emissions, not just those that would occur in the U.S.

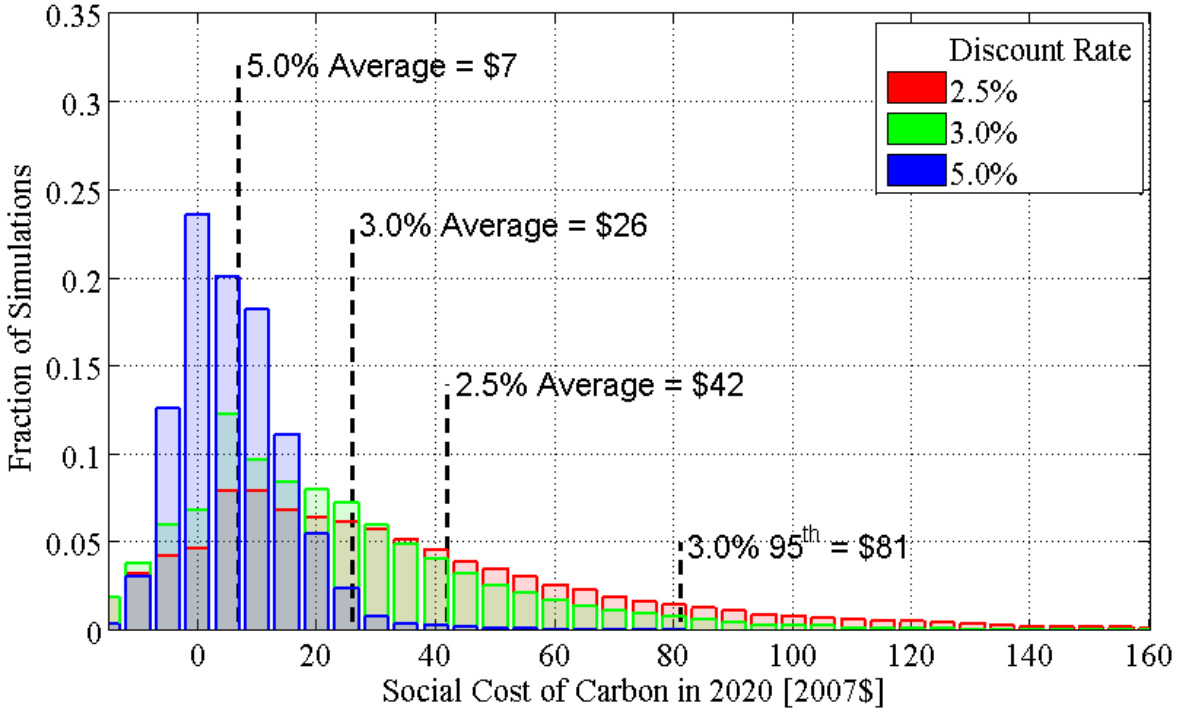
USG SCC Estimates (Feb 2010)

- The model runs produced 45 separate SCC distributions for a given year
  (3 models) x (5 socioeconomic scenarios) x (1 climate sensitivity distribution) x (3 discount rates)

- The distributions from each model and scenario were equally weighted and combined to produce three separate probability distributions for SCC in a given emissions year, one for each of the three discount rates

- Four final values chosen:
  - Average SCC at each discount rate: 2.5%, 3%, 5%
  - 95th percentile at a 3% discount rate, representing higher than expected economic impacts further out in the tails of the distribution.

Distribution of 2020 Social Cost of Carbon Values at Each Discount Rate



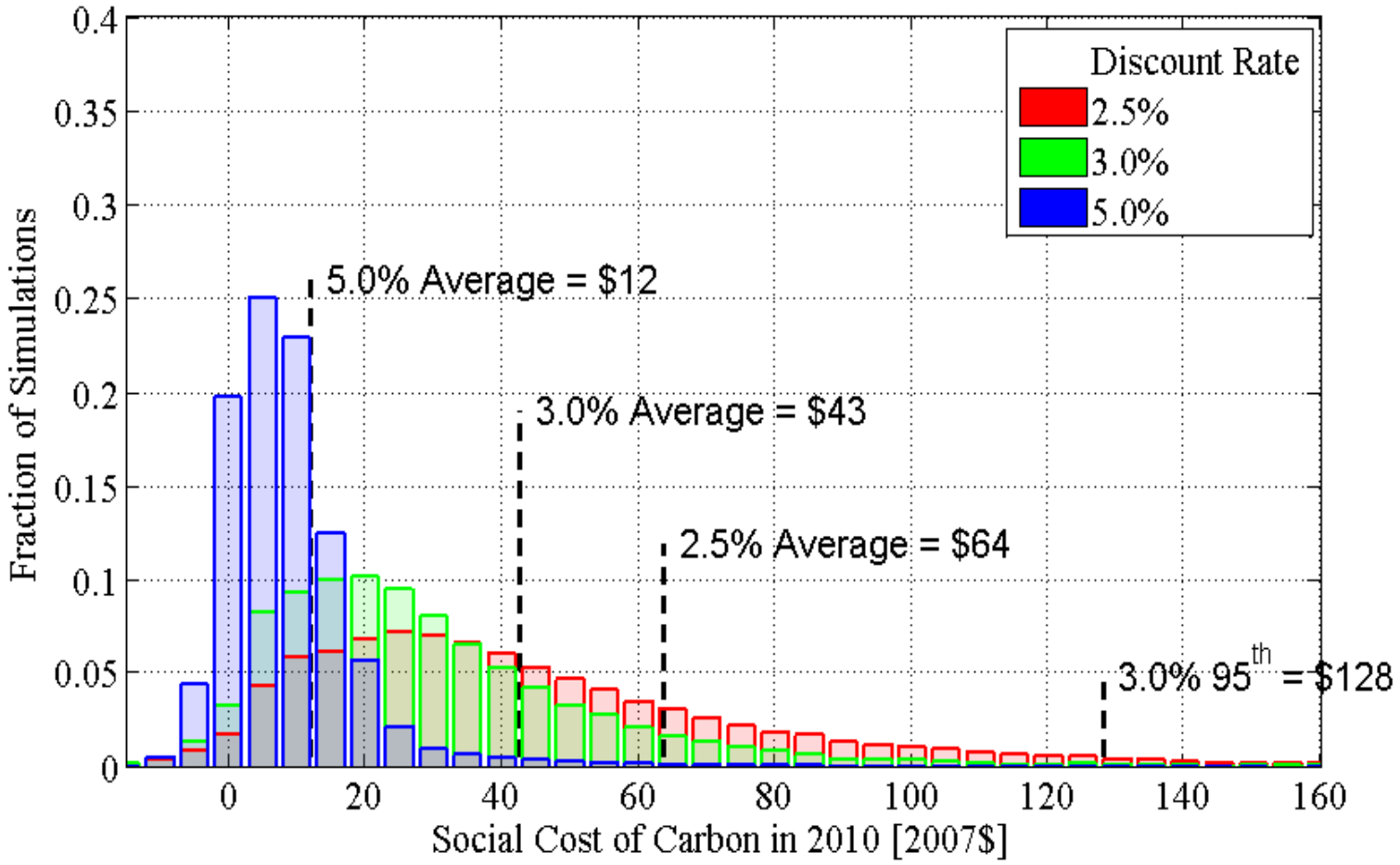
2013 Update

- While acknowledging the continued limitations of the approach taken in 2010, the USG recently updated the SCC estimates based on new versions of each IAM.
- Improvements in the way damages are modeled are confined to those incorporated into the latest versions of the models by the developers themselves in the peer-reviewed literature.
  - USG model input decisions were not revisited
- Revisions vary by model and include: improvements to calculation of sea level rise damages, updated adaptation assumptions, changes to how temperature responds to buildup of GHG concentrations.
- Some model revisions increase the SCC, others decrease it. The new estimates reflect the net effect of all of changes.

Updated USG SCC Estimates

- For 2020, the revised SCC values are: $12, $43, $64, & $128 (2007$).

Distribution of SCC Estimates for 2020 (2007$/ton CO_2)*



* Includes Nov 2013 technical correction.

Updated USG SCC Estimates, 2010-2050

- As before, the values increase over time, as determined within each model, because future emissions are expected to produce larger incremental damages as physical and economic systems become more stressed in response to greater climatic change.

Revised Social Cost of CO_2 (2007$/ton),* based on year of emission reductions

Discount Rate	5.0%	3.0%	2.5%	3.0%
Year	Avg	Avg	Avg	95th
2010	11	32	51	89
2015	11	37	57	109
2020	12	43	64	128
2025	14	47	69	143
2030	16	52	75	159
2035	19	56	80	175
2040	21	61	86	191
2045	24	66	92	206
2050	26	71	97	220

* Includes Nov 2013 technical correction. .

SCC Estimates Remain Conservative in a Number of Regards

For example,

- SCC estimates do not include damages from ocean acidification
- Damages from most large scale earth system feedback effects (e.g., Arctic sea ice loss, melting permafrost, large scale forest dieback, changing ocean circulation patterns) are not included at all in one model, and at best imperfectly captured in others.
- Many categories of direct impacts remain incomplete and rely on science lagging behind the most recent research (e.g., agriculture).
- A number of potentially significant damage categories remain exceedingly difficult to monetize (e.g., species and wildlife loss).
- Is a partial equilibrium measure of mitigation benefits

Discussion

Using the SCC for Policy Analysis

- Benefit-Cost Analysis:
  - The SCC allows the social benefits of reducing emissions of CO_2 at the margin to be compared to the costs of mitigation policies within BCA.
  - Benefits of CO_2 reduction are independent of the program design or sector.
  - If all countries use a domestic SCC estimate for analysis, then the result would be a lower level of global abatement than is socially optimal globally.
    - Furthermore, the resulting global level of abatement could be achieved at a lower cost if all countries used a common SCC value (or if international trading for emission rights was allowed) since marginal abatement costs would then be equalized across regulated sources.
- Helping to set the level of a carbon tax:
  - Carbon tax could be set equal to the SCC and adjusted over time to match an SCC that is reestimated as sources adopt new measures to reduce emissions
- SCC is not the appropriate measure for evaluating projects when the policy objective is to meet a pre-determined environmental target at lowest possible cost

Intergenerational Discounting

- For calculating the SCC, the USG used 3 constant discount rates
  - 2.5%: incorporates concern that interest rates are highly uncertain over time
  - 3%: consistent with economics literature and Circular A-4 guidance for the consumption rate of interest
  - 5%: represents the possibility climate damages are positively correlated with market returns

- USG continues to examine questions related to discounting impacts in the distant future and supports research in this field
  - EPA sponsored a small workshop at RFF in which 13 prominent economists discussed a series of charge questions on intergenerational discounting
  - One output of this workshop, a paper authored by all 13 experts was recently published in *Science*, which argues that a declining discount rate would be appropriate to analyze impacts that occur far into the future (Arrow et al. 2013)

Representation of "Catastrophic" Impacts

- Analyses of GHG mitigation benefits are often criticized for failing to adequately capture possible "catastrophic" impacts (e.g., Tol 2009, NAS 2009, SCC TSD 2010)
- 2 of the 3 IAMs used for the USG SCC do make some attempt to capture these types of impacts, albeit imperfectly
- One obstacle that has impeded progress is the inconsistent and sometimes nebulous use of "catastrophic" impacts
- Need to move beyond experiments which are abstracted from important details of the climate problem to substantively inform the policy debate and improve analyses of greenhouse gas mitigation benefits (e.g., SCC) (Kopits et al., 2013)

A Note on Non-CO_2 GHGs

- Published estimates of the social cost of other GHGs are fewer than for SCC, and most estimates are not comparable to USG SCC.
- One crude approach for proxying the social cost of other GHGs is to convert non-CO_2 emissions to CO_2 equivalent terms using global warming potentials (GWP) and then apply the SCC.
- This approach may produce large errors, because
  - It ignores important nonlinear relationships and the interaction between the gases' relative lifetimes, state variable scenarios, discounting, etc.
  - Not all impacts are due to temperature change (e.g., carbon fertilization & ocean acidification linked to CO_2; ozone linked to CH_4)
- Recent research finds GWP approach will likely understate benefits (Marten & Newbold 2012)
  - Especially at higher discount rates (e.g., 5%), emission years further out in time

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