

The social cost of carbon: a review

1. Definitions

The most general definition of SCC is the marginal damage generated by an additional ton of carbon.

a- Optimal vs. BAU reference-scenario for SCC

Like the shadow price of carbon, the social cost of carbon also depends on the future socioeconomic evolutions, and on the future pathway of carbon emissions. In particular:

- a. The SCC can be defined as the cost of increasing emissions by one ton, *starting from the optimal emission pathways*.
 - i. This SCC also depends on mitigation costs (and therefore technological change), since the optimal emission pathway depends on mitigation costs.
 - ii. In principle, this social cost of carbon is equal to the optimal Pigouvian tax level. $C' = D'$ Nordhaus (1993, 2016)
- b. The SCC can be defined as the benefits from decreasing emissions by one ton of carbon, *starting from the current trend scenario* (business as usual scenario).
 - i. This SCC is the value of the first ton that is not emitted and does not depend on mitigation costs and future technologies.
 - ii. Stern (2006) 5% for climate damage versus 1% for mitigation costs. The case for action. If $D' > C'$ then CBA turns into CEA = minimizing the cost of emission reductions consistent with the objective of carbon neutrality. Ackerman (2012)

In the presence of nonlinear climate change impacts or tipping point risks, this second SCC is higher than the first one (ref ?).

b- Global vs. Strategic SCC

Note that, most estimates of SCC are global.

Then, from one country's own perspective:

- i. part of this SCC is "selfish" (emission reductions in one country reduce impacts in this same country) and should be accounted for even in a self-interest CBA,
- ii. part is "universal" and refers to the climate public goods. The share varies in different countries.

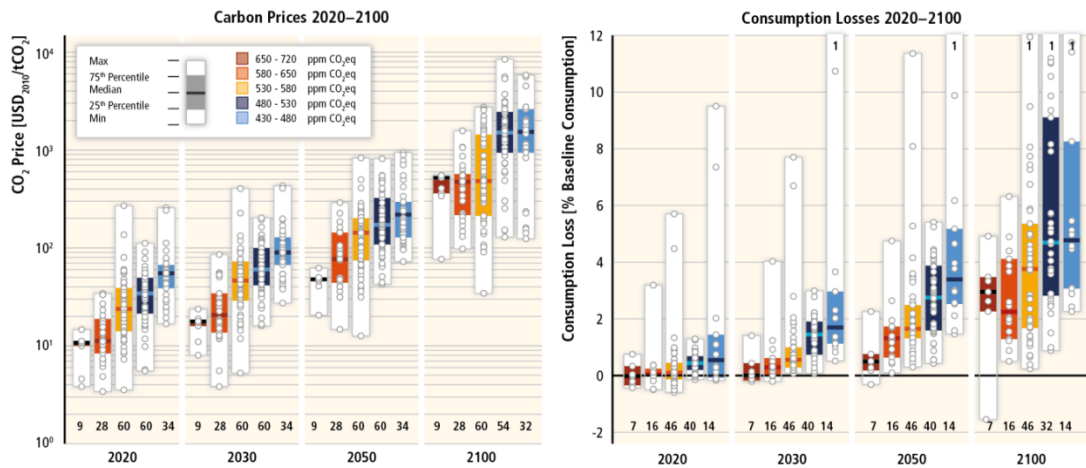
Seeking the one right estimate of the global SCC fails to recognize strategic incentives on the part of countries (Weitzman 2016, Kotchen 2016).

2. Evaluation methods and review of existing estimates

a- Main existing estimates

The literature review reveals a wide range of SCC estimates [...]

IPCC chapter 10 + AR5 Synthesis Report + US Interagency Group



Discount Rate	5.0%	3.0%	2.5%	3.0%
Year	Avg	Avg	Avg	95th
2010	10	31	50	86
2015	11	36	56	105
2020	12	42	62	123
2025	14	46	68	138
2030	16	50	73	152
2035	18	55	78	168
2040	21	60	84	183
2045	23	64	89	197
2050	26	69	95	212

Source (EPA, 2013)

This wide range of estimates shows how deep the uncertainties remain on the value of SCC. A first major source of uncertainty is built in the damage function itself.

a- Building a damage function

- a. Econometric estimates based on climate and weather variability Moore (2015) temperature effects on growth rate and capital depreciation + Hsiang (2016) + Dell

- (2014) examine how temperature, precipitation, and windstorms influence economic outcomes, insights for the “damage function”
- b. Meta-analysis to appraise climate damage by Sterner (2016), downward bias of DICE leads to major underestimation of the SCC (by a factor 3 or 4)
 - c. Highlight the large heterogeneity of impacts (tropical countries more affected, poor countries more affected, and poor people within countries more affected), which make the assessment very dependent on ethical consideration and aggregation methods. ??? + cobenefits in terms of security, migration and conflicts (Sullivan, 2015, Prieur 2016)
 - d. Valuation of non-market impacts (loss of lives or health impacts) +extension to a broader range of pollutants and impacts (aerosol/ozone precursors, products of incomplete combustion) Shindell 2015 + Levy (2016) on health cobenefits in the US + Hansen (2016)
 - e. Missing categories of impacts, such as ocean warming and acidification. + Hope (2015) on the permafrost
 - f. The impact of functional forms of different damage functions on SCC Pottier, Ambrosi, Ackerman and Stanton

Other drivers of the uncertainty of the SCC lie in the socio-economic module.

b- The socio-economic drivers of discrepancies in SCC estimates

- a. Discounting and endogeneity of relative prices (for nonmarginal impacts of climate change and to account for increasing value of superior goods) Sterner, Guesnerie
- b. Role of distribution of impacts and aversion for inequality (inter and intra generations, Fleurbaey)
- c. The role of risk aversion (distinct from time and inequality preferences), introducing a risk premium component into the SCC? Is mitigation an insurance against climate risk? Negative RP for Nordhaus vs. positive RP for Kopp. + precautionary savings by Ploeg 2014, using the asset pricing model, uncertainty increases the SCC by a risk premium Lemoine (2015) + Daniel 2016 applying asset pricing theory to calibrate the price of climate risk
- d. Uncertainty à la Weitzman; dismal theorem A tale of tails..., the limit of CBA for climate change policies+ Toman 2014) on irreversibility and Knightian uncertainty + Ploeg 2014 on the prospect of non-marginal catastrophes leading to a sudden and irreversible drop in total factor productivity. Gillingham (2015) for a comprehensive study of uncertainty in climate change, + Dietz (2012) on risk and uncertainty in the US SCC; Cai (2013, 2015)
- e. Impacts of GDP level or on the growth rate? Stern (2013) criticism of the damage representation in IAMs underestimating actual risks and impacts+ Moyer (2013) when climate change directly affects productivity then SCC is far more uncertain than previous modeling exercises + Hambel (2015) + Bansal (2016) impact on growth with empirical verification through financial markets
- f. Valuation of irreversible impacts of climate change

3. Which social utility for the SCC ?

Estimates range from negative values to more than \$1000/tCO₂. We have seen explanations why it is so. Where do we go from there?

a- More transparency : Integrated assessment models vs. expert elicitations

Two opposite approaches to deal with the utility of the SCC and the underlying IAMs:

- They help explain the drivers of the discrepancies in results: the historical “when” controversy reactivated by the Stern review and the following debates (discounting, uncertainty etc.) Espagne et al, disentangling the Stern Nordhaus controversy
- Pyndick (2013) radical criticism of IAMs challenging the very meaning of their results. His approach to revisit SCC (2016) = expert elicitation . Berg (2015) The case for CEA

b- More simplicity : Towards a simple and elegant SCC formula

Gerlagh + Gosolov (2014) analytical derivation of a simple formula for the marginal externality damage of emissions. This formula, which holds under quite plausible assumptions, reveals that the damage is proportional to current GDP, with the proportion depending only on three factors: (i) discounting, (ii) the expected damage elasticity (how many percent of the output flow is lost from an extra unit of carbon in the atmosphere), and (iii) the structure of carbon depreciation in the atmosphere.

Rezai (2016) Work on simple rule for SCC – Oxford carbon cycle where cumulative emissions drive temperature changes

c- More complexity: Towards a better integration of the finance and innovation modules

Two visions of finance :

- allocation of scarce resources (with or without price rigidities in the short run, but no long run effects). Recent literature on DSGE models

- framing expectations of agents (long run impact on growth). Recent post-keynesian stock-flow consistent models literature

The innovation module : discussion on impact of backstop technologies, CCS,

d- More political economy: signal and credibility

- a. The values depend on preferences and values (risk aversion, aversion to inequality, valuation of nonmarket impacts). There is not one unambiguous consensus optimal value or trajectory.
- b. Make the case for action. Anchor for expectations.
- c. Libecap (2013) on transaction costs: Explain one aspect of political economy difficulties in climate change mitigation – on the difficulty to align private cost with social one through private property rights only. In defense of public signals and subsidies ?
- d. Convery 2015 managing uncertain climates: some guidance for policy makers and researchers

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