

Uncertainty in the social cost of carbon

Evidence for the Stern Review

Contribution from the Stockholm Environment Institute

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This submission concentrates on the economic impact of climate change, related to the terms of reference topic:

- The economic, social and environmental consequences of climate change in both developed and developing countries, taking into account the risks of increased climate volatility and major irreversible impacts, and the climatic interaction with other air pollutants, as well as possible actions to adapt to the changing climate and the costs associated with them.

We also comment on the issue of adaptation to climate change, in support of the instruction for the report:

- An assessment of the potential of different approaches for adaptation to changes in the climate.

The Social Cost of Carbon

A risk assessment of the social cost of carbon (SCC) brings together elements of uncertainty in climate change and its impacts with uncertainties in economic valuation; both are related to the context of decision making (see Figure 1). Confidence in climate change varies, from projected temperature rises to potential system changes such as collapse of the North Atlantic circulation. Uncertainty in economic valuation relates to market impacts, non-market impacts and the indirect effects on societies, often related to values that are difficult to quantify and often impossible to monetize. Decision factors, such as equity considerations and discount rates are a third dimension of the risk assessment.

Downing et al. (2005) presents one of the most complete reviews of uncertainty in estimates of the social cost of carbon (the incremental effect of 1 additional ton of carbon) (see the full report on the Defra web site: <http://www.defra.gov.uk/environment/climatechange/carbon-cost/index.htm>). The following key messages are drawn from that review.

		Uncertainty in valuation		
		A. Market	B. Non-market	C. Socially contingent
Uncertainty in Climate Change	1. Projection			
	2. Bounded risks			
	3. System change			

Figure 1. A risk assessment approach to uncertainty in the social cost of carbon

Understanding of the social cost of carbon:

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- Our understanding of future climatic risks, spanning trends and surprises in the climate system, exposure to impacts, and adaptive capacity, is improving, but knowledge of the costs of climate change impacts is still poor. Some of this lack of knowledge arises from uncertainties that will be impossible to resolve prior to the need to make relevant policy decisions.
- The lack of adequate sectoral studies and understanding of local to regional interactions precludes establishing a central estimate of the social cost of carbon with any confidence.
- The balance of benefits and damages in the social cost of carbon shifts markedly over time, with net damages increasing in later time periods. The estimates presented below are appropriate for an early period when carbon concentrations are low (on the order of 350 ppm) and would grow significantly higher at later periods.
- Estimates of the SCC are particularly sensitive to the choice of discount rates and the temporal profile of net damages
- Vulnerability and adaptation to climate change impacts are dynamic processes responding to climatic signals, multiple stresses, and interactions among actors. Large scale impacts, such as migration, can be triggered by relatively modest climate changes in vulnerable regions.

Table 1 maps existing estimates of the SCC against a matrix of uncertainty in future climate change and economic valuation. The risk matrix shows that most of the assessments of the social cost of carbon are concentrated in the realm of climate projections and market exchanges, with some extensions to non-market sectors (such as loss of wetlands) and uncertainty in changes in climatic risks (such as wetter or drier conditions). Current estimates are likely to be an uneven sample of the plausible consequences of climate change.

Table 1. Locating the literature in a risk assessment framework

		Uncertainty in valuation		
		A. Market	B. Non-market	C. Socially contingent
Uncertainty in Climate Change	1. Projection	Over 95% of the studies are in this category; with a bias toward market costs.		Plausible effects have been posed but not adequately valued nor included in the marginal SCC
	2. Bounded risks	Some models have explicit scenarios but most are tied to benchmark 2xCO ₂ scenarios and do not cover local changes in weather.		
	3. System change and surprise	A few exploratory studies, but not sufficient to provide robust estimates of the marginal SCC		No credible studies

Uncertainty and risk:

- Various climate uncertainties such as the climate sensitivity are critical uncertainties that strongly affect the SCC. Uncertainties in coverage, sectoral assessments and regional processes are also significant.
- The choice of decision variables such as discount rate and equity weighting are extremely important and strongly affect the calculated SCC. They are not technical parameters bounded by technical uncertainty ranges. Rather, they derive from ethical considerations and value judgements. The SCC thus cannot be considered an objective, definitive number, but rather the result of subjective, negotiated, societal decisions.

Figure 2 shows the uneven distribution of regional results from one SCC model (sectoral results also show a high concentration in a few sectors). The predominance of a few regions or sectors indicates that further work at the sectoral and regional scales is required to establish confidence in global estimates of the SCC.

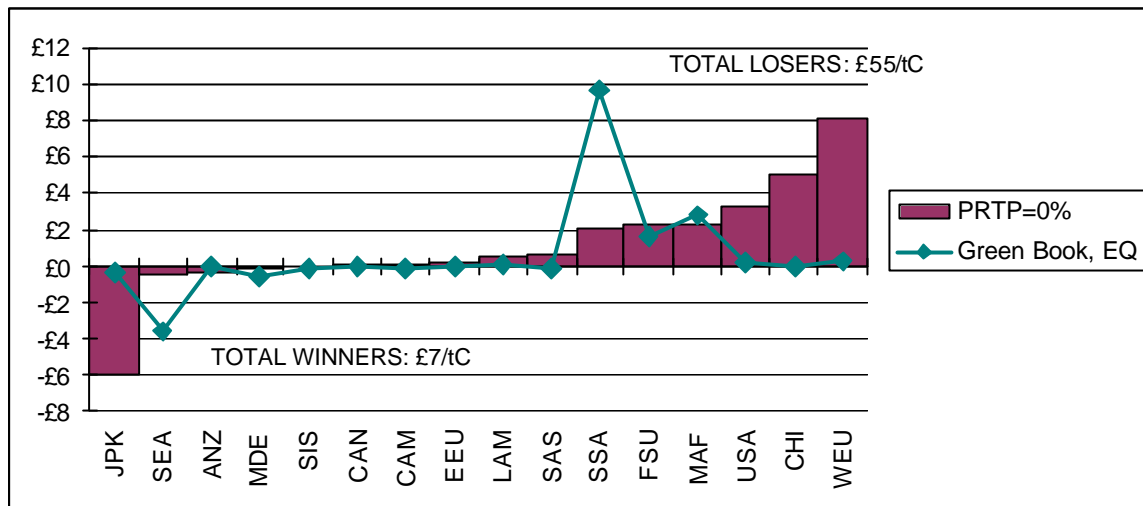


Figure 2. Regional disaggregation of median estimates of the SCC in FUND

The bars show the total damages with a Pure Rate of Time Preference = 0%), sorted from those that benefit from climate change (with a total benefit of £7/tC) to those that suffer the greatest losses (total losses are £55/tC). The regional values for the Green Book discounting scheme with equity weighting is shown for comparison—with some notable differences in the distribution of winners and losers. Note that the regional breakdown of FUND results is not intended to imply estimates of the SCC at the regional level. The uncertainty in the regional values (not shown) is likely to be greater than the global uncertainty (already considerable).

Key JPK = Japan and Korea LAM = Latin America
 SEA = Southeast Asia SAS = South Asia
 ANZ = Australia and New Zealand SSA = Sub-Saharan Africa
 MDE = Middle East FSU = Former Soviet Union
 SIS = Small island states MAF = North Africa
 CAN = Canada USA = United States of America
 CAM = Central America CHI = China
 EEU = Eastern Europe WEU = Western Europe

The range of estimates of the social cost of carbon:

- Estimates of the social cost of carbon span at least three orders of magnitude, from 0 to over 1000 £/tC, reflecting uncertainties in climate and impacts, coverage of sectors and extremes, and choices of decision variables.
- A central value of the SCC for global policy contexts is impossible to deduce. However, we can confidently say that there is a high risk that the central value of the social cost of carbon would be much higher than the lower benchmark of 35 £/tC .

The fact that one cannot ascertain a precise SCC obviously does not mean that one should assume a zero cost. This study suggests that 35 £/tC could confidently be taken as a *lower* limit. It can be used in a decision context as a benchmark to indicate the abatement cost below which mitigation actions are essentially assured to be good policy. (The figure of 35 £/tC is derived assuming a modest level of aversion to extreme risks, relatively low discount rates and equity weighting. However, pursuing all actions at a cost below 35 £/tC would not at all eliminate the possibility of serious – or even catastrophic – climate change. If no mitigation actions above the lower limit were taken, one could almost certainly

expect considerable climate damages, and hence mitigation actions costing considerably more would also be almost definitely justifiable.

The probability that the “actual” SCC exceeds the estimated lower benchmark of £35/tC is quite high for the Green Book results, and not insignificant even with a very high discount rate (Table 2, Figure 3). The risk of quite serious consequences, over £140/tC, is substantial as well.

Table 2. Summary of the probability that the SCC exceeds a given threshold in FUND

	Green Book, EW	PRTP=0%	PRTP=0%, EW	PRTP=3%
£35/tC	40%	52%	78%	8%
£50/tC	33%	47%	77%	5%
£140/tC	12%	27%	73%	2%

EW = Equity weighting. Green Book is the UK Treasury guidance on economic evaluation.

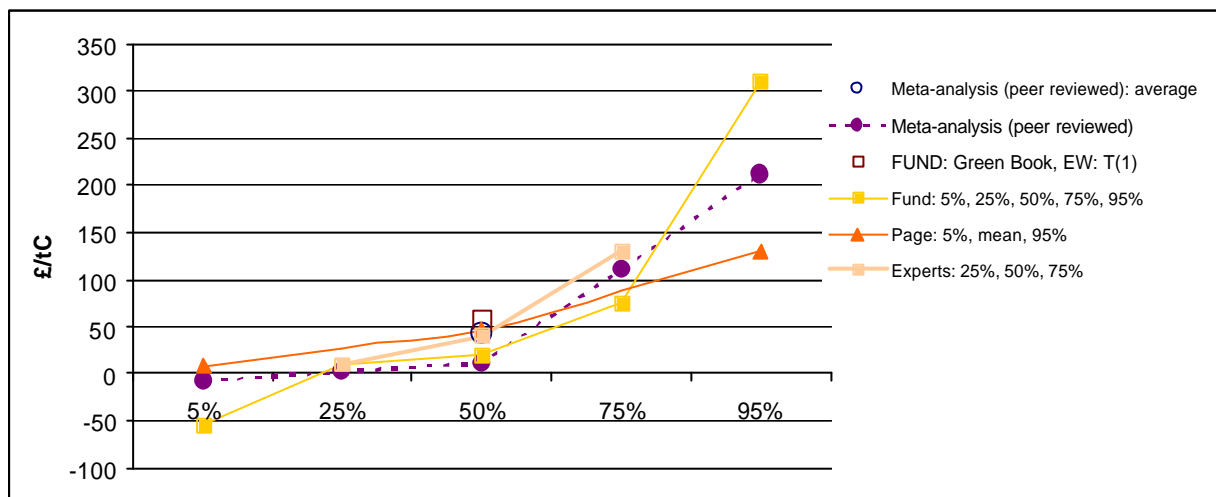


Figure 3. Comparison of distributions of estimates of the SCC

The Downing report (2005) draws together several lines of evidence: evaluation of the literature, results from two quantitative models and interviews with leading experts on the social cost of carbon. The meta-analysis of the literature, using only the peer reviewed literature and weights provided by Richard Tol, shows values from £-8/tC (5%) to £211/tC, with an average of £43/tC. The average from FUND (with 1% of the outliers trimmed) for the Green Book discounting and equity weighting is £57/tC, with a range from £-54/tC (5%) to £310/tC (95%). It should again be noted out these that these studies do not include all costs, as discussed in Table 1. The excluded costs may well be significant.

Adaptation to climate change

The economics of adaptation to climate change is still being developed. For most purposes, adapting to changing climatic risks is an ongoing process that is deeply embedded in stakeholder decision making, the social and economic networks that link decisions at diverse scales, and the interactions of environmental, economic and social threats. As such, it is difficult to disaggregate responses to only climate from responses to all other factors. The estimates of the impact of climate change, cited above, include at least in part the kinds of autonomous adaptation expected in many sectors. The FUND model in particular, adjusts estimates of damages according to the rate of climate change, an assumption that approximates the role of adaptation in reducing potential impacts at an equilibrium. It is not possible, given the state of the art at present, to calculate a cost to adaptation that might be used to balance the cost of mitigation.

Conclusion

There are several cautions that must be issued alongside any estimate of the social cost of carbon. First, costing analyses that span generations have significant intergenerational equity problems. Costing analyses discount economic costs and benefits, whereby net benefits accruing to future generations are valued less than equivalent net benefits accruing to present generations. With a phenomenon such as climate change, for which impacts are heavily weighted toward future years, this discounting is problematic in that it privileges today's generation vis-à-vis subsequent generations. Results are thus highly dependent on the subjective choice of discount rate (as demonstrated in Table 2).

Second, the magnitude of the technical uncertainty presents one major difficulty in estimating climate impacts and hence the SCC. One approach for accounting for such uncertainties is to use probability density distributions (e.g., in the climate sensitivity) but given the high degree of uncertainty, this leads to highly uncertain ranges of results with central values that are arguably meaningless from a decision-making standpoint.

Third, although climate change gives rise to some damages that can in principle be straightforwardly valued (such as damage to certain types of physical infrastructure), other damages are difficult or impossible to value. This is especially true in cases where valuation depends inherently on value judgements or ethical considerations. For example, climate change will cause loss of life, the costing of which is a value-laden and highly subjective. Some losses are of unknowable value, such as the extinction of species that might otherwise lead one day to medical cures.

Fourth, costing of climate impacts does not account adequately for extremely high impact consequences that have low but unknown probabilities. Consequences such as a shutdown of the thermohaline circulation, a major release of methane hydrates, and the loss of the West Antarctic Ice Sheet would be massively disruptive and impossible to value. Social dislocations, such as conflict, are also impossible to value. Dealing with aversion to such extreme and unpredictable risks is another subjective element of assessing the SCC.

Fifth, estimates of SCC aggregate costs and benefits across people of a range of incomes and differing levels of responsibility and agency. Climate change would lead to a regressive and inequitable redistribution, insofar as they will disproportionately affect poor communities that are less responsible for GHG emissions, while the benefits of producing GHGs accrues primarily to the wealthier emitting communities. Assuming, for instance, that the SCC were assumed to actually be the lower bound value of £35/tC, then the current global annual emissions of roughly 6 GtC would be responsible for damages ultimately amounting to more than £200 billion. Application of a "polluter pays" framework would suggest that this amount should be paid (or invested to be paid later) into adaptation and compensation for those who will eventually be harmed.

Reference:

Downing, T.E., Anthoff, D., Butterfield, B., Ceronsky, M., Grubb, M., Guo, J., Hepburn, C., Hope, C., Hunt, A., Li, A., Markandya, A., Moss, S., Nyong, A., Tol, R.S.J., and Watkiss, P. 2005. Scoping uncertainty in the social cost of carbon. London: Defra (<http://www.defra.gov.uk/environment/climatechange/carbon-cost/sei-scc/index.htm>).