Review for Economics-1056-1 The Social Cost of Atmospheric Release

General comments

This paper explores the economic damages associated with a marginal change in the release of individual pollutants to the atmosphere owing to their effects on climate and air quality. It presents a multi-impact economic valuation framework called the Social Cost of Atmospheric Release (SCAR) that extends the Social Cost of Carbon (SCC) to a broader range of pollutants and impacts. The results suggest that total atmosphere-related environmental damages plus generation costs are greater for coal-fired power than other sources, and damages associated with gasoline vehicles exceed those for electric vehicles.

In general, there are a number of paragraphs that require references, evidence and examples to support them. The author should elaborate more on the criteria used to select the pollutants analyzed in the paper and provide a description of the impacts of each pollutant on human health and the environment. It is not clear how the author selected the discount rates used in the paper. A detailed explanation is required. The Methods section should be presented before the Results section. Are market and non market values considered in the estimation of SCAR? There are a number of very important impacts (e.g. the impacts on biodiversity loss) that are not considered in the methodology. The concept of declining discount rate and its implications should be properly developed in the paper. A conclusions section is missing. Further specific comments are provided below.

Specific comments

Introduction p.2: **The first paragraph requires references. There are a number of papers that analyse "**…the choice of which impacts to 'internalize' within the economic valuation, the value of future versus present risk, and how to compare different types of impacts on a common scale.**" You could elaborate more on the debate in the literature.**

Introduction p.2: **"**Prior studies have provided compelling demonstrations of the importance of linkages between climate change and air quality valuation … but have typically not fully represented the climate impact of short-lived emissions, especially aerosols and methane.**" You could support the last statement providing references. Why is this the case? What are the problems representing the climate impact of short lived emissions?**

Introduction p.3: **"**While many uncertainties remain in this type of analysis…**" You could discuss such uncertainties here.**

Approach p.3: **"**Thus social costs for emissions of other pollutants should at minimum include their impacts on these same quantities.**" Which quantities? This is not clear.**

Approach p.4: **"**I evaluate a broad Social Cost of Atmospheric Release (SCAR) for emissions of CO_2, CH_4, carbon monoxide (CO), SO_2, BC, organic carbon (OC), nitrous oxide (N_2O) and the exemplar hydrofluorocarbon HFC-134a**" What exactly was the criteria used to select these**

pollutants?

Approach p.4: **"**The pollutants emphasized here are the major drivers of global mean climate … and the global health burden from poor air quality.**" OK, but what is the evidence? You could discuss this.**

Approach p.4: **"**This analysis is primarily concerned with pollutants that have multiple impacts (e.g. health and climate).**" You could provide a table describing the exact impacts on health and climate of each of the selected pollutants.**

Approach p.4: **"**Most of these substances are now controlled and decreasing**" what is the evidence?**

Approach p.4: **"**A few other pollutants**" examples?**

Approach p.4: **"**Other emissions also influence health, such as mercury and persistent organic pollutants, although these have no effect on climate, but valuation is not readily available in the literature.**" Economic valuation has been conducted, see for example:**

Swain, E. B., Jakus, P. M., Rice, G., Lupi, F., Maxson, P. A., Pacyna, J. M., ... & Veiga, M. M. (2007). Socioeconomic consequences of mercury use and pollution. *AMBIO: A Journal of the Human Environment*, *36*(1), 45-61.

Spadaro, J. V., & Rabl, A. (2008). Global health impacts and costs due to mercury emissions. *Risk Analysis*, *28*(3), 603-613.

Sundseth, K., Pacyna, J. M., Pacyna, E. G., Munthe, J., Belhaj, M., & Astrom, S. (2010). Economic benefits from decreased mercury emissions: Projections for 2020. *Journal of Cleaner Production*, *18*(4), 386-394.

Approach p.5: "This analysis facilitates discussion of the relative importance of those emissions with primarily a near-term influence …and those with effects that are large over long-terms" **How exactly? This is not clear**

Results p. 5: **"**Valuation of climate damages is highly sensitive to discounting, reflecting the relative value of money over time, and estimated climate-health impacts. The climate damages attributable to CO_2 (equivalent to the traditional SCC) are 11-140 $/ton using constant discounting rates of 5 to 1.4%**" Since valuation is highly sensitive to discounting, you should provide a detailed explanation of the reasons to use constant discount rates (of 5 to 1.4%) and the implications for your calculations**

Results p. 5: **"**integrated assessment model (IAM) estimates**" You could discuss this methodology**

Results p. 6: **"**I hereafter base the valuation on the mean of these two climate-health estimates, with an assumption of 50% uncertainty in both the climate-health impacts (e.g. spanning the range of these two estimates) and other climate impacts. The resulting total climate-related uncertainty spans the bulk of published damage estimates or a particular temperature increase**"**
What is the reason to base the valuation on the mean of these two estimates? Are they comparable?
Why did you assume 50% uncertainty in climate health impacts?

Results p. 6: **"**The use of a declining discount rate**" You should explain why do you use a declining discount rate**

Results p. 6: "the relative SCAR valuation per ton is much larger for methane and the aerosols or aerosol precursor species BC, SO_2 and OC than for CO_2, with a ton of methane causing ~30-90 times more damage than a ton of CO_2 and a ton of the aerosols causing up to ~6000 times more damage." **You should explain why**

Results p. 7: "Uncertainty in the regional aerosol impacts is obviously not systematic across pollutants." **This is not obvious for me. You could explain why.**

Results p. 7: **"**Differences may arise from the use of different carbon-cycle models, atmospheric lifetimes and radiative efficiencies.**" True, you should discuss the model used in your analysis and how this is different to others.**

Results p. 8: **"**I present the valuation of 1% of current global anthropogenic emissions**" Why 1%?**

Results p. 8: "Valuation of HFC-134a is always relatively small despite it having the highest per ton valuation" **You should explain why**

Illustrative applications p.9: **It is not clear how did you obtain the valuation of environmental damages presented in table 3**

Illustrative applications p.9: "much of the uncertainty is systematic across sectors" **how did you measured the uncertainty figures?**

Illustrative applications p.10: **"**the latest estimates of the health effects of ambient air pollution are much greater than the previous Global Burden of Disease values.**" You should mention them**

Illustrative applications p.11: "Environmental damages from the US average coal-fired power plant are 6.3±3.5¢, 9.0±4.2¢, and 20±9¢ per kWh with 5, 3 and 1.4% discounting, respectively." **Exactly what damages are considered here? How exactly did you obtain such figures?**

Illustrative applications p.11: "There is substantial variation across coal-fired power plants, however, with damages typically greater for older plants and less for newer ones." **You could provide some figures about the variance of emissions.**

Illustrative applications p.12: **"**The total levelized energy costs for new capacity in a recent US government estimate… are about equal for conventional coal and nuclear or renewables, with conventional combined cycle gas costing substantially less.**" You could mention the costs here.**

Discussion p. 14: "Furthermore, there are multiple benefits that have not been taken into account in this analysis." **Why? You may be underestimating costs and benefits in your valuation exercise**

Discussion p. 14: **"**Beyond health, additional impacts of emissions such as ocean acidification, biodiversity loss, ecosystem impacts of nitrogen deposition, and changes in visibility are not included in the valuation, suggesting that these damages are conservative.**" The valuation is therefore not accurate.**

Discussion p. 16: "a weaker damage function (e.g. linear in temperature change; maintaining the same valuation at 2.5°C) again would lead to a reduced sensitivity to changes in the discount rate" **True, the assumptions on the damage function are very important and should be discussed in detailed**

Discussion p. 16: "Although much further work is required to fully characterize benefits and compare with costs, this initial extension of SCC-type analyses to encompass a broader range of pollutants and impacts facilitates examination of how society values different impacts occurring over different timescales." **Due to the huge uncertainty associated with the valuation methods, I am not sure that this analysis facilitates the examination of how society values different impacts occurring over different timescales**

Methods pp. 17-18: **The first paragraph requires references. A detailed explanation of the IAM is needed here.**

Methods p.19: **"**The calculations presented here use the damage function of the DICE model [Nordhaus and Boyer, 2000], which has damages proportional to the square of the temperature change and equal to 1.8% of world output at 2.5°C.**" You should elaborate more on the assumptions of this damage function and how realistic it is to assume that the different pollutants will have the same impacts on temperature changes.**

Methods p.20: **"**SCAR values in future years are substantially larger, though the increase is uneven across pollutants (Table 4). Values increase substantially over time due to their dependence on the square of the temperature change as well as increasing population and GDP.**"** **True, and you should explain why this is the case for each pollutant**

Methods p.20: **"**An interagency analysis by the US government gives 2010 SCC values for discount rates of 5, 3 and 2.5% based on results from several IAMs examining multiple scenarios for emissions, population, GDP, etc. and a broad distribution for climate sensitivity (IWG2010; 2013). I therefore selected parameter values in the model to roughly match the average IWG2013 estimates for climate damages from CO_2 when using comparable climate-health impacts, and I use the same discount rates**" Why? You should provide a detailed explanation to follow this methodology.**

Methods p.21: **"**To examine the influence of a declining discount rate, I use a rate starting at 4% and decreasing exponentially with a 250 year time constant which roughly approximates the mean behavior seen in several prior studies [Freeman et al., 2013; Groom et al., 2007; Newell and Pizer, 2003].**" I am not sure that the author understands what a declining discount rate is. Why is an exponential discount rate used?**