ELECTRIC POWER
RESEARCH INSTITUTE

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Professors Joseph Stiglitz and Lord Nicholas Stern
Co-Chairs of the High-Level Commission on Carbon Prices
Carbon Pricing Leadership Coalition and World Bank Group

Subject: Commission on Carbon Prices Call for Input

Dear Professor Stiglitz and Lord Stern:

Thank you for the invitation to provide input. I hope my note provides useful perspective, in particular related to the social cost of carbon. We have had the good fortune of being able to do new analyses related to the subject over the last few years. Given the brevity of this contribution, my note can only highlight insights from that work. Substantially more detail and discussion are available in the various studies, and I would certainly be willing to discuss these topics with you further.

Sincerely,

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Senior Research Economist
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Enclosure

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Insights to Consider in Contemplating Carbon Pricing

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The social cost of carbon (SCC) is one of the values of carbon being considered by the High-Level Commission on Carbon Prices, as well as climate change damages in general. This note discusses a number of issues relevant to the SCC and global damage modeling, and briefly reflects on other carbon values.

The SCC is conceptually the marginal cost to society of emitting carbon dioxide (CO_2). Computationally, the SCC is the net present value of future global climate change impacts from one additional net global metric ton of CO_2 emitted to the atmosphere at a particular point in time. An SCC value is computed using two long-run scenarios – a reference scenario projecting a future global socioeconomic condition for centuries, and the resulting global greenhouse gas emissions, climate change, and net damages from that climate change; and, a pulsed scenario projecting the incremental climate change and damages over time from the addition of a pulse of CO_2 in an individual year (e.g., 2020) to the reference scenario. An SCC in 2020, therefore, is the discounted value of the additional net damages from the marginal emissions increase in 2020 relative to the reference condition.

SCC values have appeared in the literature for decades, with a broad range of estimates varying by sign and multiple orders or magnitude (e.g., Tol, 2008). In general, these estimates are not all comparable with substantive differences in assumptions, methods, discounting, and application.

SCCs are understandably regarded as an option for pricing carbon in that they represent a monetization of the climate damage externalities from activities emitting CO_2 that could be internalized into decisions by SCC pricing of emissions. However, not all SCCs are alike. It is useful to differentiate three types of SCC values: baseline, optimal, and policy. A baseline SCC is computed off of a reference scenario without future additional climate policies. An optimal SCC, on the other hand, is derived from the balancing the marginal costs and benefits (avoided damages) of reducing emissions over time to maximize societal welfare. Finally, a policy SCC is computed off of an emissions pathway constrained by a prescribed emissions reduction policy (associated with a long-run climate objective). See Figure 1 for examples of the three types of pathways.

Ideally, a carbon price should be set equal to the optimal SCC over time, thereby maximizing social welfare. Some, however, have suggested that the marginal benefit curve is flat and therefore the different SCCs will be similar. That is not what we are finding. We find that the SCC varies across the pathway types, with differences growing over time (see Table 1 for illustrative examples). How much the difference grows over time will depend on factors such as the representation of damages, climate system response, discounting, and socioeconomics. Regardless, the key observation is that marginal benefits are dynamic and the value of the first ton of emissions reduced will not equal the value of the last, especially for large emissions reductions like those required for

[1] This note was updated slightly from the initial submission—adding footnote 2, a revised reference, and page numbers.

pursuing the temperature goal of the Paris Agreement. Ignoring changes in marginal benefits is problematic and will likely result in an over-estimation of benefits.

Next, I discuss two options for setting carbon prices—U.S. Government SCCs, and using aggregate damage modeling to derive optimal SCCs. I then take a step back and consider optimal emissions pathways generally and SCC application. Finally, I offer a few remarks on other carbon values, and end with concluding thoughts.

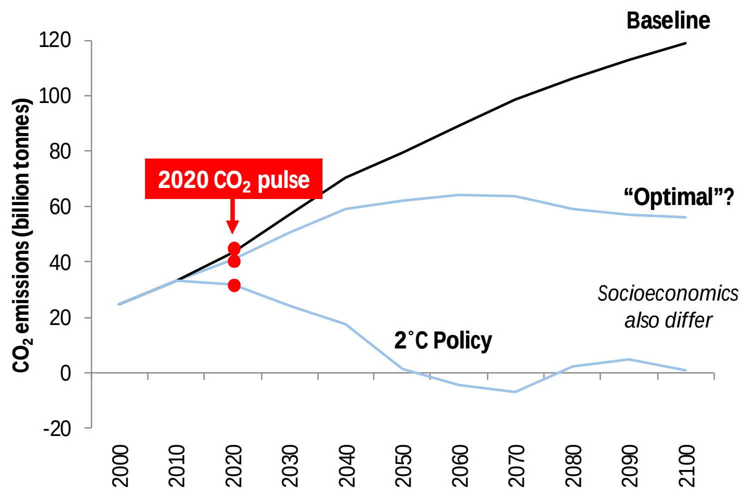

Figure 1: Examples of alternative global CO_2 emissions pathways

Table 1: Illustrative 2020 and 2100 SCC values for Figure 1 "Baseline" and "2˚C Policy" pathways ($/t$CO_2$)

U-PAGE*	2020	2100	U-FUND*	2020	2100
Baseline	$21	$123	Baseline	$6	$64
2˚C Policy	$17	$79	2˚C Policy	$0	$6

* Preliminary *modeling using the MERGE model with damage functions fitted to Rose et al. (2014, 2017) USG SCC damage component assessment results for FUND and PAGE and endogenous discounting (Rose, in prep).*

Are US Government SCCs up to the task?

The short answer is, no. When entertaining SCC values, the US Government (USG) SCC estimates are a logical option to consider.[2] The USG developed SCC estimates for future emissions changes to 2050 for use in federal rulemakings. The methodology and initial estimates were developed in 2010, and revised estimates have been produced since based on model updates and corrections (USG, 2010, 2013, 2015, and 2016). The methodology averages SCC results across three models that each produce tens of thousands of SCC estimates running alternative assumptions regarding socioeconomic and emissions futures, as well as parameter values. The USG

[2] Note that, President Trump's March 28, 2017 Executive Order ("Promoting Energy Independence and Economic Growth") withdrew the USG SCC estimates from federal regulatory use and provided alternative guidance for monetizing changes in greenhouse gases. The USG SCC estimates, however, continue to be relevant, with states, countries (e.g., Canada), other decision applications, and academics considering them for decision-making and as benchmarks (for examples, see Rose and Bistline, 2016).

SCCs have been used in over 65 federal regulations since 2008, and use has propagated to other contexts as well—e.g., other U.S. federal actions, state policy, Canadian policy, and technology evaluation (see Rose and Bistline, 2016, for a summary).

Given the USG methodology, the resulting SCCs estimates are not conceptually optimal carbon prices. Specifically, they are not derived from balancing benefits and costs, with costs not considered at all and the values produced based on an amalgamation of futures (four baseline, one policy). The bottom line is that the USG SCCs were not designed to be a carbon tax. In addition to the conceptual mismatch, the underlying modeling has some fundamental issues (discussed next).

Is aggregate global damage modeling up to the task?

The short answer here is also, no. The state of the art is problematic. A recent component-by-component assessment and inter-model comparison of current modeling examined the raw modeling and behavior (undiscounted and disaggregated) within individual components of the various models used by the USG (Rose et al., 2014, 2017). This research finds stark differences in the underlying modeling and implementation across models that produce significant differences in outcomes—for projected climate change from the same emissions inputs, and projected damages from the same climate change and socioeconomic futures. Figures 2 and 3 provide examples from this work. These differences are not well understood or supported.

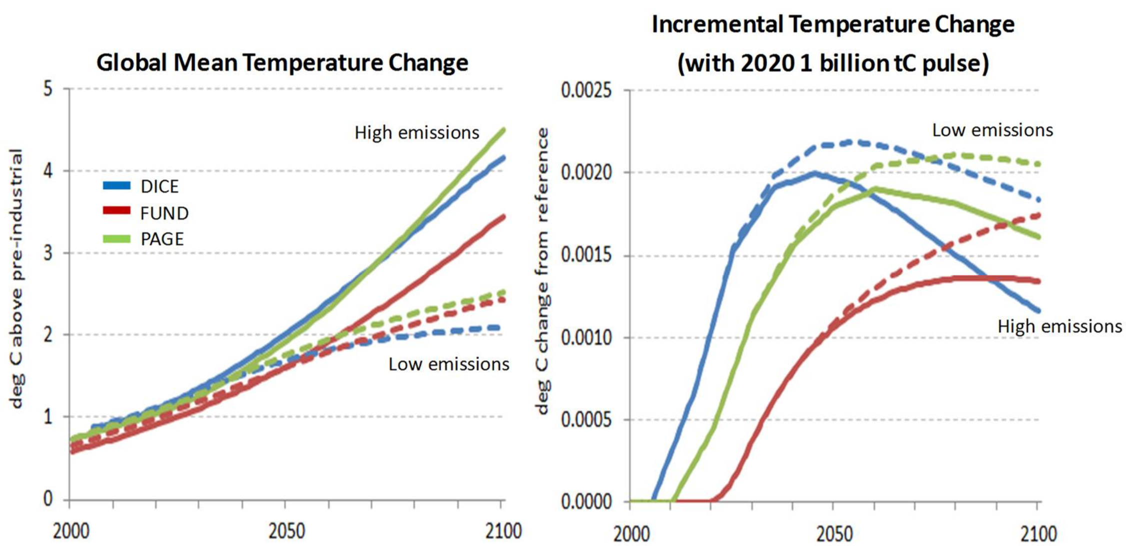

Figure 2: Projected global mean temperature change and incremental temperature change for a 2020 one billion tC pulse for identical high and low emissions projections. Developed from Rose et al. (2014, 2017)

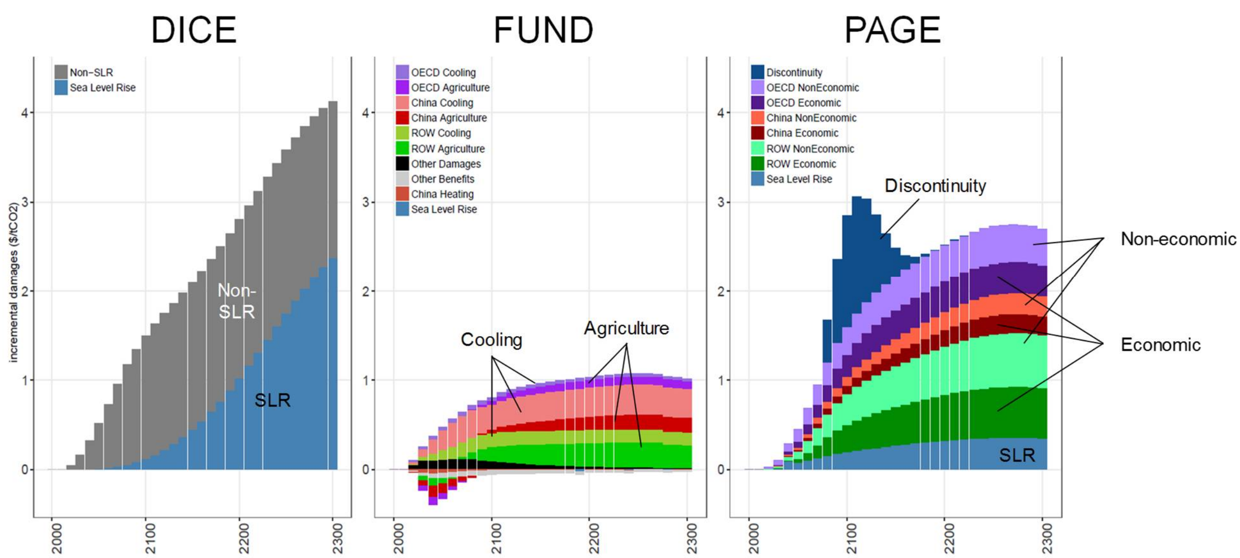

Figure 3: Projected incremental damages for an identical reference climate and socioeconomic future with a 2020 CO_2 pulse. Developed from Rose et al. (2014, 2017)

Going forward, for public and policy-maker confidence, it is essential to elucidate and evaluate the differences, and improve upon the modeling. Among other things, the differences identified to date suggest that the results from the various models may not be comparable due to structural and implementation differences that may not represent scientific uncertainty. Furthermore, current damage formulations are based on dated climate impacts literature (circa 1990/2000), with formulations in one model sometimes based on the formulations in the other models, which reduces the value of utilizing multiple models.

Fortunately, there are clear opportunities for improvement—evaluating climate modeling, updating damage representations, improving transparency and justification, and improving consideration of uncertainty (structural and parametric). These issues are first order and need to be addressed. As is, it is impossible to assess the bias in current estimates as some researchers and others have tried to do.

Finding an optimal SCC

Damage modeling issues aside, finding an optimal SCC is a challenge because identifying an optimal emissions path is far from straightforward. With uncertainties throughout the causal chain from socioeconomics through to damages, a different “optimal” emissions (and temperature) pathway coincides with each plausible set of assumptions. Figure 4, for instance, presents “optimal” emissions pathways for alternative combinations of assumptions regarding socioeconomics, climate dynamics, damages, and emissions abatement technology. The figure highlights the challenge of defining the uncertainty space, much less assigning probabilities, stochastic modeling, and identifying a single optimal pathway.

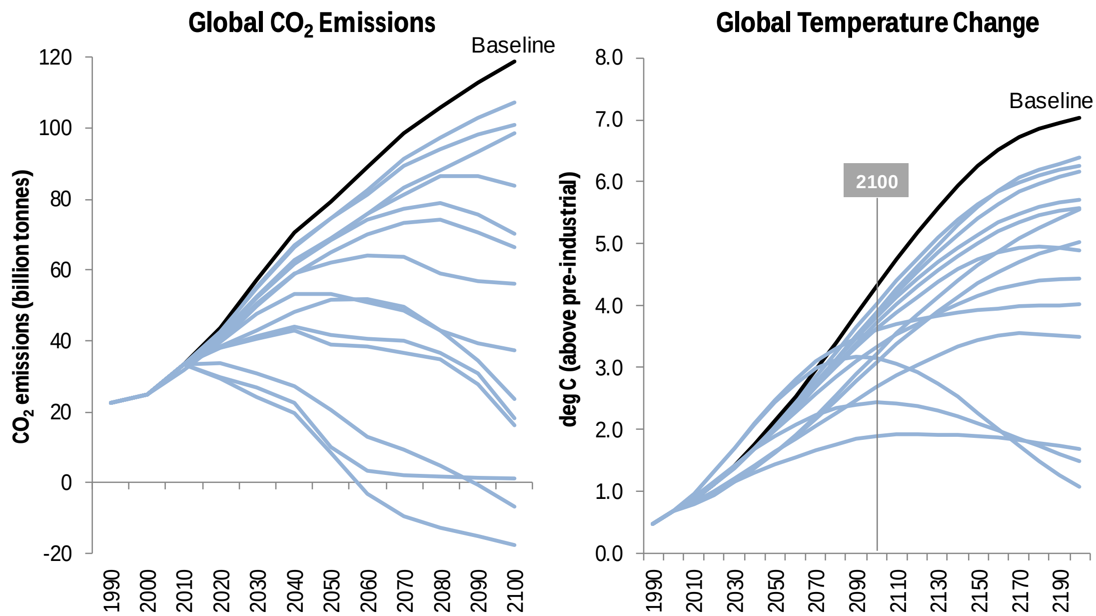

Figure 4: Optimal emissions and temperature pathways for alternative sets of assumptions. Rose (in prep).

Carbon price application

Most SCC literature and discussion focuses on damage estimation. However, there are also important SCC, and carbon tax in general, application issues that are overlooked. These issues impact the reliability of CO_2 reduction benefit and net benefit calculations, and potentially the insights and conclusions drawn. See Rose and Bistline (2016) for in-depth discussion. For instance, there are frequently inconsistencies in benefit and cost calculations in reference assumptions, treatment of uncertainty, and even the types of values compared in cost-benefit analyses. Global CO_2 effects are typically not estimated, with policies ignoring potential CO_2 changes beyond the regulated segment. If they exist, these CO_2 changes represent emissions leakage and affect the CO_2 benefits of policies (e.g., x% leakage = x% lower CO_2 benefits).

Also observed are inconsistencies in SCC use across policies, which creates distortions that result in inefficient resource allocation by assigning different values to different sources of CO_2. Finally, policy coordination is required to avoid pricing of the CO_2 externality more than once. In the last year, there are examples in the U.S. of the same carbon being priced in coal extraction, as well as at the time of coal combustion by state utility regulators and federal Clean Air Act policy. With jurisdictions acting independently, this is difficult to avoid, but economically inefficient.

Other carbon values

SCCs are not the only carbon pricing options. There are for instance, policy marginal costs of abatement derived from quantity mechanisms that constrain emissions (directly, or indirectly via atmospheric concentration or temperature objectives). Emissions abatement research has produced a rich literature with marginal cost carbon prices associated with various policy targets and assumptions. In this context, monetized damages are not essential, but perceptions of risk still are as the basis for targets. This literature has shown that abatement costs are increasing and non-linear (Clarke et al., 2014), and the marginal cost of incrementally lowering temperature constraints could rise quickly and be substantial (e.g., Blanford et al., 2014). This literature has also begun to explore second best policies that are more consistent with the world's current and likely future policy path, finding substantial cost increases with less optimistic futures regarding abatement participation and coverage and the availability of technology (Riahi et al., 2015; Clarke et al., 2014). This research is evolving and still relatively abstract and aggregate with respect to actual institutions and policy design. Additional factors, such as investment risks and incentive mechanisms, are generally not represented but will also affect costs (e.g., Rose et al., in press). While damages are currently difficult to quantify, the potential for high abatement costs implies that there is value in considering what one needs to believe to justify the cost.

Conclusion

It is important to recognize that there are different types of SCCs—baseline, optimal, and policy. Theoretically, a carbon tax should be based on an optimal emissions pathway that balances marginal benefits and costs. However, an optimal pathway and implied carbon tax path are elusive. Conceptually, the USG SCCs are not appropriate. Practically, the state of the art for global damage modeling is not up to the task; and, more generally, an optimal emissions pathway is challenging to identify. SCC (and carbon tax) application issues are also important in that they can affect estimates of CO_2 reduction benefits and net benefits. Finally, there are other options for developing a carbon tax; in particular, policy marginal costs. However, it will be important to consider the non-linearity, second-best policy worlds, and other cost factors, as well as perceptions of risk that could justify the costs.

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