Why the Social Cost of Carbon Is a Red Herring

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I. INTRODUCTION

In 2015, the Obama-era Environmental Protection Agency (EPA) released a Regulatory Impact Analysis to support its Clean Power Plan.[1] A key component of the analysis was determination of the social cost of carbon (SCC), which buttressed the Clean Power Plan's objective of reducing carbon dioxide (CO_2) emissions by making this reduction economically rational.[2] The SCC is, as this example suggests, potentially important as an input for policymakers attempting to optimize carbon-reduction policies by estimating the external costs of incremental additions of carbon to the atmosphere. In 2017, the Trump-era EPA released its own impact analysis as an overt riposte to the Obama-era analysis and the Clean Power Plan.[3] The Trump-era impact analysis

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1. U.S. ENVTL. PROT. AGENCY, EPA-452/R-15-03 REGULATORY IMPACT ANALYSIS FOR THE CLEAN POWER PLAN FINAL RULE (2015), https://www3.epa.gov/ttnecas1/docs/ria/utilities_ria_final-clean-power-plan-existing-units_2015-08.pdf [hereinafter OBAMA RIA].
2. *See id.* at 4-3.
3. *See* U.S. ENVTL. PROT. AGENCY, REGULATORY IMPACT ANALYSIS FOR THE REVIEW OF THE CLEAN POWER PLAN: PROPOSAL (2017), https://www.epa.gov/sites/production/files/2017-

reviewed the previous one and its estimation of the SCC, including "a modest reworking of the 2015 CPP RIA [Clean Power Plan Regulatory Impact Analysis] to increase transparency and illuminate the uncertainties associated with assessing benefits and costs of the CPP."[4] This "modest reworking" relegated detailed discussion of the SCC to an appendix and emphasized the uncertainty involved with calculating the SCC.[5]

The Obama-era analysis had noted extensive potential damages from excess concentration of greenhouse gases, including increased heat waves, reduced water supplies, rising sea levels, and changes in ecosystems.[6] The SCC estimates contained therein attempted to quantify these damages, to specify a cost per ton of emissions associated with such varied and long-term damages to human society and the natural world.[7] They were based upon years of development by the scientific community, including development from a U.S. government interagency working group.[8] All of that input data yielded four working SCC estimates under different scenarios: $12, $40, $60, and $120 per short ton of CO_2 emissions for the year 2020 in 2011 dollars.[9] The variation in the first three estimates was a result of differing discount rates—5%, 3%, and 2.5%, respectively, with the fourth, and highest estimate a result of taking the ninety-fifth-percentile distribution (i.e., a "tail risk" scenario) at a 3% discount rate.[10]

The Trump-era SCC estimates employed discount rates of 3% and 7%, thus using the Obama EPA's mid-range discount rate as the lowest rate and introducing the highest discount rate yet employed in the impact analyses.[11] Importantly, the Trump-era SCC estimates focused only on

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10/documents/ria_proposed-cpp-repeal_2017-10.pdf [hereinafter TRUMP RIA]; *see also* Exec. Order No. 13,783, 82 Fed. Reg. 50,580 (Mar. 28, 2017).

4. TRUMP RIA, *supra* note 3, at 1.

5. *Id.* at 162-69.

6. OBAMA RIA, *supra* note 1, at 4-2.

7. *Id.* at 4-3 to 4-7.

8. *See, e.g.,* INTERAGENCY WORKING GRP. ON SOC. COST OF GREENHOUSES GASES, TECHNICAL SUPPORT DOCUMENT: TECHNICAL UPDATE OF THE SOCIAL COST OF CARBON FOR REGULATORY IMPACT ANALYSIS—UNDER EXECUTIVE ORDER 12866 1 (2016), https://www.epa.gov/sites/production/files/2016-12/documents/sc_co2_tsd_august_2016.pdf [hereinafter IWG]. The interagency working group included scientists, economists, and policymakers from a wide range of federal agencies.

9. OBAMA RIA, *supra* note 1, at 4-7.

10. *Id.* A tail-risk scenario means, as is the case generally when discussing statistical distributions, inclusion of improbable outcomes on the tails (here, beginning at the ninety-fifth percentile) of such distributions. Here, this would mean biophysical outcomes of supposed unlikely occurrence but tremendous impact—i.e., catastrophes. *See id.* at 4-6 to 4-7.

11. TRUMP RIA, *supra* note 3, at 162; *see also* OBAMA RIA, *supra* note 1, at 4-7.

the *domestic* SCC, presenting the model-based U.S. share of the global SCC at 10%.[12] These two alterations in the Trump-era SCC estimates—changing the discount schedule and considering only the domestic SCC—were overwhelmingly responsible for a dramatic reduction in the SCC estimates: $6 per metric ton in 2020 (also in 2011 dollars) at the 3% discount rate, and just $1 at the 7% rate.[13] The conversion factor for metric ton to short ton is approximately 0.91, such that these estimates were actually about 9% lower when compared to the Obama-era estimates on an apples-to-apples basis.[14] Further, the Trump-era impact analysis neglected to generate a tail-risk estimate.[15]

Thus, in the span of just two years, the same government agency, utilizing the "best available science,"[16] put forth estimates for the same metric that had changed by so many orders of magnitude as to be farcical. This was the case even though the Trump and Obama analyses utilized the same underlying models.[17] Generally, the Trump-era RIA struck an entirely different timbre from that of the Obama-era RIA; its overall thrust was to discredit the CPP by emphasizing the benefits of decreased compliance costs and limited foregone benefits realized by repealing the CPP.[18] The Trump-era analysis evinced the intent of an administration clearly bent on discrediting climate science and indulging the fossil fuel industry—this should surprise no one.[19] What, however, did it reveal about the SCC? It can reasonably be argued that the Trump analysis revealed nothing about the SCC: because the Trump administration is so overtly committed to discrediting climate science and indulging the fossil fuel industry, its development of low SCC estimates might be decried simply as "bad science" performed by unqualified and/or compromised policy advisors.[20]

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12. TRUMP RIA, *supra* note 3, at 162.
13. *Id.* at 44.
14. *See id.*
15. *See id.*
16. *Id.* at 45.
17. *Id.* at 162.
18. *See, e.g., id.* at 3-15.
19. *See, e.g.,* Oliver Milman & Dominic Rushe, *Emails Reveal Close Ties Between EPA Boss Scott Pruitt and Fossil Fuel Interests*, WIRED (Feb. 22, 2017, 6:34 PM), https://www.wired.com/2017/02/emails-reveal-close-ties-epa-boss-scott-pruitt-fossil-fuel-interests/.
20. *See, e.g.,* Union of Concerned Scientists v. Pruitt, No. 1:18CV10129, 2018 WL 527888, at *1, *1-4 (D. Mass. Jan. 23, 2018) (a complaint alleging that, in essence, EPA Administrator Pruitt purged eminent scientists from advisory councils in favor of industry-friendly scientists so as to compromise the agency's scientific integrity); *see also* Peter Fairley, *States Are Using Social Cost of Carbon in Energy Decisions, Despite Trump's Opposition*, INSIDE CLIMATE NEWS (Aug. 14, 2017), https://insideclimatenews.org/news/11082017/states-climate-change-policy-calculate-social-cost-carbon (describing state actions based upon an SCC

However, this Comment will argue that the SCC is essentially a distraction with regard to climate issues. What this means, with "SCC" here acting as a proxy for the precise SCC estimates that have been derived by scientific-economic models, is that such models can tell us—especially those of us who are holistically concerned about climate change—very little or nothing about many things that are of critical importance in this regard. By framing massively complex biophysical phenomena in standard economic terms and creating an illusion of precision, SCC estimates generally act as a red herring for those concerned with effective climate action. This Comment will posit that there certainly *is* a SCC—that is, that carbon emissions clearly do generate negative externalities—but that attempting to pinpoint the SCC is largely an exercise in futility.

For example, while the aforementioned Trump-era SCC estimates may appear absurd—and quite possibly offensive to those distressed by climate change and overall environmental degradation—they are not *wrong* in an objective sense. Instead, they reflect model output in response to changed inputs (discount rates and regional share), which themselves reflect philosophical preferences. In aggregate, the SCC estimates developed by the interagency working group and others represent a strange marriage of conventional economic-financial logic, arbitrary economic-financial logic, massively expansive biophysical phenomena, preference, and uncertainty management utilized to create a digestible input—a dollar amount—for use in the dominant cost-benefit analysis (CBA) framework. Unsurprisingly, such an approach fails to account for the many aspects of life for which markets do not exist or are inadequate. Further, because climate change has the potential for catastrophic damages, which the models cannot tell us much at all about and which can dominate SCC estimates,[21] we are talking about modeling a special kind of uncertainty: that which is capable of substantially altering nearly all life as we know it. This is not like modelling, for example, the fair value of a corporation or the intergenerational gross domestic product of a country given varying macroeconomic inputs—the downside risk here is conceivably apocalyptic in a literal and global sense. A catastrophic outcome in this arena cannot be readily assuaged

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of $40+ per ton, and thus in line with the Obama-era estimates, and in disregard of the Trump-era estimates).

21. Consider in this regard the Obama-era SCC estimates, which included a tail-risk calculation: that estimate, at a 3% discount rate, was $120 per ton—three times the amount of the non-tail-risk 3% estimate and still likely a conservative estimate. *See* OBAMA RIA, *supra* note 1, at 4-6 to 4-7.

through, for example, accommodative monetary policy or filing for bankruptcy.

This Comment, which will explicate these concerns and assertions, is organized accordingly: Part II will provide a necessary background of the history and terminology involved with advanced SCC work; Part III will discuss some of the ways in which SCC estimates have found their way into policy and law; Part IV will delineate specific ways in which SCC estimates can be illusory or distracting with regard to more effective climate policy; and Part V, the conclusion, will suggest a more aggressive, broad-based approach for climate change policy.

II. THE SOCIAL COST OF CARBON—BACKGROUND AND DEFINITIONS

The SCC refers to the long-term economic damage inflicted by one ton of carbon dioxide CO_2 emissions in a given year.[22] Taken literally, SCC thus refers only to damages, or costs—specifically, marginal costs—although the term is loaded with a great deal more. As the aforementioned volte-face in EPA policy suggests, SCC analysis can be politicized.[23] Further, to have much meaning in any robust, policy-oriented context, the SCC needs to be weighed against the benefits of CO_2 emissions so as to enable CBA.

Contemporary thought on SCC has its most proximate roots in William D. Nordhaus's seminal research on the economics of the greenhouse effect.[24] Nordhaus, a longtime Professor of Economics at Yale, was a pioneer in taking an established economics approach and applying it to the issue of greenhouse gases and climate change.[25] That approach was basic optimization through the plotting of marginal cost and benefit (i.e., abatement of damages from greenhouse emissions) curves, with the marginal benefit curve appearing as an oddly squiggled line because "we know little about the shape of the damage function."[26] These curves were merely illustrative, and, as is standard in economics frameworks, were underpinned by a series of equations and reliance on

22. *See, e.g.*, *The Social Cost of Carbon*, U.S. ENVTL. PROTECTION AGENCY, https://19january2017snapshot.epa.gov/climatechange/social-cost-carbon_.html (last visited Apr. 3, 2018).

23. *See, e.g.*, Transparency and Honesty in Energy Regulations Act of 2016, H.R. 5668, 114th Congress (2016) (a West Virginia Republican sponsoring legislation that would "prohibit the Secretary of Energy and the Administrator of the Environmental Protection Agency from taking the social cost of carbon or the social cost of methane into account when taking any action, and for other purposes").

24. *See* William D. Nordhaus, *To Slow or Not to Slow: The Economics of the Greenhouse Effect*, 101 ECON. J. 920 *passim* (1991).

25. *See id.*

26. *Id.* at 923.

key assumptions—e.g., increasing marginal cost of abatement—to arrive at a workable equilibrium solution.[27] Nordhaus's work invited responses by others who were also interested in placing global environmental issues in macroeconomic frameworks.[28] For example, Robert Ayres and Jörg Walter, who possessed meaningfully different academic backgrounds from that of Nordhaus, reviewed and critiqued various aspects of Nordhaus's cost estimates of climate change upon the U.S. economy.[29] After discussing a wide range of effects and costs—e.g., land loss and price changes related to sea-level rise, a concomitant increase in refugees, and changes in flora—they considered to be inadequately estimated by Nordhaus, Ayres and Walter confirmed their suspicion that potential losses from climate change "greatly" exceeded those calculated by Nordhaus.[30]

Generally, SCC analysis can be divided into two approaches: marginal cost (damages) and CBA.[31] While marginal cost and CBA can be called alternative approaches, they are not mutually exclusive but rather different ways of presenting and considering data. Specifically, CBA analysis may incorporate a marginal cost curve, with the optimal emissions level at any given time being that at which the marginal cost of abatement equals the marginal benefit of abatement.[32] The marginal cost approach may be defined as an attempt to calculate the reduction in future damage levels resulting from a given increase in abatement at an earlier point in time.[33] Thus, a marginal cost approach when defined in this way is concerned with the intertemporal elasticity of the marginal cost curve, and hence coincides with the basic definition of SCC given above—that is, how much a given increase in emissions today harms global society across the future.

Much recent work on SCC has focused on refining empirical models that seek to determine the SCC.[34] Virtually all SCC estimates have been derived from one of, or a combination of, three integrated

27. *Id.* at 924-27.

28. *See, e.g.,* Robert U. Ayres & Jörg Walter, *The Greenhouse Effect: Damages, Costs and Abatement*, 1 ENVTL. & RESOURCE ECON. 937 *passim* (1991).

29. *Id.* at 241-47 (specifically responding to Nordhaus assumptions and estimates in a 1989 workshop paper and a 1990 book chapter).

30. *Id.* at 247.

31. Richard Clarkson & Kathryn Deyes, *Estimating the Social Cost of Carbon Emissions* 5 (Gov't Econ. Serv. Working Paper 140, Jan. 2002), http://www.civil.uwaterloo.ca/maknight/courses/CIVE240-05/week3/carbon%20social%20cost.pdf.

32. *Id.* at 7.

33. *Id.* at 10.

34. Matthew J. Kotchen, *Which Social Cost of Carbon? A Theoretical Perspective* 2 (Nat'l Bureau of Econ. Research, Working Paper No. 22246, 2016).

assessment models (IAMs).[35] Notably, Nordhaus has continued to work on SCC models: for example, in 2011 he published SCC estimates based on the RICE-2011 model,[36] and in 2014 he published SCC estimates based on the DICE-2013R model.[37] Examining such models at a broad level allows for a greater feel for what actually goes into them, without wading deeply into the details. Nordhaus built models based on established economic growth theory and analogized the capital investments in the standard framework to climate investments for SCC purposes.[38] It included a division of the world into twelve regions (RICE is the regionalized version of the DICE model); a social welfare function increasing in the per capita consumption of each generation, with diminishing marginal utility of consumption; an assumption of market equilibrium; calculation of damages relative to major economic sectors, sea-level rise, human health, nonmarket damages, and the possibility of catastrophes; and consideration of equity weightings, which weight damages to the poor more heavily than those to the rich.[39] The model was run across a range of discount rates, with a 2005 U.S. base rate of 4.1%.[40] That model yielded a 2015 SCC of $44 (in 2005 U.S.-dollar international prices) per ton of carbon, or $12 per ton of CO_2; the inclusion of uncertainty increased the expected value of SCC by approximately 8%, while the inclusion of equity weighting generally reduced the SCC.[41]

The DICE-2013R model, also pricing in 2005 U.S.-dollar international prices, yielded a SCC estimate of $18.60 per ton of CO_2 for 2015—55% higher than the RICE-2011 estimate.[42] The DICE-2013R model entailed numerous input changes and revisions, including the assumption of sustained total factor productivity growth, a less-rapid decline of de-carbonization in multiple areas of the world, and a 25% addition to the damages function to monetize impacts such as loss of

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35. William D. Nordhaus, *Estimates of the Social Cost of Carbon: Concepts and Results from the DICE-2013R Model and Alternative Approaches*, 1 J. ASS'N ENVTL. & RESOURCE ECONOMISTS 273, 291 (2014).

36. William D. Nordhaus, *Estimates of the Social Cost of Carbon: Background and Results from the RICE-2011 Model* (Cowles Found. for Research in Econ., Yale Univ., Discussion Paper No. 1826, 2011).

37. Nordhaus, *supra* note 35.

38. Nordhaus, *supra* note 36, at 3.

39. *Id.* at 3-4, 7, 10.

40. *Id.* at 34 (these discount rates are calculated as the real after-tax rate on consumption, by region—i.e., as a real interest rate).

41. *Id.* at 1.

42. Nordhaus, *supra* note 35, at 273.

biodiversity and ocean acidification.[43] Like the RICE model, the DICE model was run across a range of discount rates, including "base," "low," and "*Stern Review*" runs; as stated, the determination of discount rate(s) can, and did, have a significant impact on the SCC.[44] The Nordhaus models are not just of academic interest: the aforementioned Interagency Working Group (IWG) utilized the DICE model to help develop its SCC estimates in support of the CPP.[45] The DICE model was likewise used in the Trump-era RIA, with the RICE model's regional breakdown utilized to establish the 10% U.S. share of global SCC.[46]

The two other major IAMs are the Policy Analysis of the Greenhouse Effect (PAGE) and Climate Framework for Uncertainty, Negotiation, and Distribution (FUND) models.[47] Along with Nordhaus's DICE, the IWG utilized PAGE and FUND in an attempt to draw combined insights from the three leading IAMs.[48] The PAGE model, developed by Chris Hope, a Cambridge energy and climate specialist, has also been used by European policymakers considering the SCC.[49] Importantly, PAGE is far more concerned than DICE with environmental-climatic nuances, inventories, and effects, including "tipping points."[50] When the IWG published an early SCC estimate in 2010—which, as mentioned, included combined input from DICE, PAGE, and FUND—it was significantly lower than a PAGE-only estimate, in meaningful part because of higher discount rates and lack of equity weighting.[51]

FUND was initially developed by Richard Tol, a Dutch-British specialist in environmental economics.[52] Like PAGE, and unlike DICE, which is utility-based, FUND is output-based, meaning that it is

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43. *Id.* at 278-79.
44. *Id.* at 284, 287-88; Nordhaus, *supra* note 36, at 34.
45. IWG, *supra* note 8, at 3; OBAMA RIA, *supra* note 1, at 4-3.
46. TRUMP RIA, *supra* note 3, at 162.
47. Nordhaus, *supra* note 35, at 291; *see also* Laurie T. Johnson & Chris Hope, *The Social Cost of Carbon in U.S. Regulatory Impact Analyses: An Introduction and Critique*, 2 J. ENVTL. STUD. & SCI. 205, 207 (2012).
48. OBAMA RIA, *supra* note 1, at 4-4.
49. Johnson & Hope, *supra* note 47, at 207-08.
50. *See* Nordhaus, *supra* note 35, at 292; Johnson & Hope, *supra* note 47, at 207 n.4. A tipping point in this context is, generally, some threshold level of temperature increase—for example, the oft-cited 2°C level determined through various international negotiations—beyond which numerous ecological systems will be so altered as to constitute a sort of chaotic state-change. *See, e.g.,* Casey Ivanovich, *Everything You Need to Know About Climate Tipping Points*, ENVTL. DEF. FUND (Nov. 1, 2017), http://blogs.edf.org/climate411/2017/11/01/everything-you-need-to-know-about-climate-tipping-points/.
51. Johnson & Hope, *supra* note 47, at 205-06.
52. *See* FUND—CLIMATE FRAMEWORK FOR UNCERTAINTY, NEGOT. & DISTRIBUTION, http://www.fund-model.org (last visited Mar. 23, 2018).

concerned with measuring the effects of abatement on various aggregates, as opposed to the marginal cost of abatement relative to a social welfare function.[53] Also like PAGE, FUND is directed towards considering the overwhelming uncertainty involved with endeavoring to measure the many possible impacts of climate change.[54] For example, because of modeling differences in the carbon cycle and other biophysical phenomena, FUND predicts the lowest global temperature increase among the three IAMs over the course of this century relative to incremental increases in the temperature path, while PAGE is the most sensitive to these marginal changes.[55]

While Nordhaus's early work served as the most proximate origin of contemporary discussion on SCC because it first applied a macroeconomic framework to the specific issue of greenhouse gases,[56] it nonetheless fell within a long line of research, as well as legal case and policy history, placing environmental issues in overtly economic terms.[57] Likewise, since Nordhaus initially began publishing work on the economics of the greenhouse effect, research on SCC has developed and spread. For example, the United Kingdom consistently updates its carbon prices for use in policy development and appraisal, including carbon budgeting.[58] The nomenclature in this field has also evolved during recent decades. For example, "global warming" and the "greenhouse effect" seem to have been widely supplanted by "climate change," which refers to a broader scope of carbon-related damages than just long-term temperature increase.[59]

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53. *See* Nordhaus, *supra* note 35, at 292.

54. *See id.*; *see also* STEVEN ROSE, ELEC. POWER RESEARCH INST., UNDERSTANDING THE SOCIAL COST OF CARBON: A TECHNICAL ASSESSMENT 1, 11-19 (Dec. 8, 2014), https://www.usea.org/sites/default/files/event-/SRose%20-%20Understanding%20the%20SCC%20-%20USEA%20Dec%202014%20pdf.pdf.

55. ROSE, *supra* note 54, at 24-25.

56. *See* Nordhaus, *supra* note 24, at 920.

57. In the United States, for example, the *Boomer v. Atlantic Cement Co.* case was a landmark in applying general cost-benefit analysis to an environmental nuisance. *See* Boomer v. Atl. Cement Co., 257 N.E.2d 870, 872 (N.Y. 1970). The *Boomer* decision was an illustration of the so-called law and economics approach, pioneered in particular by various Chicago school economists. *See, e.g.,* Robin I. Mordfin & Marsha Ferziger Nagorsky, *Chicago and Law and Economics: A History*, U. CHI. L. SCH., https://www.law.uchicago.edu/news/chicago-and-law-and-economics-history (last visited Apr. 3, 2018). Broadly, Nordhaus's and similar work can be viewed as a further evolution in the field of environmental economics.

58. *Carbon Valuation*, GOV.UK, https://www.gov.uk/government/collections/carbon-valuation--2 (last visited Mar. 23, 2018).

59. *See, e.g., What's the Difference Between Global Warming and Climate Change?*, CLIMATE REALITY PROJECT (Oct. 26, 2016), https://www.climaterealityproject.org/blog/difference-between-global-warming-and-climate-change.

Clearly, work on the SCC is concerned with a global externality and a collective action problem. That is, CO_2 emissions aggregate and are borderless, with the potential to inflict damages globally, without regard to whether a given country or region has emitted a large amount of greenhouse gas. The externality here is that the world generally is forced to absorb carbon-related damages without regard to which entity inflicted them.[60] The collective action problem is that solving global environmental problems is an international good that requires participation from a large number of countries and other entities, which may have an incentive to defect from a costly regime of carbon reduction.[61] Determination of the SCC, which can be construed as a "shadow price" of carbon, and thus the appropriate tax level in an efficient market,[62] often involves discussion of a carbon tax. Because such a tax would be borne by various entities—most notably, constituents of the fossil fuel industry—there is also some level of collective action by special interests who wish to influence or suppress usage of SCC analysis.[63]

Thus, while determination of the SCC is foremost a macroeconomic endeavor because it involves estimating damages at a national and/or global level, the overarching problem can also be construed in microeconomic terms, wherein individual states determine their own cost-benefit incentives as a function of both domestic and global SCC.[64] This game-theoretic framework adds a necessary strategic component because it considers the incentives individual countries, each of which has a domestic SCC that is lower than the global SCC, face as a function of a global problem.[65] Such a framework also alludes to the difficulty involved with forming the incentives necessary to construct international action on climate change, such as the Paris Agreement: while a Nash equilibrium[66] exists in a simple, two-country game given a

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60. *See, e.g.*, Christian Gollier, *Fighting Climate Change and the Social Cost of Carbon*, U. PA., KLEINMAN CTR. FOR ENERGY POL'Y (Apr. 29, 2016), https://kleinmanenergy.upenn.edu/policy-digests/fighting-climate-change-and-social-cost-carbon.

61. *See, e.g.,* Kotchen, *supra* note 34, at 18.

62. *See, e.g.,* Nordhaus, *supra* note 36, at 2.

63. *See, e.g., Food, Fossil Fuels, and Filthy Finance*, *passim* (Oxfam Briefing Paper No. 191, Oct. 17, 2014), https://www.oxfam.org/sites/www.oxfam.org/files/file_attachments/bp191-fossil-fuels-finance-climate-change-171014-en.pdf [hereinafter Oxfam Briefing Report].

64. Kotchen, *supra* note 34, at 1.

65. *Id.* at 13, 18-25.

66. A Nash equilibrium is, generally, a stable outcome to a problem engendered when rational, utility-maximizing opposing actors cannot gain a marginal advantage by deviating from their own optimal strategy after taking into account the optimal strategy of the opponent(s).

certain incentive structure,[67] the framework necessarily becomes more complicated when many countries are negotiating. Such an analysis, of course, also says nothing about actual enforcement and defection with regard to international climate agreements. Further, within a country, coalition-building will likely occur, whereby special interests, whether ostensibly pro or anti-SCC, seek to influence the determination of the SCC and/or carbon tax level.[68]

III. THE SOCIAL COST OF CARBON IN POLICY AND LAW

The SCC is foremost meant to be a policymaking tool. Because it seeks to distill very complex and uncertain biophysical and economic phenomena into a single number, the SCC is meant to provide policymakers with a concise input to use when considering the costs and benefits of carbon-related policies.

For example, the United Kingdom (U.K.) routinely used updated SCC values to inform decisions involving project or policy CBA, as well as the setting of economic instruments such as taxes and subsidies.[69] The U.K.'s usage of the SCC in policy decisions must also be viewed in light of the fact that it passed its Climate Change Act in 2008, which provided for explicit carbon budgets.[70] Notably, the U.K., which had used a baseline SCC of $83 per ton, ceased calculating the SCC in favor of estimating the mitigation costs necessary to achieve its aggressive CO_2 reduction program.[71] Sweden has levied carbon since 1991—the tax was initially set at $133 per ton—and can thus be said to have instituted an aggressive SCC before "SCC" even entered the public discourse.[72] The OECD has sponsored work on the SCC and related policy.[73] Generally, Europe, which can safely be said to be progressive environmentally, has been the leader in SCC and climate change work, with the PAGE and FUND models having European developers, the U.K.'s *Stern Review*

67. Kotchen, *supra* note 34, at 7-9.

68. *See, e.g., Food, Fossil Fuels, and Filthy Finance*, *supra* note 63.

69. Paul Watkiss, *The Social Cost of Carbon*, OECD, https://www.oecd.org/env/cc/37321411.pdf (last visited Mar. 9, 2018); *see also Carbon Valuation*, *supra* note 58.

70. *Climate Change Act 2008*, LEGISLATION.GOV.UK, http://www.legislation.gov.uk/ukpga/2008/27/contents (last visited Mar. 23, 2008).

71. FRANK ACKERMAN & ELIZABETH A. STANTON, ECONS. FOR EQUITY & ENV'T, THE SOCIAL COST OF CARBON (June 2010), http://e3network.org/wp-content/uploads/2015/04/Ackerman_Social_Cost_of_Carbon.pdf.

72. *See* Folke Bohlin, *The Swedish Carbon Dioxide Tax: Effects on Biofuel Use and Carbon Dioxide Emissions*, 15 BIOMASS & BIOENERGY 283 (1998).

73. *See* OECD, EFFECTIVE CARBON RATES PRICING CO_2 THROUGH TAXES AND EMISSIONS TRADING SYSTEMS (2016), http://www.keepeek.com/Digital-Asset-Management/oecd/taxation/effective-carbon-rates_9789264260115-en#page1.

playing an important international role in developing SCC estimates,[74] and the European Union instituting an emissions trading system.[75]

Australia instituted a tax on carbon from 2012 to 2014, when the center-right prime minister Tony Abbott saw it repealed, with the price having been set at about $20 per ton.[76] Canada largely adopted the SCC numbers developed by the U.S. IWG for use in its own impact analyses.[77] A number of countries have used the SCC as an input for CBA when considering investments in the transportation or energy sectors.[78] Mexico passed a tax on carbon from fossil fuel use[79] and also agreed to use a similar SCC estimate to that being used by Canada and the Obama-era United States.[80] While many countries levy taxes on carbon-producing fuels, their levels are generally set too low relative to the overall cost of carbon pollution because they do not account for externalities induced by carbon—this is especially true of coal and natural gas, whereas gasoline tax rates (such as Brazil's, which reflects its policy favoring sugarcane biofuel) are sometimes set much higher.[81] Importantly, China, with its giant, mixed-system economy and carbon emissions, developed its own plan aimed at reducing emissions, which included tougher regulations on pollution and measures to create carbon markets.[82]

In the United States, the SCC was used, as stated, to support the Obama administration's CPP.[83] The CPP itself was controversial,[84] and a

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74. *See* NICHOLAS STERN, THE ECONOMICS OF CLIMATE CHANGE: THE STERN REVIEW (2007).

75. *Climate Action*, EUR. COMMISSION, https://ec.europa.eu/clima/policies/ets_en (last visited Mar. 23, 2018).

76. Julia Baird, *A Carbon Tax's Ignoble End: Why Tony Abbott Axed Australia's Carbon Tax*, N.Y. TIMES (July 24, 2014), https://www.nytimes.com/2014/07/25/opinion/julia-baird-why-tony-abbott-axed-australias-carbon-tax.html.

77. *Environment and Climate Change*, GOV'T CAN., http://ec.gc.ca/cc/default.asp?lang=En&n=BE705779-1 (last visited Mar. 9, 2018).

78. Kotchen, *supra* note 34, at 1.

79. Juan-Carlos Altamirano & Julia Martínez, *Mexico's Three Big Steps Towards Comprehensive Carbon Pricing*, WORLD RESOURCES INST. (Apr. 14, 2017), http://www.wri.org/blog/2017/04/mexicos-3-big-steps-towards-comprehensive-carbon-pricing.

80. *U.S., Canada, and Mexico Agree to Use Similar Measures for the Social Cost of Carbon to Value GHG Reductions*, VINSON & ELKINS: CLIMATE CHANGE BLOG (July 19, 2016), https://www.velaw.com/Blogs/Climate-Change-Blog/U-S---Canada--and-Mexico-Agree-to-Use-Similar-Measures-for-the-Social-Cost-of-Carbon-to-Value-GHG-Reductions/.

81. *See* IAN PERRY, DIRK HEINE, ELIZA LIS & SHANJUN LI, INT'L MONETARY FUND, GETTING ENERGY PRICES RIGHT: FROM PRINCIPLE TO PRACTICE 6 (2014).

82. Peter Dizikes, *Study: China's New Policies Will Lower CO2 Emissions Faster, Without Preventing Economic Growth*, MIT NEWS (Feb. 9, 2016), http://news.mit.edu/2016/china-policies-lower-emissions-faster-without-preventing-economic-growth-0209 (summarizing key findings from an MIT professor's study on Chinese carbon reduction plans).

83. OBAMA RIA, *supra* note 1, at 4-3.

number of politicians, particularly Republicans from states with powerful fossil fuel lobbies, likewise set their sights on the SCC.[85] The Trump-era EPA simply defanged the SCC in its impact analysis by applying it only domestically and using different discount rates.[86] It bears mentioning that the Trump-era EPA has also done the same thing with an even more potent greenhouse gas: methane.[87]

According to one report, the SCC was used by multiple federal agencies in making decisions on approximately 100 actions.[88] Given the current administration, it is difficult to imagine the SCC having any sway at the federal agency level. However, it is entirely possible that various bureaucrats, even if furtively, will continue to study the SCC and perhaps seek to actively utilize it in some manner.[89] Further, policymakers in New York, Minnesota, Illinois, Colorado, Maine, and Nevada have used the SCC to weigh the CO_2 impact from their power grids, and some of these states further use the SCC to determine incentive programs for supplanting fossil fuels.[90] California, which is environmentally progressive and willing to defy the Trump administration in this regard,[91] launched a cap-and-trade rule for large generators (25,000+ tons of CO_2 emissions) in 2013.[92] However, the price of carbon on California's market is significantly lower than most SCC estimates.[93]

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84. *See, e.g.,* Laurence H. Tribe, *The Clean Power Plan Is Unconstitutional*, WALL ST. J. (Dec. 22, 2014), https://www.wsj.com/articles/laurence-tribe-the-epas-clean-power-plan-is-unconstitutional-1419293203.

85. *See, e.g.,* Transparency and Honesty in Energy Regulations Act of 2016, H.R. 5668, 114th Congress (2016); Bruce Lieberman, *SCC—Social Costs of Carbon: A Continuing Little-Told Story*, YALE CLIMATE CONNECTIONS (Sept. 9, 2013), https://www.yaleclimateconnections.org/2013/09/scc-social-costs-of-carbon-a-continuing-little-told-story/ (noting various forms of opposition from Republican members of Congress from Pennsylvania, Louisiana, Texas, California, and West Virginia, as well as major energy companies).

86. TRUMP RIA, *supra* note 3, at 162.

87. *See* Niina Heikkinen, *EPA Revises the Social Cost of a Potent Greenhouse Gas*, SCI. AM. (Nov. 20, 2017), https://www.scientificamerican.com/article/epa-revises-the-social-cost-of-a-potent-greenhouse-gas/.

88. *The True Cost of Carbon Pollution*, ENVTL. DEF. FUND, https://www.edf.org/true-cost-carbon-pollution (last visited Mar. 23, 2018).

89. *See* Hannah Hess, *Despite Trump Executive Order, Social Cost of Carbon Still Studied by Federal Agency*, SCIENCE (June 15, 2017), http://www.sciencemag.org/news/2017/06/despite-trump-executive-order-social-cost-carbon-still-studied-federal-agency.

90. Fairley, *supra* note 20.

91. *See, e.g.,* Adam Nagourney & Henry Fountain, *California, at Forefront of Climate Fight, Won't Back Down to Trump*, N.Y. TIMES (Dec. 26, 2016), https://www.nytimes.com/2016/12/26/us/california-climate-change-jerry-brown-donald-trump.html.

92. *California Cap and Trade*, CTR. FOR CLIMATE & ENERGY SOLUTIONS, https://www.c2es.org/content/california-cap-and-trade/ (last visited Mar. 23, 2018).

93. *See California Carbon Dashboard*, CLIMATE POL'Y INITIATIVE, http://calcarbondash.org (last visited Mar. 23, 2018).

While use of the SCC in U.S. policymaking has been scattered and inchoate, it has generated a bit of case law. For example, in *Zero Zone, Inc. v. United States Department of Energy*, commercial refrigeration interests challenged the Department of Energy's (DOE) rulemaking with regard to improving the energy efficiency of such products.[94] The Obama-era DOE had utilized the SCC as part of its decision-making process—specifically, it had used the SCC to account for the environmental benefits stemming from increased energy efficiency—and the petitioners in *Zero Zone, Inc.* argued that the relevant statute did not allow the DOE to consider environmental factors in its setting of efficiency standards.[95] The petitioners also argued that the SCC calculations were unduly flawed because they were made by unnamed persons, the models were not peer reviewed, and the damages functions (which included potential harms like sea-level rise) were arbitrary.[96] The court in *Zero Zone, Inc.* had "no doubt" that Congress had endowed the DOE with the authority to consider the SCC in its CBA and further held that its usage of the SCC was neither arbitrary nor capricious.[97] Notably, discussion of the SCC also cropped up in *Sierra Club v. Federal Energy Regulatory Commission* (FERC), one part of broader litigation concerning the FERC's approval of natural-gas pipelines.[98] In that case, the D.C. Circuit, holding that the FERC must at least address greenhouse-gas emissions in its environmental impact statement for the National Environmental Policy Act, also ordered the agency to explain its position on the SCC.[99]

IV. THE DELUSIVE SOCIAL COST OF CARBON

For an environmentalist in the United States, merely knowing of those who assiduously oppose deployment of the SCC in policymaking—largely Republican politicians in concert with the fossil-fuel lobby—may well cause a visceral reaction encouraging the environmentalist to wholeheartedly support usage of the SCC. However, it should be emphasized that wariness of SCC estimates as they have been put forth, most notably by the IWG and the EPA, is *not* the same as doubting the veracity of climate change, or climate science generally—in

94. Zero Zone, Inc. v. U.S. Dept. of Energy, 832 F.3d 654 (7th Cir. 2016).
95. *Id.* at 677.
96. *Id.* at 678.
97. *Id.* at 677-78.
98. Sierra Club v. Fed. Energy Regulatory Comm'n, 867 F.3d 1357, 1364, 1375 (D.C. Cir. 2017).
99. *Id.* at 1375.

fact, it can be quite the contrary. For those genuinely concerned about global carbon emissions and climate change, it is important to understand and question the nature of the IAMs and particular estimates of the SCC. It is particularly imperative to inspect the key assumptions underlying such estimates, as alterations to these assumptions can result in substantial changes to the estimates. In short, if too much in the models is arbitrary, highly uncertain, or merely in the eye of the beholder, then they form an unstable basis for policymaking. Further, they necessarily reduce to a dollar figure, or simply do not account for, countless elements of life that may have great value that is not easily quantified. This Part will examine four explicit ways in which IAM-driven SCC estimates can be misleading, arbitrary, or otherwise problematic.

A. What Discount Rate?

The issue of discounting is at the forefront of SCC critiques.[100] Even Nordhaus, who effectively introduced the contemporary conception of the SCC and has spent the past couple decades refining his greenhouse-gas models, readily admits that the selection of discount rates poses a major problem for SCC usage.[101] This recognition will be true for all rational SCC critiques, as it is obvious that even a moderate change to the discount rate can have a profound impact on the SCC because climate-change damages stretch indefinitely into the future.

Discounting with regard to the SCC plays a different role, both functionally and philosophically, from that in financial discounting. In financial discounting, the fundamental logic of the discount rate is that money has time-value and this must be reflected in intertemporal calculations.[102] Depending upon the situation, an appropriate and transparent discount rate may be derived from the prime rate, Treasury yields, LIBOR, a cost-of-capital calculation, or some other rate/yield and applied to judge the relative value of alternative investments, income streams, debt payments, etc. over time. The discount rate as utilized in Nordhaus's macroeconomic model is a rate of time preference and is applied to a general social utility function.[103] Time preference in this economic framework is used to measure the degree to which current

100. *See, e.g.,* Ackerman & Stanton, *supra* note 71.

101. Nordhaus, *supra* note 35, at 308.

102. *See, e.g., Present Value and Discounting*, INVESTOPEDIA, https://www.investopedia.com/walkthrough/corporate-finance/3/time-value-money/present-value-discounting.aspx (last visited Mar. 23, 2018).

103. Nordhaus, *supra* note 35, at 276.

society values its utility (consumption), which in the DICE model is calculated as the product of all living individuals and the utility of a representative individual with average income,[104] over that of future generations.

Economic discourse generally relegates the question of whether it is *right* for the current generation to value its own consumption over that of future generations to ethics.[105] Some argue on ethical grounds that the rate of time preference should be zero.[106] It can even be argued that discount rates should be negative. Regardless, when it comes to the SCC, it is readily apparent that the underlying economic-scientific models, even though couched in familiar terms and concepts, are an attempt at a particularly massive project. Because the SCC is—even though taking into consideration wide-ranging biophysical damages—an economic calculation, it ultimately reduces almost *everything* to standard economic discourse and distills it all into a number. If SCC estimates are unduly reduced because of the use of higher discount rates, then this can be written off as an ethical or logical problem. If SCC estimates are substantially increased because model developers have now decided to include catastrophic damage possibilities in the models, then this is the models being refined, even if longer-term uncertainty remains at the same high level. In essence, the SCC is little more than a mirror, reflecting what we think we know and what we wish to see. This truism is distilled in the discount rate, which immediately adjusts the SCC up or down depending on the subject's valuation of life in the future.

Practically, it is not readily apparent where SCC discount rates should even come from. In a standard investment scenario, the projected rates of return of various investments are readily available. For example, one may immediately obtain the yield on a given Treasury bond, projected rate of return for the S&P 500, or interest paid on a money market account, and place capital in any one of these markets or use the rates to weigh alternative investments. While rates of time preference are routinely calculated based upon financial and macroeconomic data, and generally yield estimates in the 2% to 5% range,[107] there is no reason to

104. Stephen C. Newbold, Summary of the DICE Model 3, Paper Prepared for the EPA/DOE Workshop: Improving the Assessment and Valuation of Climate Change Impacts for Policy and Regulatory Analysis (Nov. 18-19, 2010), https://yosemite.epa.gov/ee/epa/eerm.nsf/vwAN/EE-0564-114.pdf/$file/EE-0564-114.pdf.

105. Robert S. Pindyck, *Climate Change Policy: What Do the Models Tell Us?*, 51 J. ECON. LITERATURE 860, 864 (2013).

106. *See, e.g.*, Hal R. Varian, *Recalculating the Costs of Global Climate Change*, N.Y. TIMES (Dec. 14, 2006), http://www.nytimes.com/2006/12/14/business/14scene.html.

107. Pindyck, *supra* note 105, at 864.

believe that such a number, which would normally exist in a capital allocation framework, can be reasonably applied in the context of carbon emissions and climate change. This is logically possible in Nordhaus's models because carbon budgeting has been analogized to capital investment budgeting in a standard macroeconomic framework. But is it logical or appropriate to analogize capital budgeting to the budgeting of an element that can have such a profound impact on all aspects of life?

Further, because the rate of time preference in a standard economic framework should have some relationship to the real interest rate,[108] discount rates should fluctuate downwards during unexpected deflationary periods, and vice versa. In this regard, it is compelling to note that the Trump-era EPA's usage of 3% and 7% discount rates was supported by an Office of Management and Budget (OMB) Circular redistributed under the Obama administration.[109] This Circular stated that, "[f]or regulatory analysis, you should provide estimates of net benefits using both 3 and 7 percent."[110] The rationale was that 7% was an estimate of the average before-tax rate of return to private capital in the U.S. (not global) economy, while 3% was an estimate of the rate of time preference as reflected by the difference between the average post-1973, ten-year Treasury yield and the average Consumer Price Index (CPI) annual rate of inflation—i.e., a measure of the real interest rate.[111] Put simply, it makes little sense to tether climate policy, which seeks to address long-term biophysical phenomena, to monetary policy. To wit, since the 2008 global financial crisis, ten-year Treasuries have yielded an average of approximately 2.6%,[112] while the CPI has averaged an increase of approximately 1.7% per annum.[113] Thus, during the past decade or so, the real interest rate according to this metric has been approximately 1%. This fact was reflected in neither updated OMB discounting guidance nor in the Trump-era EPA's impact analysis.

In a capital investment framework, *actual* rates would be used for discounting and investment decisions. In contrast, the OMB Circular

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108. *See, e.g.*, Kei-Mu Yi & Jing Zhang, *Real Interest Rates Over the Long Run* 1 (Federal Reserve Bank of Minneapolis, Economic Policy Paper 16-10, Sept. 2016), https://www.minneapolisfed.org/~/media/files/pubs/eppapers/16-10/kei-mu-yi-epp.pdf.

109. *Circular A-4*, OFF. MGMT. & BUDGET (OMB) (Sept. 17, 2003), https://obamawhitehouse.archives.gov/omb/circulars_a004_a-4/.

110. *Id.*

111. *Id.*

112. *See, e.g.*, *10 Year Treasury Rate by Year*, MULTPL.COM, http://www.multpl.com/10-year-treasury-rate/table/by-year (last visited Mar. 23, 2018).

113. *See, e.g.*, *Consumer Price Index Data from 1913 to 2018*, US INFLATION CALCULATOR, http://www.usinflationcalculator.com/inflation/consumer-price-index-and-annual-percent-changes-from-1913-to-2008/ (last visited Mar. 23, 2018).

provided discount rates based on a particular measure taken from longer-term capital markets and suggested that these be used indefinitely for regulatory CBAs.[114] In this context, there is no reason to believe that the 3% discount rate would be logically appropriate in a macroeconomic environment featuring structurally higher deflationary (or inflationary) tendencies. Regardless, the determination of discount rate in SCC estimates has been a mishmash of standard economic logic, arbitrary economic logic, and ethics that is unappealing, especially in the climate change context.[115] Generally, because of the negative intertemporal externalities produced by excess CO_2 emissions, SCC estimates *should*, but generally do not, entail a rate of time preference lower than the rate of interest.[116]

It is not debatable that a given SCC estimate may be dramatically raised or lowered by changing the discount rate, and that the discount rate often used in SCC models reflects subjective or arbitrary assessments of the value of future phenomena. As stated, the selection of discount rate in this context may be relegated to ethics or may simply be extrapolated from financial data and deployed as it would be in any other capital allocation context. It may be the example par excellence of *homo economicus* applying his logic too broadly. Hence, we see highly accomplished economists backed by large amounts of data and advanced modelling capabilities derive SCC estimates as wildly divergent as \$20 and \$200 per ton.[117] Because of the fundamental importance of the discount rate, the "model itself is almost a distraction"[118] and a wide range of discount rates can be rationally defended based upon one's perspective.

B. *Outsized Uncertainty*

Unfortunately, climate change denialists have seized upon the uncertainty inherent in climate science to systematically sow doubt as to

114. *Circular A-4*, *supra* note 109.

115. *See* Pindyck, *supra* note 105, at 862-64 (addressing the arbitrary nature of fundamental aspects of IAMs).

116. *See* Morio Kuninori & Masayuki Otaki, *The Revelation of the Time Preference Rate and Intertemporal Negative Externality* (DBJ Research Ctr. on Global Warming, Discussion Paper Series No. 53 7-8, Oct. 2015), http://www.dbj.jp/ricf/pdf/research/DBJ_RCGW_DP53.pdf.

117. Pindyck , *supra* note 105, at 863.

118. Robert S. Pindyck, *The Use and Misuse of Models for Climate Policy* 10 (Nat'l Bureau of Econ. Research, Working Paper No. 21097, Apr. 8, 2015), http://www.nber.org/papers/w21097.pdf.

the existence of climate change generally.[119] Nonetheless, while climate science has been developing rapidly, it is necessarily and admittedly subject to a great degree of uncertainty across multiple aspects.[120] This is to be expected as climate change is so massive in scale and potential impact, occurs somewhat unpredictably over long periods of time, and is not conducive to regular laboratory trials.

In the IAMs, negative climate impacts are accounted for through a myriad of damages functions. In turn, these functions necessarily rely upon estimates of climate sensitivity—the response of global temperature levels to a doubling of CO_2 in the atmosphere.[121] Knowing how the world's climate would actually respond to mass increases of CO_2 is probably the central question, as temperature is the key driver of damages in all three major IAMs.[122] However, key feedback loops—the channels through which CO_2 emissions affect temperature—remain shrouded in mystery, and may stay that way for the indefinite future.[123] Ultimately, the central problem of the SCC project is fraught with "known unknowns," as well as "unknown unknowns"—likely genuine surprises of significant impact.[124]

Within the broad sweep of climate sensitivity uncertainty, the potential for catastrophic damages is a critical component of SCC critiques.[125] Catastrophic damages here are not difficult to imagine—e.g., phenomena such as mass flooding, refugee crises, widespread ecosystem collapses, and collapses of water and food supplies—and have the

119. *See, e.g.,* Naomi Oreskes, *The Fact of Uncertainty, the Uncertainty of Facts, and the Cultural Resonance of Doubt*, 373 PHIL. TRANSACTIONS A 1, 16 (2015), http://rsta.royalsociety publishing.org/content/roypta/373/2055/20140455.full.pdf.

120. *See, e.g.,* Myles R. Allen & David J. Frame, *Call Off the Quest*, 318 SCIENCE 582, 583 (2007); Wendy S. Parker & James S. Risbey, *False Precision, Surprise, and Improved Uncertainty Assessment*, 373 PHIL. TRANSACTIONS A 1, 2, 7 (2015), http://rsta.royalsociety publishing.org/content/roypta/373/2055/20140453.full.pdf.

121. *See, e.g.,* Pindyck , *supra* note 105, at 865.

122. *See* ROSE, *supra* note 54, at 19.

123. *See, e.g.,* Allen & Frame, *supra* note 120, at 583.

124. *See, e.g.,* Parker & Risbey, *supra* note 121, at 8 ("The climate system is a prime example: there is good evidence that, over the last 150 years, the climate system has been subjected to significant and rapid increases in atmospheric greenhouse gas concentrations . . . . As this forcing is increasing over time, so is the risk of genuine surprise in climate system behavior. The foregoing suggests that agents sometimes can have good evidence that multiple risk factors for genuine surprise are present. While agents generally will not be in a position to quantify in a precise way the risk of genuine surprise, they may be justified in concluding that, when it comes to questions of interest, the risk is not small and indeed is increasing with time. This seems to be the case with the climate system when it comes to many questions that interest scientists and decision-makers, such as questions about the extent of global and regional climate change that would result under different greenhouse gas emission scenarios.").

125. *See, e.g.,* Ackerman & Stanton, *supra* note 71.

potential to substantially influence SCC estimates.[126] However, it is not clear that the major IAMs have anything meaningful to say about such catastrophic outcomes.[127] For example, the PAGE model, which is far more concerned than DICE with catastrophic thresholds, assumes catastrophic damages in the tails of temperature distributions.[128] However, it cannot say, because of the scientific uncertainty in this regard, much at all about how, when, and why those damages would likely occur. The Nordhaus models have not typically concerned themselves with such tipping points because they are too uncertain and have only "conceptually" included the economic costs of catastrophic outcomes.[129] It is possible, under certain conditions, for extreme tail outcomes to "dominate economic calculations like the SCC."[130] However, "[t]he nature of tail events is that we have little past experience with them, and besides, climate change is a unique one-off event."[131] Thus, as with discounting, the IAMs and their SCC estimates have little to tell us about the "correct" determination of tipping points and tail risk, even though these can have a significant impact upon the SCC.

Further, such significant and potentially devastating uncertainty can reasonably have an impact on the logical choice of discount rate. Weitzman, by using the IWG's models but employing a risk-adjusted, time-varying discount schedule meant to hedge against the risk of catastrophic outcomes, found a significantly higher SCC (from $183 to $266 per ton at gamma-adjusted rates of, respectively, 3% to 1%) than did the interagency working group using the constant discount rate schedule.[132] Interestingly, included in Weitzman's exposition was a random variable that could be interpreted as "merit goods," such as "preservation of life," which could not be readily related to standard consumption.[133]

While a great deal of attention has been paid to dealing with uncertainty in the IAMs,[134] the reality of this enterprise is that a high degree of uncertainty is baked in and cannot reasonably be estimated

126. *See, e.g.,* Nordhaus, *supra* note 35, at 298-99; Pindyck, *supra* note 105, at 869-70.
127. *See, e.g.,* Pindyck, *supra* note 105, at 869.
128. Nordhaus, *supra* note 35, at 292, 297.
129. *Id.* at 298.
130. Martin L. Weitzman, *Fat Tails and the Social Cost of Carbon*, 104 AM. ECON. REV. 544, 546 (2014).
131. *Id.*
132. Martin L. Weitzman, *Tail-Hedge Discounting and the Social Cost of Carbon*, 51 J. ECON. LITERATURE 873, 881 (2013).
133. *Id.* at 876.
134. *See, e.g.,* IWG, *supra* note 8.

away.[135] Nordhaus stated, with regard to an empirical SCC model, that "[i]t is clear that there are major uncertainties about the value of the SCC . . . these involve parameters like the discount rate . . . [i]n addition, there are geophysical and economic uncertainties, such as those involving the climate system, population growth, or future productivity growth."[136] This significant uncertainty draws a dividing line between those who think it can be managed so as to render the ultimate SCC estimates useful[137] and those who think that it makes them "close to useless."[138]

Even when taking catastrophic damages into account, SCC models still necessarily view them through a facile lens of highly speculative statistical probability and, ultimately, economic damages. For example, the 1999 version of Nordhaus's RICE model produced a population-weighted damages estimate of only 0.10% of global output owing to "human settlements and ecosystems" damages at a global temperature increase of 2.5°C.[139] The population-weighted damages from "catastrophes" under the same scenario was just over 1% of global output.[140] By 2013, Nordhaus had decided to incorporate the damages estimate from Tol's FUND model, which estimated a base case of 3% global output damages from an increase of 3°C.[141] However, because these damages did not account for factors such as biodiversity, ocean acidification, sea-level rise, and accelerated climate change, Nordhaus added 25% to the monetized damages amount, recognizing that this was in line with other models but "largely a judgmental adjustment."[142] How much are healthy oceans and biodiversity actually worth? We cannot say, and neither can the models.

Because advanced SCC estimates, such as those derived by the IWG and DICE, are backed by sophisticated models and extensive data, they may lend themselves to precision bias. Precision bias refers to a cognitive bias, or logical fallacy, whereby precision is confused with accuracy.[143] At a broad level, this SCC determination project can be

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135. *See, e.g.,* Pindyck, *supra* note 105, at 867.
136. Nordhaus, *supra* note 36, at 17.
137. *See, e.g.,* Nordhaus, *supra* note 35, at 301.
138. Pindyck, *supra* note 105, at 861.
139. Newbold, *supra* note 104, at 5.
140. *Id.*
141. Nordhaus, *supra* note 35, at 278. Note that 3°C is well above the 2°C target set, albeit for possibly political rather than hard scientific reasons, via international negotiations. *See, e.g., Why 2 Degrees Celsius Is Climate Change's Magic Number*, PBS.ORG (Dec. 2, 2015), https://www.pbs.org/newshour/show/why-2-degrees-celsius-is-climate-changes-magic-number.
142. Nordhaus, *supra* note 35, at 279.
143. *See, e.g.,* Pindyck, *supra* note 118, at 1.

analogized to health risk-based regulations in the development of major U.S. environmental statutes, such as the Clean Air Act. A salient criticism of these risk-based regulations was that science simply did not know enough to make risk-based standard setting competent or rational.[144] The same can be said of the IAMs and, generally, attempts to accurately pinpoint the SCC: there is simply too much uncertainty standing in the way of accuracy. This is not a failing of climate science, which faces the singular challenge of figuring out the intricacies of global climate change on short notice. Rather, it is an issue of the IAMs, which attempt to corral all of this uncertainty, rationalize it, and make it palatable through illusory precision.

C. All That Goes Unaccounted For

The SCC in this context is, of course, anthropocentric. It is an economic-scientific tool intended to refine the decision-making structure for human policymakers and does not purport to resolve ethical questions concerning the value of having a given species not go extinct, the aesthetic value of an unflooded coastline, or the peace of mind that may come from knowing the Great Barrier Reef is healthy. Likewise, the IAMs cannot purport to give voice to those who exist outside of their constructs, including human and non-human animals. Even though the IAMs have grown more expansive and complex over time, a great deal necessarily falls through their cracks. Obviously, such scientific-economic estimates cannot, and should not, attempt to describe and value everything in the world, and yet this Comment would be remiss if it failed to mention some key omissions.

As evidenced by Part III's discussion of SCC and similar analysis in policy, it is evident that the IAMs and SCC estimates have been almost entirely a creature of the Western, industrialized world. Therein, it is likely not a coincidence that the three major English-speaking frontier countries—the United States, Canada, and Australia, all of which are natural-resource rich—generally developed meaningfully lower SCC estimates than did various countries in Europe. Again, the SCC can be easily manipulated to reflect preferences, philosophies, assumptions, and so on. Even with that caveat, a macroeconomic model such as DICE gives little or no voice to those many whose livelihoods are not properly captured by its aggregate social welfare function. Even though the IAMs

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144. Adam Babich, *Too Much Science in Environmental Law*, 28 COLUM. J. ENVTL. L. 119 (2003); Wendy E. Wagner, *The Science Charade in Toxic Risk Regulation*, 95 COLUM. L. REV. 1613 (1995).

purport to provide valuable input to a global problem, it is not clear if they are in line with the carbon-cost projections and plans developed by major emitters China[145] and India.[146] Likewise, there is no sense that various countries, let alone communities within those countries, that would be most directly affected by sea-level rise—e.g., Bangladesh,[147] Vietnam, Thailand—or continued desertification—e.g., many in Africa—have much input in the process. There is little room for valuation of qualitative aspects of human livelihood, such as maintenance of traditional lifestyles, psychological well-being, physical health, and aesthetic fulfillment, that could be significantly affected by extreme climate change. When it comes to non-human animals, the models have little to say about the value of their continued existence beyond how it may affect humanity's.

As Ackerman and Stanton noted,

> Some of the serious anticipated damages from climate change, such as loss of endangered species, unique habitats and environments, and human lives and communities cannot be reasonably quantified or monetized regardless of how valuable they really are. Much of the literature used to inform the Administration's estimates omits these values entirely, effectively giving them a value of zero. As a result, estimates of the SCC may be too low or logically incomplete.[148]

This was written with regard to the IWG's 2010, and thus Obama-era, SCC estimate of $21 per ton of CO_2.[149] By 2013, the IWG's SCC estimate had grown to $37 per ton—thus, an increase of 76% in just three years—even though it failed to include a massive range of potential damages in its calculations.[150] Howard provided in this regard a detailed review of the SCC literature, which also happened to reveal just how expansive and uncertain the whole project was.[151] For example, while

145. *See* Jane Qiu, *China Gets Tough on Carbon*, NATURE (June 12, 2013), https://www.nature.com/news/china-gets-tough-on-carbon-1.13175.

146. *See India—Social Value of Carbon,* DEEP CARBONIZATION PATHWAYS PROJECT, http://deepdecarbonization.org/wp-content/uploads/2015/07/DDPP-Country-case-study_India_Social-value-of-carbon.pdf (last visited Apr. 3, 2018).

147. *See* Susannah Fisher, *Bangladesh: From Adaptation to Low Carbon Resilience?*, INT'L INST. FOR ENV'T & DEV. (July 10, 2013), https://www.iied.org/bangladesh-adaptation-low-carbon-resilience (noting that some constituencies in Bangladesh have been offended that they may be asked to curtail emissions even though most damage has been caused by rich, industrial countries).

148. Ackerman & Stanton, *supra* note 71.

149. *Id.*

150. *See* PETER HOWARD, COST OF CARBON PROJECT, OMITTED DAMAGES: WHAT'S MISSING FROM THE SOCIAL COST OF CARBON (Mar. 13, 2014), http://costofcarbon.org/files/Omitted_Damages_Whats_Missing_From_the_Social_Cost_of_Carbon.pdf.

151. *Id.*

arguing that the $37 estimate represented the lower bound of the true SCC, Howard noted: "The study of climate change's social impacts [including aspects such as violence and political unrest] is still emerging despite a lack of ability to predict their severity or likelihood";[152] "[n]one of the most widely adopted IAMs . . . address the multiple damages due to ocean acidification";[153] and "[e]conomists not only struggle to place a value on biodiversity, but they also lack the understanding of how climate change will affect intricate systems and processes."[154]

Despite the 76% increase in the IWG's SCC estimate, it was still meaningfully lower than the U.K.'s central case[155] and much lower than Sweden's.[156] Howard highlighted, on behalf of several environmental/policy organizations, a detailed list of things that would likely be affected by climate change but had not been accounted for in the $37 estimate.[157] As stated, this list was expansive, but still certainly missed some things—this is because climate change can conceivably affect *nearly everything*. Howard wrote in partial response to "conservative politicians and industry groups" who thought the $37 estimate was actually too high.[158] As stated, the IWG's estimate was slashed by the Trump-era EPA just a few years later.[159] This could be accomplished simply by adjusting the discount rates and focusing on domestic SCC.[160] However, this exchange—between environmental groups and policymakers, within a specific policymaking group and agency (the IWG and EPA), and administrations (Obama and Trump)—also helped reveal the many possible costs of climate change that elude the IAMs.

D. Strategic Considerations

Examining the key political-economic considerations with regard to forcing substantial climate policy action in the United States is obviously well beyond the scope of this brief Comment. However, given the aforementioned politicization of SCC analysis, as well as climate policy generally, it is useful to mention some key aspects in this regard as they relate to the overall thrust of this piece.

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152. *Id.* at 33.
153. *Id.* at 42.
154. *Id.* at 29.
155. Ackerman & Stanton, *supra* note 71.
156. Bohlin, *supra* note 72, at 283.
157. HOWARD, *supra* note 150.
158. *Id.* at 4.
159. *See* TRUMP RIA, *supra* note 3, at 44.
160. *Id.* at 44, 162.

Because of, in particular, the malleability of SCC estimates for the reasons discussed above, they may not be useful unless something approaching an ex-ante ideological consensus exists. As demonstrated by the opposition to even the $37 estimate,[161] as well as the Trump-era EPA's steep downward revision of the SCC numbers,[162] SCC estimates reflect ideology as much as they reflect the actual, long-term externality cost of climate change. Importantly, despite the arbitrariness inherent in the IAMs and SCC estimates, it is entirely possible that SCC estimates can be greatly increased or decreased without being arbitrary or capricious in a legal sense.[163] For example, while environmentalists and many others may well disagree with it, the Trump-era EPA's usage of the 7% discount rate was supported by an OMB Circular.[164] There also does not seem to be anything facially arbitrary or capricious about U.S. policymakers considering only domestic costs, even if it seems patently unfair; there is no reason to think that U.S. policymakers *must* make an effort to compensate for global externalities.

Thus, while those genuinely concerned about climate action may view incorporation of IAM-developed SCC estimates as a positive because they assign *some* cost to carbon-driven externalities, they must be aware of how easily such estimates can be "reasonably" manipulated. The lesson here is that those who would rely on models to develop pinpoint SCC estimates for usage in macro-level CBAs tether themselves to a technocratic solution that is built upon vast uncertainty and subjective preference. Because of the subjectivity involved with discounting and treatment of uncertainty, it seems unlikely that high SCC estimates can help with building climate-oriented consensus in the United States on a broad scale.

Generally, much of the U.S. environmental regulatory regime is predicated upon the logic of CBA. Because U.S. environmental law and policy are frequently concerned with the costs and benefits of government actions, and if the various pinpoint SCC estimates coming from sources such as the IWG and the *Stern Review* are to be cast aside, one who wants more climate action within the existing policy-law framework may wonder how then to put carbon-driven externalities in a

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161. HOWARD, *supra* note 150, at 4.

162. *See* TRUMP RIA, *supra* note 3, at 44.

163. The arbitrary and capricious standard is well known as a basic threshold of reasonableness in U.S. administrative law. *See* 5 U.S.C. § 706(2)(A) (2012). As the *Zero Zone* case suggested, it seems that deployment of particular SCC estimates, as long as they are based on some sort of documented and orderly logic, is well within an agency's purview under a deferential standard.

164. *See Circular A-4*, *supra* note 109.

neat dollar amount to facilitate CBA. Pindyck's suggestion in this regard is logical and far simpler than the IAMs: consider catastrophic climate change akin to the threat of nuclear warfare, as was done for game-theoretic calculations during the Cold War.[165] Indeed, extreme climate change would seem to have destructive potential conceptually on par with some level of nuclear warfare, and such an approach simplifies the endeavor by not having to concern itself with, for example, deep-ocean carbon processes[166] or the dollar value of a mass refugee crisis in South Asia. While such an approach does not resolve the discounting issue and would still deal with meaningful uncertainty in terms of formulating catastrophic probabilities, it at least absolves itself of precision bias.

It may be that climate change is *the* issue with which the existing U.S. environmental regulatory framework is least equipped to deal.[167] This is because climate change constitutes a truly global collective action problem with unpredictable and difficult-to-quantify damages spread out over time and space. Because of the sometimes glacial and seemingly unpredictable nature of climate damages, it is not particularly difficult for climate-change denialists to obfuscate and misdirect in this regard. While the aforementioned issues with regard to discounting and valuation will be true for many environmental CBAs, it is the scope of the problem that makes it singularly daunting. Specifying a meaningfully positive SCC seems to entail *something* in this respect—that is, recognition that carbon emissions generate external damages—and perhaps it indeed does constitute substantive progress. However, those who would consider inclusion of IAM-generated estimates, particularly high-dollar ones, of the SCC to be an unmitigated success should nonetheless pay heed to the crow on the shoulder: a high degree of arbitrariness is currently baked into these estimates and it is quite difficult to know the degree to which they may be relied upon for accuracy or manipulated by agencies across different administrations.

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165. Pindyck, *supra* note 105, at 869-70.

166. *See, e.g., Carbon Cycle*, NASA, https://science.nasa.gov/earth-science/oceanography/ocean-earth-system/ocean-carbon-cycle (last visited Mar. 23, 2018).

167. There is disagreement, for example, with reasonable arguments on both sides, about whether the Clean Air Act is adequate for dealing with climate change. *See, e.g.,* DANIEL A. FARBER & AMY SINDEN, CTR. FOR PROGRESSIVE REFORM, SIX MYTHS ABOUT CLIMATE CHANGE AND THE CLEAN AIR ACT (Mar. 2011), http://www.progressivereform.org/articles/Clean_Air_Act_1105.pdf; Robert R. Nordhaus, *Modernizing the Clean Air Act: Is There Life After 40?*, 33 ENERGY L.J. 365 (2012); William W. Buzbee, *Clean Air Act Dynamism and Disappointments: Lessons for Climate Legislation to Prompt Innovation and Discourage Inertia*, 32 WASH. U. J.L. & POL'Y 33 (2010).

V. CONCLUSION

The question that developers of precise SCC estimates are ultimately seeking to answer is how to efficiently reduce carbon emissions based upon expected costs and benefits of those reductions. This is a natural, logical, and important question, particularly given the prevalence of standard economic logic in our political economy. However, development of precise SCC estimates as discussed throughout this Comment, besides being beset with the issues already mentioned, have not generally been deployed to answer what may be a more important question: how to most efficiently reduce the probability of catastrophic outcomes. Answering such a question would still be subject to significant uncertainty based upon the best-available science but would at least frame the endeavor with tail risk at the forefront and logically engender solutions based upon hard carbon budgeting and/or taxation geared towards a conservative emissions target—e.g., actual compliance with the international protocols from which the United States seems prone to defect.

While there is no ready answer for how to approach greenhouse gas-induced climate change, especially given the entrenchment of existing environmental regulatory regimes and CBA, this Comment lends itself to supporting governmental approaches such as aggressive carbon budgeting, technology-based standards, and the use of taxes and incentives to force innovation. More localized and novel efforts, such as mass reforestation and low-carbon urban planning, should likewise be encouraged. The point is to, in aggregate, focus on approaches that place biophysical risks, which are more nebulous yet potentially catastrophic, at the forefront and to confront the problem of climate change through an aggressive, broad-based effort that treats it as a matter of survival, not as a matter of trying to fit all of existence into a facile economic framework or probability distribution.

Regardless, the carbon-intensive industrialization that has defined this epoch may have left us collectively in uncharted territory for which quotidian modes of policymaking will prove inadequate. It may be that it is too late and we are already living in an irreversible tail-risk world; it may be that some tremendous battery technology will appear in time to render carbon-intensive processes obsolete and obviate the worst possible outcomes. While uncertainty is woven into all human endeavor and its existence alone is obviously not reason to shy away from exploring solutions to big problems, it is nonetheless wise to consider that otherwise reliable tools may not be best suited for this particular task.