

THE SOCIAL COST OF CARBON—WHAT’S NEW AND NEXT?

Maximilian Auffhammer

*University of California, Berkeley
National Bureau of Economic Research
CESifo*

As described by Fridligstein and others,¹ atmospheric concentrations of CO₂ have risen from 278 parts per million (ppm) in 1750 to 419.3 ppm in 2023. While pre-industrial revolution growth in concentrations was largely due to land use changes and deforestation, the source of emissions rapidly shifted towards the combustion of fossil fuels, with a total of 490 +/- 25 gigatons of carbon being emitted between 1850 and 2023. Roughly 46 percent of cumulative emissions stemmed from coal, 35 percent from burning of oil, and 15 percent from burning of natural gas. In 1850, the United Kingdom was responsible for 62 percent of emissions, yet today China (31%), the United States (13%), India (8%), and the EU-27 countries (7%) are responsible for roughly 60 percent of total emissions. Unmitigated growth in the combustion of fossil fuel will continue to drive up atmospheric concentrations leading to increased atmospheric forcing, which will translate into changing weather patterns including, but not limited to, higher temperatures in summer and winter, changed precipitation patterns, storm intensities, and area burned by wildfires.²

This paper is a writeup of the keynote delivered at the XXVI Annual Conference of the Central Bank of Chile, “Implications of Climate Change and Ecosystem Services Degradation for Macroeconomic and Financial Stability” on November 28, 2023. All errors are the author’s.

1. See Friedlingstein and others (2025).

2. See IPCC (2023).

Implications of Climate Change and Ecosystem Services Degradation for Macroeconomic and Financial Stability, edited by Maximilian Auffhammer, Elías Albagli, Sofia Bauducco, and Gonzalo García-Trujillo, Santiago, Chile. © 2025 Central Bank of Chile.

Emissions of greenhouse gases (GHG) present one of the more complex cases of a global externality, as most GHGs are long-lived and mix fairly uniformly around the globe. Hence the damages from a ton of, for example, CO₂ emitted accrue to humans and ecosystems globally—regardless of the source or location of emissions—and to possibly dozens of future generations due to the stock-pollutant-like nature of CO₂. The issue is further complicated by the fact that the ambient environment is a key input to virtually all economic sectors—both market (e.g., agriculture, energy consumption, productivity) and nonmarket (ecosystem services, mortality, biodiversity).

Basic economic theory going back to Pigou (1920) suggests that the first-best solution is a per-unit carbon tax set at the marginal external damage. To set a remotely optimal carbon tax, one must know what the external damage of different GHGs along their emissions paths is. The question arises of how to calculate the marginal damage of a single ton of GHGs at a given point in time.

In 2024, roughly 24 percent of global GHG emissions were covered by a form of carbon pricing. Six percent of emissions are covered by a carbon tax and the remaining 18 percent by a tradeable permit system. Prices charged per ton of CO₂ range from USD 0.61 (Indonesia Emissions Trading System) to USD 167 (Uruguay's Carbon Tax). Permits in the larger carbon markets were trading at about USD 61 (EU ETS), USD 39 (California ETS), USD 18 (Regional Greenhouse Gas Initiative—RGGI), and USD 14 (China National ETS).³

The Social Cost of Carbon (SCC) under certain assumptions provides an estimate of the external damages from one ton of CO₂ emitted at a point in time. The SCC can hence not only provide guidance as to how to set an optimal emissions tax but also be used in benefit-cost analysis to evaluate proposed and existing policies. Calculating this “most important number few people have heard of” has an important history in academia and provides a premier case study of how an academic exercise turned into a tool that has evaluated trillions of dollars in benefits in benefit-cost analyses across the globe.

In what follows, I briefly describe its evolution and provide an overview of key next steps in this important and active research agenda.

3. See World Bank (2025).

1. HISTORICAL EVOLUTION OF THE SOCIAL COST OF CARBON

The impact of climate change on economic outcomes has a long history in the field. One of the early examples of such work is Huntington (1917), who argues that long-term climate variability and soil degradation were significant contributors to the decline of the Roman civilization. He reviews historical, archaeological, and ecological evidence suggesting that shifts in rainfall patterns and increasing aridity led to lower agricultural productivity, which in turn triggered social and political instability. Yet quantifying the economic damages of a single ton of CO₂ in an academically rigorous way did not start until the 1980s. William Nordhaus' (1982) paper in the *American Economic Review* started off a literature that accelerated in the 1990s.⁴ Bill Cline's book (1992) is often cited as one of the seminal works that outlined the issue and, most importantly, characterized what one would need to understand in order to credibly calculate economic damages. There are a number of great reviews of the history of SCC, which are worth consulting for those interested.⁵

William D. Nordhaus is widely recognized for advancing the concept of the social cost of carbon, particularly through the development of his Dynamic Integrated Climate-Economy (DICE) model beginning in the 1990s.⁶ By integrating economic theory with climate science, Nordhaus provided a framework for quantifying the economic damages associated with carbon emissions, significantly shaping the way policymakers and economists approach climate-related externalities. While the conceptual framework is clearly key to answering the question of how a changing climate affects current and future economic welfare, calculating that number poses a massive challenge that requires drawing on tools, methods, and insights from across the field of economics and beyond; for example, climate science. In the early days, three approaches emerged. Nordhaus (1994) simply asked experts what they thought economic damages of climate change were going to be. In his 1992 DICE and 1996 Regional Integrated Climate-Economy (RICE) work, he and others in the literature would rely on the "enumerative methods".⁷ The enumerative approach

4. For example, Ayres and Walter (1991), Nordhaus (1991), Haraden (1992), Peck and Teisberg (1993), Reilly and Richards (1993), Fankhauser (1994), Smith (1996), Titus (1992).

5. For example, Tol (2011), and Chapter 5 in National Research Council (2010).

6. See Nordhaus (1992, 1994).

7. See Tol (2011).

proceeds by assembling estimates of the physical impacts of climate change one at a time, typically drawn from natural science research based on laboratory experiments, climate models, or impact models. Each identified effect is then assigned a monetary value, and the resulting figures are aggregated to produce an overall estimate. A third approach, known as the *statistical approach*,⁸ relies on directly estimating welfare impacts by exploiting observed spatial variation in climate within a single area. By examining how land prices, incomes, and expenditures differ across regions, this method infers the economic effects of climate differences.

Prior to 2008, the social cost of carbon literature was largely academic, and there was not one single number that was used in the required regulatory impact analyses (RIA) underlying federal rulemaking. A ruling by the Ninth Circuit Court of Appeals pushed back on a proposed fuel efficiency rule by the Department of Transportation, suggesting that failure to place a monetary value on foregone damages from avoided climate change due to more efficient vehicles was “arbitrary and capricious”. In response, the Obama administration in 2009 convened an Interagency Working Group (IWG) made up of representatives from all relevant agencies⁹ to come up with a scientifically defensible social cost of carbon. The IWG chose three prominent integrated assessment models (IAM) available at the time to calculate an SCC: the DICE,¹⁰ the Climate Framework for Uncertainty, Negotiation, and Distribution (FUND),¹¹ and the Policy Analysis of the Greenhouse Effect (PAGE).¹² An IAM links GHG emissions to atmospheric concentrations, projects resulting in changes in temperature and climate, estimates of physical impacts (like sea level rise or crop loss), translates those into economic damages, and discounts future harms to present value. The three chosen IAMs differ in structure and assumptions, but all aim to provide a coherent estimate of the SCC. It is noteworthy that two of the models were open-source (DICE, FUND) and one was not (PAGE).

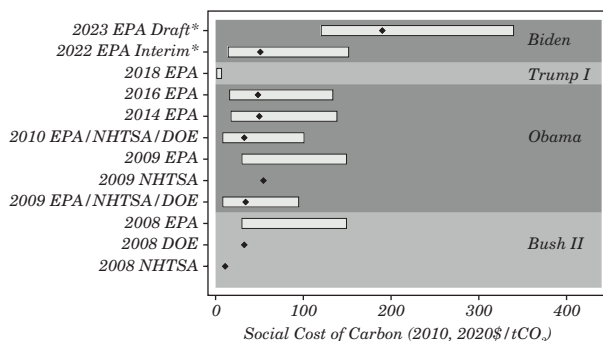
8. See Nordhaus and others (1994); Mendelsohn and others (2000 a,b).

9. Council of Economic Advisers, Council on Environmental Quality, Department of Agriculture, Department of Commerce, Department of Energy, Department of Transportation, Environmental Protection Agency, National Economic Council, Office of Energy and Climate Change, Office of Management and Budget, Office of Science and Technology Policy, Department of the Treasury.

10. Nordhaus (1992).

11. Tol (1996); Anthoff and Tol (2014).

12. Hope (1993).

Figure 1. Historical Values of the SCC by the U.S. Federal Government

Source: As indicated.

Notes: Ranges indicate high and low values reported. The diamond indicates a central value reported. All values are for the 2010 social cost of carbon, except for the * values, which are for 2020, as the report does not list a 2010 number.

The Interagency Working Group largely adopted the default assumptions chosen by the original developers of the IAMs, including parameter values and functional forms.¹³ However, two notable departures stand out: the IWG applied a unified probability distribution for the equilibrium climate sensitivity (ECS) across all three models and relied on a standardized set of five socioeconomic and emissions scenarios to project future conditions. Additionally, the present value of projected damages was calculated using three fixed discount rates applied consistently across the models. In the technical support document, the IWG presented the distribution of the SCC for different years of emission and discount rates, weighting each IAM equally.

There were numerous updates to the SCC during the two Obama administrations, ultimately settling at an SCC of USD 42/ton emitted in 2020.¹⁴ The Obama administration asked the National Academies of Sciences, Engineering, and Medicine (NASEM) to review their methodology to calculate the SCC, and an expert panel was convened. This panel delivered its finding weeks before the 2017 inauguration of President Donald Trump, whose one of his earliest executive actions disbanded the IWG and reset the SCC to USD 1–7, by restricting damages to domestic damages only and increasing

13. See IWG (2010).

14. See IWG (2016).

the discount rate. Four years later, President Biden reconvened the IWG and reinstated the SCC to USD 51/ton, which was a simple adjustment for inflation of the Obama SCC. He also charged the IWG with implementing the changes suggested by the National Academies. Figure 1 below shows the historical values of the SCC used by the U.S. Federal Government—a number that has been adopted by numerous governments across the world.

2. THE CURRENT STATE OF AFFAIRS

After the announcement of the dissolution of the IWG in 2017, academics took up the challenge to address the short-run and some of the long-run suggestions made by the National Academies (2017). Two teams formed separate but connected efforts to improve the SCC—the Climate Impact Lab (CIL) (University of California at Berkeley, University of Chicago, Rutgers University, and Rhodium) and Resources for the Future (RFF). The progress resulted in modelling that ultimately led to the updated SCC of USD 190/tCO₂.¹⁵ Here I summarize some of the significant changes in modelling of the different “modules” (socioeconomic scenarios, climate, damage functions, and discounting) using the recent Greenhouse Gas Impact Value Estimator (GIVE)¹⁶ model and the Data-Driven Spatial Climate Impact Model (DSCIM)¹⁷ and show the impacts of some of the modelling choices on the distribution of the SCC. Rennert and others (2022) and the Environmental Protection Agency (EPA) (2023) provide a significantly more detailed discussion of the modelling innovations, which I summarize below.

2.1 Socioeconomic Module

Resources for the Future developed a set of long-run probabilistic socioeconomic pathways to meet the specific requirements of estimating the SCC. These include the need for: (i) a 300-year time horizon to capture most discounted climate damages; (ii) regionally disaggregated GDP and population data; (iii) accounting for uncertainty in future technology and policy, including anticipated mitigation efforts; and (iv) modeling the interdependence of population, economic growth, and emissions.

15. See EPA (2023).

16. See RFF (2025).

17. See CIL (2022).

These scenarios address limitations in the earlier pathways used by the IWG, which drew on five deterministic pathways extending to 2100. Those scenarios were criticized for their narrow uncertainty range and limited representation of global scenario literature. In contrast, the new pathways explicitly characterize uncertainty using a mix of statistical and expert-driven methods. Country-level population projections through 2300 extend the United Nation’s probabilistic framework, with expert review from leading demographers. For GDP per capita, the study employs a multifactor Bayesian dynamic model centered on a global frontier, calibrated using expert elicitation data from the RFF Economic Growth Survey.

Unlike the previous pathways, which were scenario-based and lacked explicit probability distributions, the new scenarios offer fully probabilistic projections that better reflect deep long-term uncertainty. Wide ranges in the scenarios underscore the limitations of the previous scenarios beyond 2100, which provided a false sense of confidence.

In addition, the new model uses a survey to construct probabilistic, multi-century emissions trajectories not only for CO₂, but also for CH₄ and N₂O. These incorporate expert assessments of technological change, mitigation policies, carbon sinks, and the interaction between economic growth and emissions. This joint modeling of socioeconomic and emissions uncertainty provides a more robust foundation for estimating the SCC and is publicly available for uses beyond the modeling of the SCC.

2.2 Climate Model

In the new approach, the global climate system and carbon cycle are represented using the Finite Amplitude Impulse Response (FaIR) model,¹⁸ a reduced-complexity emissions-based climate model. FaIR incorporates state-dependent feedbacks by linking cumulative carbon uptake and background warming to the efficiency of land and ocean sinks. This enables the model to replicate key equilibrium and impulse-response behaviors observed in more complex Earth system models—capabilities absent from earlier models used in SCC estimation. FaIR is run using probabilistically sampled emissions trajectories for CO₂, CH₄, and N₂O from the scenarios discussed above. Climate response uncertainty is addressed through a 2,237-member ensemble

18. See Millar and others (2017).

of calibrated parameters developed for the IPCC's Sixth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC). In short, the new climate modeling approach addressed the significant criticisms raised by the climate scientists on the NASEM report.

Sea-level rise in GIVE is modeled using Building Blocks for Relevant Ice and Climate Knowledge (BRICK),¹⁹ which generates probabilistic projections of regional sea-level change by combining contributions from thermal expansion, glaciers, ice sheets, and land water storage. BRICK is calibrated against observed sea-level data from 1850–2017 using a Bayesian framework, with priors informed by paleoclimate evidence and previous studies. A Markov chain-based approach enables robust propagation of uncertainty and captures tipping dynamics in the Antarctic ice sheet.

2.3 Damage Functions

Previous IAMs had employed severely outdated damage functions.²⁰ A desirable damage function for these models should:

- be applicable globally,
- incorporate long-run adaptation,
- carry a causal interpretation,
- be valid for 200+ years, and
- allow for heterogeneity across space, groups, and time.

The two empirically based damage modules (GIVE and DSCIM) differ in terms of the parameterization of the damage functions as well as sectoral coverage.²¹ GIVE models damages for health, energy, agriculture, and coastal regions. The damage functions the RFF/GIVE team drew on are drawn from the existing literature and a reanalysis thereof in some cases. What is noteworthy in the damage function for agriculture in this model is the fact that it incorporates some general equilibrium/trade effects based on Moore and others (2017).

The DSCIM model developed by the CIL includes damages for health, energy, labor productivity, agriculture, and coastal regions. What is appealing about the DSCIM damage functions is that they are estimated by using a consistent econometric framework that uses

19. See Wong (2017).

20. See EPA (2023).

21. A more detailed discussion of the estimation of damage functions is provided in EPA (2023), Carleton and Hsiang (2016), Auffhammer (2018), and Kolstad and Moore (2020).

variation in weather to parameterize local response to weather shocks, which can vary based on income and climate. This allows one to “bend” the damage function as a future world becomes warmer and richer. To parameterize their damage functions, the CIL collected a massive dataset on subnational outcomes (e.g., mortality and agricultural yields) and weather data and used econometrically estimated damage functions to extrapolate global damages.

Literature often attaches a causal interpretation to these damage functions. This is a reasonable assumption in sample; yet, as anyone would acknowledge, whether a functional relationship parameterized on historical data is “causally valid”, 275 years in the future is maybe overly optimistic. Imagine forecasting global emissions for 2025 in the year 1750—prior to the industrial revolution—even if one had the statistical insights and computational ability we do today. It is important to acknowledge the uncertainty—beyond the econometric uncertainties—inherent in these damage functions going forward. It is also important to acknowledge that the forecast error here could go in both directions, depending on whether and how we adapt to climate change.

2.4 Discounting

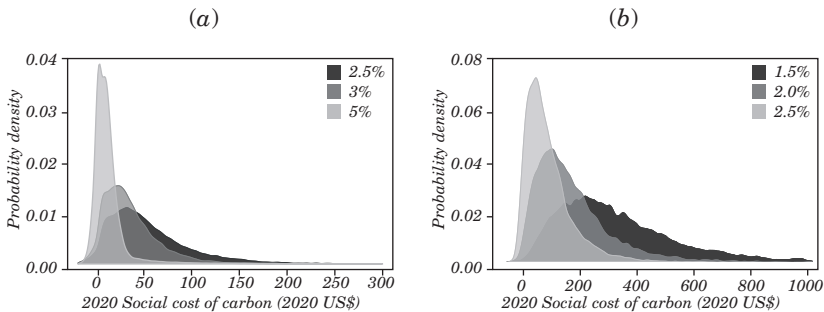
The updated approach follows the discounting framework recommended by the NASEM, summarized in Newell and others (2022). Because CO₂ remains in the atmosphere for centuries, today’s emissions generate damages far into the future, which must be discounted back to the present. The new IAMs adopt a Ramsey-style discounting approach, linking discount rates to economic growth. This formulation structurally models uncertainty in future consumption growth, producing a stochastic discount factor (SDF) that reflects variability in discount rates over time. Unlike earlier U.S. government estimates that assumed a constant discount rate and no risk aversion, this method reinstates the theoretical link between growth and discounting. The calibration employed yields a near-term discount rate of 2 percent, aligning with historical real risk-free interest rates. This Ramsey-style model—despite alternatives like ambiguity aversion—remains the dominant framework for regulatory and policy analysis under uncertainty, given its ability to incorporate both risk and intertemporal substitution in valuing climate damages currently.

2.5 Impacts of Modelling Choices

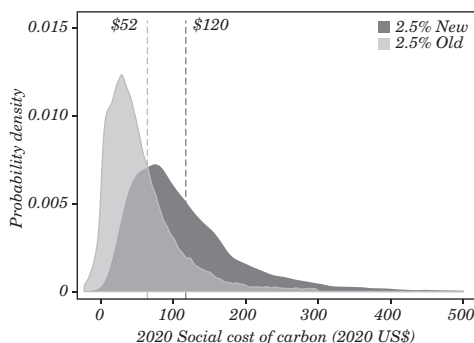
Much discussion surrounds what the impacts of different modelling choices are on the significantly higher SCC after updates were implemented. Rennert and others (2022) show a comparison of the GIVE model to the DICE model under different assumptions and conclude that the choice of discount rate is the single biggest contributor to the higher SCC, followed by the updates to the damage function. Another exercise one could conduct is to compare the distributions of the SCC before and after the update, which I show in Figure 2, below. It is clear that the distributions for the updated SCC have significantly higher density in the right tail. But is this simply due to the difference in discounting? The pre-update version used discount rates of 2.5, 3, and 5 percent, while the updated version used 1.5, 2, and 2.5 percent, in addition to a different discounting approach, partly based on expert elicitation work by Drupp and others (2018).

In Figure 3, I overlay the distributions for the discount rate scenarios that overlap in rate. The dashed distribution uses the constant rate 2.5 percent approach, while the solid distribution uses the Ramsey style 2.5 percent approach. One can see that there is a difference in the central tendency of USD 68/ton, which is not purely due to the choice of discounting, which is significant given the overall increase from USD 52/ton to USD 190/ton.

Figure 2. The Social Cost of Carbon Pre and Post Update



Source: Author's research.

Figure 3. SCC Pre and Post Update for the Same Discount Rate

Source: Author's research.

3. THE NEXT STEPS

The revisions of the SCC released in EPA (2023) addressed most of the short-run recommendations made by the National Academies (2017) as well as some of the longer-run recommendations. There remain, however, several aspects of how the SCC is calculated that will serve as fruitful avenues of research.

3.1 Sectoral Coverage

The most recent modelling effort covers five sectors—human mortality, agriculture, energy, coastal property, and productivity. These sectors were included due to the availability of data resources to estimate damage functions, which were thought to satisfy the criteria discussed above. The only previously used model that had meaningful sectoral resolution, the FUND model, covered many more sectors, such as forestry, water resources, vector-borne diseases, and big storms. Sectors that are not included at all are species loss, migration, air pollution, wildfires, crime & conflict, human amenity value, and morbidity, to name but a few. While with increasing data availability there are significant efforts underway to add forestry, wildfires, and migration, there is still much work to be done for additional sectors. As the National Academies report pointed out, the further one gets from goods and services traded in markets, the harder it gets to quantify welfare effects. One of the most important aspects of further

inquiry is the climate-change-induced loss of natural amenities and, more generally, natural resources. Environmental economics has a long history valuing natural resources, and efforts to link these to the social cost of carbon are in their early stages. One can, however, envision ways that the study presented at this conference by Justin Johnson and Steve Polasky could link to the SCC work, which could meaningfully enrich the next estimates of the social cost of carbon.

3.2 General Equilibrium and Spillover Effects

Many commodities are traded in global markets, and some are storable for varying time horizons. This is especially true for agriculture. As climate change shifts local weather distributions around the globe in significant ways, it will continue to be true that, while some regions might experience a negative weather shock, others might not—in the same year. The effect of a negative weather shock in one region on local and global crop prices is likely going to depend on what is happening in grain-producing regions elsewhere. A bad shock in Australian wheat might be offset by a good year in Canadian wheat, for example. Further, as has been pointed out in a massive literature in agricultural economics, the level of existing storage might also be able to smooth out local negative weather shocks' effects on global prices. The vast majority of damage functions and currently used models do not explicitly build in trade and global general equilibrium effects into the calculation of the social cost of carbon. There is, however, a burgeoning literature in international trade that explicitly models the effect of climate shocks on trade; for example, Desmet and Rossi-Hansberg (2024).

While modeling spillover effects in a trade context is part of the economics toolkit, other sectors are much more difficult to model. Specifically, it is hard to model and almost impossible to monetize the effect of migration on economic outcomes or on conflicts or other indirect effects of climate shocks on conflicts; for example, negative yield shocks that can set off local violent conflicts. While one might hope to be able to quantify some of these effects for specific local areas, it is more difficult to imagine a damage function, for example, weather and conflict, that also has monetized welfare impacts attached. The National Academies report urges regulators when it is not possible to monetize outcomes, to list them in the units the individual damage sector is reported or measured in.

3.3 Equity Weighting

As discussed above, the practice of discounting has received extensive attention in the calculation of the social cost of carbon. This practice reflects how society values current versus future costs and benefits. However, there is a similar concept that has received much less attention—the practice of income or equity weighting. It is generally well understood that the marginal value of a dollar's worth of consumption to a poor person is higher than the value of that same dollar to a rich person. Further, as Prest and others (2024) point out, climate impacts are often monetized using estimates of individuals' willingness to pay (WTP) for mitigation, but these measures are constrained by individuals' income levels, meaning that lower-income populations typically register lower WTP values. As a result, monetized damage assessments may systematically undervalue the harms faced by these groups, raising ethical and equity concerns for many observers. Equity weighting incorporates distributional weights into regulatory analysis, assigning greater marginal value to benefits and costs accruing to lower-income populations relative to higher-income groups, which addresses both concerns.²² Equity weighting is used by the German government in its calculation of the SCC. The United Kingdom and, more recently, the United States have allowed for the use of equity weighting in benefit-cost analysis. The question is, of course, whether this makes a significant difference when calculating the SCC. Prest and others (2024) show, using the GIVE model, that incorporating equity weighting for reasonable choices of weighting parameter(s) increases the SCC by a factor of 8, which suggests that addressing this important issue has significant effects on the number ultimately used in benefit-cost analyses.

3.4 Domestic versus Global Number

There has been a small but vocal movement among certain policymakers to advocate for the use of a domestic SCC in climate policy, effectively discounting harms incurred beyond national borders. This approach was most notably institutionalized under the first Trump administration, which recalibrated the social cost of carbon to reflect only domestic damages. Yet this is fundamentally at odds with the nature of GHG emissions, which constitute a global externality—

22. See Azar and Sterner (1996); Anthoff and Hepburn (2009); Anthoff and others (2009).

damages from a marginal ton of CO₂ accrue both domestically and internationally. Achieving global efficiency in climate policy requires each country, including the United States, to employ a globally derived SCC in its regulatory analysis. If instead each nation relied solely on a domestic SCC, the aggregate abatement level would fall well below the globally optimal benchmark, resulting in inefficiently high emissions across the board.

Moreover, the SCC a country adopts has strategic implications. As Kotchen (2018) notes, all nations possess a “strategic SCC” that is different from their purely domestic SCC, reflecting the interdependent nature of global climate action. The SCC adopted by one country can influence the choices of others, creating a strategic complementarity that reinforces the case for a globally harmonized metric.

Beyond these conceptual arguments, current models are ill-suited to produce accurate domestic SCCs, especially when “domestic” is defined in terms of citizenship. For instance, the U.S. military maintains a global presence with approximately 450,000 personnel stationed overseas, whose exposure to foreign-climate impacts directly links U.S. emissions to the welfare of U.S. citizens abroad. The same applies to the estimated 9 million U.S. civilians living overseas. A domestic-only SCC would effectively assign a welfare weight of zero to all of these individuals, as the models can only calculate damages by region, not residency.

Additionally, climate change is projected to increase the frequency and severity of global conflict, potentially triggering U.S. military deployments and broader geopolitical instability. These general equilibrium effects—ranging from increased troop exposure to downstream disruptions in global supply chains for critical inputs like rare earth elements—are omitted from current SCC models. This omission further underscores the inadequacy of a domestically bounded SCC in capturing the full scope of climate damages relevant to national welfare.

3.5 Extreme Events

One of the most forceful criticisms of IAMs relates not only to their parameterization, but also to their current inability to meaningfully incorporate catastrophic climate risk.²³ Pindyck’s central critique is

23. See Pindyck (2013, 2017).

both that these models are built around arbitrary assumptions that tend to focus narrowly on expected outcomes and marginal changes in global average temperature, translating those into smooth welfare losses over long time horizons. But this framing misses what should be the main concern: the risk of rare but severe tail events—climate tipping points, runaway feedback loops, or large-scale ecological collapse—that could lead to dramatic and irreversible damage to human welfare and economic systems. These are precisely the types of outcomes that economic theory tells us should dominate decision-making under uncertainty, yet current IAMs are not capable of capturing them in a rigorous fashion. Pindyck argues that this results in a false sense of analytical precision, as these models generate point estimates of the social cost of carbon that appear authoritative, but in reality, they rest on assumptions that are deeply uncertain and, in many cases, untestable. Pindyck's view is that this modeling paradigm is misleading for policy. Rather than trying to optimize emissions reductions based on these models, he argues for a risk-management approach that treats climate policy as a form of insurance.

4. CONCLUSIONS

The social cost of carbon represents a key parameter when evaluating the cost and benefits of policies that will affect the emissions of greenhouse gases going forward. Recent updates by the U.S. Environmental Protection Agency with significant support from academics resulted in an increase of the SCC from USD 52/ton to USD 190/ton. This represents one of the most successful transfers of academic research into the policymaking process to date. However, much work remains to be done. Sectoral coverage is missing important sectors such as forests, biodiversity, conflict, migration, and morbidity, to name but a few. Further, the treatment of extreme events is limited and mostly does not incorporate truly extreme events, which may dominate the marginal changes currently modeled. A most promising active research agenda is building around extending the incorporation of general equilibrium and trade effects into the SCC. Further opportunities for interdisciplinary collaboration present themselves in the discussion around equity weighting, which has linkages to philosophy. Further, a deeper discussion around the legal aspects of using a domestic social cost of carbon is warranted, as the economics are clear. While the SCC is often seen as a number that is used solely in benefit-cost analysis, it is used in the private sector and by financial

institutions as a measure of carbon damages when fully evaluating companies and “green” investment opportunities, extending its reach beyond ministries of energy and the environment.

REFERENCES

- Anthoff, D., C. Hepburn, and R.S.J. Tol. 2009. “Equity Weighting and the Marginal Damage Costs of Climate Change.” *Ecological Economics* 68(3): 836–49.
- Anthoff, D. and R.S.J. Tol. 2014. FUND—Climate Framework for Uncertainty, Negotiation and Distribution. Version 3.8.
- Anthoff, D., R.S.J. Tol, and G.W. Yohe. 2009. “Risk Aversion, Time Preference, and the Social Cost of Carbon.” *Environmental Research Letters* 4(2): 024002.
- Auffhammer, M. 2018. “Quantifying Economic Damages from Climate Change.” *Journal of Economic Perspectives* 32(4): 33–52.
- Ayres, R. and J. Walter. 1991. “The Greenhouse Effect: Damages, Costs and Abatement.” *Environmental and Resource Economics* 1(3): 237–70.
- Azar, C. and T. Sterner. 1996. “Discounting and Distributional Considerations in the Context of Global Warming.” *Ecological Economics* 19(2): 169–84.
- Carleton, T.A. and S.M. Hsiang. 2016. “Social and Economic Impacts of Climate.” *Science* 353.6304: aad9837.
- Climate Impact Lab (CIL). 2022. “Data-driven Spatial Climate Impact Model” (DSCIM) Version092022-EPA.
- Cline, WR. 1992. *The Economics of Global Warming*. Washington, DC: Institute For International Economics.
- Desmet, K. and E. Rossi-Hansberg. 2024. “Climate Change Economics over Time and Space.” *Annual Review of Economics* 16(1): 271–304.
- Drupp, M.A., M.C. Freeman, B. Groom, and F. Nesje. 2018. “Discounting Disentangled.” *American Economic Journal: Economic Policy* 10(4): 109–34.
- Environmental Protection Agency (EPA). 2023. Supplementary Material for the Regulatory Impact Analysis for the Final Rulemaking, “Standards of Performance for New, Reconstructed, and Modified Sources and Emissions Guidelines for Existing Sources: Oil and Natural Gas Sector Climate Review” EPA Report on the Social Cost of Greenhouse Gases: Estimates Incorporating Recent Scientific Advances.
- Fankhauser, S. 1994. “The Social Costs of Greenhouse Gas Emissions: An Expected Value Approach.” *The Energy Journal* 15(2): 157–84.
- Friedlingstein, P., M. O’Sullivan, M.W. Jones, R.M. Andrew, J. Hauck, P. Landschützer, C. Le Quéré, H. Li, I.T. Lujikx, A. Olsen, and G.P.

- Peters. 2025. "Global Carbon Budget 2024." *Earth System Science Data* 17(3): 965–1039.
- Haraden, J. 1992. "An Improved Shadow Price for CO₂". *Energy* 17(5): 419–26.
- Hope, C., J. Anderson, and P. Wenman. 1993. "Policy Analysis of the Greenhouse Effect: An Application of the PAGE Model." *Energy Policy* 21(3): 327–38.
- Huntington, E. 1917. "Climatic Change and Agricultural Exhaustion as Elements in the Fall of Rome." *Quarterly Journal of Economics* 31(2): 173–208.
- Intergovernmental Panel on Climate Change (IPCC). 2023. Sections In: Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, H. Lee and J. Romero (eds.)]. IPCC, Geneva, Switzerland.
- Interagency Working Group on the Social Cost of Carbon (IWG). 2010. "Technical Support Document: Social Cost of Carbon for Regulatory Impact Analysis under Executive Order 12866"
- Interagency Working Group on the Social Cost of Carbon (IWG). 2016. Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866.
- Kolstad, C.D. and F.C. Moore. 2020. "Estimating the Economic Impacts of Climate Change Using Weather Observations." *Review of Environmental Economics and Policy* 14(1): 1–24.
- Kotchen, M.J. 2018. "Which Social Cost of Carbon? A Theoretical Perspective." *Journal of the Association of Environmental and Resource Economists* 5(3): 673–94.
- Mendelsohn, R.O., W.N. Morrison, M.E. Schlesinger, and N.G. Andronova. 2000a. "Country-specific Market Impacts of Climate Change." *Climate Change* 45(3-4): 553–69.
- Mendelsohn R.O., M.E. Schlesinger, and L.J. Williams. 2000b. "Comparing Impacts across Climate Models". *Integrated Assessment* 1(1): 37–48.
- Millar, R.J., Z.R. Nicholls, P. Friedlingstein, and M.R. Allen. 2017. "A Modified Impulse-Response Representation of the Global Near-Surface Air Temperature and Atmospheric Concentration Response to Carbon Dioxide Emissions." *Atmospheric Chemistry and Physics* 17: 7213–28.

- Moore, F.C., Baldos, U., Hertel, T., and D.B. Diaz. 2017. "New Science of Climate Change Impacts on Agriculture Implies Higher Social Cost of Carbon." *Nature Communications* 8(1): 1–9.
- National Academies of Sciences, Engineering, and Medicine (NASEM). 2017. *Valuing Climate Damages: Updating Estimation of the Social Cost of Carbon Dioxide*. Washington, DC: The National Academies Press. <https://doi.org/10.17226/24651>.
- National Research Council. 2010. *Hidden Costs of Energy: Unpriced Consequences of Energy Production and Use*. Committee on Health, Environmental, and Other External Costs and Benefits of Energy Production and Consumption; Board on Environmental Studies and Toxicology; Division on Earth and Life Studies; Board on Energy and Environmental Systems; Division on Engineering and Physical Sciences; Board on Science, Technology, and Economic Policy; Policy and Global Affairs. Washington, DC: The National Academies Press.
- Newell, R.G., W.A. Pizer, and B.C. Prest. 2022. "A Discounting Rule for the Social Cost of Carbon." *Journal of the Association of Environmental and Resource Economists* 9(5): 1017–46.
- Nordhaus, W. 1982. "How Fast Should We Graze the Global Commons?" *American Economic Review* 72(2): 242–46.
- Nordhaus, W.D. 1991. "To Slow Or Not To Slow: The Economics of the Greenhouse Effect." *Economic Journal* 101(407): 920–37.
- Nordhaus, W.D. 1992. "An Optimal Transition Path for Controlling Greenhouse Gases." *Science* 258(5086): 1315–19.
- Nordhaus, W.D. 1994. *Managing the Global Commons: The Economics of Climate Change*. Boston, MA: MIT Press.
- Nordhaus, W.D. and Z. Yang. 1996. "A Regional Dynamic General-Equilibrium Model of Alternative Climate-Change Strategies." *American Economic Review* 86(4): 741–65.
- Peck, S.C. and T.J. Teisberg. 1993. "Global Warming Uncertainties and the Value of Information: An Analysis Using CETA." *Resource and Energy Economics* 15(1): 71–97.
- Pigou, Arthur C. 1920. *The Economics of Welfare*. Macmillan.
- Pindyck, R.S. 2013. "Climate Change Policy: What Do the Models Tell Us?" *Journal of Economic Literature* 51(3): 860–72.
- Pindyck, R.S. 2017. "The Use and Misuse of Models for Climate Policy." *Review of Environmental Economics and Policy* 11(1): 100–14.
- Prest, B.C., L. Rennels, F. Errickson, and D. Anthoff. 2024. "Equity Weighting Increases the Social Cost of Carbon." *Science* 385(6710): 715–17.

- Reilly, J. and K. Richards. 1993. "Climate Change Damage and the Trace Gas Index Issue." *Environmental and Resource Economics* 3(1): 41–61.
- Rennert, K., F. Errickson, B.C. Prest, L. Rennels, R.G. Newell, W. Pizer, and D. Anthoff. 2022. "Comprehensive Evidence Implies a Higher Social Cost of CO₂." *Nature* 610(7933): 687–92.
- Resources for the Future (RFF). 2025. The Mimi Framework.
- Smith J.B. 1996. "Standardized Estimates of Climate Change Damages for the United States." *Climate Change* 32(3):313–26.
- Titus J.G. 1992. "The Costs of Climate Change to the United States." In *Global Climate Change : Implications, Challenges and Mitigation Measures*, edited by S.K. Majumdar, L.S. Kalkstein, B. Yamal, J.W. Miller, and L.M. Rosenfeld. Easton, PA: Pennsylvania Academy of Science.
- Tol, R.S.J. 1996. "The Climate Framework for Uncertainty, Negotiation and Distribution." In *An Institute on the Economics of the Climate Resource*, edited by K.A. Miller and R.K. Parkin. Boulder, CO: University Corporation for Atmospheric Research.
- Tol, R.S.J. 2011. "The Social Cost of Carbon." *Annual Review of Resource Economics* 3(1): 419–43.
- Wong, T.E. 2017. "BRICK v0.2, a Simple, Accessible, and Transparent Model Framework for Climate and Regional Sea-Level Projections." *Geoscience Model Deviation* 10: 2741–60.
- World Bank Group. 2025. *State and Trends of Carbon Pricing Dashboard*.