February 6, 2023

The Honorable Ann E. Misback

Secretary, Board of Governors of the Federal Reserve System

20th Street and Constitution Ave NW

Washington DC 20551

Dear Secretary Misback:

This is a comment on the proposed regulation "Principles for Climate-Related Financial Risk Management for Large Financial Institutions" Docket No. OP-1793.

Financial institutions are subject to scenario analyses and stress tests which, in part, determine the systemic risk those institutions pose to the financial system. Due to the interconnectedness of, and leverage present in, the financial system, individual financial institutions have the potential to create risks not only for themselves, but their customers, competitors, and other parties as well. Such systemic risk means not just the risk of loss to a single financial institution, but the financial system. Systemic risk must be monitored by the Federal Reserve, per the Dodd-Frank Act. Systemic risk can arise from financial institutions borrowing from or lending to each other or having other significant exposure to each other. Losses or a complete failure of one financial institution can cascade to others, resulting in general failure. The nature of fractional reserve banking, for example, makes the financial system inherently prone to overleverage. Furthermore, due to the fungibility of many assets, the liquidation of a single financial institution may cause a fire sale which reduces the price not only of the particular asset owned by that financial institution, but of the same or similar assets owned by other institutions. Thus, those other institutions may quickly find themselves overleveraged due to a depreciation of their asset levels, and they themselves must begin selling assets to reduce their own leverage. The result is a negative feedback loop wherein devaluations spawn further devaluations. The Federal Reserve evaluates the positions of large financial institutions during both these stress tests and scenario analyses to determine if such systemic risk exists and what, if anything, is present to offset such risk.

These scenario analyses and stress tests are fundamentally financial in nature. The proposed rule, however, would alter that calculus and incorporate climate-related evaluations. Therefore, the systemic risk imposed by financial institutions would be judged partly on those institutions' positions regarding carbon emissions. The modeling in this area is highly problematic, which would result in unreliable results from both scenario analyses and stress tests. In fact, the ability to reduce apparent systemic risk artificially under this proposed rule could actually increase the true systemic risk present in the financial system. The inability to model climate change and its economic effects accurately makes it impossible for both financial institutions and the Federal Reserve to determine the systemic risk stemming from fossil fuels or carbon emissions.

The proposed rule specifically asks if there are "areas where the draft principles should be more or less specific given the current data availability and understanding of climate-related financial risks? What other aspects of climate-related financial risk management, if any, should the Board consider?"

The tremendous uncertainty associated with the social cost of carbon (SCC) is relevant for this question.[1] The SCC is an estimate in dollars of the cumulative long-term damage caused by one ton of CO_2 emitted in a specific year. That number also represents an estimate of the benefit of avoiding or reducing one ton of CO_2 emissions. The SCC is estimated by Integrated Assessment Models (IAMs), which have been used in the past by the federal government as a basis for regulatory policy. For example, the Obama administration's Interagency Working Group (IWG) had drawn upon three models – abbreviated as DICE, FUND, and PAGE—to estimate the SCC.[2,3] The Biden administration appears to be using other models as well.[4]

As any model is as good as the assumptions from which it is composed, we took these IAMs in house at The Heritage Foundation and tested their sensitivity to a variety of important and reasonable assumptions. We have found that under very reasonable assumptions they can offer a plethora of different estimates of the SCC, ranging from extreme damages to overall benefits.

SCC estimates in IAMs are highly sensitive to at least four factors:

1. Discount Rates: chosen to calculate the present value of future emissions and reductions.
2. Time Horizon: chosen to estimate cumulative damages from rising GHG concentration.
3. Equilibrium Climate Sensitivity: estimated climate sensitivities chosen to estimate the warming impact of projected increases in atmospheric GHG concentration.
4. Negative SCC Values and Agricultural Benefits: assumptions regarding agricultural impact

We find the estimated economic impact of climate change depends heavily on the assumptions made as part of estimation. The plausible range of estimates is wide enough that climate change

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[1] Some of the remarks in this comment was also utilized in a separate regulatory comment. See Patrick Michaels, Kevin Dayaratna, Marlo Lewis. Federal Energy Regulatory Commission, Notice Inviting Technical Conference Comments, 86 FR 66293." https://cei.org/wp-content/uploads/2022/04/CEI-Comments-Michaels-Dayaratna-Lewis-Docket-No-PL21-3-000-January-7-2022.pdf

[2] IWG, Technical Support Document: - Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis - Under Executive Order 12866, August 2016, p. 4, https://www.epa.gov/sites/default/files/2016-12/documents/sc_co2_tsd_august_2016.pdf (hereafter IWG, TSD 2016).

[3] For the DICE (Dynamic Integrated Climate and Economy) model, see William D. Nordhaus, "DICE/RICE Models," https://williamnordhaus.com/dicerice-models. For the FUND (Framework for Uncertainty, Negotiation, and Distribution) model, see "FUND Model, http://fund-model.org (accessed September 15, 2021). For the PAGE (Policy Analysis for the Greenhouse Effect) model, see Climate CoLab, "PAGE," https://www.climatecolab.org/wiki/PAGE

[4] Interagency Working Group, "Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide Interim Estimates under Executive Order 13990" https://www.whitehouse.gov/wp-content/uploads/2021/02/TechnicalSupportDocument_SocialCostofCarbonMethaneNitrousOxide.pdf (hereafter IWG, TSD 2021) and United States Environmental Protection Agency, "EPA External Review Draft of "Report on the Social Cost of Greenhouse Gases: Estimates Incorporating Recent Scientific Advances," November 11, 2022, https://www.epa.gov/environmental-economics/scghg

could have a positive effect or a negative effect on welfare. The Federal Reserve should account for the range of effects in its scenario analyses and stress tests.

Regardless of the method used to estimate the costs of climate change, the proposed rule includes a number of flaws in how it proposes to address systemic financial risk.

1. Including subjective climate modeling decisions increases the subjectivity of financial institutions' scenario analyses and stress tests.
2. Using climate considerations as offsets could increase the amount of financial systemic risk.
3. The rule contains no limiting principle as to which risks should or should not be included in scenario analyses and stress tests on the grounds of reducing climate change.

The proposed rule should not move forward without addressing these concerns.

The Economic Impact of Climate Change

How Discount Rates Affect the SCC[5]

Models used to estimate the SCC rely on the specification of a discount rate. A discount rate is necessary to compare dollar benefits between time periods because benefits that occur immediately are more valuable than benefits that occur with a delay. Discount rates reflect a person or society's preferences to wait for benefits to occur. The choice of a discount rate is inherently subjective because willingness to wait may vary across people.

Discounting is essential in benefit-cost analysis because compliance costs are best viewed as investments intended to yield benefits in the future. Applying discount rates enables agencies to compare the projected rate of return from CO_2-reduction expenditures to the rates of return from other potential investments in the economy.

Office of Management and Budget (OMB) guidance in Circular A-4 specifically stipulates that agencies discount the future costs and benefits of regulations using both 3.0 percent and 7.0 percent discount rates.[6] The Obama and Biden administrations have suggested that a 7 percent discount rate is an affront to intergenerational equity, apparently on the theory that discount rates higher than 1-2 percent imply that people living today are more valuable than people living decades or centuries from now.[7]

We respectfully disagree. The point of discounting is not to rank the worth of different generations but to have a consistent basis for comparing alternate investments. Only then can policymakers determine which investments are most likely to transmit the most valuable capital stock to future generations. In other words, discounting clarifies the *opportunity cost* of investing

[5] Sections 3-6 draw upon Kevin Dayaratna's testimony on "Climate Change, Part IV: Moving Toward a Sustainable Future," before the House Oversight and Reform Subcommittee on the Environment, September 24, 2020, https://oversight.house.gov/sites/democrats.oversight.house.gov/files/Dayaratna%20Testimony%2C%20updated%20for%20Sept%2024%20hearing.pdf.

[6] Office of Management and Budget, "Circular A-4," Obama White House, February 22, 2017, https://obamawhitehouse.archives.gov/omb/circulars_a004_a-4/ (accessed September 27, 2021).

[7] IWG, TSD 2021, pp. 17-19.

in climate mitigation, for example, rather than medical research, national defense, or trade liberalization.

Not only is it reasonable to include a 7 percent discount rate in SCC estimation, it is arguably the best option because 7 percent is the rate of return of the New York Stock Exchange over the last hundred and twenty-five years and thus particularly pertinent to the financial institutions impacted by this rule.[8] Only by using a 7 percent discount rate can policymakers assess the wealth foregone when government invests in GHG reduction rather than other policy objectives or simply allows companies and households to invest more of their dollars as they see fit.

Institute for Energy Research economist David Kreutzer illustrates the point as follows. Suppose an emission-reduction investment produces $100 in benefits by 2171 (150 years from now). That is equivalent to investing $5.13 today with a 2 percent annual ROI. But if the same $5.13 is invested in stock that appreciates at 7 percent annually, the investment yields $131,081 in 2171. Clearly, that is a much larger bequest to future generations. How does that negatively affect "intergenerational equity"? It would confer much greater wealth on posterity, endowing them with far more productive capital stock.

Kreutzer also notes that all baseline scenarios assume future generations are richer than current generations. He comments:

> It is a terrible policy to make investments that return $100 instead of $131,081, but it is virtually brain-dead to argue the bad return is justified on equity grounds. Those alive centuries from now are almost certain to be much wealthier, healthier, and possessed of technology to better overcome any adversity—including climate change.[9]

It is hard to shake the suspicion that the IWG declines to use a 7 percent discount rate, even as a sensitivity case analysis, because doing so would spotlight the comparatively low rates of return of GHG-reduction policies.

At The Heritage Foundation, Dayaratna and colleagues ran DICE and FUND using a 7.0 percent discount rate to quantify how much the IWG's lower discount rates increases SCC estimates. Below is the 2016 Technical Support Documents' SCC estimates[10] followed by the Heritage analysts' results published in the peer-reviewed journal *Climate Change Economics*:[11]

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[8] D. W. Kreutzer, "Discounting Climate Costs," Heritage Foundation *Issue Brief* No. 4575, June 16, 2016, https://www.heritage.org/environment/report/discounting-climate-costs; Kevin Dayaratna, Rachel Greszler and Patrick Tyrrell, "Is Social Security Worth Its Cost?" Heritage Foundation Backgrounder No. 3324, July 10, 2018, https://www.heritage.org/budget-and-spending/report/social-security-worth-its-cost.

[9] David Kreutzer, IER Comments on Social Cost of Greenhouse Gas Estimates, Docket No. OMB-2021-0006, June 24, 2021, HTTPS://WWW.INSTITUTEFORENERGYRESEARCH.ORG/CLIMATE-CHANGE/IER-COMMENTS-ON-SOCIAL-COST-OF-CARBON-ESTIMATES/.

[10] IWG, Technical Support Document: - Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis - Under Executive Order 12866, August 2016, p. 4, https://www.epa.gov/sites/default/files/2016-12/documents/sc_co2_tsd_august_2016.pdf (hereafter IWG, TSD 2016).

[11] K. Dayaratna, R. McKitrick, and D. Kreutzer, "Empirically Constrained Climate Sensitivity and the Social Cost of Carbon," *Climate Change Economics*, Vol. 8, No. 2 (2017), p. 1750006-1-1750006-12, https://www.worldscientific.com/doi/abs/10.1142/S2010007817500063 (hereafter Dayaratna et al. (2017)).

Table ES-1: Social Cost of CO_2, 2010 – 2050 (in 2007 dollars per metric ton of CO_2)

Year	5% Average	**3% Average**	2.5% Average	High Impact (95th Pct at 3%)
2010	10	**31**	50	86
2015	11	**36**	56	105
2020	12	**42**	62	123
2025	14	**46**	68	138
2030	16	**50**	73	152
2035	18	**55**	78	168
2040	21	**60**	84	183
2045	23	**64**	89	197
2050	26	**69**	95	212

	DICE Model Average SCC – Baseline, End Year 2300			
Year	**Discount Rate – 2.5%**	**Discount Rate – 3.0%**	**Discount Rate – 5.0%**	**Discount Rate – 7.0%**
2020	$56.92	$37.79	$12.10	$5.87
2030	$66.53	$45.15	$15.33	$7.70
2040	$76.96	$53.26	$19.02	$9.85
2050	$87.70	$61.72	$23.06	$12.25

	FUND Model Average SCC – Baseline, End Year 2300			
Year	**Discount Rate – 2.5%**	**Discount Rate – 3.0%**	**Discount Rate – 5.0%**	**Discount Rate – 7.0%**
2020	$32.90	$19.33	$2.54	–$0.37
2030	$36.16	$21.78	$3.31	–$0.13
2040	$39.53	$24.36	$4.21	$0.19
2050	$42.98	$27.06	$5.25	$0.63

If any government agency is going to use SCC analysis, it should include SCC discounted at 7 percent as part of its benefit-cost analysis, because only on that basis can the public compare climate policy "investments" to other capital expenditures. And only through such comparisons can policymakers reasonably assess which investments will best position future generations to inherit the most productive capital stock. Furthermore, as the above analysis illustrates, under a 7 percent discount rate, the SCC is essentially zero and might even be negative at times, suggesting overall net benefits to climate change.

How the Time Horizon Affects the SCC

Human beings use technology to adapt to environmental conditions. Consequently, the loss functions in IAMs depend on assumptions about how adaptive technologies will be developed and deployed as the world warms. It is essentially impossible to forecast technological change decades, let alone centuries, into the future.

Consider U.S. natural gas as an example. Around the turn of this century, it was accepted wisdom that our supplies were running so low that large net imports would be required. A mere ten years later, thanks to the widespread use of hydraulic fracturing of shale, it was apparent there are literally hundreds of years of supply within rock layers under vast areas of the lower-48 states (as well as in Europe and China, as later discovered).

Substitution of gas-fired combustion for coal firing reduces net greenhouse gas emissions by nearly 60 percent. Supercritical natural-gas fired turbine technology can actually reduce net emissions to *zero* in an experimental plant,[12] though a much-anticipated commercial-grade upscaling has yet to be achieved. These developments only serve to emphasize how foolhardy it is to use, as the IWG does, a 300-year period (2000-2300). Dayaratna and his former Heritage Foundation colleague David Kreutzer ran the DICE model with a significantly shorter, albeit still unrealistic, time horizon of 150 years into the future.[13]

Here are the DICE-estimated SCC values with a baseline ending in 2300:

TABLE 1

Average SCC Baseline, End Year 2300

Year	Discount Rate: 2.5%	Discount Rate: 3%	Discount Rate: 5%	Discount Rate: 7%
2010	$46.57	$30.04	$8.81	$4.02
2015	$52.35	$34.32	$10.61	$5.03
2020	$56.92	$37.79	$12.10	$5.87
2025	$61.48	$41.26	$13.60	$6.70
2030	$66.52	$45.14	$15.33	$7.70
2035	$71.57	$49.03	$17.06	$8.70
2040	$76.95	$53.25	$19.02	$9.85
2045	$82.34	$57.48	$20.97	$11.00
2050	$87.69	$61.72	$23.06	$12.25

Source: Calculations based on Heritage Foundation Monte Carlo simulation results using the DICE model. B 2860 heritage.org

Here are the results with a baseline ending in 2150:

[12] See for example Sonia Patel, "Breakthrough: NET Power's Allam Cycle Test Facility Delivers First Power to ERCOT Grid," Power, November 18, 2021, https://www.powermag.com/breakthrough-net-powers-allam-cycle-test-facility-delivers-first-power-to-ercot-grid/

[13] Dayaratna and Kreutzer, *Loaded DICE: An EPA Model Not Ready for the Big Game*, Backgrounder No. 2860, The Heritage Foundation, November 21, 2013, https://www.heritage.org/environment/report/loaded-dice-epa-model-not-ready-the-big-game.

TABLE 3

Average SCC, End Year 2150

Year	Discount Rate: 2.5%	Discount Rate: 3%	Discount Rate: 5%	Discount Rate: 7%
2010	$36.78	$26.01	$8.66	$4.01
2015	$41.24	$29.65	$10.42	$5.02
2020	$44.41	$32.38	$11.85	$5.85
2025	$47.57	$35.11	$13.28	$6.68
2030	$50.82	$38.00	$14.92	$7.67
2035	$54.07	$40.89	$16.56	$8.66
2040	$57.17	$43.79	$18.36	$9.79
2045	$60.27	$46.68	$20.16	$10.92
2050	$62.81	$49.20	$22.00	$12.13

Source: Calculations based on Heritage Foundation Monte Carlo simulation results using the DICE model. B 2860 heritage.org

The SCC estimates drop substantially—in some cases by more than 25 percent—as a result of ending the SCC estimation period in 2150.

-How the Equilibrium Climate Sensitivity (ECS) Distribution Affects the SCC

The key climate specification used in estimating the SCC is the equilibrium climate sensitivity (ECS) distribution. Such distributions probabilistically quantify the earth's temperature response to a doubling of CO_2 concentrations.

ECS distributions are derived from general circulation models (GCMs) or more comprehensive earth system models (ESMs), which attempt to represent physical processes in the atmosphere, ocean, cryosphere and land surface. The IWG used the ECS distribution from a study by Gerard Roe and Marcia Baker published 15 years ago in the journal *Science*.[14] This non-empirical distribution, calibrated by the IWG based on assumptions it selected in conjunction with past Intergovernmental Panel on Climate Changes (IPCC) recommendations,[15] is no longer scientifically defensible.[16] In particular, since 2011, a variety of newer and empirically-constrained distributions have been published in the peer-reviewed literature. Many of those distributions suggest lower probabilities of extreme global warming in response to CO_2 concentrations. Figure 1 are three such distributions:[17]

[14] Gerard H. Roe and Marcia B. Baker. 2007. Why Is Climate Sensitivity So Unpredictable? *Science*, Vol. 318, No. 5850, pp. 629–632, https://science.sciencemag.org/content/318/5850/629.

[15] IWG, Technical Support Document: - Social Cost of Carbon for Regulatory Impact Analysis - Under Executive Order 12866, February 2010, pp. 13-14, https://www.epa.gov/sites/default/files/2016-12/documents/scc_tsd_2010.pdf (hereafter IWG, TSD 2010).

[16] Patrick J. Michaels, "An Analysis of the Obama Administration's Social Cost of Carbon," testimony before the Committee on Natural Resources, U.S. House of Representatives, July 22, 2015, https://www.cato.org/publications/testimony/analysis-obama-administrations-social-cost-carbon.

[17] Nicholas Lewis, "An Objective Bayesian Improved Approach for Applying Optimal Fingerprint Techniques to Estimate Climate Sensitivity," *Journal of Climate*, Vol. 26, No. 19 (October 2013), pp. 7414–7429, https://journals.ametsoc.org/view/journals/clim/26/19/jcli-d-12-00473.1.xml; Alexander Otto et al., "Energy Budget Constraints on Climate Response," *Nature Geoscience*, Vol. 6, No. 6 (June 2013), pp. 415–416,

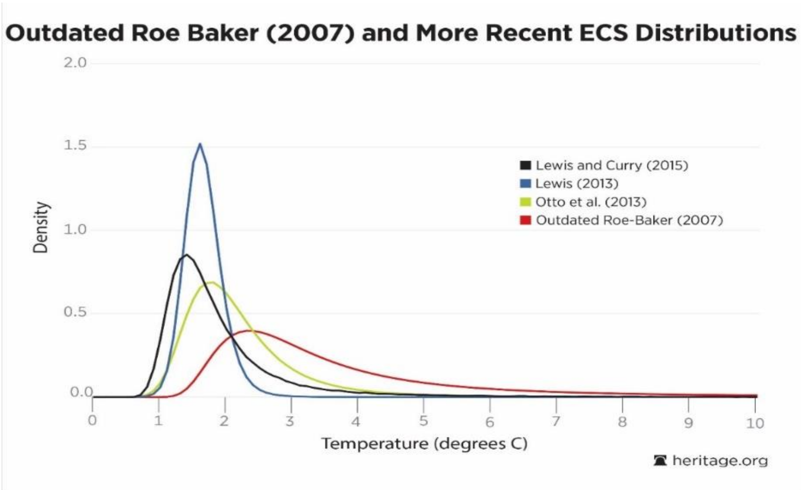

Figure 1: A variety of equilibrium climate sensitivity (ECS) distributions

The areas under the curves between two temperature points represent the probability that the earth's temperature will increase between those amounts in response to a doubling of CO_2 concentration. For example, the area under the curve from 4°C onwards (known as right-hand "tail probability") represents the probability that the earth's temperature will warm by more than 4°C in response to a doubling of CO_2 concentrations. Note that the more up-to-date ECS distributions (Otto et al., 2013; Lewis, 2013; Lewis and Curry, 2015) have significantly lower tail probabilities than the outdated Roe-Baker (2007) distribution used by the IWG.

Here, again, is the IWG's 2016 SCC estimates for 2020-2050:

Table ES-1: Social Cost of CO_2, 2010 – 2050 (in 2007 dollars per metric ton of CO_2)

Year	5% Average	**3% Average**	2.5% Average	High Impact (95th Pct at 3%)
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https://www.nature.com/articles/ngeo1836; Nicholas Lewis and Judith A. Curry, "The Implications for Climate Sensitivity of AR5 Forcing and Heat Uptake Estimates," *Climate Dynamics*, Vol. 45, No. 3, pp. 1009–1923, http://link.springer.com/article/10.1007/s00382-014-2342-y.

In *Climate Change Economics*, Dayaratna and colleagues re-estimated the DICE and FUND models' SCC values using the more up-to-date ECS distributions and obtained the following results:[18]

	DICE Model Average SCC – ECS Distribution Updated in Accordance with Lewis and Curry (2015), End Year 2300			
Year	**Discount Rate – 2.5%**	**Discount Rate – 3.0%**	**Discount Rate – 5.0%**	**Discount Rate – 7.0%**
2020	$28.92	$19.66	$6.86	$3.57
2030	$33.95	$23.56	$8.67	$4.65
2040	$39.47	$27.88	$10.74	$5.91
2050	$45.34	$32.51	$13.03	$7.32

	FUND Model Average SCC – ECS Distribution Updated in Accordance with Lewis and Curry (2015), End Year 2300			
Year	**Discount Rate – 2.5%**	**Discount Rate – 3.0%**	**Discount Rate – 5.0%**	**Discount Rate – 7.0%**
2020	$5.86	$3.33	–$0.47	–$1.10
2030	$6.45	$3.90	–$0.19	–$1.01
2040	$7.02	$4.49	–$0.18	–$0.82
2050	$7.53	$5.09	$0.64	–$0.53

Using the more up-to-date ECS distributions dramatically lowers SCC estimates. The IWG's outdated assumptions overstate the probabilities of extreme global warming, which artificially inflates their SCC estimates. In its Fifth Assessment Report (AR5), the IPCC used the Coupled Model Intercomparison Project Phase 5 (CMIP5) models to project future warming and the associated climate impacts.[19] Figure 2 compares predicted and observed average tropospheric temperature over the tropics.[20] The observations come from satellites, weather balloons, and reanalyses.[21] A careful look analysis reveals that only one of the 102 model runs correctly

[18]Dayaratna, McKitrick, and Kreutzer, "Empirically Constrained Climate Sensitivity and the Social Cost of Carbon."
[19] Program for Climate Model Diagnosis and Intercomparison, CMIP5 – Coupled Model Intercomparison Project Phase 5 – Overview, https://pcmdi.llnl.gov/mips/cmip5/.
[20] The CMIP5 predictions are available at https://climexp.knmi.nl/start.cgi.
[21] Climate reanalyses produces synthetic histories of recent climate and weather using all available observations, a consistent data assimilation system, and mathematical modeling to fill in data gaps. See National Center for Atmospheric Research, Atmospheric Reanalysis: Overview & Comparison,

simulates what has been observed. This is the Russian climate model INM-CM4, which also has the least prospective warming of all of them, with an ECS of 2.05°C, compared to the CMIP5 average of 3.2°C.

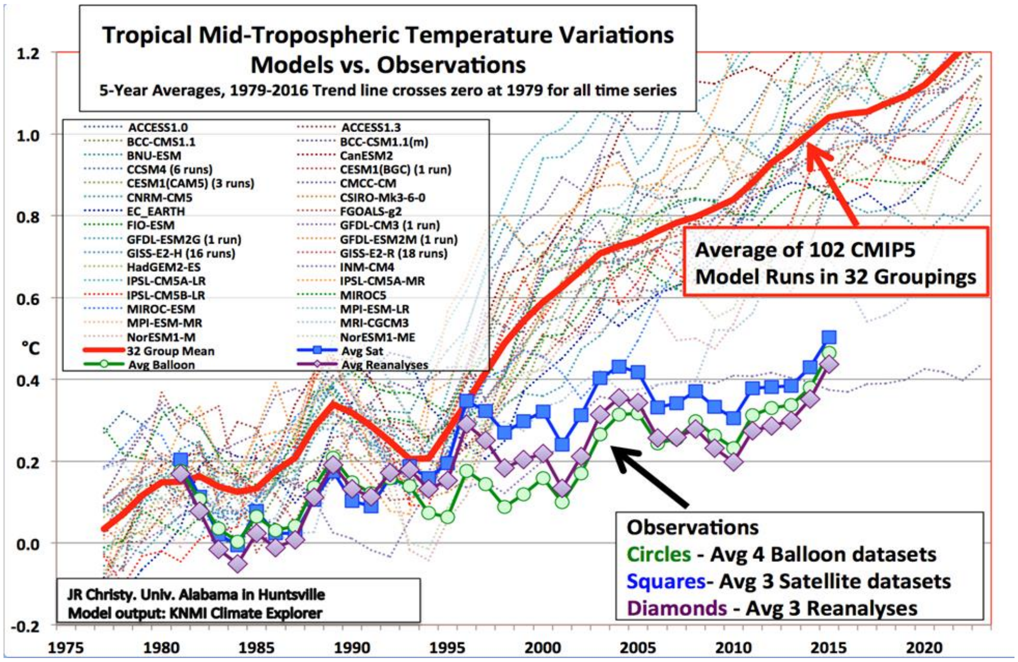

Figure 2. Solid red line—average of all the CMIP-5 climate models; Thin colored lines—individual CMIP-5 models; solid figures—weather balloon, satellite, and reanalysis data for the tropical troposphere. [22]

Best scientific practice uses models that work and does not seriously consider those that do not. This is standard when formulating the daily weather forecast, and should be the standard with regard to climate forecasts.

The IPCC's recently released Sixth Assessment Report (AR6) uses a new suite of models, designated CMIP6. As shown by McKitrick and Christy (2020) however, the CMIP6 models are even worse.[23] Of the two models that work, the Russian INM-CM4.8, has even less warming than its predecessor, with an ECS of 1.8°C, compared to the CMIP6 community value of around four degrees.[24] The other one is also a very low ECS model from the same, group, INM-CM5. The model mean warming rate exceeds observation by more than two times at altitude in the tropics.

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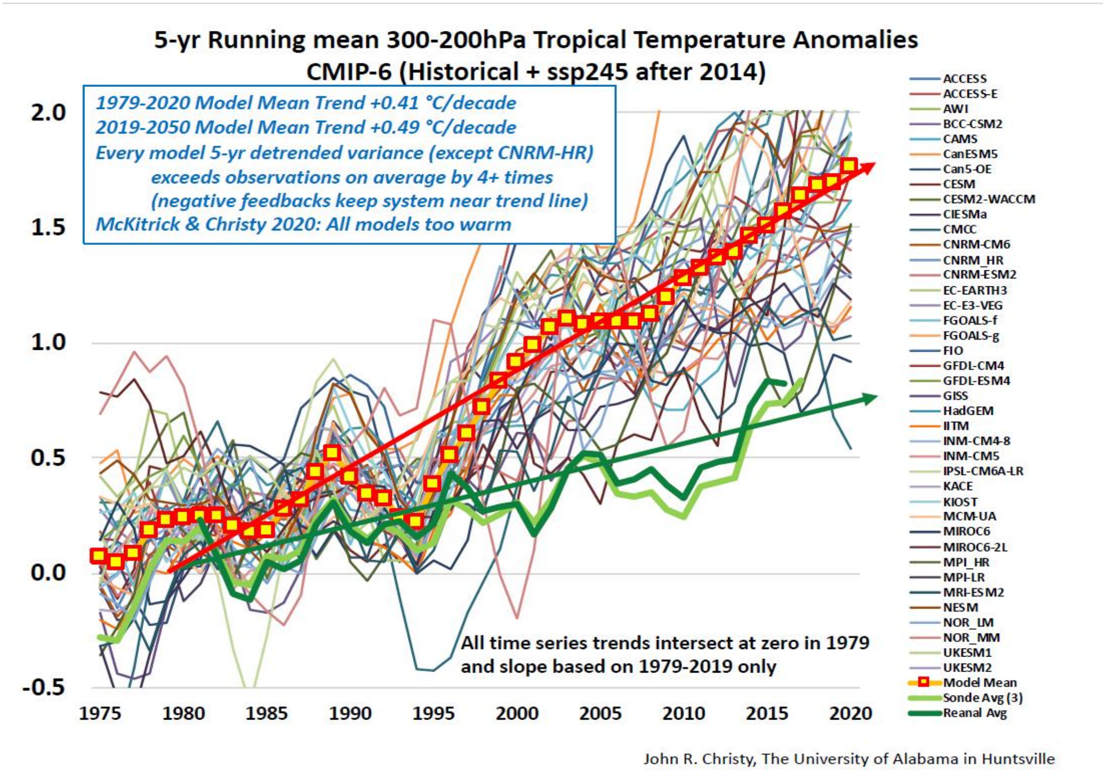
https://climatedataguide.ucar.edu/climate-data/atmospheric-reanalysis-overview-comparison-tables and ECMWF, Climate Reanalysis, https://www.ecmwf.int/en/research/climate-reanalysis

[22] Christy, J.R.: 2017, [in "State of the Climate in 2016"], *Bull. Amer. Meteor. Soc*. 98, (8), S16-S17, https://journals.ametsoc.org/view/journals/bams/98/8/2017bamsstateoftheclimate.1.xml.

[23] R. McKitrick and J. Christy. 2020. Pervasive Warming Bias in CMIP6 Tropospheric Layers. *Earth and Space Science* Volume 7, Issue 9, https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2020EA001281.

[24] Most (not all) of the CMIP-6 models were available for McKitrick and Christy (2020); this figure is the mean ECS of what was released through late 2020.



Quoting from McKitrick and Christy's conclusion:

> The literature drawing attention to an upward bias in climate model warming responses in the tropical troposphere extends back at least 15 years now … Rather than being resolved, the problem has become worse, since now every member of the CMIP6 generation of climate models exhibits an upward bias in the entire global troposphere as well as in the tropics.

Zeke Hausfather, hardly a climate skeptic, has noted that while the CMIP6 models are warmer than the previous generation, the warmer they are, the more they over-forecast warming in recent decades, confirming what McKitrick and Christy found.[25]

Zhu, Poulsen, and Otto-Bliesner (2020) used a CMIP6 model called CESM2 to project warming from an emission scenario that reaches 855 parts per million by 2100—roughly three times the pre-industrial concentration. Despite being tuned to match the behavior of 20th century climate, CESM2 produced a global mean temperature "5.5°C greater than the upper end of proxy temperature estimates for the Early Eocene Climate Optimum." That was a period when CO_2 concentrations of about 1,000 ppm persisted for millions of years.[26] Moreover, the modeled tropical land temperature exceeded 55°C, "which is much higher than the temperature tolerance

[25] Zeke Hausfather, "Cold Water on Hot Models," The Breakthrough Institute, February 11, 2020, https://thebreakthrough.org/issues/energy/cold-water-hot-models.

[26] NOAA National Centers for Environmental Information, Early Eocene Period, 54 to 48 Million Years Ago, https://www.ncdc.noaa.gov/global-warming/early-eocene-period.

of plant photosynthesis and is inconsistent with fossil evidence of an Eocene Neotropical rainforest."[27]

Altogether, faulty assumptions regarding climate sensitivity have been manifested in the SCC and associated regulatory policy, and more realistic assumptions inject significant uncertainty into the potential long-term impact of climate change.

-Negative SCC Values

Policymakers and the media often assume carbon dioxide emissions have only harmful impacts on society. However, CO_2 emissions have enormous direct agricultural[28] and ecological benefits,[29] global warming lengthens growing seasons,[30] and warming potentially also alleviates cold-related mortality, which may exceed heat-related mortality by 20 to 1.[31]

Of the three IAMs used by the IWG, only the FUND model estimates CO_2 fertilization benefits. Dayaratna and colleagues investigated whether a model with CO_2 fertilization benefits could produce negative SCC estimates. A negative SCC means that each incremental ton of CO_2 emissions produces a net benefit.

The researchers calculated the probability of a negative SCC under a variety of assumptions. Below are some of the results published both at the Heritage Foundation as well as in the peer-reviewed journal *Climate Change Economics*:[32]

	FUND Model Probability of Negative SCC – ECS Distribution Based on Outdated Roe–Baker (2007) Distribution, End Year 2300			
Year	**Discount Rate – 2.5%**	**Discount Rate – 3.0%**	**Discount Rate – 5.0%**	**Discount Rate – 7.0%**

[27] Jiang Zhu, Christopher J. Poulsen & Bette L. Otto-Bliesner. 2020. High climate sensitivity in CMIP6 model not supported by paleoclimate. *Nature Climate Change* volume 10, pages 378–379, https://www.nature.com/articles/s41558-020-0764-6.

[28] Literally hundreds of peer-reviewed studies document significant percentage increases in food crop photosynthesis, dry-weight biomass, and water-use efficiency due to elevated CO_2 concentrations. See the Center for the Study of Carbon Dioxide and Global Change's Plant-Growth Database: http://co2science.org/data/plant_growth/plantgrowth.php

[29] See, for example, Randall J. Donahue et al. 2013. Impact of CO2 fertilization on maximum foliage cover across the globe's warm, arid environments. *Geophysical Research Letters* Vol. 40, 1–5, https://friendsofscience.org/assets/documents/CO2_Fertilization_grl_Donohue.pdf; Zaichun Zhu et al. The Greening of the Earth and Its Drivers. 2016. *Nature Climate Change* 6, 791-795, https://www.nature.com/articles/nclimate3004; and J.E. Campbell et al. 2017. Large historical growth in global gross primary production. *Nature* 544, 84-87, https://www.nature.com/articles/nature22030.

[30] EPA, Climate Change Indicators: Length of Growing Season, https://www.epa.gov/climate-indicators/climate-change-indicators-length-growing-season.

[31] Antonio Gasparrini et al. 2015. Mortality risk attributable to high and low ambient temperature: a multicountry observational study, *The Lancet*, Volume 386, Issue 9991, https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(14)62114-0/fulltext.

[32] Dayaratna and Kreutzer, "Unfounded FUND: Yet Another EPA Model Not Ready for the Big Game," Backgrounder No. 2897, April 29, 2014, http://thf_media.s3.amazonaws.com/2014/pdf/BG2897.pdf; and Dayaratna et al. (2017).

2020	0.084	0.115	0.344	0.601
2030	0.080	0.108	0.312	0.555
2040	0.075	0.101	0.282	0.507
2050	0.071	0.093	0.251	0.455

	FUND Model Probability of Negative SCC – ECS Distribution Updated in Accordance with Otto et al. (2013), End Year 2300			
Year	**Discount Rate – 2.5%**	**Discount Rate – 3.0%**	**Discount Rate – 5.0%**	**Discount Rate – 7.0%**
2020	0.268	0.306	0.496	0.661
2030	0.255	0.291	0.461	0.619
2040	0.244	0.274	0.425	0.571
2050	0.228	0.256	0.386	0.517

	FUND Model Probability of Negative SCC – ECS Distribution Updated in Accordance with Lewis (2013), End Year 2300			
Year	**Discount Rate – 2.5%**	**Discount Rate – 3.0%**	**Discount Rate – 5.0%**	**Discount Rate – 7.0%**
2020	0.375	0.411	0.565	0.685
2030	0.361	0.392	0.530	0.645
2040	0.344	0.371	0.491	0.598
2050	0.326	0.349	0.449	0.545

	FUND Model Probability of Negative SCC – ECS Distribution Updated in Accordance with Lewis and Curry (2015), End Year 2300			
Year	**Discount Rate – 2.5%**	**Discount Rate – 3.0%**	**Discount Rate – 5.0%**	**Discount Rate – 7.0%**
2020	0.402	0.432	0.570	0.690
2030	0.388	0.414	0.536	0.646
2040	0.371	0.394	0.496	0.597
2050	0.354	0.372	0.456	0.542

As the above statistics illustrate, under a variety of reasonable assumptions, the SCC has a substantial probability of being negative. In fact, in some cases, the SCC is more likely to be negative than positive, which implies—if one adopts the perspective of a central planner—that the Federal Reserve should, in fact, subsidize (not limit) CO_2 emissions. We, of course, oppose such interventionism. Our purpose here is to illustrate the extreme sensitivity of these models to reasonable changes in assumptions as well as to point out that the probabilities of negative SCC value are non-trivial and potentially quite substantial.

Updated Agricultural Benefits and Benefit-Cost Analysis

It is a well-established fact that increases in CO_2 concentration enhance plant growth by increasing their internal water use efficiency as well as raising the rate of net photosynthesis.[33] As discussed in the previous section, the FUND model attempts to incorporate those benefits; however, this aspect of the model is grounded on research that is one-to-two decades old. Even so, as discussed in the preceding section, Dayaratna et al. (2017) found substantial probabilities of negative SCC using the outdated assumptions in FUND. Dayaratna et al. (2020) summarized more recent CO_2 fertilization research in a peer-reviewed study published in *Environmental Economics and Policy Studies* and re-estimated the FUND model's SCC values upon updating those assumptions.[34] To facilitate the Federal Reserve's review of that research, we excerpt several paragraphs from Dayaratna et al. (2020):

> Three forms of evidence gained since then indicates that the CO_2 fertilization effects in FUND may be too low. First, rice yields have been shown to exhibit strong positive responses to enhanced ambient CO_2 levels. Kimball (2016) surveyed results from Free-Air CO_2 Enrichment (FACE) experiments, and drew particular attention to the large yield responses (about 34 percent) of hybrid rice in CO_2 doubling experiments, describing these as "the most exciting and important advances" in the field. FACE experiments in both Japan and China showed that available cultivars respond very favorably to elevated ambient CO_2. Furthermore, Challinor et al. (2014), Zhu et al. (2015) and Wu et al. (2018) all report evidence that hybrid rice varietals exist that are more heat-tolerant and therefore able to take advantage of CO_2 enrichment even under warming conditions. Collectively, this research thus indicates that the rice parameterization in FUND is overly pessimistic.
>
> Second, satellite-based studies have yielded compelling evidence of stronger general growth effects than were anticipated in the 1990s. Zhu et al. (2016) published a comprehensive study on greening and human activity from 1982 to

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[33] K.E. Idso and S.B. Idso. 1994. Plant responses to atmospheric CO2 enrichment in the face of environmental constraints: A review of the past 10 years' research. *Agricultural and Forest Meteorology*, 69, 153-203, https://www.sciencedirect.com/science/article/abs/pii/0168192394900256; Jennifer Cuniff et al. 2008. Response of wild C4 crop progenitors to subambient CO_2 highlights a possible role in the origin of agriculture. G*lobal Change Biology* 14: 576-587, https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1365-2486.2007.01515.x.

[34] Kevin Dayaratna, Ross McKitrick, and Patrick Michaels. 2020. Climate sensitivity, agricultural productivity and the social cost of carbon in FUND. *Environmental Economics and Policy Studies* 22: 433-448, https://link.springer.com/article/10.1007/s10018-020-00263-w.

2009. The ratio of land areas that became greener, as opposed to browner, was approximately 9 to 1. The increase in atmospheric CO_2 was just under 15 percent over the interval but was found to be responsible for approximately 70 percent of the observed greening, followed by the deposition of airborne nitrogen compounds (9 percent) from the combustion of coal and deflation of nitrate-containing agricultural fertilizers, lengthening growing seasons (8 percent) and land cover changes (4 percent), mainly reforestation of regions such as southeastern North America ….

Munier et al. (2018) likewise found a remarkable increase in the yield of grasslands. In a 17-year (1999-2015) analysis of satellite-sensed LAI, during which time the atmospheric CO_2 level rose by about 10 percent, there was an average LAI increase of 85 percent. A full 31 percent of earth's continental land outside of Antarctica is covered by grassland, the largest of the three agricultural land types they classified. Also, for summer crops, such as maize (corn) and soybeans, greening increased an average of 52 percent, while for winter crops, whose area is relatively small compared to those for summer, the increase was 31 percent. If 70 percent of the yield gain is attributable to increased CO_2, the results from Zhu et al (2016) imply gains of 60 percent, 36 percent and 22 percent over the 17-year period for, respectively, grasslands, summer crops and winter crops, associated with only a 10 percent increase in CO_2, compared to parameterized yield gains in the range of 20 to 30 percent for CO_2 doubling in FUND.

Third, there has been an extensive amount of research since Tsingas et al. (1997) on adaptive agricultural practices under simultaneous warming and CO_2 enrichment. Challinor et al. (2014) surveyed a large number of studies that examined responses to combinations of increased temperature, CO_2 and precipitation, with and without adaptation. In their metanalysis, average yield gains increased 0.06 percent per ppm increase in CO_2 and 0.5 percent per percentage point increase in precipitation, and adaptation added a further 7.2 percent yield gain, but warming decreased it by 4.9 percent per degree C. In FUND, 3°C warming negates the yield gains due to CO_2 enrichment. However, based on Challinor et al.'s (2014) regression analysis, doubling CO_2 from 400 to 800 pm, while allowing temperatures to rise by 3°C and precipitation to increase by 2 percent, would imply an average percent yield increase ranging from 2.1 to 12.1 percent increase, indicating the productivity increase in FUND is likely too small.

Based on that literature, Dayaratna et al. (2020) updated the FUND model's coefficients to increase its agricultural benefits by 15 percent and 30 percent. In addition, the authors used an updated ECS distribution—that of Lewis and Curry (2018).[35] In the charts below,

[35] Lewis and Curry. 2018. The impact of recent forcing and ocean heat uptake data on estimates of climate sensitivity. *Journal of Climate* Vol. 31: 6051-6071, https://journals.ametsoc.org/view/journals/clim/31/15/jcli-d-17-0667.1.xml.

the last three columns show the mean SCC as well as the associated probability of negative SCC values under different discount rates.

	FUND Model Average SCC, agricultural component updated – Discount Rate – 2.5%			
	Roe Baker (2007)	**Lewis and Curry (2018)**	**Lewis and Curry (2018) + 15%**	**Lewis and Curry (2018) + 30%**
2020	$32.90	$3.78 / 0.46	$0.62 / 0.53	-$1.53 / 0.59
2030	$36.16	$4.69 / 0.44	$1.25 / 0.51	-$1.02 / 0.57
2040	$39.53	$5.76 / 0.42	$2.03 / 0.48	-$0.33 / 0.54
2050	$42.98	$6.98 / 0.39	$2.96 / 0.46	-$0.55 / 0.51

	FUND Model Average SCC, agricultural component updated – Discount Rate – 3%			
	Roe Baker (2007)	**Lewis and Curry (2018)**	**Lewis and Curry (2018) + 15%**	**Lewis and Curry (2018) + 30%**
2020	$19.33	$1.61 / 0.49	-$0.82 / 0.57	-$2.74 / 0.63
2030	$21.78	$2.32 / 0.47	-$0.35 / 0.54	-$2.39 / 0.61
2040	$24.36	$3.18 / 0.44	$0.28 / 0.51	-$1.85 / 0.57
2050	$27.06	$4.21 / 0.42	$1.08 / 0.48	-$1.12 / 0.54

	FUND Model Average SCC, agricultural component updated – Discount Rate – 5%			
	Roe Baker (2007)	**Lewis and Curry (2018)**	**Lewis and Curry (2018) + 15%**	**Lewis and Curry (2018) + 30%**
2020	$2.54	-$1.02 / 0.62	-$2.25 / 0.71	-$3.41 / 0.78
2030	$3.31	-$0.77 / 0.58	-$2.14 / 0.67	-$3.41 / 0.74
2040	$4.21	-$0.39 / 0.54	-$1.89 / 0.63	-$3.24 / 0.70
2050	$5.25	$0.15 / 0.49	-$1.47 / 0.58	-$2.87 / 0.65

	FUND Model Average SCC, agricultural component updated – Discount Rate – 7%

	Roe Baker (2007)	Lewis and Curry (2018)	Lewis and Curry (2018) + 15%	Lewis and Curry (2018) + 30%
2020	-$0.37	-$1.25 / 0.71	-$2.06 / 0.80	-$2.84 / 0.85
2030	-$0.13	-$1.18 / 0.67	-$2.08 / 0.76	-$2.94 / 0.82
2040	$0.19	-$0.98 / 0.62	-$1.98 / 0.71	-$2.91 / 0.77
2050	$0.63	-$0.66 / 0.56	-$1.74 / 0.65	-$2.71 / 0.72

As the results illustrate, under more realistic assumptions regarding agricultural productivity and climate sensitivity, the mean SCC essentially drops to zero and in many cases has a substantial probability of being negative. At a minimum, Dayaratna et al. (2020) further demonstrates that the SCC is highly sensitive to very reasonable changes in assumptions. The models can therefore suggest a variety of outcomes of climate change – ranging from catastrophic disaster or continued prosperity to climate change – all under very reasonable assumptions.

The Board should consider this vast uncertainty in the economic impact of climate change in considering climate-related financial risk management associated with the proposed rule. Most notably, as a result of this uncertainty, the proposed rule is arbitrary and capricious and therefore should not be implemented.

Cost Benefit Analysis of Carbon-Based Regulation

The proposed rule also specifically asks: "What challenges, if any, could financial institutions face in incorporating these draft principles into their risk management frameworks?"

Policies such as the proposed rule seek to drive private capital out of fossil-intensive investments and into "climate-aligned" investments. [36] Political proponents typically prefer a combination of mandates and subsidies to decarbonize the economy, but forecasting the economic impacts is difficult because there are many moving parts and hidden costs.

It is, however, quite practical to model the cost of carbon taxes set at different prices and calculate the emission reductions and associated macroeconomic, household, and energy market impacts. Another virtue of this approach is that it can give a reasonable picture of the lowest cost required to achieve a specific level of emission reduction. Most economists agree that a carbon tax is a more efficient mitigation policy than a hodgepodge of mandates, prohibitions, and subsides. Unlike prescriptive regulations, project denials, or massive spending programs, taxing CO_2 emissions incentivizes all economic actors to find and exploit economical emission-reduction opportunities. In addition, the revenues can be used to cut other taxes.

[36] Some of the remarks in this section was also utilized in a separate regulatory comment. Marlo Lewis, Kevin Dayaratna, and Patrick Michaels, "The Enhancement and Standardization of Climate-Related Disclosures for Investors" https://cei.org/wp-content/uploads/2022/06/CEI-Lewis-Comments-SEC-Climate-Risk-Disclosure-June-17-2022-Final-Amended-Version-with-changes-accepted.docx.pdf

A 2022 Heritage Foundation analysis using a clone of the U.S. Energy Information Administration's National Energy Modeling System (NEMS) to project the economic impacts and emission reductions from seven alternative revenue-neutral carbon taxes.[37] The Heritage analysts modeled carbon taxes with per-ton prices of $35, $54, $75, $100, $150, and $300. Each alternative tax begins in 2022 with half of the specified value per ton of CO_2, and increases annually by 2.5 percent each year thereafter until it doubles to its full value. In these simulations, revenues from the tax are rebated back to consumers in a deficit-neutral manner.

As it turns out, none of the alternatives comes close to achieving NetZero emissions by 2050. Notably, even the $300 per ton carbon tax would only reduce emissions to 44 percent of 2005 levels in 2030 and 47 percent in 2040. At higher-priced carbon taxes, the model crashes, so it is not able to simulate the economic impacts of achieving NetZero emissions by 2050.[38]

Nonetheless, the $300 per ton carbon tax has severe economic impacts, including:

- An overall average reduction of more than 1.2 million jobs per year;
- A peak employment reduction of more than 7.8 million jobs;
- An average annual income loss for a family of four of $5,100;
- A total income loss for a family of four exceeding $87,000 over the 18-year time horizon (illustrated in Figure 3).
- An aggregate GDP loss of over $7.7 trillion over the 18-year time horizon; and,
- Increases in household electricity expenditures averaging 23 percent per year.

[37] Kevin D. Dayaratna, Katie Tubb, and David Kreutzer, "The Unsustainable Costs of President Biden's Climate Agenda," Heritage Foundation Backgrounder 3713, https://www.heritage.org/energy-economics/report/the-unsustainable-costs-president-bidens-climate-agenda
[38] The technical reasons for the model's inability to simulate the effects of carbon taxes above $300 per ton are complex and not germane to the argument we are making in these comments.

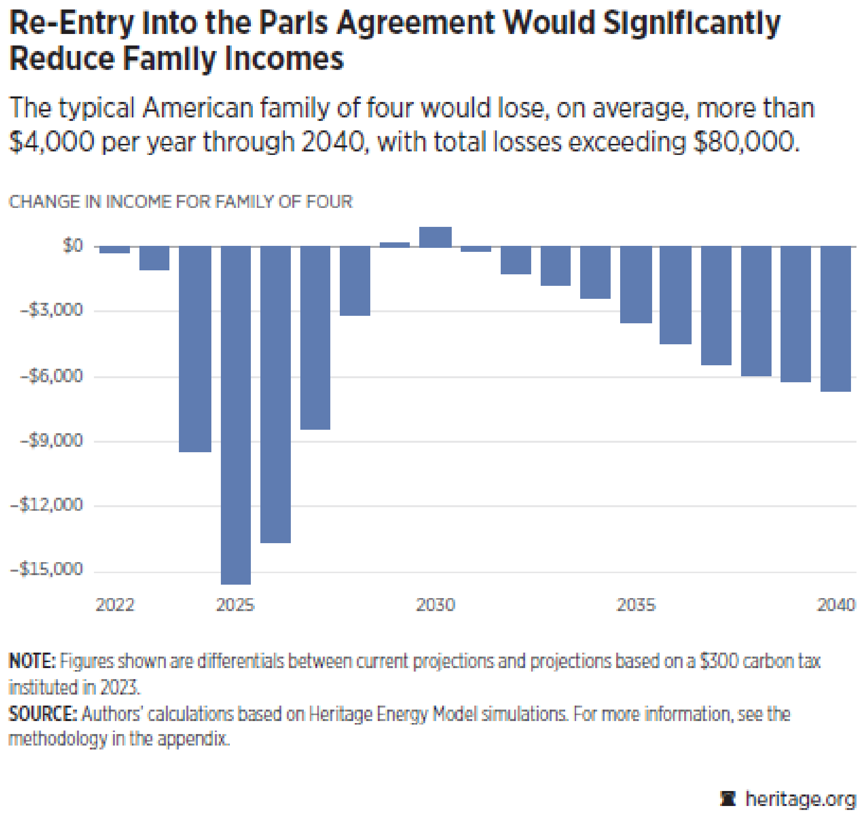

Figure 3. Family income impact $300 carbon tax (simulated as re-entry into Paris agreement)

Those formidable economic sacrifices would achieve no detectable climate benefits. Even assuming a climate sensitivity of 4.5°C—50 percent higher than the IPCC's best estimate of 3.0°C[39]—eliminating all U.S. emissions immediately would avert less than 0.2°C of global warming by 2100. Figure 4 illustrates this result.

[39] IPCC, AR6, *Climate Change 2021: The Physical Science Basis*, Summary for Policymakers, p. 11, https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_SPM.pdf.

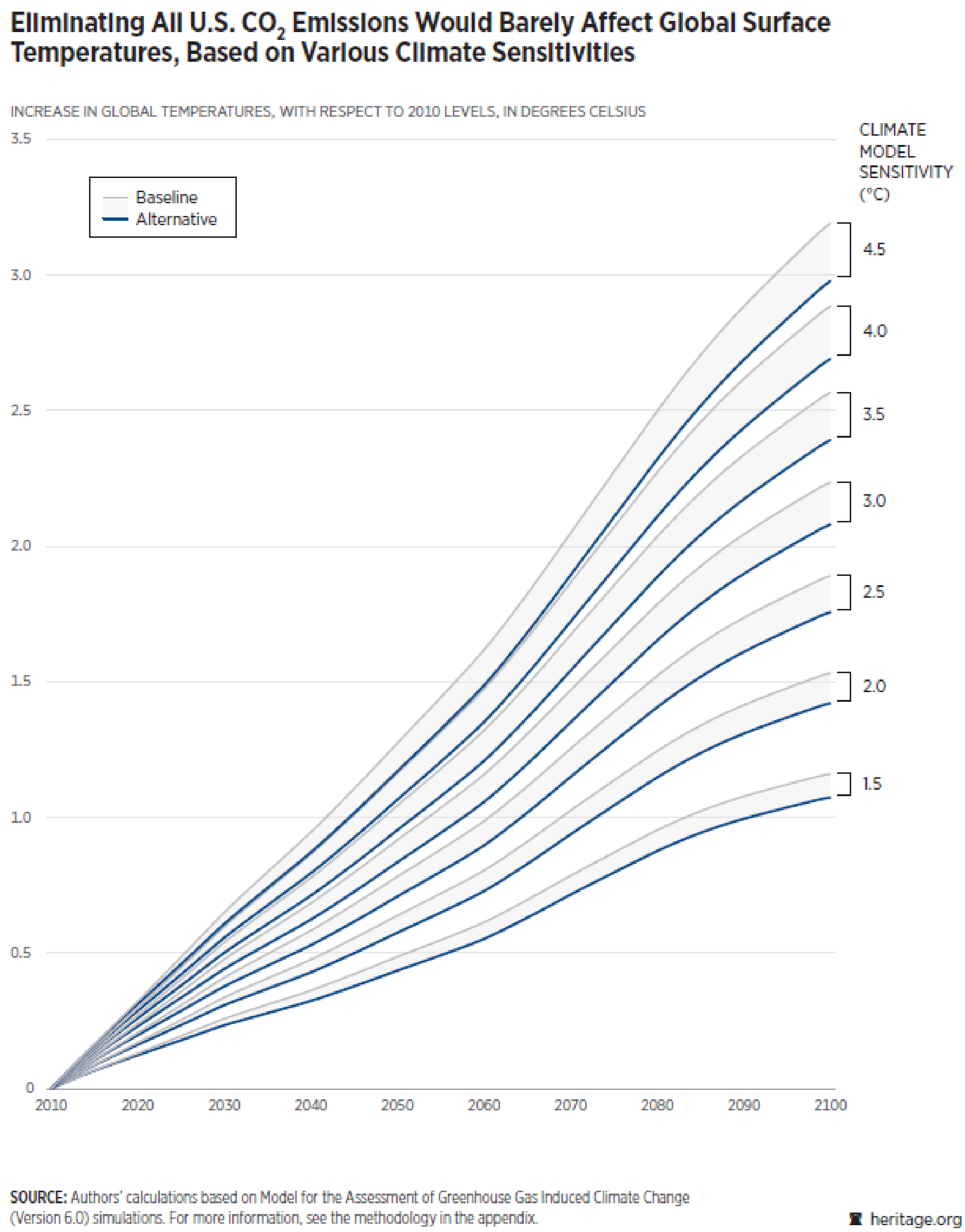

Figure 4. The climate impact of eliminating CO2 emissions from fossil fuels completely.

The $300 per ton tax would avert less than 0.1°C. If the IPCC's best sensitivity estimate is used, the warming reduction achieved by the $300 per ton tax is below the 0.08°C margin of error.[40] It is thus undetectable. As a result, policies such as the proposed rule aimed to actively discourage investment in fossil fuels, will result in significant economic impacts and negligible environmental costs. These policies will therefore backfire on the very financial institutions that the

[40] NOAA, Global Temperature Uncertainty, https://www.ncei.noaa.gov/access/monitoring/dyk/global-precision (accessed June 14, 2022).

Board is seeking to impose these rules upon. The economic costs, however, will also be to the economy writ large, thus creating its own systemic risk of lower growth rates.

Addressing Systemic Risk in the Financial System

Three additional points dealing specifically with systemic risk should be considered, two of which stem in part from both the unreliability of climate modeling and the relatively small net gains derived from even the most optimistic scenarios in attempting to impact climate change.

First, financial institutions' positions are evaluated, in part, according to the systemic risk they pose to the entire financial system. This rule at first appears merely to expand the scope of that assessment to include previously ignored impacts that are not necessarily financial in origin but whose effects are of a financial nature. However, as explained previously, the uncertainty involved in climate modeling effectively makes it impossible accurately to assess the long-term impact of financial institutions' positions on the climate. Since the outputs of those climate models are heavily dependent upon the assumptions of their authors, as opposed to sufficient data, given the latter's unavailability, using any kind of climate modeling injects an element of randomness into a financial institution's scenario analysis and stress test. Instead of providing a more comprehensive risk assessment of financial institutions' positions, this rule would reduce the reliability of scenario analyses and stress tests.

Second, the use of this rule will provide an incentive to divest of fossil fuel investments and reallocate that capital to other investments with less carbon emissions because scenario analyses and stress tests for financial institutions will penalize carbon, given the assumption that carbon emissions negatively impact climate change. The divestiture of fossil fuel investments, as well as a position in carbon-neutral or carbon-reducing investments can then be used to offset financial risk elsewhere in a financial institution's position. Thus, financial institutions would be reducing investment in areas which have, to this date, been relatively free of systemic risk, while simultaneously increasing their tolerance for additional risk to themselves and the financial system. Financial institutions, therefore, would be able to allocate additional investment in areas that pose systemic risk while remaining within acceptable tolerances under this proposed rule. Therefore, the rule does not reduce systemic risk, but could increase it by effectively increasing the threshold for systemic risk that a financial institution is permitted to reach.

This is compounded by the reality that fossil fuels are, for most applications, the most cost-effective and efficient source of energy available to date. Their efficiency, dispatchability, and lack of reliance on storage capacity reduce risk to both energy and financial markets. With reliable return on investment, virtually regardless of market conditions given their price inelasticity, fossil fuels contribute positively to reducing an institution's systemic risk.

Third, the introduction of nonfinancial elements into the scenario analyses and stress tests of financial institutions opens a veritable Pandora's Box because almost any widespread human activity can be argued to have financial implications. For example, the use of artificial contraception can be argued to impact both birth rates and economic growth rates. Those changes can alter the systemic risk assessment of financial institutions. By the logic outlined in this proposed rule, investments in this area should also be considered when analyzing the systemic risk posed by financial institutions. This rule has no limiting principle by which incorporation of climate analysis is justified but other logically similar analyses are excluded.

Conclusion

In summary, the proposed rule is not only arbitrary and capricious, but it is counterproductive to its stated goal of risk management.

Thank you for addressing these concerns.

Respectfully submitted,

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