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CONGRESSIONAL TESTIMONY

Climate Change, Part IV: Moving Toward a Sustainable Future

Testimony before
Subcommittee on Environment
Committee on Oversight and Reform
U.S. House of Representatives

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Chairman Rouda, Ranking Member Green, and other Members of the subcommittee, thank you for the opportunity to testify about the economic effects of climate change. My name is Kevin Dayaratna. I am the Principal Statistician, Data Scientist, and Research Fellow at The Heritage Foundation. The views I express in this testimony are my own and should not be construed as representing any official position of The Heritage Foundation.

From turning on a light switch, to starting up our cars, to enabling this very hearing to operate, energy is one of the most fundamental aspects of civilization. Unfortunately, however, many people take energy for granted. Over the course of the past decade, it has been a fundamental goal of policymakers in Washington to expand regulations across the energy sector of the economy to address climate change. As a result, it is important to quantify the impacts of this fundamental building block both in terms of the economy as well as in terms of the climate. Over the course of my work at The Heritage Foundation, my colleagues and I have used the same models that the federal government has used to quantify these impacts ourselves. We have found in our work published both at Heritage and in the peer-reviewed literature that these policies aimed at decarbonization are predicated on user-manipulated models. Moreover, we have found that these policies will result in devastating economic impacts along with negligible impacts on the climate. Policies aimed at taking advantage of our vast oil and gas supply, on the other hand, will grow the economy for years to come.

The Justification for Climate Policies and Regulations

For much of the past decade, the federal government has sought to expand regulations across the energy sector of the economy. One of the primary justifications for doing so has been the social cost of carbon (SCC), which is defined as the economic damages associated with a metric ton of carbon-dioxide (CO_2) emissions summed across a particular time horizon.[1]

There are three primary statistical models that the Obama Administration's Interagency Working Group (IWG) has used to estimate the SCC—the DICE Model, the FUND model, and the PAGE model.[2] Over the past several years at The Heritage Foundation,

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[1] The official definition of the social cost of carbon is the economic damages per metric ton of CO_2 emissions, and is discussed further in U.S. Environmental Protection Agency, "The Social Cost of Carbon," https://19january2017snapshot.epa.gov/climatechange/social-cost-carbon_.html (accessed September 23, 2020).

[2] For the DICE model, see William D. Nordhaus, "DICE/RICE models – William Nordhaus, Yale Economics," https://sites.google.com/site/williamdnordhaus/dice-rice (accessed September 23, 2020). For the FUND model, see "FUND—Climate Framework for Uncertainty, Negotiation and Distribution," http://fund-model.org (accessed September 23, 2020). For the PAGE model, see Climate CoLab, "PAGE," https://www.climatecolab.org/wiki/PAGE (accessed September 23, 2020). See also U.S. Interagency Working Group on Social Cost of Greenhouse Gases, "Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866," May 2013, revised November 2013, https://www.epa.gov/sites/production/files/2016-12/documents/sc_co2_tsd_august_2016.pdf (accessed September 23, 2020); U.S. Interagency Working Group on Social Cost of Greenhouse Gases, "Addendum to Technical Support Document on Social Cost of Carbon for Regulatory Impact Analyses under Executive Order 12866: Application of Methodology to Estimate the Social Cost of Methane and the Social Cost of Nitrous Oxide," August

my colleagues and I have used the DICE and FUND models, testing their sensitivity to a variety of important assumptions. Our research, published as Heritage Foundation publications, in the peer-reviewed literature, and discussed in my prior Congressional testimony, has repeatedly illustrated that although these models might be interesting academic exercises, they are extremely sensitive to very reasonable changes to assumptions.[3] As a result, these models can be manipulated by user-selected assumptions and are thus not legitimate for guiding regulatory policy.

These models are estimated by Monte Carlo simulation. The general idea behind Monte Carlo simulation is that since some aspects of the models are random, the models are repeatedly estimated to generate a spectrum of probable outcomes. As a result of principles in probability theory, repeated estimation for a sufficient amount of time provides a reasonable characterization of the SCC's distributional properties.

As with any statistical model, however, these models are grounded by assumptions. In our work, my colleagues and I have rigorously examined three important assumptions: the choice of a discount rate, a time horizon, and the specification of an equilibrium climate sensitivity distribution.

How the Discount Rate Affects the SCC

Models used to estimate the SCC rely on the specification of a discount rate. The concept of discount rates is best viewed by considering an expenditure today as a benefit in the future via an investment. Discounting future benefits of averting climate damage compares the rate of return from CO_2 reduction to the rate of return that could be expected from other investments. In principle, discounting runs the compound rate of return exercise backwards, calculating how much would need to be invested at a

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2016, https://www.epa.gov/sites/production/files/2016-12/documents/addendum_to_sc-ghg_tsd_august_2016.pdf (accessed September 23, 2020); and U.S. Interagency Working Group on Social Cost of Greenhouse Gases, "2010 Technical Support Document: Social Cost of Carbon for Regulatory Impact Analysis under Executive Order 12866," February 2010, https://www.epa.gov/sites/production/files/2016-12/documents/scc_tsd_2010.pdf (accessed September 23, 2020).

[3] Kevin D. Dayaratna and David W. Kreutzer, "Unfounded FUND: Yet Another EPA Model Not Ready for the Big Game," Heritage Foundation *Backgrounder* No. 2897, April 29, 2014, http://www.heritage.org/research/reports/2014/04/unfounded-fund-yet-another-epa-model-not-ready-for-the-big-game (accessed September 23, 2020); Kevin D. Dayaratna and David W. Kreutzer, "Loaded DICE: An EPA Model Not Ready for the Big Game," Heritage Foundation *Backgrounder* No. 2860, November 21, 2013, http://www.heritage.org/research/reports/2013/11/loaded-dice-an-epa-model-not-ready-for-the-big-game (accessed September 23, 2020); Kevin D. Dayaratna and David Kreutzer, "Environment: Social Cost of Carbon Statistical Modeling Is Smoke and Mirrors," *Natural Gas & Electricity*, Vol. 30, No. 12 (2014), pp. 7–11; 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; Kevin D. Dayaratna, "An Analysis of the Obama Administration's Social Cost of Carbon," testimony before the Committee on Natural Resources, U.S. House of Representatives, July 23, 2015; and Kevin D. Dayaratna, "At What Cost? Examining the Social Cost of Carbon," testimony before the Committee on House, Sciences, and Technology, U.S. House of Representatives, February 28, 2017.

reasonably expected interest rate today to result in the value of the averted future climate damage.[4]

The Environmental Protection Agency ran these models using 2.5 percent, 3.0 percent, and 5.0 percent discount rates despite the fact that the Office of Management and Budget guidance in Circular A-4 has specifically stipulated that a 7.0 percent discount rate be used as well.[5] In my research, we re-estimated these models using a 7.0 percent discount rate in a variety of publications. Below are our results published in the peer-reviewed journal *Climate Change Economics*:

	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

As the above tables illustrate, the SCC estimates are drastically reduced under the use of a 7.0 percent discount rate. In fact, under the FUND model, the estimates are negative. These changes in the discount rate can cause the SCC to drop by as much as 80 percent or more. I will discuss the negative social cost of carbon subsequently in this report.

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[4] D. W. Kreutzer, “Discounting Climate Costs,” Heritage Foundation *Issue Brief* No. 4575, June 16, 2016, https://www.heritage.org/environment/report/discounting-climate-costs (accessed September 23, 2020).

[5] 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 23, 2020), and Paul C. “Chip” Knappenberger, “An Example of the Abuse of the Social Cost of Carbon,” Cato-at-Liberty, August 23, 2013, http://www.cato.org/blog/example-abuse-social-cost-carbon (accessed September 23, 2020).

How the Time Horizon Affects the SCC

It is essentially impossible to forecast technological change decades, let alone centuries, into the future. Regardless, however, these SCC models are based on projections 300 years into the future. In my work at Heritage with my former colleague David Kreutzer, I changed this time horizon to the significantly less, albeit still unrealistic, time horizon of 150 years into the future, and we obtained the following results for the DICE model in our work published in 2013:[6]

	DICE Model Average SCC - End Year 2150			
Year	**Discount Rate - 2.5%**	**Discount Rate – 3.0%**	**Discount Rate – 5.0%**	**Discount Rate – 7.0%**
2020	$44.41	$32.38	$11.85	$5.85
2030	$50.82	$38.00	$14.92	$7.67
2040	$57.17	$43.79	$18.36	$9.79
2050	$62.81	$49.20	$22.00	$12.13

Clearly, the SCC estimates drop substantially as a result of changing the end year (in some cases by over 25 percent).

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

Models used to estimate the SCC also take into account assumptions regarding the planet's climate sensitivity. An important question, however, is the accuracy of such assumptions. Professor John Christy testified in both 2013 and 2016 regarding the efficacy of climate change projections and juxtaposed them against actual weather balloon and satellite data.[7] Christy has exposed the sheer inadequacy of the Intergovernmental Panel on Climate Change's (IPCC) models in forecasting global temperatures:

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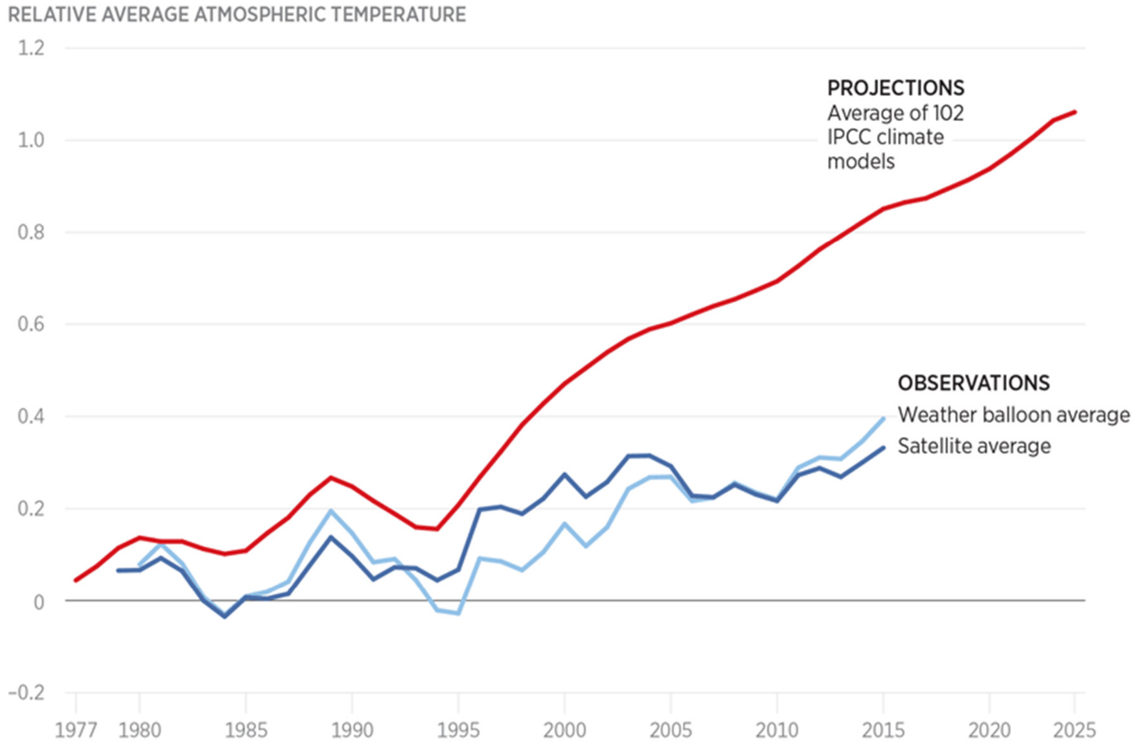
[6] Dayaratna and Kreutzer, "Loaded DICE: An EPA Model Not Ready for the Big Game."

[7] John R. Christy, testimony before the Committee on Science, Space & Technology, U.S. House of Representatives, February 2, 2016, and John R. Christy, "A Factual Look at the Relationship Between Climate and Weather," testimony before the Subcommittee on Environment, Committee on Natural Resources, U.S. House of Representatives, December 11, 2013.

CHART 2

Climate Models Predict Too Much Warming



NOTE: The starting value for each series is normalized so that a linear regression would pass the zero-degree mark at 1979.
SOURCE: U.S. House Committee on Science, Space and Technology, testimony by John R. Christy of University of Alabama in Huntsville, February 2, 2016, https://science.house.gov/sites/republicans.science.house.gov/files/documents/HHRG-114-SY-WState-JChristy-20160202.pdf (accessed April 12, 2016).

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The climate specification used in estimating the SCC is that of an ECS distribution. These distributions probabilistically quantify the earth's temperature response to a doubling of CO_2 concentrations. The ECS distribution used by the IWG is based on a paper published in the journal *Science* twelve years ago by Gerard Roe and Marcia Baker. This non-empirical distribution, calibrated by the IWG based on assumptions that the group decided on climate change in conjunction with IPCC recommendations, has been deemed to be "no longer scientifically defensible."[8] Since then, a variety of newer and more up-to-date distributions have been suggested in the peer-reviewed literature. Many of these distributions, in fact, suggest lower probabilities of extreme global warming in response to CO_2 concentrations. Below are a few such distributions:[9]

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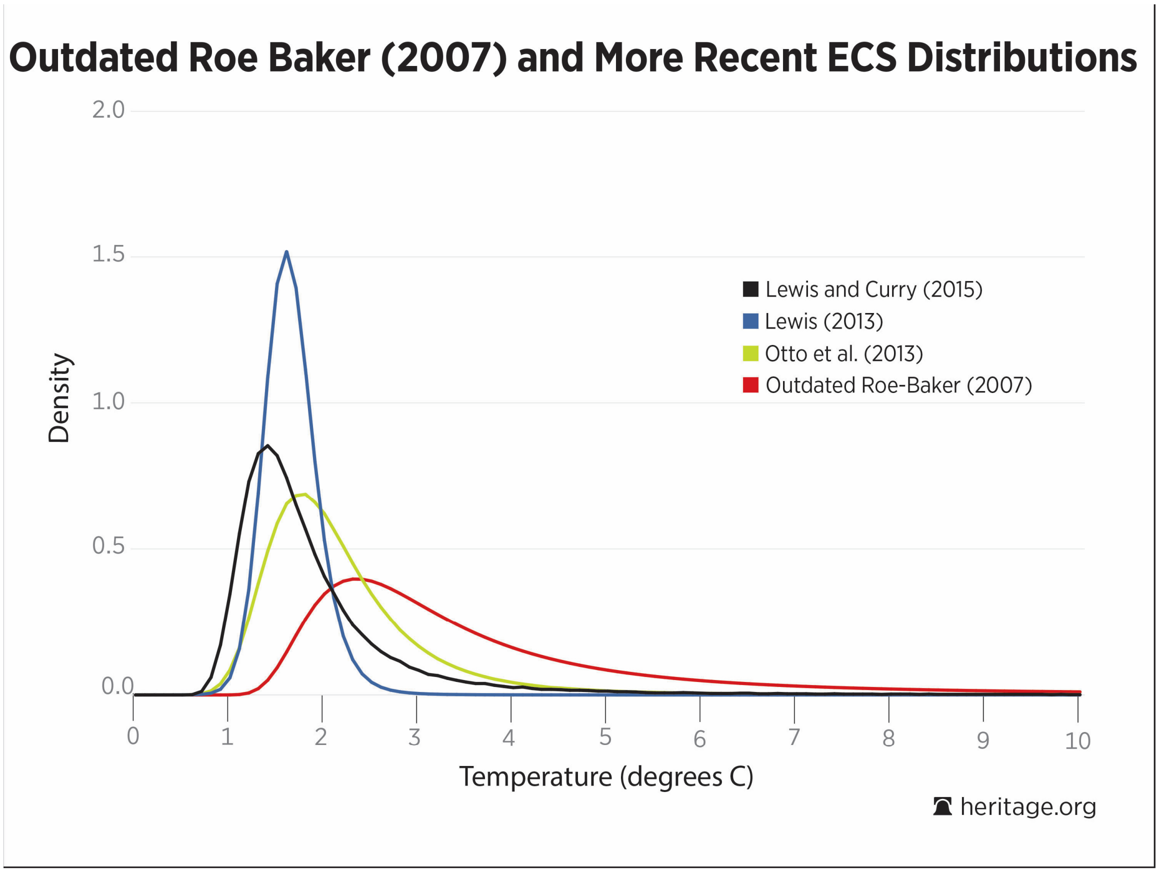
[8] Patrick J. Michaels, "An Analysis of the Obama Administration's Social Cost of Carbon," testimony before the Committee on Natural Resources, U.S. House of Representatives, July 22, 2015, https://www.cato.org/publications/testimony/analysis-obama-administrations-social-cost-carbon (accessed September 23, 2020).

[9] Gerard H. Roe and Marcia B. Baker, "Why Is Climate Sensitivity So Unpredictable?" *Science*, Vol. 318, No. 5850 (October 26, 2007), pp. 629–632; Nicholas Lewis, "An Objective Bayesian Improved Approach


Outdated Roe Baker (2007) and More Recent ECS Distributions

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The area under the curve between two temperature points represents the probability that the earth's temperature will increase between those amounts in response to a doubling of CO_2 concentrations. For example, the area under the curve from 4 degrees C onwards (known as a "tail probability") provides the probability that the earth's temperature will warm by more than 4 degrees Celsius 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. In our research published in *Climate Change*

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for Applying Optimal Fingerprint Techniques to Estimate Climate Sensitivity," *Journal of Climate*, Vol. 26, No. 19 (October 2013), pp. 7414–7429; Alexander Otto et al., "Energy Budget Constraints on Climate Response," *Nature Geoscience*, Vol. 6, No. 6 (June 2013), pp. 415–416; 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 (accessed September 23, 2020); and U.S. Interagency Working Group on Social Cost of Greenhouse Gases, "2010 Technical Support Document: Social Cost of Carbon for Regulatory Impact Analysis under Executive Order 12866," February 2010, https://www.epa.gov/sites/production/files/2016-12/documents/scc_tsd_2010.pdf (accessed September 23, 2020).

Economics, we re-estimated the SCC having used these more up-to-date ECS distributions and obtained the following results:[10]

	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

Again, we notice drastically lower estimates of the SCC using these more up-to-date ECS distributions. These results are not surprising—the IWG's estimates of the SCC were based on outdated assumptions that overstated the probabilities of extreme global warming, which artificially inflated their estimates of the SCC.

The Negativity of the SCC

Policymakers often associate carbon dioxide emissions with negative impacts on society.[11] Not all of these models, however, suggest that such impacts are solely negative.

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[10] Dayaratna, McKitrick, and Kreutzer, "Empirically Constrained Climate Sensitivity and the Social Cost of Carbon."

[11] See for example, Tom DiChristopher, "Alexandria Ocasio-Cortez just released her massive Green New Deal — here's what's in it" CNBC, https://www.cnbc.com/2019/02/07/aoc-just-updated-her-massive-green-new-deal--heres-whats-in-it.html (accessed September 23, 2020); Mitt Romney, "Romney says climate change happening, humans contribute," Associated Press, https://apnews.com/879ae4dc07e74c669d873f5ce9e6a9e2 (accessed September 23, 2020)

The FUND model, in fact, allows for the SCC to be negative based on feedback mechanisms due to CO_2 emissions. In my research at The Heritage Foundation, my colleagues and I computed the probability of a negative SCC under a variety of assumptions. Below are some of our results published both at Heritage as well as in the peer-reviewed journal *Climate Change Economics*:[12]

	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%**
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

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[12] Dayaratna and Kreutzer, "Unfounded FUND: Yet Another EPA Model Not Ready for the Big Game," and Dayaratna, McKitrick, and Kreutzer, "Empirically Constrained Climate Sensitivity and the Social Cost of Carbon."

	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 very reasonable set of assumptions, the SCC is overwhelmingly likely to be negative, which would suggest the government should, in fact, subsidize (not limit) CO_2 emissions. Of course, we by no means use these results to suggest that the government should actually subsidize CO_2 emissions, but rather to illustrate the extreme sensitivity of these models to reasonable changes to assumptions and can thus be quite easily fixed by policymakers.

Agricultural Benefits and Cost/Benefit 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.[13] As discussed earlier, the FUND model attempts to incorporate these benefits; however, this aspect of the model is grounded on research that is one to two decades old. My co-authors and I discussed these limitations in another one of our peer-reviewed publications (Dayaratna et al 2020), published in *Environmental Economics and Policy Studies*:[14]

> "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%) 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

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[13] 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; Cuniff, J., Osborne, C.P., Ripley, B.S., Charles, M. and Jones, G. (2008) Response of wild C4 crop progenitors to subambient CO2 highlights a possible role in the origin of agriculture. Global Change Biology 14: 576-587

[14] K. Dayaratna, R. McKitrick, and P. Michaels, "Climate sensitivity, agricultural productivity and the social cost of carbon in FUND," Environmental Economics and Policy Studies, Vol 22 (2020), p.433-448

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. (2013). 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 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% of the observed greening, followed by the deposition of airborne nitrogen compounds (9%) from the combustion of coal and deflation of nitrate-containing agricultural fertilizers, lengthening growing seasons (8%) and land cover changes (4%), 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%. A full 31% 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%, while for winter crops, whose area is relatively small compared to those for summer, the increase was 31%. If 70% of the yield gain is attributable to increased CO_2, the results from Zhu et al (2016) imply gains of 60%, 36% and 22% 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 ^{o}C. In FUND, 3 ^{o}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 ^{o}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."

Consequently, we analyzed the FUND model, updating the model's coefficients corresponding to agricultural benefits by 15% and 30% increases in addition to utilizing more up to date assumptions regarding ECS distributions. Below are some of the results presented in Dayaratna et al (2020) utilizing the Lewis and Curry (2018) ECS distribution.[15] In the last three columns, the entry shows the mean SCC as well as the associated probability of negative SCC.

	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%

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[15] Nic Lewis and Judith Curry, "The impact of recent forcing and ocean heat uptake data on estimates of climate sensitivity," The Journal of Climate Vol 31, No 15 (2018), 6051–6071.

	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 our results illustrate, under more recent 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. These results further demonstrate that the SCC is highly sensitive to very reasonable changes to assumptions and is thus readily prone to user manipulation.

The Economic Impact of Commonly Suggested Regulations

As energy is the fundamental building block of society, it is important to understand the economic impact of associated policies pursued by lawmakers. In our research at The Heritage Foundation, we have used the Heritage Energy Model, a clone of the Department of Energy's National Energy Modeling System, to quantify the economic impact of both implementing further carbon-based regulations as well as repealing existing ones. One policy we analyzed was the Clean Power Plan, a policy initiated by the Obama Administration to regulate carbon-based emissions. We found that through 2035, the policy would result in an average employment shortfall of over 70,000 lost jobs, a loss of income of more than $10,000 for a family of four, an up to 5 percent increase in household electricity expenditures, and an aggregate $1 trillion loss in gross domestic product (GDP). I discussed these facts during congressional testimony for the House, Sciences, and Technology Committee in June 2016.[16]

In addition, we also used the Heritage Energy Model to quantify the economic impact of the Paris Agreement on the American economy. In our research published in 2016, we found that the economic impacts would be quite devastating—in particular through 2035, the country would see an average employment shortfall of nearly 400,000 lost jobs, a loss of income of more than $20,000 for a family of four, an up to 20 percent increase in household electricity expenditures, and an aggregate $2.5 trillion loss in GDP.

Most recently, we used the Heritage Energy Model to quantify the economic impact of the Green New Deal. Published earlier this year, we found that the economic impacts would be also be quite staggering: Through 2040 the country would incur an average employment shortfall of over 1.1 million lost jobs, a loss of income of over $165,000 for a family of four, an up to 30 percent increase in household electricity expenditures, and an aggregate $15 trillion loss in GDP as illustrated in the following charts.

CHART 2

How the Green New Deal Would Affect Employment

The Green New Deal would cause an average annual shortfall of 1.2 million jobs through 2040, with a peak of more than 5.3 million jobs lost in 2023.

NOTE: Figures shown are differentials between current projections and projections based on the Green New Deal being enacted in 2020.
SOURCE: Authors' calculations based on Heritage Energy Model simulations. For more information, see the methodology in the appendix.

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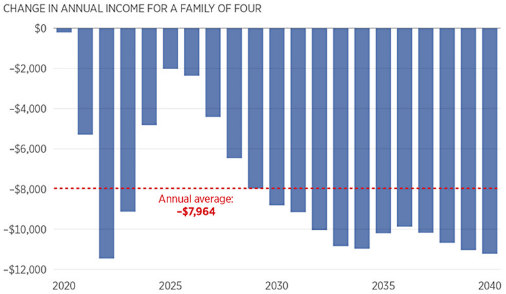
CHART 3

Family Incomes Would Take Major Hit Under Green New Deal

Under the Green New Deal, the typical family of four would lose an average of nearly $8,000 in income every year, or a total of more than $165,000 through 2040.



NOTE: Figures shown are differentials between current projections and projections based on the Green New Deal being enacted in 2020.
SOURCE: Authors' calculations based on Heritage Energy Model simulations. For more information, see the methodology in the appendix.

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In other research at The Heritage Foundation, we considered the impact of taking advantage of the significant shale oil and gas supply available here in the U.S. The Institute for Energy Research has noted that North America alone has over 1.4 trillion barrels of oil and 2.2 quadrillion cubic feet of natural gas. My colleagues and I have used the Heritage Energy Model to look into the impact of actually taking advantage of these resources. Our research found that if this vast supply were actually utilized that through 2035, the country would see an average employment gain of nearly 700,000 jobs, an increase in over $27,000 for a family of four, a marked reduction in household electricity

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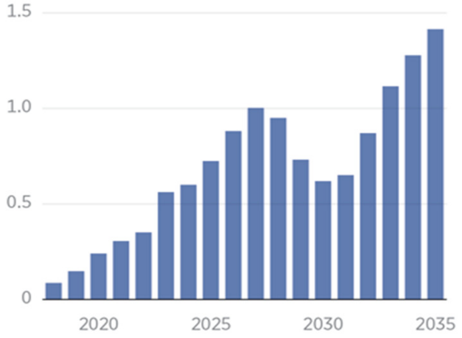
[16] Kevin D. Dayaratna, "The Economic Impact of the Clean Power Plan," testimony before the Committee on House, Science, and Technology, U.S. House of Representatives, June 24, 2015, https://www.heritage.org/testimony/the-economic-impact-the-clean-power-plan (accessed September 23, 2020).

expenditures, and an aggregate $2.4 trillion increase in GDP as depicted in the following charts.[17]

CHART 1

How Unleashing America's Energy Abundance Would Affect U.S. Jobs

OVERALL EMPLOYMENT DIFFERENTIAL BY YEAR, IN MILLIONS



SOURCE: Heritage Foundation calculations using the Heritage Energy Model. See methodology for details.

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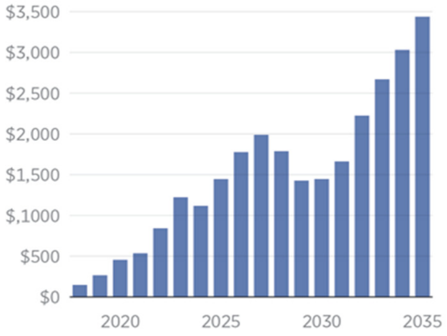
CHART 3

Unleashing America's Energy Abundance: Higher Family Incomes

PERSONAL INCOME DIFFERENTIAL BY YEAR FOR A FAMILY OF FOUR, IN INFLATION-ADJUSTED DOLLARS



SOURCE: Heritage Foundation calculations using the Heritage Energy Model. See methodology for details.

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[17] Kevin D. Dayaratna and Nicolas D. Loris, "Assessing the Costs and Benefits of the Green New Deal," Heritage Foundation *Backgrounder* No. 3427, July 24, 2019, https://www.heritage.org/energy-economics/report/assessing-the-costs-and-benefits-the-green-new-deals-energy-policies (accessed September 23, 2020); Kevin D. Dayaratna, Nicolas D. Loris, and David W. Kreutzer, "The Obama Administration's Climate Agenda: Will Hit Manufacturing Hard," Heritage Foundation *Backgrounder* No. 2990, November 13, 2014, http://www.heritage.org/research/reports/2014/11/the-obama-administrations-climate-agenda-underestimated-costs-and-exaggerated-benefits (accessed September 23, 2020); Kevin D. Dayaratna, Nicolas D. Loris, and David W. Kreutzer, "The Obama Administration's Climate Agenda: Underestimated Costs and Exaggerated Benefits," Heritage Foundation *Backgrounder* No. 2975, November 13, 2014, http://www.heritage.org/research/reports/2014/11/the-obama-administrations-climate-agenda-underestimated-costs-and-exaggerated-benefits (accessed September 23, 2020); Nicholas D. Loris, Kevin Dayaratna, and David W. Kreutzer, "EPA Power Plant Regulations: A Backdoor Energy Tax," Heritage Foundation *Backgrounder* No. 2863, December 5, 2013, http://www.heritage.org/research/reports/2013/12/epa-power-plant-regulations-a-backdoor-energy-tax (accessed September 23, 2020); David W. Kreutzer, Nicholas D. Loris, and Kevin Dayaratna, "Cost of a Climate Policy: The Economic Impact of Obama's Climate Action Plan," Heritage Foundation *Issue Brief* No. 3978, June 27, 2013, http://www.heritage.org/research/reports/2013/06/climate-policy-economic-impact-and-cost-of-obama-s-climate-action-plan (accessed September 23, 2020); David W. Kreutzer and Kevin Dayaratna, "Boxer–Sanders Carbon Tax: Economic Impact," Heritage Foundation *Issue Brief* No. 3905, April 11, 2013, http://www.heritage.org/research/reports/2013/04/boxer-sanders-carbon-tax-economic-impact (accessed September 23, 2020); "Consequences of Paris Protocol: Devastating Economic Costs, Essentially Zero Environmental Benefits," Heritage Foundation *Report*, April 13, 2016, http://www.heritage.org/environment/report/consequences-paris-protocol-devastating-economic-costs-essentially-zero (accessed September 23, 2020); Institute for Energy Research, *North American Energy Inventory*, December 2011, https://www.instituteforenergyresearch.org/wp-content/uploads/2013/01/Energy-Inventory.pdf (accessed September 23, 2020); and Kevin Dayaratna and Nicholas Loris, "Turning America's Energy Abundance into Energy Dominance," Heritage Foundation *Report*, November 3, 2017, https://www.heritage.org/energy-economics/report/turning-americas-energy-abundance-energy-dominance (accessed September 23, 2020).

The Climate Impact of Commonly Suggested Regulations

Advocates of carbon tax/carbon reduction–based policies often claim that these policies are necessary to save the planet from the negative impacts of climate change.[18] To quantify the impact of such policies, we have also estimated the environmental impact of these and other policies using the Model for the Assessment of Greenhouse Gas Induced Climate Change. In work published with my colleague Nick Loris in 2019, we simulated the impact of eliminating fossil fuel CO_2 emissions from the United States completely. Under a climate sensitivity assumption of 4.5 degrees Celsius, we found that complete elimination of CO_2 emissions from fossil fuels would result in less than 0.2 degree Celsius temperature reduction and 2 cm of sea level rise reduction The following chart, taken from Dayaratna and Loris (2019) contains simulation results of the temperature impact of completely eliminating fossil fuel CO_2 emissions from the United States under a variety of other climate sensitivity assumptions as well:[19]

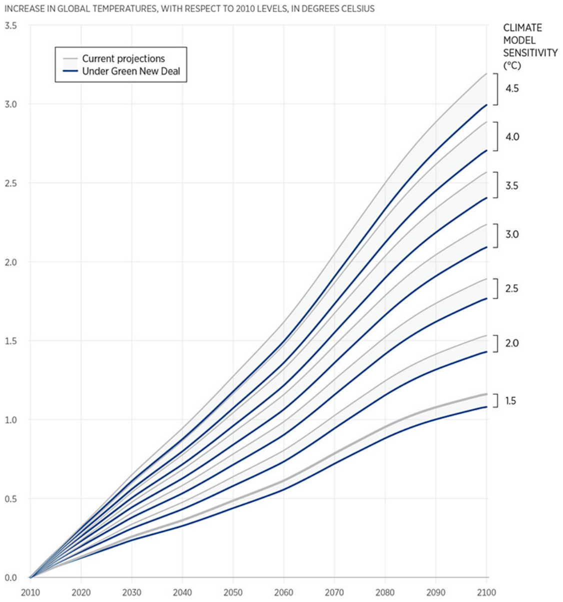

CHART 6

Eliminating All U.S. CO_2 Emissions Would Barely Affect Global Surface Temperatures

Based on various climate model sensitivities.

SOURCE: Authors' calculations based on Model for the Assessment of Greenhouse Induced Climate Change (Version 6.0) simulations.

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[18] See, for example, Bill McKibben, "Why We Need a Carbon Tax, And Why It Won't Be Enough," Yale Environment 360, September 12, 2016, https://e360.yale.edu/features/why_we_need_a_carbon_tax_and_why_it_won_be_enough (accessed September 23, 2020).

[19] Dayaratna and Loris, "Assessing the Costs and Benefits of the Green New Deal"

In a third exercise, we modeled the climate impact of taking advantage of the oil/gas resources discussed in Dayaratna et al. (2017). We again found a negligible impact of less than 0.003 degree Celsius change in temperature and 0.02 cm of sea level rise increase.[20]

Conclusions

Policies aimed at "decarbonizing" the American economy are predicated on faulty models that are prone to user-selected manipulation. These policies will raise the cost of energy, thus resulting in devastating economic impacts. On the other hand, policies that are aimed at taking advantage of the American oil and gas supply have tremendous potential to grow the economy. And, moreover, either policy—regulatory or de-regulatory—will have negligible impact on the climate.

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[20] Kevin Dayaratna and Nicholas Loris, "Turning America's Energy Abundance into Energy Dominance," Heritage Foundation *Report*, November 3, 2017, https://www.heritage.org/energy-economics/report/turning-americas-energy-abundance-energy-dominance (accessed September 23, 2020), and University Corporation for Atmospheric Research, "MAGICC/SCENGEN," http://www.cgd.ucar.edu/cas/wigley/magicc/ (accessed September 23, 2020).

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