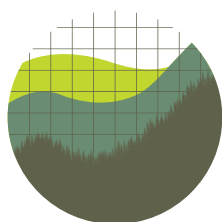




About Time

*Recalibrating the Discount Rate for the
Social Cost of Greenhouse Gases*



Institute for
Policy Integrity

NEW YORK UNIVERSITY SCHOOL OF LAW

June 2021
Peter Howard
Jason A. Schwartz

Copyright © 2021 by the Institute for Policy Integrity.
All rights reserved.

Institute for Policy Integrity
New York University School of Law
Wilf Hall, 139 MacDougal Street
New York, New York 10012

Peter Howard, Ph.D. is the Economics Director at the Institute for Policy Integrity at New York University School of Law, where Jason A. Schwartz is the Legal Director. The authors would like to thank Richard Revesz for valuable input.

This report does not necessarily reflect the views of NYU School of Law, if any.

Table of Contents

Executive Summary	1
I. Economic Principles for Selecting the Discount Rate	3
I.A. The Capital-Based Rate Is Inappropriate for Climate Policy.....	4
I.A.1. The Estimated Capital-Based Rate Is Too High.....	4
I.A.2. The Theory for the Capital-Based Approach Is Inapplicable	6
I.B. Consumption-Based Rates Derived Directly from Market Data Should Be Lower than Past Estimates, But Also Require Further Adjustment	8
I.B.1. Updated Market Evidence Supports a Much Lower Consumption-Based Rate	8
I.B.2. Even a Lower Rate May Be an Overestimate Due to Limitations of the Purely Descriptive Approach.....	10
I.C. Moving to the Ramsey Framework.....	11
I.D. Factoring Uncertainty into the Ramsey Framework.....	13
I.D.1. Considering Growth Uncertainty and Declining Discount Rates.....	14
I.D.2. Project Risks and GDP-Damage Correlations	15
I.D.3. Separating Risk Aversion from Inequity Aversion	20
I.D.4. Ambiguity Aversion	21
I.E. The Scarcity and Limited Substitutability of Non-Market Goods	22
I.F. Multiple Adjustments Together Will Yield Lower Discount Rates	25
II. Legal Principles for Selecting the Discount Rate	26
II.A. The Laws Shaping Agencies' Discretion on Discount Rates.....	27
II.A.1. Statutes Require Use of the Best Available Data.....	28
II.A.2. Executive Orders Require Use of the Best Available Data.....	30
II.A.3. Statutes Often Require Consideration of Future Generations	31
II.A.4. Executive Orders Require Consideration of Future Generations	33
II.A.5. Courts Will Give Agencies Considerable, But Not Unlimited, Discretion on Discount Rates	34
II.B. Legal Considerations for Selecting Central Discount Rates and a Sensitivity Range	37
II.C. Legal Considerations for Consistency in Discounting	39
Conclusion	43

Executive Summary

Over a decade has passed since the Interagency Working Group on the Social Cost of Greenhouse Gases (Working Group) selected its discount rates, thereby determining how much or how little weight would be given to the climate effects that will impact future generations. Nearly two decades have passed since the federal government holistically reviewed its broader choice of discount rates for analyzing agency actions. In the intervening years, new data and new literature have emerged that strongly point toward the need for lower discount rates. In short, it is about time for an update.

The central discount rate selected by the Working Group in 2010—3%—was estimated from the average Treasury note interest rates from 1973-2002. The Working Group selected a rate based on this kind of data (i.e., a consumption-based discount rate) after properly concluding that a rate based on private returns on investment (i.e., a capital-based discount rate) would be inappropriate for analysis of climate damages. But simply recalculating this average using **new data from the last twenty years**—during which interest rates have fallen and savings rates have risen—**would suggest a significantly lower discount rate, of at most 2%**. Updated methodologies for studying trends would reanalyze the same data and find an even lower discount rate, closer to 1%. Market forecasts indicate that a rate above 2% is unlikely in the foreseeable future. Given the importance of the discount rate in estimating the social cost of greenhouse gases, discount-rate updates of this magnitude would have a large influence on the social cost estimates.

But even such estimates based on updated market data and methodologies require further adjustments. Any update based solely on market data will ignore multiple key factors, including our ethical obligations to future generations and the ways in which climate change may disrupt future economic development. Instead of relying just on market data, the Working Group should move toward a longstanding, well-accepted economic framework known as the extended Ramsey equation, which not only can be calibrated to reflect the latest market data, but also can be calibrated according to recent expert elicitations and the best economic literature on other appropriate adjustments. Notably, **expert elicitations reveal a growing consensus for a central discount rate at or below 2%**—and that is before even fully accounting for important extensions and adjustment to the formula.

For example, there is also a strong consensus in the economics literature that uncertainty over future economic growth supports both a lower overall discount rate and also a *declining* discount rate schedule, under which effects further into the future are discounted at lower rates. Additional evidence on project risk, risk aversion, aversion to inter-generational inequity, and ambiguity aversion also counsels in favor of lower rates. In aggregate, the literature on these issues supports adjusting the long-run discount rate down to a range between 0.5% and 1.9%. Finally, because non-market goods (like environmental goods and services) will grow at a slower rate in the future than market goods—and will likely decline due to climate change—the rate appropriate for discounting future environmental goods should be lower than the standard market discount rate. This effect can conservatively decrease the lower end of the discount rate range by another 0.5%.

In light of all this evidence, but also recognizing that the lowest discount rate that the Working Group previously used was 2.5%, **a new range of discount rates appropriate for calculating the social cost of greenhouse gases could be conservatively estimated as between 0.5%-2.5%, with a central estimate of 1.5%.**

Agencies should follow the Working Group’s guidance on applying new social cost of greenhouse gas estimates based on updated discount rates—and, as appropriate, should make any corresponding adjustments to the discount rates applied to other costs and benefits in their analyses—as agencies have substantial discretion to implement best practices in selecting discount rates. Statutes and executive orders both support agency choices that are grounded in the best available data and that reflect consideration of the welfare of future generations. However, agencies will need to justify their choices, including any departures from prior practices. Moreover, agencies will either need to adopt consistent approaches to discounting across all climate and non-climate costs and benefits under analysis, or else will need to thoroughly justify any differences in the discount rates applied to different contexts. **Developing a declining discount rate schedule would be one straightforward option to achieve a more consistent approach to discounting across all costs and benefits.** But if the federal government remains hesitant to adopt a declining discount rate schedule, other approaches are possible, including if necessary by thoroughly explaining why special economic, legal, and ethical considerations require discounting climate effects at a lower rate than other costs and benefits.

I. Economic Principles for Selecting the Discount Rate

Since 2010, the Interagency Working Group on the Social Cost of Greenhouse Gases (Working Group) has used three discount rates to calculate the net present value of the future climate costs and benefits that will occur in the decades and centuries after a ton of greenhouse gases is emitted. Its central discount rate has been 3%, chosen to be consistent with the Office of Management and Budget (OMB)’s default recommendation for a consumption-based rate from *Circular A-4*, the guidance on regulatory analysis published in 2003. The consumption-based rate (also called the social rate of time preference, or SRTTP) assumes that the rate at which the average saver discounts future consumption should be the measure of how society as a whole is willing to trade current for future consumption (see Section I.B for more details). The 3% figure was based on calculations made in 2003 of the average real rate of return on ten-year U.S. Treasury notes from 1973-2002.¹

The Working Group also derived two additional rates for use as sensitivity analysis.² A higher rate of 5% was used to cover the possibility that climate damages will be positively correlated with market returns (see Section I.D.2). A slightly lower rate of 2.5% was used to address multiple concerns, including that economic growth and discount rates are uncertain over time (see Section I.D.1), that climate damages might be negatively correlated with market returns (see I.D.3), and that rates derived solely from market data do not reflect ethical responsibilities to future generations on climate change (see Section I.B.2).

The Working Group determined that a capital-based rate was inappropriate for analysis of climate policies.³ The capital-based rate (also called the social opportunity cost of capital, or SOC) is premised on the idea is that government actions disrupt the private investment of capital, which could otherwise have been invested in the market to earn a return. For multiple reasons, *Circular A-4*’s default capital-based rate of 7% is much too high (see Section I.A.1), and the theoretical bases for the rate are incongruous with analysis of climate policy (see Section I.A.2).

This section begins by providing additional justifications for why a capital-based rate is inappropriate for climate analysis. The central consumption-based rate used in the past also requires adjustments. New market data and better methodologies for applying market data indicate the rate should be much lower than previously calculated. But any discount rate based exclusively on market data will reflect only the

¹ Interagency Working Group on the Social Cost of Carbon, Technical Support Document: Social Cost of Carbon for Regulatory Impact Analysis at 20 (2010) [hereinafter 2010 TSD] (calculating the average rate at 2.7%, but picking 3% to be consistent with *Circular A-4*); Interagency Working Group on the Social Cost of Greenhouse Gases, Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide—Interim Estimates under Executive Order 13990 at 19 (2021) [hereinafter 2021 Interim TSD] (noting *Circular A-4* had estimated the rate at 3.1%, based on data from 1973-2002).

² 2010 TSD, *supra* note 1, at 23; 2021 Interim TSD, *supra* note 1, at 17.

³ Interagency Working Group on the Social Cost of Carbon, Response to Comments: Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12,866 at 36 (2015) [hereinafter 2015 Response to Comments] (“Circular A-4 is a living document. . . . [T]he use of 7 percent is *not* considered appropriate for intergenerational discounting. There is wide support for this view in the academic literature, and it is recognized in Circular A-4 itself.” (emphases added)).

current generation’s preferences for trading off their own consumption over time, and so ignores our responsibilities to future generations. Moreover, discount rates derived exclusively from market data will not sufficiently reflect the fact that future growth rates are uncertain, that climate damages might be negatively correlated with market rates, that non-market goods will grow scarcer over time, and other factors that require a downward adjustment in the discount rate. This section argues for moving to a different framework to calculate discount rates that can be informed not just by market data, but also by expert elicitation and the most recent economic literature on appropriate adjustments.

I.A. The Capital-Based Rate Is Inappropriate for Climate Policy

As the Working Group summarizes, *Circular A-4* proposed a capital-based rate only as an imprecise, second-best option for discounting.⁴ The analytically preferred approach (called the “shadow price” approach) is to apply a consumption-based discount rate after converting costs and benefits to reflect their value in equivalent units of consumption.⁵ But because calculating costs and benefits in consumption-equivalent values may be challenging, *Circular A-4* suggested that agencies could instead apply two alternate discount approaches: (1) a straight application of a consumption-based rate derived from market data (without necessarily first converting all costs and benefits to consumption-based equivalents; this rate is discussed further below, Section I.B); and (2) a capital-based rate.

The capital-based discount rate theoretically assesses whether the net benefits from government action will exceed the returns that society could earn by instead investing the same resources in the private sector. But this framework for discounting and comparing benefits and costs only makes sense under the “extreme” assumption that all the costs of government action would fully displace private investment.⁶ In this way, the capital-based rate “at best creat[es] a lower bound on the estimate of net benefits,” by applying a *maximum* discount rate that reflects an extreme case not likely to apply to many government actions.⁷

The Working Group’s February 2021 Interim Technical Support Document presents some arguments on why the capital-based rate—calculated in 2003 as 7%—both is too high and also is inappropriate for climate policy. This section provides additional arguments, which may be helpful in further defending against litigation or political efforts seeking to reimpose the capital-based rate in the analysis of climate policy.

I.A.1. The Estimated Capital-Based Rate Is Too High

On the theory that government actions will disrupt the private investment of capital, which could otherwise have been invested in the market to earn a return that will benefit society, the capital-based approach derives a discount rate from market data on private investment returns, as an imperfect proxy

⁴ 2021 Interim TSD, *supra* note 1, at 18-19; Off. of Mgmt. & Budget, Circular A-4 at 33 (2003) (calling the shadow price approach the “analytically preferred method” and then recommending an alternate “default position”).

⁵ Circular A-4, *supra* note 4, at 33.

⁶ Interim 2021 TSD, *supra* note 1, at 18-19.

⁷ *Id.*

for society's benefits from investment. *Circular A-4*'s default rate of 7% was based on the National Income and Product Accounts data, with parameters estimated using what the Council of Economic Advisers has called "imperfect data like tax returns, surveys and imputations."⁸ As the Environmental Protection Agency has noted, alternative estimation strategies could instead generate capital-based rates as low as 4.5%.⁹ Furthermore, while the estimate should be based on the marginal rate of return to private investment, the marginal rate is hard to observe directly, and analysts have instead assumed that average rates of returns can be used as a proxy; but if average rates are higher than marginal rates (for example, "because firms probably make the most profitable investments first"), the methodologies will overestimate the capital-based rate.¹⁰

A capital-based rate derived from market data will also overestimate the discount rate that society should use, because of market distortions. Market distortions mean that society's rate of return on investment (i.e., what the capital-based discount rate estimate arguably should be) diverges from the private return on investment (i.e., what the observable market data show). While *Circular A-4* focused on how taxation distorts the market rate of return,¹¹ private returns to capital investment also include returns based on the production of negative social externalities, on the exercise of market power, and on private (as opposed to social) risk premiums. Consequently, the capital-based discount rate should be adjusted downward. Consider, for example, that private investors in oil and gas will earn market returns based in part on their ability to transfer some of the pollution costs generated by their investment onto society, in the form of negative health and environmental externalities. If government aims to maximize social welfare, government should not use a private rate of return (which is inflated by the market's ability to externalize damages) as the benchmark for discounting and comparing the net social benefits of government action. Yet current estimates of the capital-based discount rate do not subtract out returns from externalities, market power, or private risk premiums—and so are artificially high.

Indeed, recent evidence suggests the magnitude of such distortions. Taxation, along with market power, externalities, private risk premiums, and other factors, are the reasons why the capital-based rate diverges from the consumption-based rate in the first place.¹² In recent decades, the consumption-based rate has been falling (as explored further below, Section I.B.1), while estimates of returns to private capital investment have remained fairly constant.¹³ Yet taxation cannot explain the growing apparent gap between

⁸ Council of Econ. Advisers, *Discounting for Public Policy: Theory and Recent Evidence on the Merits of Updating the Discount Rate* at 2 (2017) [hereinafter "CEA"]. Note that while some estimation strategies have produced relatively stable capital-based rates over recent decades, *id.*, current market data can reflect the preferences of only the current generation of investors, based on current conditions, and does not necessarily predict what future private rates of return will look like far into the future. Notably, there are "no regular private forecasts of the economywide rate of return." *Id.* at 2.

⁹ EPA, *Guidelines for Preparing Economic Analyses* at 6-11 (2010) (citing, for example, Moore et al. (2004)'s estimate based on AAA corporate bonds).

¹⁰ CEA, *supra* note 8, at 4 (also noting it is possible that average returns could be lower than marginal returns, if new investments are made on the basis of better information).

¹¹ *Circular A-4*, *supra* note 4, at 33.

¹² CEA, *supra* note 8, at 3-4.

¹³ *Id.* at 11-12.

the rates, since the effective tax rate has declined in recent decades.¹⁴ Therefore, the relative stability of the rate of return to private capital investments, even as the consumption-based rate and tax rates have been falling, may be driven by increasing market power, externalities, or rising private risk premiums¹⁵—none of which should be reflected in the discount rates that society uses to make decisions. Estimates of the capital-based approach should be adjusted downward if they are to be used at all.

I.A.2. The Theory for the Capital-Based Approach Is Inapplicable

As mentioned above, under *Circular A-4*'s guidance, the capital-based rate comes into play only if costs and benefits cannot be converted into consumption-based equivalents. But the reduced-form integrated assessment models (IAMs) used to calculate the social cost of greenhouse gases already estimate climate damages “in terms of reduced consumption (or consumption equivalents).”¹⁶ Therefore, as the Working Group observes, implementing *Circular A-4*'s guidance would dictate use of the consumption-based discount rate, especially if any other costs resulting from displaced capital investments due to the regulation or other agency action can also be converted into consumption-based equivalents (either through the shadow price of capital approach or by estimating costs in a general equilibrium framework).¹⁷ The National Academies of Sciences agreed that a capital-based rate would be inappropriate for use with the social cost of greenhouse gases, given that climate damages are estimated in consumption-equivalent units.¹⁸

A broader issue for the applicability of the capital-based rate is how often the costs of agency actions will actually displace capital investments. A straight application of the capital-based discount rate is appropriate only if the costs of agency actions fully displace capital investments—that is, if the government action crowds out private investment. However, as the United States has a relatively open economy—with increased connectedness and trade with foreign economies compared to in 1992 when OMB first set a 7% capital-based discount rate¹⁹—there is less of a chance that U.S. government actions will crowd out private investments.²⁰ Additionally, the magnitude of the costs and benefits involved in many agency actions will be relatively small compared to the overall U.S. debt, again making it unlikely that agency actions will significantly crowd out private U.S. investment.²¹ Some agency actions may also induce more private investment than they displace.²² Finally, the costs of many agency actions will be more

¹⁴ See Econ. Pol'y Inst., Corporate Tax Rates and Economic Growth Since 1947, fig.B (2013), <https://perma.cc/PQ62-2SKB>.

¹⁵ See CEA, *supra* note 8, at 11 (noting, for example, that monopoly rents may have increased); R.J. Caballero et al., *Rents, Technical Change, and Risk Premia Accounting for Secular Trends in Interest Rates, Returns on Capital, Earning Yields, and Factor Shares*, 107 AM. ECON. REV. 614 (2017).

¹⁶ 2021 Interim TSD, *supra* note 1, at 17.

¹⁷ *Id.* at 18.

¹⁸ National Academies of Sciences, Engineering, and Medicine, *Valuing Climate Damages: Updating Estimation of the Social Cost of Carbon Dioxide* at 167 (2017) [hereinafter NAS].

¹⁹ OMB, Circular A-94 at 9, 57 Fed. Reg. 53,519 (Nov. 10, 1992).

²⁰ See EPA, Guidelines, *supra* note 9, at 6-11.

²¹ *Id.*

²² 2021 Interim TSD, *supra* note 1, at 19 (noting that if the social returns to induced investments have not been quantified, using a capital-based discount rate “is not even a lower bound”).

likely to be borne primarily through displaced consumption rather than displaced investment; some recent agency analyses of major climate policies, for example, have assumed high or even complete pass-through of costs to consumers.²³ Under any of these conditions—an open economy; a policy effect small relative to U.S. debt; the potential to induce new investment; or pass-through of costs to consumers—applying a high capital-based discount rate may be worse than creating a lower-bound estimate of net benefits²⁴—it may inaccurate, misleading, and simply inappropriate.

In theory, agencies could try to determine what portion of the costs of government action may affect capital formation as opposed to consumption and blend the capital-based discount rate with the consumption-based discount rate in proportion. However, not only is estimating this split extremely difficult,²⁵ but such a blended rate would still be inappropriately high for application to long-term, inter-generational government decisions, especially given uncertainty and ethical considerations.²⁶

Long-term time horizons in general counsel strongly against application of a capital-based rate. The Interim Technical Support Document cites Li and Pizer’s work on how the capital-based rate is inappropriate when benefits occur in the future.²⁷ Notably, Li and Pizer find that, given their best estimate of the shadow price of capital, the appropriate social discount rate collapses to the consumption-based rate relatively quickly, in the span of just several decades.²⁸ Given the long time horizon that analysis of climate policies demands, the capital-based rate is simply inapplicable.

Ethical and climate-specific considerations bolster the case against capital-based rates. As discussed further below, market data does not reflect society’s preferences toward or obligations to future generations, and so basing a discount rate solely on market data ignores such important inter-generational considerations.²⁹ Furthermore, several standard justifications for capital-based discount rates break down given the particular threats of climate change. For example, one argument for capital-based discount rates is that spending capital on climate abatement policies has opportunity costs and so, in policy analysis, future costs and benefits should be discounted at the rate of return to capital. However, the irreversible, uncertain, and catastrophic risks of climate change may disrupt this “opportunity cost” rationale: while it may seem, for instance, that future, wealthier generations might have better opportunities to address climate change for themselves, irreversible or catastrophic damages could arise that make future mitigation efforts more expensive or impossible.³⁰ Similarly, if climate damages are “non-marginal,” such

²³ E.g., Nat’l Highway Traffic Safety Admin. & Env’tl. Prot. Agency, Final Regulatory Impact Analysis: The Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule for Model Year 2021-2026 Passenger Cars and Light Trucks at 829, tbl.VI-181 (2020), <https://perma.cc/Y7G3-EBB9> (assuming that line 1 = line 3, indicating all manufacturer costs will be passed to vehicle buyers).

²⁴ 2021 Interim TSD, *supra* note 1, at 18-19.

²⁵ EPA, Guidelines, *supra* note 9, at 6-8 to 6-10 (“The literature is not conclusive on the degree of crowding out.”).

²⁶ 2021 Interim TSD, *supra* note 1, at 19.

²⁷ *Id.*

²⁸ Qingran Li & William A. Pizer, Use of the Consumption Discount Rate for Public Policy over the Distant Future, 107 J. ENVTL. ECON. & MGMT. 102,428 (2021).

²⁹ Richard L. Revesz & Matthew R. Shahabian, *Climate Change and Future Generations*, 84 S. CAL. L. REV. 1097 (2011).

³⁰ *Id.* at 1149-52.

that climate change significantly affects the very natural resources needed to drive economic growth, growth could plummet or even turn negative.³¹ Overall, a capital-based approach to discounting is simply not appropriate in the context of climate change.

I.B. Consumption-Based Rates Derived Directly from Market Data Should Be Lower than Past Estimates, But Also Require Further Adjustment

A descriptive approach to calculating a consumption-based discount rate (also called the social rate of time preference, or SRTP) assumes that the rate at which the average saver discounts future consumption should be the measure of how society as a whole is willing to trade current for future consumption. The tax-free rate of return on low-risk securities, like government notes and bonds, is commonly used as a proxy for estimating the consumption-based rate. The Working Group's Interim Technical Support Document recognizes that recent market data shows the consumption-based rate should be lower than past estimates, and also acknowledges some enduring ethical dilemmas with using market data as the main proxy for a consumption-based rate. This section expands on both those points, first by citing additional evidence in support of a lower rate. The section then suggests that, given limitations in the market data, the Working Group should shift away from estimating constant discount rates derived largely from market rates. Instead the Working Group should consider moving toward discount rates based on the extended Ramsey formula, which can be calibrated based on expert elicitations and the latest economic literature as well as market data, in order to better capture growth uncertainty and other important adjustments.

I.B.1. Updated Market Evidence Supports a Much Lower Consumption-Based Rate

Circular A-4 and the Working Group have, in the past, estimated consumption-based discount rates by taking the mean of long-run interest rates for low-risk investments. In 2003, *Circular A-4* used 10-year Treasury note data from 1973-2002, found an average rate of 3.1%, and settled on an estimated consumption-based discount rate of 3%.³² In 2010, the Working Group looked at similar data, found an average rate of 2.7%, and also settled on a 3% rate, to be consistent with *Circular A-4*.³³ However, as the Working Group recognizes in its February 2021 Interim Technical Support Document,³⁴ real Treasury interest rates on the 10-year notes have fallen fairly steadily since at least 2000, and even recently hit negative numbers.³⁵ As a result, applying the same methodology to more recent data on Treasury rates

³¹ *Id.* at 1153 & n.246 (citing Heal's observation that estimates of productivity growth based on historical records omit depletion of natural resources, and thus bias discount rates upwards).

³² *Circular A-4* at 33-34.

³³ 2010 TSD, *supra* note 1, at 20 (using the data from Newell & Pizer 2003, and adjusting for federal taxes based on 2003-2006 tax rates).

³⁴ 2021 Interim TSD, *supra* note 1, at 19-20.

³⁵ OMB, Table of Past Years Discount Rates from Appendix C of OMB Circular No. A-94 (Dec. 21, 2020), <https://perma.cc/SVYS-LAFH> (showing that rates on 30-year bonds have also fallen steadily); *see also* CEA, *supra* note 8, at 5 (explaining past negative real rates were due largely to very high inflation, whereas recent negative numbers are because of very low nominal rates and not because of high inflation).

(i.e., from 1991-2020) would indicate a consumption-based discount rate of 2%.³⁶ The Council of Economic Advisers came to the same conclusion in 2017: that based on more recent data and forecasts, the consumption-based discount rate should be at most 2%.³⁷ Simply replacing old data (from 1970-2002) with updated data (1991-2020) by itself presents a straightforward and compelling case for significantly lowering the Working Group's central discount rate.

In addition to the steady decline in U.S. Treasury rates over the last two decades, there is considerable other empirical evidence to support a lower estimate of a consumption-based discount rate.³⁸ For example, other advanced economies worldwide have seen similar recent downward trends in their rates.³⁹ Meanwhile, U.S. savings rates have climbed over the last decade,⁴⁰ suggesting consumers are placing somewhat less value on current consumption relative to future consumption.⁴¹ These data-points reinforce the conclusion that the consumption-based discount rate should be at most 2%.

Forecasts for future rates have also fallen. As of 2017, the federal executive branch's forecast of long-run real interest rates for 10-year notes was 1.4%, and the Blue Chip consensus forecast was 1.5%.⁴² A 2020 report published by the Congressional Budget Office found that, because of factors like slowing global growth rates and increasing savings rates tied to increasing life expectancy, real interest rates on 10-year U.S. Treasury notes would likely be between 1.2%-2.3% over the next several decades.⁴³

Moreover, newer methodologies can better account for the stochastic nature of the bond interest rate data—in other words, the fact that the data can be characterized by random variation over time.⁴⁴ Bauer and Rudebusch recently found that, had an updated methodology been applied to the same data used by OMB in 2003, *Circular A-4's* calculation of the consumption-based discount rate would have dropped

³⁶ 2021 Interim TSD, *supra* note 1, at 20.

³⁷ CEA, *supra* note 8, at 4-7, 12.

³⁸ A few papers on U.K. and Singapore housing markets may also provide some revealed-preference evidence for long-run market discount rates. See Eric Fesselmeyer et al., *How Do Households Discount Over Centuries? Evidence from Singapore's Private Housing Market* (IZA Disc. Paper 9862, 2016); Stefano Giglio et al., *Climate Change and Long-Run Discount Rates: Evidence from Real Estate* (NBER No. w21767, 2018) (finding evidence of a downward sloping discount rate for real estate).

³⁹ CEA, *supra* note 8, at 6 (showing rates in Japan, France, Germany, the United Kingdom, Canada, and Korea); Edward Gamber, Cong. Budget Off., *The Historical Decline in Real Interest Rates and Its Implications for CBO's Projections* at 22-24 (CBO Working Paper 2020-09, Dec. 2020), <https://perma.cc/63AW-VHD4> CBO at 22, 24 (showing declining global rates).

⁴⁰ FRED St. Louis, Personal Saving Rate, <https://fred.stlouisfed.org/series/PSAVERT> (from 1992-2003, the rate averaged 6.4%; increased to an average of 7% over 2008-2019; spiked in 2020 during the recession).

⁴¹ *But see* Revesz & Shahabian, *supra* note 29, at 1135 (first posing that savings rates should be interpreted in light of technological growth and other factors, before concluding that savings rates and other observed market data provide little useful guidance on an appropriate intergenerational discount rate).

⁴² CEA, *supra* note 8, at 2, 6; *see also id.* at 7 (citing similar data from futures markets).

⁴³ Gamber, CBO, *supra* note 39, at 4-7 (listing other factors, including slowed labor force growth, a global savings glut, a shortage of safe assets, and secular stagnation); *id.* at 39 (showing medium-term and long-term forecasts).

⁴⁴ See Richard G. Newell & William A. Pizer, *Discounting the Distant Future: How Much Do Uncertain Rates Increase Valuations?*, 46 J. ENVTL. ECON. & MGMT. 52 (2003).

from 3% down to about 2%.⁴⁵ And when Bauer and Rudebusch took the average estimates from the recent literature, which draws on more recent data, they found an average equilibrium real rate of interest of 0.68% in the prior decade.⁴⁶

In short, due to demographic shifts, other trends, and improved methodologies, the best empirical estimate of the discount rate based on long-term interest rates in the current period is under 1%—and is likely to remain under 2% or less for the foreseeable future.⁴⁷

1.B.2. Even a Lower Rate May Be an Overestimate Due to Limitations of the Purely Descriptive Approach

Even as market evidence strongly supports lowering the discount rate, there are many reasons to believe that such a lowered estimate could still be too high.⁴⁸ This is because of limitations of a purely descriptive approach to calibrating the discount rate based on market data alone.

Market rates reflect only the investment preferences and relatively short-run expectations of the current generation. Inter-generational discount rates are not generally observable in the market.⁴⁹ Because the current generation of consumers, savers, and investors will not fully or efficiently consider the welfare of future generations, discount rates based on market data may overestimate the optimal rate for society to use in an inter-generational context. Society has a longer planning horizon than most individuals. For example, the probability of death likely causes individuals to demand a relatively higher rate of return when trading their own current versus future consumption;⁵⁰ by contrast, the probability of an end-of-civilization event is relatively low and so can only justify an exceedingly small discount rate.⁵¹ Relying on data on relatively short-run average returns can be particularly misleading in calculating a long-run declining discount rate schedule.⁵²

While the current generation of consumers and investors will not fully or efficiently consider the welfare of future generations in their market behavior, most people do have a strong ethical preference to split

⁴⁵ Michael D. Bauer & Glenn D. Rudebusch, *The Rising Cost of Climate Change: Evidence from the Bond Market* (Fed. Reserve Bank Working Paper 2020-25); see also 2010 TSD, *supra* note 1, at 20 (calculating the rate as 2.7%).

⁴⁶ Bauer & Rudebusch, *supra* note 45 (averaging estimates from Del Negro et al. (2019), Johannsen & Merten (2016), Laubach & Williams (2016), Kiley (2020), Christensen & Rudebusch (2015), and Bauer & Rudebusch (2020)).

⁴⁷ See *id.*

⁴⁸ It is also possible that foreign demand for safe investments could be driving down U.S. Treasury rates by reflecting the time preferences of foreign investors, which arguably should not influence U.S. policy analyses. See CEA, *supra* note 8, at 3. If true, this could partially offset some of the other factors suggesting that market data leads to an overestimated discount rate. But regardless, it is yet another reason why market data should be supplemented by other inputs, like expert elicitation.

⁴⁹ EPA, Guidelines, *supra* note 9, at 6-12 (explaining that intergenerational discounting is complicated by the fact that “the ‘investment horizon’ is longer than what is reflected in observed market interest rates representative of intertemporal consumption tradeoffs made by the current generation”). Real estate investments are among the few potentially intergenerational assets, though real estate investments, too, may generate externalities.

⁵⁰ CEA, *supra* note 8, at 3.

⁵¹ See Revesz & Shahabian, *supra* note 29, at 1116-17 (discussing the Stern Report’s reliance on a world-ending disaster to justify a pure rate of time preference of 0.1%, but noting even that seems too high).

⁵² See Giglio et al. (2018), *supra* note 38.

resources fairly between generations, as shown in informal surveys conducted by Richard Revesz,⁵³ but they need government to help implement this preference for them.⁵⁴ And whereas market data on savings rates and investment preferences can reflect only intrapersonal market behavior and not inter-generational preferences, empirical evidence on inter-vivos wealth transfers to subsequent generations and stated-preferences studies on people’s attitudes about discount rates over long time horizons suggest lower discount rates than typically estimated from market data.⁵⁵

Finally, discount rates derived solely from market data cannot account for uncertainty or ethics, as the Working Group recognized,⁵⁶ or the limited substitutability of market and non-market goods (as explored below, Section I.E).

For all these reasons, the Working Group should supplement its calibration of the discount rate by considering evidence besides just market data. The Working Group should consider moving toward discount rate schedules based on the extended Ramsey discount rate equation, which can be informed by expert elicitation and the latest economic literature as well as any updated and reliable market data, and so can be adjusted to reflect growth uncertainty and other key factors.⁵⁷ Because of the growing consensus in the economic literature around the value of key parameters, a reasonable range of discount rates (along with central and maximum values) can be estimated by using the Ramsey equation.

I.C. Moving to the Ramsey Framework

In an ideal world under certainty, isoelastic preferences,⁵⁸ and perfect substitutability between market and non-market goods and capital, the simple Ramsey equation is derived as

$$r = \rho + \eta \times g$$

where ρ is the pure rate of time preference, η is the elasticity of the marginal utility of consumption (and also equals the coefficient of relative risk aversion and the aversion to inequality over time), and g is the growth rate in per capita consumption.

The Ramsey framework offers several advantages for estimating the discount rate, especially in the climate context. First, it provides a means of extrapolating discount rates into the future as economic growth slows

⁵³ Revesz & Shahabian, *supra* note 29, at 1123 (reporting the “overwhelming response” from asking professional and academic audiences how to divide resources among different generations living on an isolated island; Kenneth Arrow reported the same ethical intuition and acknowledged that a positive pure rate of time preference would be inconsistent with this overwhelming ethical intuition).

⁵⁴ *Id.* at 1142 (without government enforcement mechanisms, “people . . . who would otherwise be willing to sacrifice collectively for future generations by mitigating climate change may not reflect that preference in their everyday behavior if they think their sacrifice alone will have little impact”).

⁵⁵ *Id.* at 1136, 1139-41, 1141.

⁵⁶ 2021 Interim TSD, *supra* note 1, at 21.

⁵⁷ See NAS, *supra* note 18, at 18-19 (recommending a Ramsey-like formula).

⁵⁸ That is, $U(C) = \frac{C^{1-\eta}-1}{1-\eta}$ where U and C equal utility and per capita consumption, respectively.

towards a steady state.⁵⁹ Second, it explicitly connects the discount rate to consumption growth, reflecting that climate damages affect the discount rate.⁶⁰ Last, the formula can be extended in several ways to allow for: a consistent framework for addressing uncertainty (see Section I.D.); preferences to avoid inter-generational inequality (see Section I.D.3); and the imperfect substitutability of market and non-market goods (see Section I.E.).

The Ramsey equation can be calibrated descriptively to market data,⁶¹ but also by applying expert elicitations or other normative approaches developed in the economics literature. Some prior reviews of early literature catalogue a range of estimates for the individual parameters in the simple Ramsey equation⁶² that now seem high, outdated, or inconsistent in light of the most recent expert elicitations, which support a central discount rate value at or below 2%.⁶³ One reason for the range of estimates from earlier literature is that the parameters in the simple Ramsey equation, like the elasticity of marginal utility of consumption, capture too many distinct types of preferences: for example, risk aversion, aversion to inter-generation inequality, and consumption smoothing are all embedded into that elasticity term.⁶⁴ Some of the extensions of the Ramsey formula discussed below, based on more recent literature, disentangle these factors and so may lead to more accurate estimates of the discount rate.

Another reason for the range of estimates from earlier literature is potential disparities between experts taking a descriptive versus prescriptive approach. For example, those taking a descriptive approach may estimate a higher pure rate of time preference in an effort to try to match observed market data about savings rates. On the other hand, a large group of experts favors a pure rate of time preference either of zero, based on the ethical argument that all generations should be treated equally (Ramsey himself favored this popular argument),⁶⁵ or of only slightly above zero, based on some small probability of the world ending.⁶⁶ As mentioned above, the informal surveys conducted by Revesz reveal a widespread preference among professional and academic audiences for inter-generational equality, and Revesz's scholarship with Shahabian catalogues the wide support among prominent scholars for a low or zero pure rate of time

⁵⁹ See CEA, *supra* note 8, at 7.

⁶⁰ NAS, *supra* note 18, at 18; Peter H. Howard & Derek Sylvan, *Wisdom of the Experts: Using Survey Responses to Address Positive and Normative Uncertainties in Climate-Economic Models*, 162 CLIMATIC CHANGE 213 (2020).

⁶¹ For example, Nordhaus calibrates the simple Ramsey equation to reflect the observed market savings rate, see Revesz & Shahabian, *supra* note 29, at 1117-19 (summarizing Nordhaus's approach).

⁶² The National Academy of Sciences noted that two reviews of earlier literature (the Working Group's review in 2010, and the Intergovernmental Panel on Climate Change's review in 2014) came to overlapping ranges for these parameters: 0-2% (IPCC, 2014, with 2% being the "largest value cited," and "the majority" supporting zero or near-zero values) and 0-3% (Working Group, 2010) for the pure rate of time preference; and 1 to 4 for the elasticity of the marginal utility of consumption. NAS, *supra* note 18, at 163 (also finding a 2% growth rate is a common assumption).

⁶³ See *infra* note 73, and accompanying text.

⁶⁴ See Kenneth Arrow et al., *Should Governments Use a Declining Discount Rate in Project Analysis?*, 8 REV. EVNTL. ECON. & POL'Y 145 (2014).

⁶⁵ See Revesz & Shahabian, *supra* note 29, at 1104-06.

⁶⁶ *Id.* at 1116 (describing the Stern Report).

preference.⁶⁷ In a prominent expert elicitation, Drupp et al. (2018) report that the mode response—that is, the most commonly given response from experts—was a pure rate of time preference of zero.⁶⁸

Indeed, as the Working Group noted, expert elicitation shows a “surprising degree of consensus among experts.”⁶⁹ Standard techniques for expert elicitation are very useful for either calibrating individual parameters in the Ramsey formula or directly estimating a constant discount rate or a discount schedule.⁷⁰ For example, Hansel et al. (2020) find median values of 0.5% for the pure rate of time preference and 1% for the elasticity of marginal utility of consumption,⁷¹ implying a discount rate of 1.7%.⁷² Both Howard and Sylvan (2020) and Drupp et al. (2018) find a median estimate of the appropriate social discount rate of 2%.⁷³ Such estimates imply that the individual parameters in the Ramsey equation may be lower than previously estimated: for example, a developing understanding of how future climate damages could negatively affect economic growth may indicate that experts have reevaluated the growth term. Thus, before even examining extensions of the Ramsey equation that may further lower the appropriate discount rate estimates, there is strong evidence from the literature of a growing consensus for a central discount rate value at or below 2%.

However, Drupp et al. (2018) finds some disparities between individuals’ direct estimates of the appropriate social discount rate and their views on individual parameters in the Ramsey formula.⁷⁴ This disparity likely stems from the fact that the basic parameters of the simple Ramsey formula are inadequate to fully and consistently capture important factors like uncertainty and limited substitution between market and non-market goods. Notably, Drupp et al. (2018) find lower estimates of the appropriate social discount rate among experts who specifically highlighted issues of uncertainty or relative prices in their survey response. Therefore, this report looks at these key extensions of the Ramsey formula next.

I.D. Factoring Uncertainty into the Ramsey Framework

To account for uncertainty about climate change in estimates of the social cost of greenhouse gases, either a risk-free discount rate can be applied to certainty-equivalent marginal damages, or a risk-adjusted discount rate can be applied to deterministic marginal damages.⁷⁵ This section of the report explores this

⁶⁷ *Id.* at 1114-16, 1122-23.

⁶⁸ Moritz Drupp et al., *Discounting Disentangled*, 10 AM. ECON. J.: ECON. POL’Y 109 (2018).

⁶⁹ 2021 Interim TSD, *supra* note 1, at 20.

⁷⁰ See Policy Integrity’s separate report submitted to this docket on expert elicitation techniques: Peter Howard & Derek Sylvan, *Expert Elicitation and the Social Cost of Greenhouse Gases* (Policy Integrity Report, 2021).

⁷¹ Martin Hansel et al., *Climate Economics Support for the UN Climate Targets*, 10 NATURE CLIMATE CHANGE 781 (2020) (also finding somewhat different corresponding parameters when asking experts to vote directly on the social cost of carbon).

⁷² In the DICE-2016R2 model with an average growth rate of 1.2% over 300 years; different assumptions about the growth rate would change this estimate.

⁷³ Howard & Sylvan, *supra* note 60; Drupp et al. (2018), *supra* note 68 (also eliciting views on the appropriate real, risk-free interest rate).

⁷⁴ Drupp et al. (2018), *supra* note 68.

⁷⁵ See D. Lemoine, *The Climate Risk Premium: How Uncertainty Affects the Social Cost of Carbon*, 8 J. ASSOC. ENVTL. & RES. ECON. 27 (2021).

latter option. In the past, the Working Group used uncertainty to justify considering both a slightly lower discount rate (2.5%) and a substantially higher discount rate (5%) as sensitivity analyses compared to its central rate (3%). As this section shows, based on more recent literature, proper treatment of uncertainty points to a much lower overall range of discount rates.

I.D.1. Considering Growth Uncertainty and Declining Discount Rates

Intuitively, uncertainty over future economic growth will lead to increased savings rates and so to a corresponding decrease in the discount rate. The best way for the Working Group to account for growth uncertainty is to adopt an extended Ramsey equation:

$$r = \rho + \eta * g - 0.5\eta(\eta + 1)\sigma^2$$

where ρ is the pure rate of time preference, η is the aversion to inter-generational inequality (also equal to the elasticity of the marginal utility of consumption), and the future growth of consumption (g) is uncertain, with a mean of μ and variance of σ^2 .⁷⁶

Applying this extended Ramsey formula leads to two conclusions. First, the overall discount rate should be lower as a result of growth uncertainty, because the precautionary response to uncertainty is to increase savings, and because global growth rates will likely slow down over time toward a steady state.⁷⁷ Second, because empirical evidence for the United States indicates that growth rates are stochastic and are correlated over time, the extended Ramsey formula implies a declining discount rate schedule.⁷⁸ There is a strong consensus in the economics literature that uncertainty over economic growth and future discount rates results in a declining discount rate schedule.⁷⁹ Furthermore, discount rates will decline over time if growth shocks are correlated, and the positive correlation of growth shocks will likely strengthen over time as climate change causes an uncertain but possibly permanent reduction in consumption.⁸⁰

Though the Working Group was in the past hesitant to move toward a declining discount rate schedule, that approach is actionable and appropriate now. Other countries have adopted their own declining

⁷⁶ See Christian Gollier & James K. Hammitt, *The Long-Run Discount Rate Controversy*, 6 ANN. REV. RESOURCE ECON. 273 (2014). The formula can also be written as $r = \rho + \eta * \mu - 0.5\eta^2\sigma^2$.

⁷⁷ The Working Group assumed a slowdown in growth of GDP per capita from 2100 to 2300 until reaching zero in 2300, see 2010 TSD, *supra* note 1, at 43-45; Table 1 shows that experts expect a slowdown in global annual per-capita output between the first half and the second half of the 21st century in Peter Christensen, Kenneth Gillingham & William D. Nordhaus, *Uncertainty in Forecasts of Long-Run Economic Growth*, 115 PNAS 5409 (2018). DICE-2016R2 model runs in William D. Nordhaus, *Revisiting the Social Cost of Carbon*, 114 PNAS 1518 (2017) show a slowdown in the annual growth rate of consumption per capita from 2.6% in 2020 to 0.6% in 2300 with an average annual growth rate of 1.2%.

⁷⁸ Maureen Cropper et al., *Declining Discount Rates*, 104 AM. ECON. REV. 538 (2014); Kenneth Arrow et al., *Should Governments Use a Declining Discount Rate in Project Analysis?*, 8 REV. ENVTL. ECON. & POL'Y 145 (2014); Intergov't Panel on Climate Change, *Climate Change 2014: Synthesis Report* (2014).

⁷⁹ First demonstrated in Martin L. Weitzman, *Gamma Discounting*, 91 AM. ECON. REV. 260 (2001), the certainty-equivalent discount rate declines over time and towards the lowest possible rate under uncertainty about the future discount rate; this result stems directly from taking expectations over the discount factor instead of the discount rate.

⁸⁰ Christian Gollier, *Should We Discount the Far-Distant Future at Its Lower Possible Rate?*, 3 ECON. OPEN-ACCESS (2009); Christian Gollier, *Ecological Discounting*, 145 J. ECON. THEORY 812 (2010).

schedules,⁸¹ and several empirical discount rate schedules have been estimated for the United States.⁸² Importantly, as detailed further below (Section II.C), broadly adopting a declining discount rate schedule for use in agency analysis can help agencies resolve possible inconsistencies in their application of discount rates, which may otherwise create some legal risks.

If the Working Group instead decides to continue using constant discount rates rather than a declining discount rate schedule, the Working Group should still adjust those constant rates downward to account for growth uncertainty. In the past, the Working Group essentially reduced its central discount rate (which had been 3%) down by 0.5% to produce a lower rate (i.e., 2.5%) that somewhat better accounted for growth uncertainty. If the Working Group continues to apply this approach, it should check the latest literature to determine the most appropriate rate reduction that will reflect growth uncertainty. For example, Drupp et al. (2018)'s data suggests a rate reduction of 0.7% may be more appropriate,⁸³ and other literature could support even greater reductions. Since the discussion in the section above revealed a growing consensus for a central discount rate value at or below 2% based on the simple Ramsey formula, the extended formula may suggest that a constant discount rate that reflects growth uncertainty should be between 1.3% to 1.5%.⁸⁴ That said, for the reasons given above, a declining discount rate framework would be preferable.

I.D.2. Project Risks and GDP-Damage Correlations

In the past, the Working Group justified using a higher discount rate for sensitivity analysis on the grounds that climate damages could be positively correlated with GDP.⁸⁵ But more recent thinking about such

⁸¹ 2021 Interim TSD, *supra* note 1, at 21-22.

⁸² See Newell & Pizer, *supra* note 44; Ben Groom et al., *Discounting the Distant Future: How Much Does Model Selection Affect the Certainty Equivalent Rate?*, 22 J. APPLIED ECONOMETRICS 641 (2007); Mark C. Freeman et al., *Declining Discount Rates and the Fisher Effect: Inflated Past, Discounted Future?*, 73 J. ENVTL. ECON. MGMT. 32 (2015). Under a variety of assumptions about the stochastic process underlying discount rates, Bauer & Rudebusch (2020), *supra* note 45, demonstrate a declining term structure that shifts with the equilibrium real interest rate. Using elicited social discount rate data, Weitzman (2001), *supra* note 79, and Mark C. Freeman & Ben Groom, *Positively Gamma Discounting: Combining the Opinions of Experts on the Social Discount Rate*, 125 ECON.J. 1015 (2015) derives two alternative gamma discount rate schedules depending on whether experts provided forward or spot rates. However, these two schedules also depend on interpreting the elicited responses as normative values, and flatter schedules result if interpreted fully or partially as forecasts (as collecting more data should produce an asymptotically efficient estimate assuming unbiased responses).

⁸³ Drupp et al. (2018), *supra* note 68. Note that a Ramsey equation could be calibrated to this lower rate following methods similar to Howard and Sylvan (2020) or Hansel et al. (2020). Alternatively, the ethical parameters underlying the Ramsey equation could be applied on the theoretical specification: $-0.5\eta(1 + \eta)\sigma^2$. Assuming η equals 1 or 1.35 based on the mean and median in Drupp et al., (2018) and a growth rate of per capita consumption of 2% with a 4% standard deviation, the precautionary savings effect $-0.5\eta(1 + \eta)\sigma^2$ is -0.2% to -0.3%. If we consider the maximum value $\eta = 3$, then the term becomes -1% and even higher at -1.3% when considering the standard Epstein-Zinn calibration of $\psi = 10$ and $\eta = 2/3$.

⁸⁴ When we jointly control for declining discount rates and limited substitution between market and non-market goods, the discount rate only falls by 0.5%. However, in this case, the Working Group should also control for limited substitution, resulting in a discount rate of approximately 1%.

⁸⁵ 2010 TSD, *supra* note 1, at 20; 2021 Interim TSD, *supra* note 1, at 17.

correlations, project risks, and “climate betas” suggests there is as much, if not more, reason to favor a lower discount rate.

Climate damages could be positively correlated with GDP. To begin, the reduced-form IAMs calculate damages as a percentage of GDP,⁸⁶ so as GDP increases, the monetized damages calculated by the IAMs will increase as well. High GDP also suggests greater economic activity, which could correlate with increased emissions, and so each extra marginal ton of emissions will inflict greater damages given high background concentrations of greenhouse gases and a climate system that is already stressed. Additionally, at a higher global GDP, individuals may have greater wealth and so have an increased willingness to pay for environmental protection, thus increasing the monetized damages from climate change.⁸⁷ But if a world with greater climate damages is also a world with higher overall GDP—and with all the welfare benefits of higher GDP—a self-interested current generation arguably may prefer to spend fewer resources on climate mitigation and more resources on its own current consumption, on the assumption that the richer future world can take care of itself. (Note that, because climate change may involve irreversible and catastrophic damages that make future attempts at climate mitigation or adaptation much more expensive or impossible, this may prove to be a bad assumption. Reasons why damages and GDP may *not* be positively correlated are explored below.)

Climate mitigation policies can be thought of as insurance policies, protecting the future against the worst-case outcomes. But if a climate mitigation policy will pay off the most in the future only in a world with a higher overall GDP, perhaps the climate policy was not such good insurance. If high climate damages are more likely than not to be correlated with high GDP, the current generation may prefer its own consumption over climate mitigation efforts, and thus adopt a higher discount rate.⁸⁸

In the past, the Working Group used this line of thinking to justify selection of a much higher discount rate (5%) for sensitivity analysis, as compared to its central rate (3%).⁸⁹ The Working Group also acknowledged in the past that returns to climate policies could instead be *negatively* correlated with market returns, such that a climate policy will pay off more in the future if overall GDP declines. The Working Group combined this rationale together with two other independent rationales for lower discount rates—

⁸⁶ DICE and PAGE have proportional damage functions. FUND has a mix, but even the non-proportional damages are proportional to income, though not explicitly.

⁸⁷ Note that if damage estimates do not reflect this increased willingness to pay for environmental protection, this fact may weigh in favor of a *lower* discount rate. See Revesz & Shahabian, *supra* note 29, at 1159; W. Kip Viscusi et al., *Responsible Precautions for Uncertain Environmental Risks*, 10 J. BENEFIT COST ANAL. 296, 312 (2019) (“If there is a positive income elasticity with respect to the benefit component, the unit benefit values will also be increasing over time at some growth rate g . Because benefits are also increasing, the pertinent net discount rate that accounts for the effect of the rising level of incomes on policy benefits is approximately $(1 + r - g)^n$.”).

⁸⁸ Arguably, society should put less weight on projects that increase society’s aggregate risk and more weight on projects that decrease this risk. See Christian Gollier, *The Cost-Efficiency Carbon Pricing Puzzle* (Working Paper, 2021). But see Revesz & Shahabian, *supra* note 29, at 1131 (noting that while an earlier generation may be entitled to retain a greater share of resources if they work hard to generate those resources, an earlier generation may also be responsible for protecting subsequent generations if the earlier generation caused the harm, and ultimately questioning whether “the choice of a discount rate” can adequately address such moral issues).

⁸⁹ 2010 TSD, *supra* note 1, at 20.

uncertainty over economic growth, and ethical objections in an inter-generational context—to also calculate a slightly lower rate (2.5%) for sensitivity analysis.⁹⁰

The Ramsey equation can be extended with an additional term to account for project risk.⁹¹ Applying standard assumptions incorporated by the current IAMs, the equation can be rewritten as:

$$r = \rho + \eta \mu - 0.5\eta^2\sigma^2 + \beta\eta\sigma^2$$

where β (“beta”) captures the uncertainty or risk about the returns that climate policies will deliver for future consumption. A positive beta suggests that climate mitigation policies will pay off more if the world is in a better overall economic state, and thus suggests a higher discount rate; a negative beta suggest that climate mitigation policies will pay off more if the world is in a worse overall economic state, and thus suggest a lower discount rate.

Though some past work seemed to support a positive climate beta estimate,⁹² there are numerous reasons to doubt that beta is positive. Some recent work has critiqued past estimates of positive betas⁹³ and instead estimated negative climate betas.⁹⁴ More generally, a positive correlation between damages and GDP may not hold, or climate betas may possibly be negative, under numerous conditions:

⁹⁰ *Id.* at 23.

⁹¹ Simon Dietz et al., *The Climate Beta*, 87 J. ENVTL. ECON. & MGMT. 258 (2018); Christian Gollier, *Discounting and Growth*, 104 AM. ECON. REV. 534 (2014).

⁹² See Dietz et al. (2018), *supra* note 91 (finding that the climate beta is positive when uncertainty is primarily driven by emissions-neutral progress (i.e., not climate impact uncertainty) and climate damages are small). William D. Nordhaus, *Estimates of the Social Cost of Carbon: Background and Results from the RICE-2011 Model* (NBER tech. rep., 2011) hints at a positive climate beta when he states that DICE finds the climate damages are largest when GDP is largest. However, Nordhaus’ observation is partially driven by DICE’s proportional damage function that builds-in a structural climate beta of 1. See Ton S. van den Bremer & Rick van der Ploeg, *The Risk-Adjusted Carbon Price* (CESifo Working Paper No. 7592, 2019); Stefano Giglio et al., *Climate Finance* (NBER Working Paper 28226, 2020); Lemoine, *supra* note 75. Specifically, climate damages are measured in DICE as a percentage of GDP, such that any shock to GDP explicitly impacts damages and emissions positively.

⁹³ Lemoine, *supra* note 75, argues that Dietz et al. (2018)’s finding of a positive climate beta, instead of a negative beta, is due to insufficient damage variance (as damage uncertainty operates primarily through the growth insurance channel); this critique would be consistent with recent discussions by William D. Nordhaus, *Revisiting the Social Cost of Carbon*, 114 PNAS 1518 (2017); *Climate Change: The Ultimate Challenge for Economics*, 109 AM. ECON. REV. 1991 (2019), and by Richard S. Tol, *The Economic Effects of Climate Change*, 23 J. ECON. PERSPECTIVES 29 (2009), *The Economic Impacts of Climate Change*, 12 REV. ENVTL. ECON. & POL’Y 4 (2018). The Dietz et al. (2018) damage function relies partially on Tol (2009)’s meta-analysis. Using similar data and techniques as Tol (2009), Nordhaus (2017) increases his meta-regression’s standard error estimate to half the damage coefficient because the OLS standard error was too small. Nordhaus (2019) replaces this damage function with two damage functions derived using meta-analysis. Consistent with Nordhaus (2017)’s argument, these two damage functions significantly differ indicating an underestimating of uncertainty. Even Tol (2009) notes that the underlying damage estimates omit categories of climate damages (and benefits), while Tol (2018) updated the estimates conducting additional sensitivity analyses. In fact, Tol (2018)’s meta-regression estimates fairly wide standard errors after adjusting for the uncertainty underlying the damage estimates themselves. Specifically, Tol (2018) states, “The uncertainty about the estimates of the impact of climate change on total economic welfare is rather large.”

⁹⁴ Lemoine, *supra* note 75 (finding a negative climate beta with damages impacting consumption growth, consumption, damage, and temperature uncertainty, and no tipping points). See also Maria Sandsmark & Haakon Vennemo, *A Portfolio*

- if climate change affects economic growth rates⁹⁵ or fundamentally alters available resources;⁹⁶
- if climate damages are not just a function of GDP but are additive independent of changes in income;⁹⁷
- if catastrophic climate risks occur or if sudden tipping points break any proportional relationship between GDP and climate damages;⁹⁸
- if more standard assumptions about risk aversion are applied;⁹⁹
- if adaptation increases with income,¹⁰⁰ and so climate damages become negatively correlated with income growth as a wealthier future society adapts;¹⁰¹

Approach to Climate Investments: CAPM and Endogenous Risk, 37 ENVTL. RES. ECON. 681 (2007); K. Daniel et al., *Applying Asset Pricing Theory to Calibrate the Price of Climate Risk* (NBER Working Paper 22795, 2015); but see Dietz et al., *supra* note 91 (challenging the methodology).

⁹⁵ Lemoine, *supra* note 75. Some evidence points to growth impacts existing, M. Burke et al., *Global Non-Linear Effect of Temperature on Economic Production*, 527 NATURE 235 (2015) and others only in developing countries, M. Dell et al., *Temperature Shocks and Economic Growth: Evidence from the Last Half Century*, 4 AM. ECON. J.: MACROECON. 66 (2012); M. Letta & R.S. Tol, *Weather, Climate and Total Factor Productivity*, 73 ENVTL. & RES. ECON. 283 (2019), though this work is controversial, Richard G. Newell et al., *The GDP-Temperature Relationship: Implications for Climate Change Damages*, 108 J. ENVTL. ECON. & MGMT. 102,445 (2021). As growth impacts are more likely as climate change becomes more severe, C.P. Traeger, *Why Uncertainty Matters: Discounting Under Intertemporal Risk Aversion and Ambiguity*, 56 ECON. THEORY 627 (2014); Peter Howard & Derek Sylvan, *Gauging Economic Consensus on Climate Change* (Policy Integrity Report, 2021), the beta likely declines in severity.

⁹⁶ Revesz & Shahabian, *supra* note 29, at 1153 (noting that if climate change impacts the natural resources needed to drive growth, growth could plummet or even turn negative); *id.* at n.246 (citing Heal's observation that estimates of productivity growth based on historical records omit depletion of natural resources, and thus bias discount rates upwards).

⁹⁷ van den Bremer & van der Ploeg, *supra* note 92, at 30.

⁹⁸ Giglio et al. (2018), *supra* note 38; Giglio et al. (2020), *supra* note 92; *see also* Revesz & Shahabian, *supra* note 29, at 1149-52 (warning that the irreversible, uncertain, and catastrophic risks of climate change disrupt the opportunity cost rationale for discounting; while it may seem that a future, wealthier generation may have better opportunities to address climate change, irreversible or catastrophic damages could arise that make future mitigation efforts more expensive or impossible).

⁹⁹ Lemoine, *supra* note 75, and van den Bremer & van der Ploeg, *supra* note 92, demonstrate that the climate beta is certain to be negative even in the face of proportionality due to the uncertainty over the model parameters producing covariances between these parameters and consumption. There are two questions: (1) the correlation between consumption per capita and abatement; (2) the correlation between growth in consumption per capita and abatement. If relative risk aversion is greater than 1 in the case of isoelastic preferences (a standard assumption in IAMs using isoelastic preferences), Lemoine (2021) and van den Bremer & van der Ploeg (2019) demonstrate that the climate beta is certain to be negative as the growth insurance channel dominates the damage scaling effect via proportional damages (also known as, the built-in climate beta).

¹⁰⁰ Tol (2018), *supra* note 92; Howard & Sylvan (2021), *supra* note 95.

¹⁰¹ Giglio et al. (2018), *supra* note 38; Giglio et al. (2020), *supra* note 92.

- if climate damages are distributed unevenly across sectors, such that non-market goods and services suffer disproportionate impacts not necessarily connected to any rise in GDP;¹⁰²
- or if climate damages and GDP growth are distributed unevenly across the world, with the countries suffering the most from climate damages experiencing the least economic growth.¹⁰³

Under such conditions, climate betas may be more likely to be negative than positive, and so the discount rate could be much lower.¹⁰⁴

Another consideration is that climate betas capture whether GDP is generally correlated with damages, but do not necessarily capture whether extreme risks at the tail end of probability distributions are aligned, such that a low-probability but catastrophic climate outcome could be correlated with certain lower-probability GDP outcomes. If a key motivation of insurance-like climate policies is to avoid worst-case outcomes, climate betas may not fully capture that.

Any discount rate that the Working Group selects for sensitivity analysis based on assumptions about positive or negative GDP-damage correlations should reflect realistic assumptions about growth, should be empirically grounded,¹⁰⁵ and should also deal with the fact that the climate beta may change over time.

¹⁰² Non-market damages make up a large portion of damage. Peter H. Howard & Derek Sylvan, *Expert Consensus on the Economics of Climate Change* (Policy Integrity Report, 2015); Peter H. Howard & Thomas Sterner, *Few and Not So Far Between: A Meta-Analysis of Climate Damage Estimates*, 68 ENVTL. & RES. ECON. 197 (2017). Agriculture, outdoor recreation, and other sectors could also be disproportionately affected. Though non-market damages are connected to GDP to some extent, as willingness to pay for non-market services increases with income (directly) and increased scarcity (indirectly), if non-market damages make up a large portion of total damages, the climate beta may be less connected to GDP. Traeger, *supra* note 95.

¹⁰³ Revesz & Shahabian, *supra* note 29, at 1155. The issue of inter-regional equity could also be addressed by equity weights, *id.* at 1156, and issues of region-specific discount rates are complex. But at a more general level, because the ethical issues of inter-generational discounting can also implicate inter-regional equity, a higher discount rate based on climate betas may be inadvisable, and a lower discount rate may be justifiable.

¹⁰⁴ Lemoine, *supra* note 75, estimates a discount rate of 3% in the short-run, declining to 1% in around 500 years (and the deterministic discount rate declines from 3% to 1.5% implying that IWG's 3% rate is high even under certainty), while Giglio et al. (2018), *supra* note 38, finds a discount rate below the risk-free rate of 1.5% (1% to 2%). van den Bremer & van der Ploeg, *supra* note 92, find a discount rate of 2.9% in the base period (i.e., "not growth corrected") with a pure rate of time-preference of 1.5%. Note that their market rate uses a pure rate of time preference of 5.5%, which far exceeds the 95th percentile in Drupp et al. (2018) of 4% and is likely more consistent with a capital discount rate.

¹⁰⁵ Even if a climate beta were to be positive, it is critical to note that economic theory still implies that the deterministic discount rate (i.e., the simple Ramsey equation) used to derive the central discount rate by the Working Group would exceed the certainty-equivalent discount rate under growth and project uncertainty as long as if $\beta > 0.5\eta \approx 1$ if $\eta \approx 2$ (Using the theoretical specification of the risk premium $r = \rho + \eta \mu - 0.5\eta^2 \sigma^2 + \beta \eta \sigma^2$, we can also rewrite the extended Ramsey equation as $r = \delta + \eta * \mu + \eta \sigma^2 (\beta - 0.5\eta)$). The Working Group should take note of Lemoine (2021)'s response to Dietz et al. (2018). Under isoelastic preferences (as assumed by the Working Group), starting with the Working Group's prior central risk-free rate of 3% and then adjusting for project risk, only the Working Group's prior rate of 2.5% (as opposed to the 5% rate) makes empirical sense. However, since the Working Group assumed $\eta > 1$ and applied isoelastic preferences, see 2010 TSD *supra* note 1, the climate beta should be negative, see Lemoine, *supra* note 75, implying that a rate of 2.5% appears high under the Working Group's prior assumptions (and the 5% discount rate is not justifiable under current

Moreover, if Working Group continues to assume that $\eta > 1$ and continues to apply isoelastic preferences, then, as Lemoine (2021) shows, the climate beta is negative and could justify only a downward shift from the risk-free discount rate (not an upward shift, as the Working Group assumed in 2010 by adopting the 5% discount rate for sensitivity analysis).¹⁰⁶ Furthermore, any upward adjustment to account for project risk in sensitivity analysis should be accompanied by another discount rate for sensitivity analysis that is adjusted down by at least the same (if not greater) proportion, given the evidence of possible negative climate betas. This downward adjustment should not be rolled into the same adjustments made for growth uncertainty and ethical considerations (as in 2010, when the Working Group said that its single adjustment from 3% down to 2.5% for sensitivity analysis covered three different rationales—growth uncertainty, negative correlations, and inter-generational ethics). Instead, any adjustment made for project risk should be separate from adjustments made for growth uncertainty and inter-generational ethics.

Ultimately, the precise effect of the climate beta on the discount rate is somewhat uncertain, because it is also mediated by the risk premium (i.e., the amount of excess return that individuals demand as compensation for exposure to risk), and estimates of the risk premium from market data and economic models vary.¹⁰⁷ One solution to deal with this issue is to apply Epstein-Zin-Weil preferences, as explored next.

I.D.3. Separating Risk Aversion from Inequity Aversion

In the simple Ramsey equation, η is the elasticity of the marginal utility of consumption, but also represents the coefficient of relative risk aversion, as well as the aversion to inequality over time. Having one variable do triple duty masks how individual factors influence the discount rate.¹⁰⁸ A related problem arises with estimating the “insurance premium,” which is the product of the climate beta (β) multiplied by the risk premium (π). While market data supports a risk premium as high as $\pi = 5\%$, application of isoelastic preferences support $\pi = \eta\sigma^2 \approx 0.3$ to 0.5% . This discrepancy is known as the “equity premium puzzle,” and it complicates applying an insurance premium.¹⁰⁹

One solution to these issues, accepted in much of the literature, is to apply Epstein-Zin-Weil preferences and separate out the risk aversion parameter from the aversion to inter-generation inequality. Those two

modeling assumptions and instead should lower the discount rate below the risk-free rate). Regardless, given recent empirical evidence, both the risk-free rate and the risk-adjusted rate should be lowered.

¹⁰⁶ See *supra* note 105.

¹⁰⁷ Dietz et al. (2018), *supra* note 91; Drupp et al. (2018), *supra* note 68.

¹⁰⁸ In fact, it is quintuple duty as the aversion to income inequality equals the inverse of the elasticity of intertemporal substitution. Plus, in the extended Ramsey equation, one plus the elasticity of marginal utility of consumption is society’s level of prudence (i.e., aversion to ambiguity).

¹⁰⁹ Dietz et al. (2018), *supra* note 91, at 271 (“The large discrepancy between these two recommendations may be seen as a manifestation of the well-known ‘equity premium puzzle.’ Three decades of research on this financial puzzle suggests that the model-based CCAPM approach fails to capture many dimensions of the real world, in particular the existence of structural uncertainties and fat tails (Weitzman, 2007b). Although including these dimensions in our model is beyond the reach of this paper – a new concept of β will need to be developed to accommodate these features – we are inclined to accept this position.”).

parameters are not, in fact, the same: real-world evidence suggests that while risk aversion tends to be higher, aversion to inter-generational inequality is low. Disentangling those parameters and recalibrating the extended Ramsey equation results in even lower discount rates.¹¹⁰ Interestingly, Gollier (2017), a primary advocate of a positive climate beta, finds a constant or slightly declining discount rate when jointly addressing uncertainty and risk.¹¹¹

The Working Group should consider adopting the methodology of Traeger (2014)¹¹² to analyze the extended Ramsey rate under Epstein-Zin-Weil preferences and with growth and project uncertainty, but when the climate beta is unknown. Traeger assumes that the unknown climate beta parameter is uniformly distributed from -1 to 1. The Working Group could begin by calculating a central declining discount rate schedule that assumes no correlation between growth and project risk (though considering growth uncertainty). Then for sensitivity analyses, the Working Group could follow Traeger, bounding the extended Ramsey discount rate by assuming that climate betas are between -1 and 1, such that:

$$r = \rho + \eta g - 0.5\psi(1 + \eta)\sigma^2 \pm \psi\sigma^2$$

where ψ is relative risk aversion and η is aversion to intergenerational inequality. If the Working Group had used that approach with its original data and estimates from 2010, it would have found a central rate at 2.5%, with a range of 0.5%-4.5%. (Though note, as explained above, in 2010 the Working Group assumed $\eta > 1$ and so should have applied a negative climate beta.) After recalibrating these estimates based on new market data, new expert elicitations and other evidence about the parameters, and a declining discount rate framework, this approach should result in a lower central estimate and a lower range.

I.D.4. Ambiguity Aversion

Ambiguity—that is, “unknown unknowns”—can further affect the discount schedule, because people and governments are generally ambiguity adverse, such that the certainty-equivalent discount rate declines and the risk premium increases.¹¹³ Empirical evidence indicates that humans are ambiguity adverse: they prefer known unknown (i.e., probability distribution functions) to unknown unknowns (i.e., uncertainty over even the probability distribution functions). In fact, Traeger derives an additional term that further

¹¹⁰ E.g., Ravi Bansal et al., *Climate Change and Growth Risks* (NBER w23,009, 2017) (finding a risk-free rate of 0.9% annually and a consumption risk premium of 1.7%, implying 10-year and 100-year rates of 1.5% and 2.4%, respectively); Ravi Bansal et al., *Climate Change Risk* (2019), <https://perma.cc/4NUK-SVKJ> (finding a higher risk free rate at 1.83%); Y. Cai & T.S. Lotzenk, *The Social Cost of Carbon with Economic and Climate Risks*, 127 J. POL. ECON. 2684 (2019) (finding a discount rate of 2.4%); Lemoine, *supra* note 75 (implying a significant decline in the discount rate, based on the fact that the social cost of carbon estimate increases significantly when switching from isoelastic utility function to the Epstein-Zin preferences). Even Christian Gollier—a primary advocate of a positive climate beta—finds in Gollier et al., *Term Structures of Discount Rates: An International Perspective* (Toulouse School of Economics, 2017) only a maximum discount rate of 2-2.5%, and that is while not accounting for tipping points, underrepresenting damage uncertainty, failing to explicitly model adaptation, and failing to allow climate change to affect economic growth. Based on this literature overall, 2.5% seems to be the upper limit of discount rates without even the consideration of relative prices.

¹¹¹ Gollier et al. (2017), *supra* note 110.

¹¹² Traeger, *supra* note 95.

¹¹³ *Id.*; Giglio et al. (2020), *supra* note 92.

extends the Ramsey formula under Epstein-Zin-Weil preferences and demonstrates that ambiguity aversion decreases the discount rate, potentially by more than the precautionary effect (if ambiguity aversion is larger than risk aversion) and is unaffected by the direction of the project beta.¹¹⁴ In general, ambiguity version will decrease the discount rate—potentially quite significantly.¹¹⁵ The Working Group should carefully consider how to account for ambiguity uncertainty in its discount rates.

I.E. The Scarcity and Limited Substitutability of Non-Market Goods

Economists recognized decades ago that the value of non-market goods—particularly environmental goods and services—may increase relative to market goods if they become relatively scarcer.¹¹⁶ Environmental goods and services may naturally become scarcer over time, and climate change will almost certainly accelerate and exacerbate that trend. A future increase in market goods would not necessarily make up for, or substitute for, the loss of many kinds of environmental goods and services that may be threatened by climate change.¹¹⁷

Because the Ramsey equation incorporates a growth term, but non-market goods will grow at a lower rate than market goods, a discount rate based on the Ramsey equation applicable to non-market goods should be lower than a discount rate calibrated for market goods. And because impacts to non-market goods and services are expected to be a large portion of total climate damages,¹¹⁸ analysis of policies that will mitigate climate change and so preserve non-market goods should use lower discount rates (what can be called the “ecological discount rate”), as compared to the standard consumption discount rate.¹¹⁹ The magnitude of the decrease in the discount rate depends on how quickly non-market goods become scarcer and on how readily market goods can or cannot substitute for non-market goods.¹²⁰ In general, limited substitutability will lead to a lower ecological discount rate,¹²¹ and that rate should decrease further because uncertainty over the growth (or decline) of environmental goods and their relation to GDP is even greater than uncertainty over general economic growth (see Section I.D.1 on growth uncertainty).¹²² (Note that there

¹¹⁴ Traeger, *supra* note 95, at 651.

¹¹⁵ See Giglio et al. (2020), *supra* note 92.

¹¹⁶ Anthony C. Fisher & John V. Krutilla, *Resource Conservation, Environmental Preservation, and the Rate of Discount*, 89 Q.J. ECON. 358 (1975). Environmental goods may also be more valuable if the future is wealthier, since wealthier individuals have a higher willingness to pay to protect the environment.

¹¹⁷ See Revesz & Shahabian, *supra* note 29, at 1149 (warning of the potential incommensurability of environmental goods and money).

¹¹⁸ See Howard & Sylvan (2015), *supra* note 102; Howard & Sterner, *supra* note 102.

¹¹⁹ Frederick van der Ploeg, *Discounting and Climate Policy* (CESifo Working Paper 8441, 2020).

¹²⁰ *Id.*; Gollier (2010), *supra* note 80, at 825 (estimating environmental goods as a function of market goods finding a negative relationship) Moritz A. Drupp, *Limits to Substitution Between Ecosystem Services and Manufactured Goods and Implications for Social Discounting*, 69 ENVTL. & RES. ECON. 135 (2018); Moritz A. Drupp & Martin C. Hansel, *Relative Prices and Climate Policy: How the Scarcity of Nonmarket Goods Drives Policy Evaluation*, 13 AM. ECON. J.: ECON. POL’Y 168 (2021). Gollier (2010, p. 825) estimates.

¹²¹ Gollier (2010), *supra* note 80, at 814.

¹²² Gollier (2010), *id.*, proves these results when the loss of environmental and the loss of consumption goods are mutually aggregating. Specifically, Gollier (2010) proves these results when the representative agent is: risk adverse to market and non-market risks; correlation averse between market and non-market goods; prudence in market and non-market good

may be some additional considerations for health impacts as compared to other environmental impacts.¹²³)

Currently, the reduced-form IAMs used by the Working Group to calculate the social cost of greenhouse gases assume perfect substitutability of market and non-market goods, on both the consumption and production sides of the climate and economic models. If instead the models accounted for the real elasticities of substitution between market and non-market goods (in both the utility functions and the production functions), the relative growth rates of environmental goods and per capita consumption would become key parameters in calibrating the discount rate.

Analysts have two main choices to account for the scarcity and limited substitutability of non-market goods in climate models. First, analysts could apply estimates of future relative pricing to convert future non-market goods into consumption units commensurable with future market goods, then use a discount rate appropriate for general consumption (adjusted to depend partly on the relative growth of environmental goods over time).¹²⁴ Second, analysts can calculate an ecological discount rate, apply it to determine the present value of non-market goods, and then adjust the present value of non-market goods based on relative prices so they can be summed together with the present value of market goods. Because this report is about discounting, this section focuses somewhat more on the latter approach and summarizes some estimates an ecological discount rate.¹²⁵

On the consumption side, relaxing the assumption of perfect substitution would decrease the ecological discount rate, due to the lower—and likely negative—growth rate for non-market goods relative to

consumption; and cross-prudent in market and non-market good consumption. In other words, “the representative agent always prefers to incur one of the two harms for certain, with the only uncertainty being about which one will be received, as opposed to a 50–50 gamble of receiving the two harms simultaneously, or receiving neither.” *Id.*

¹²³ When addressing discounting of health impacts, the Working Group may want to consider additional issues. First, relative prices may be different for health than for environmental goods, as environmental goods are becoming relatively scarcer. Second, some of the reduced-form IAMs, in particular FUND, already adjusts the value of statistical life (VSL) for rising incomes. As this partially captures relative prices, the Working Group should consider replacing this VSL with a constant VSL if it plans to use a lower social discount rate based on relative prices (i.e., between 0% to 1%). Third, the U.S. VSL is based on a combination of contingent valuation and revealed preference studies, which do not originally specify or control for when the mortality event would (or was perceived to) occur, leading to the potential that the willingness to pay to avoid mortality risks was already at least partly discounted by the respondents; this can lead to double discounting compounded by the application of higher private discount rates by the respondents. Arden Rowell, *The Cost of Time: Haphazard Discounting and the Undervaluation of Regulatory Benefits*, 85 NOTRE DAME L. REV. 1505 (2010). As these additional considerations discussed here move in opposite directions, a prudent way forward for the Working Group may be to make no further adjustments for health impacts. But the Working Group should be aware of these issues.

¹²⁴ See M. Hoel & Thomas Sterner, *Discounting and Relative Prices*, 84 CLIMATIC CHANGE 265 (2007); Thomas Sterner & U.M. Persson, *An Even Sterner Review: Introducing Relative Prices into the Discounting Debate*, 2 REV. ENVTL. ECON. & POL’Y 61 (2008). Drupp and Hansel, *supra* note 120 (2021) demonstrate that the Sterner and Persson (2008) assumptions results in an ecological discount rate (r_e) six percentage points (6%) lower than the consumption discount rate (r_c) in the near term declining to a 3% difference by 2100. See also B.A. Bastien-Olvera & F.C. Moore, *Use and Non-Use Value of Nature and the Social Cost of Carbon*, 4 NATURE SUSTAINABILITY 101 (2021) (for different estimates).

¹²⁵ See Gollier & Hammitt, *supra* note 76. An additional benefit according to Gollier (2010), *supra* note 80, at 813, is that the latter method is easier to implement under uncertainty, as the former method requires the calculation of certainty equivalent non-market damages.

standard economic growth. In general, if environmental goods grow at a lower rate than market goods, the ecological discount rate is always below the consumption discount rate, and the discount rate declines over time if the elasticity of the marginal utility of the environmental good with respect to market good consumption is decreasing over time (a reasonable assumption under positive economic growth rates and evidence of declining environmental goods and services).¹²⁶

Some early modeling exercises, which assumed fairly strong complementarity (thus, more limited substitution), found that the ecological discount rate would be significantly lower than the market discount rate.¹²⁷ For example Sterner and Perssons (2008) found a relative price difference of 4.8%, suggesting an ecological discount rate much lower than the consumption discount rate.¹²⁸ Taking into account the fact that some level of ecosystem services is necessary for basic subsistence, Drupp (2018) finds that the average ecological discount rate is initially 1.1% lower than the market rate in the current period, and the rate is 1.5% lower over 300 years.¹²⁹ Using real world data, Baumgärtner et al. (2015) estimate the ecological discount rate will be about 0.9% lower than the consumption discount rate, though the authors believed that to be an underestimate.¹³⁰ Using categories non-market goods with similar sectoral coverage as reduced-form IAMs' damage functions, Drupp and Hansel (2021) find the ecological discount rate to be 1.8% lower than the consumption discount rate.¹³¹ It is notable that in a survey of discount rate experts, Drupp et al. (2018) find that respondents commenting on relative prices provide a significantly lower

¹²⁶ See Gollier (2010), *supra* note 80; C.P. Traeger, *Sustainability, Limited Substitutability, and Non-Constant Social Discount Rates*, 62 J. ENVTL. ECON. & MGMT. 215 (2011) (but note that ecological discount rate can increase when the elasticity of substitution declines, though not necessarily, contrary to common conception).

¹²⁷ See Hoel & Sterner, *supra* note 124; Gollier (2010), *supra* note 80; R.E. Kopp et al., *The Influence of the Specification of Climate Change Damages on the Social Cost of Carbon*, 6 ECON.: OPEN ACCESS 1 (2012).

¹²⁸ Sterner & Persson, *supra* note 124. Some other findings include: N.R. Kocherlakota, *The Equity Premium: It's Still a Puzzle*, 34 J. ECON. LIT. 42 (1995) finds that environmental goods declines in market goods and estimates $r_e = 1.5\%$ and $r_c = 3.2\%$ driven by the economic growth rate far exceeding the ecological growth rate (i.e., assuming $\sigma = 1$ which is relatively close to the latest empirical evidence in Drupp and Hansel, *supra* note 120). A lower wedge of 1% by S. Baumgärtner et al., *Ramsey Discounting of Ecosystem Services*, 61 ENVTL. & RES. ECON. 273 (2015), and 1.1% increasing to 1.5% by Drupp (2018), *supra* note 120, are estimated with an earlier empirical estimate of the elasticity of substitution of $\sigma = 2.2$, updated by Drupp & Hansel, *supra* note 120, to $\sigma = 1.3$. Gollier (2010), *supra* note 80, estimates $r_e = 1.5\%$ and $r_c = 3.2\%$, so a wedge of 1.7%. Again, this indicates that a 3% discount rate in the climate change context when damages are split 50-50 between market and non-market damages is unlikely.

¹²⁹ Drupp (2018), *supra* note 120.

¹³⁰ Using real world data for 10 ecosystems for five countries finding that $r_c - r_e = 0.9 \pm 0.3$ globally based on a central value of $\sigma = 2.6$.

¹³¹ Drupp & Hansel, *supra* note 120. They also find a mean estimate of a relative price difference of 2.7% (use their best judgement to select $\sigma = 0.9$ with a 95th percent confidence interval of $\sigma = 0.7$ to $\sigma = 1.3$; estimate of relative prices 95th percent confidence interval of 1.8% to 3.5%) which would imply needing to lower the pure rate of time preference by 0.6% when calculating an ecological discount rate using the Ramsey equation, on the optimal path, though the relative value for calculating the SCC is unclear (as it is likely larger in BAU setting and likely smaller with lower values of δ and η).

discount rate than other experts did: 1% lower.¹³² Other countries have recommended discounting environmental goods at a 1% lower rate due to findings like this.¹³³

While the initial literature focuses on substitution on the consumption side, ecosystem services also support the production of goods and services: therefore, scarcity and the limited substitutability of physical or human capital in place of natural capital in the production process can also have effects relevant for the discount rate. If the elasticity of substitution in the production function is less than 1, then the consumption discount rate will decline over time towards the ecological discount rate.¹³⁴ A sufficiently negative growth rate in environmental services could even push the market discount rate below the pure rate of time preference. There is little empirical evidence on the elasticity of substitution between natural and other capital in the production function. Despite the uncertain elasticity of substitution, Gollier (2019) assumes that uncertain future economic and environmental growth rates follow random walks, and shows that the ecological discount rate always declines and decreases over time with a mean preserving spread. Calibrating the model to real world asset data, Gollier finds in the near term a risk-free discount rate (from the extended Ramsey equation) of 1.22%, a risk premium of 2.18%, and an ecological discount rate of approximately 1.62%.¹³⁵

In short, there is sufficient evidence to justify further lowering the discount rate based on the increasing scarcity and limited substitutability of non-market goods over time.

I.F. Multiple Adjustments Together Will Yield Lower Discount Rates

To summarize the main conclusions from above, multiple lines of evidence point toward a lower discount rate than 3%. First, market data now suggest a central consumption-based discount rate under 2%—before accounting for uncertainty, risk, or relative prices. If we embrace the Epstein-Zin-Weil preferences (based on the Working Group’s desire to look at possible positive or negative correlation between GDP and climate damages)—and calibrate with common parameter values, the central discount rate is approximately 2% in the short-run (with a range of 1.7% to 2.3%), shifting to a long-run rate of approximately 1.9% (with a range of 1.5% to 2.4%). As these values do not account for the precautionary term becoming more negative over time or growth rates slowing down, a formal modeling of these declining rates is necessary, or the pure rate of time preference should decline to between 0% and 0.5%.

¹³² Drupp et al. (2018), *supra* note 68

¹³³ Based on this earlier empirical evidence of a 1% lower ecological discount rate, the Netherlands, France, and Norway recommend discounting environmental goods at a 1% lower rate. See Baumgärtner et al., *supra* note 128; X. Zhu et al., *Discounting in the Presence of Scarce Ecosystem Services*, 98 J. ENVTL. ECON. & MGMT. 102,272 (2019). However, the more recent work of Drupp and Hansel (2021), *supra* note 120, and Drupp et al. (2018), *supra* note 68, imply that this is likely an underestimate in the case of integrated assessment models putting the relative price difference closer to 2%.

¹³⁴ For example, the market discount rate will decline from 3% to 2.4% under an elasticity of substitution of 1 and relatively optimistic environmental growth assumptions. Zhu et al., *supra* note 133.

¹³⁵ To address the equity premium puzzle, Christian Gollier, *Valuation of Natural Capital Under Uncertain Substitutability*, 94 J. ENVTL. ECON. & MGMT. 54 (2019), assumes that there are infrequent consumption disasters (an alternative solution to Epstein-Zin-Weil preferences). While the ecological discount rate is relatively stable for 40 years, it rapidly collapses to negative infinity thereafter (reaching negative rates in 45 years and triple digit negative rates within 50 years). This implies a bliss maturity rate of less than 100 years.

This places the range at between 0.5% and 1.9% in the long-run. Finally, the relative prices of non-market goods can further push down both the ecological discount rate and the market discount rate, which can be approximated by further decreasing the pure rate of time preference by 0.6% or more. In light of that, but taking a conservative approach (and also recognizing that the lowest discount rate that the Working Group previously used was 2.5%), a new range of discount rates appropriate for calculating the social cost of greenhouse gases could be conservatively estimated as between 0.5%-2.5%, with a central estimate of 1.5%.

That could indeed still be a conservative overestimate, because the factors explored above could all interact. In much of the literature discussed above, economists study the effect of adjusting one parameter at a time. But all of these adjustments—growth uncertainty, project uncertainty, ambiguity aversion, relative prices of non-market goods—are warranted and should be implemented by the Working Group. The adjustments may be additive, and they may also interact and result in further effects to the discount rate. For example, because market and non-market goods may not be linked in the same way to GDP, accounting for the limited substitution between non-market and market goods may further undermine the argument for a positive climate beta.

Any combination of the recommendations outlined above—using more recent market data; switching to an extended Ramsey framework that can be calibrated with expert elicitations as well as market data; adjusting for growth uncertainty, project uncertainty, ambiguity aversion, and relative prices of non-market goods—will lower the discount rates selected by the Working Group. The next section of the report outlines the legal principles the Working Group and agencies should consider when changing their choice of discount rates.

II. Legal Principles for Selecting the Discount Rate

In March 2017, President Trump issued Executive Order 13,783, disbanding the Working Group and advising agencies to reconsider “appropriate discount rates . . . consistent with the guidance contained in OMB Circular A-4” when monetizing the value of changes in greenhouse gas emissions.¹³⁶ Agencies quickly interpreted those instructions as a command to apply both default discount rates from *Circular A-4* when calculating the social cost of greenhouse gases: the 7% capital-based rate as well as the 3% consumption-based rate.¹³⁷

In February 2021, the reconstituted Working Group readopted, on an interim basis, the same three consumption-based discount rates it had first derived in 2010, and it thoroughly explained why the 7% capital-based rate was inappropriate.¹³⁸ Since then, two lawsuits have already challenged the Working

¹³⁶ Exec. Order No. 13,783 § 5(c), 82 Fed. Reg. 16,093, 16,096 (Mar. 31, 2017).

¹³⁷ Bureau of Land Mgmt., Regulatory Impact Analysis for the Proposed Rule to Suspend or Delay Certain Requirements of the 2016 Waste Prevention Rule at 55 (2017), <https://perma.cc/2H7P-RQBF>; accord Env'tl. Prot. Agency, Memorandum: Estimated Cost Savings and Forgone Benefits Associated with the Proposed Rule “Oil and Natural Gas: Emission Standards for New, Reconstructed, and Modified Sources: Stay of Certain Requirements” at 8, 15, Oct. 17, 2017, <https://perma.cc/L2JM-NNVR>.

¹³⁸ 2021 Interim TSD, *supra* note 1, at 18-19.

Group’s approach to the discount rates, arguing that the Working Group had failed to adequately explain its change from the prior administration’s approach, its departure from *Circular A-4*’s guidance, or more generally its refusal to use the 7% capital-based rate.¹³⁹ These will certainly not be the last lawsuits over the social cost of greenhouse gases, and because the choice of the discount rate has a prominent effect on the size of the social cost estimates, any future changes to the discount rates may attract additional legal challenges as well as political scrutiny.¹⁴⁰

This section explains that agencies have considerable discretion to implement best practices in selecting discount rates. As such, agencies should follow the Working Group’s guidance on applying new social cost of greenhouse gas estimates based on updated discount rates, and agencies also should make any appropriate corresponding adjustments to the discount rates used for other costs and benefits in their analyses. Agencies need to thoroughly justify their choices, explain any departures from prior practice or rejections of alternate options, and ground their decisions in the science and economics. Statutes and executive orders requiring agencies to base their decisions on the best available data and to consider the welfare of future generations should help bolster agencies’ authority to follow the Working Group’s guidance in selecting lower discount rates when calculating and applying the social cost of greenhouse gases. One issue that agencies should be particularly mindful of is the need either to consistently apply discount rates throughout their analyses, or else to adequately explain why different discount rates are appropriate and justified in different contexts.

II.A. The Laws Shaping Agencies’ Discretion on Discount Rates

It is somewhat rare for a statute to specify either the discount rate¹⁴¹ or the time horizon¹⁴² for analysis of an agency decision, though Congress has at times prescribed the discount rate for agencies to use in assessing the costs or benefits of particular projects, investments, grants, loans, employee compensation, and other similar analyses.¹⁴³ When Congress has not specified a rate, agencies are still generally obligated

¹³⁹ Complaint, *Louisiana v. Biden*, No. 2:21-cv-01074 (W.D.La. filed Apr. 22, 2021), available at <https://perma.cc/KV66-YF7T>; Complaint, *Missouri v. Biden*, No. 4:21-cv-00287-AGF at 20-21 (E.D. Mo. filed Mar. 8, 2021).

¹⁴⁰ For example, in 2017, some members of Congress introduced legislation seeking to prohibit use of the social cost of greenhouse gases unless the estimate “uses the discount rates of 3 and 7 percent.” H.R. 3117, 115th Cong. § 4(b)(2)(C) (2017).

¹⁴¹ It is possible Congress has never specified a discount rate to use in a regulatory cost-benefit analysis. See Cass Sunstein, *Cost-Benefit Default Principles*, 99 MICH. L. REV. 1651, 1711 (2001) (“I have been unable to find *any* statute that specified a discount rate for agencies to follow.”).

¹⁴² E.g., 42 U.S.C. § 8254 (specifying the Department of Energy determine a discount rate to apply in calculating the energy lifecycle costs of federal buildings over a period of either 40 years or the expected life, whichever is shorter). Cf. *Nuclear Energy Inst. v. EPA*, 373 F.3d 1251, 1270 (D.C. Cir., 2004) (explaining the fact that Congress “mentions 10,000 years” in a statute on setting standards for nuclear waste disposal did not mean Congress had set that period as the analytical time frame; in fact, the agencies needed to assess human health risks over a much longer period, since Congress required consistency with recommendations from the National Academy of Sciences).

¹⁴³ See, e.g., 42 U.S.C. § 2065(4)(B) (specifying that for determining the net present value of costs of uranium leases and take-back programs, the discount rate “shall be not greater than the average interest rate on marketable Treasury securities”); 42 U.S.C. § 1962d-17 (incorporating by reference the rate for discounting future benefits and costs in certain river basin plans and the evaluation of related projects); 33 U.S.C. § 579a(b)(2)(B)(x)-(xi) (incorporating by reference the discount rates to

to base decision on the best available information, and while these obligations are not always judicially enforceable, they create important norms that counsel agencies to review and update key values and inputs over time. Furthermore, the text and purpose of key statutes granting authority to administrative agencies reveal a concern for future generations, indicating a need for agencies to meaningfully consider the interests of future generations when exercising authority. Executive orders reinforce these twin requirements to use the best data and consider future generations. Together, such laws will provide supports for agencies' selection of updated discount rates that are well-grounded in the latest data and economic literature, and that are more appropriate to the inter-generational context of climate analysis. Courts will likely give agencies considerable discretion to update their discount rates consistent with best practices, but the case law defines some limits and so provides insights for agencies on how to proceed.

II.A.1. Statutes Require Use of the Best Available Data

Several statutes contain specific requirements for individual agencies to use the best available data in particular decisionmaking contexts.¹⁴⁴ Regardless of whether any such requirements are judicially enforceable, they all contribute to a norm for agencies to use the best available information in their economic analyses. A few notable statutory requirements apply more broadly across federal agencies and across multiple types of decisions.

For example, the National Environmental Policy Act (NEPA) broadly charges all federal agencies to “identify develop methods and procedures . . . [to] insure that presently unquantified environmental amenities and values may be given appropriate consideration,”¹⁴⁵ and the Council on Environmental Quality's implementing regulations for NEPA call on agencies to “ensure the professional integrity,

use in reporting the benefit-cost ratios of certain Army Corps of Engineers projects); 2 U.S.C. § 661a(5)(E) (specifying that for federal credit programs, using a discount rate of the average interest rate on Treasury securities of similar maturity); 16 U.S.C. § 838l(b)(1) (specifying use of the Treasury rate as the discount rate for Bonneville Power Administration refinancing); 45 U.S.C. § 821(1)(E) (specifying that for certain railroad financing, the discount rate is the average interest rate on marketable Treasury securities of similar maturity); 5 U.S.C. § 8135 (specifying that the U.S. government will use a 4% discount rate to calculate the present value of a lump-sum workers compensation payment).

Some of Congress's past pronouncements on discount rates may have become obsolete. *See, e.g.*, 10 U.S.C. § 2922b (Amendment Notes) (showing that Pub. L. 101-510 § 2852(a), 104 Stat 1485 (Nov. 5, 1990), struck out old statutory language requiring use of a 7% discount rate and a maximum 25-year period, and instead adopted new language allowing the cost-effectiveness of renewable energy systems to be determined using life-cycle cost methods set by the Department of Energy).

¹⁴⁴ *E.g.* 49 USC § 31136(f)(1) (“Within each regulatory impact analysis of a proposed or final major rule issued by the Federal Motor Carrier Safety Administration, the Secretary [of Transportation] shall, whenever practicable... (B) formulate estimates and findings based on the best available science.”); 42 USC § 300g-1(b)(3)(A) (“In carrying out this section [of the Safe Drinking Water Act], and, to the degree that an Agency action is based on science, the Administrator shall use (i) the best available, peer-reviewed science... and (ii) data collected by accepted methods or best available methods.”). In its guidelines implementing the Information Quality Act, OMB adopts the Safe Drinking Water Act's standard for information quality and applies it generally to all agencies' use of information in analyzing “risks to human health, safety and the environment.” 67 Fed. Reg. 8452, 8458 (Feb. 22, 2002) (adopting the “principles applied by Congress . . . [in] the Safe Drinking Water Act”).

¹⁴⁵ 42 U.S.C. § 4332(2)(B).

including scientific integrity of the discussions and analyses in environmental documents,” and to “make use of reliable existing data and resources.”¹⁴⁶

Another notably broadly provision, relevant to the application of the social cost of greenhouse gases, was adopted in the Energy Policy Act of 2005:

It is the sense of Congress that Federal agencies conducting assessments of risks to human health and the environment from energy technology, production, transport, transmission, distribution, storage, use, or conservation activities shall use sound and objective scientific practices in assessing such risks, shall consider the best available science (including peer reviewed studies), and shall include a description of the weight of the scientific evidence concerning such risks.¹⁴⁷

While the language expresses “the sense of Congress” and may not be strictly enforceable, it also uses the mandatory phrase “shall” and applies to any Federal agency’s analysis of any health or environmental risk from any “activit[y]” relating to energy, including the combustion of fossil fuels.

Even more broadly, in 2001, Congress passed the Information Quality Act (also known as the Data Quality Act), which required agencies, with OMB’s guidance, to “ensur[e] and maximiz[e] the quality, objectivity, utility, and integrity of information (including statistical information) disseminated.”¹⁴⁸ Though brief, the Information Quality Act requires all federal agencies—including independent agencies¹⁴⁹—to incorporate data that is objective, accurate, complete, and reliable. The term “information disseminated” has been interpreted by OMB to include both the risk assessments¹⁵⁰ and the cost-benefit analyses¹⁵¹ prepared by an agency to inform regulatory or other actions. According to OMB’s guidance, the standards for information quality and reproducibility are somewhat heightened for “influential scientific, financial, or statistical information” that “will have . . . a clear and substantial impact on important public policies,”¹⁵² but consistency with peer-reviewed studies makes technical and scientific information “presumptively objective.”¹⁵³ Thus whenever the choice of discount rate will have a

¹⁴⁶ 40 C.F.R. § 1502.23.

¹⁴⁷ 42 USC § 13557; Pub. L. 109-58, title XIV § 1401, 119 Stat. 1061 (Aug. 8, 2005).

¹⁴⁸ Information Quality Act § 515(a), 44 U.S.C. § 3516 note.

¹⁴⁹ The Information Quality Act applies to Federal agencies subject to the Paperwork Reduction Act. 67 Fed. Reg. at 8453 (“These guidelines apply to Federal agencies subject to the Paperwork Reduction Act.”). Because the Paperwork Reduction Act applies to “any executive department . . . or other establishment in the executive branch . . . or any independent regulatory agency,” 44 U.S.C. § 3502(1) (excepting only the General Accounting Office, the Federal Election Commission, the governments of the District of Columbia and U.S. territories, and “Government-owned contractor-operated facilities, including laboratories”), the Information Quality Act similarly applies to independent agencies.

¹⁵⁰ 67 Fed. Reg. at 8454 (providing “a risk assessment prepared by the agency to inform the agency’s formulation of possible regulatory or other action” as the main example of an “agency initiated distribution of information”).

¹⁵¹ *Id.* at 8457 (referencing a “regulatory impact analysis prepared by an agency for a major rule”); *see also* Circular A-4 at 43 (“Under the Information Quality Law, agency guidelines, in conformance with the OMB government-wide guidelines (67 FR 8452, February 22, 2002), have established basic quality performance goals for all information disseminated by agencies, including information disseminated in support of proposed and final rules. The data and analysis that you use to support your rule must meet these agency and OMB quality standards.”).

¹⁵² 67 Fed. Reg. at 8455.

¹⁵³ *Id.* at 8454 (but explaining that the presumption can be rebutted by persuasive evidence).

substantial influence on important policy decisions, agencies have a heightened responsibility to ensure their choice is objective, accurate, and consistent with peer-reviewed work. Some courts have held that the Information Quality Act is not judicially enforceable,¹⁵⁴ but it nonetheless creates important expectations and norms against which agencies can assess the quality of their data. Agencies' selections of discount rates will be on firmer footing if they clear the standards under the Information Quality Act.

II.A.2. Executive Orders Require Use of the Best Available Data

Reinforcing the above statutory requirements, several key executive orders require agencies to use the best available data—particularly in regulatory impact analyses. President Clinton's Executive Order 12,866, which continues to guide regulatory analyses today, requires executive agencies to base regulatory decisions “on the best reasonably obtainable scientific, technical, economic, and other information concerning the need for, and consequences of, the intended regulation.”¹⁵⁵ President Obama's Executive Order 13,563—also still operational today—expanded on that language to specify that “each agency is directed to use the best available techniques to quantify anticipated present and future benefits and costs as accurately as possible.”¹⁵⁶ That language was added in part to call attention to future generations (as discussed below), but more generally it directly implicates discounting, by calling on agencies to accurately weigh both present and future effects using the best techniques.

Even more broadly, at the end of President Biden's first week in office, he issued a *Memorandum on Restoring Trust in Government through Scientific Integrity and Evidence-Based Policymaking*. The two first sentences read:

It is the policy of my Administration to make evidence-based decisions guided by the best available science and data. Scientific and technological information, data, and evidence are central to the development and iterative improvement of sound policies, and to the delivery of equitable programs.¹⁵⁷

The fact that this Memorandum was part of a suite of prominent early actions intended to set an ambitious tone for the Biden administration, especially on climate change,¹⁵⁸ lends this Memorandum extra weight. The connection made between data-driven policy and equity also has implications for the discount rate, again especially in the context of climate change.

Thus, even if agencies were not already required by the statutes explore above to use the best available data to determine their discount rates, these executive actions fill any remaining gap. Though these

¹⁵⁴ See, e.g., *Salt Inst. v. Leavitt*, 440 F.3d 156, 159 (4th Cir. 2006).

¹⁵⁵ Exec. Order No. 12,866 § 1(b)(7).

¹⁵⁶ Exec. Order. No. 13,563 § 1(c).

¹⁵⁷ Pres. Biden, *Memorandum on Restoring Trust in Government through Scientific Integrity and Evidence-Based Policymaking* (Jan. 27, 2021).

¹⁵⁸ See White House, *Fact Sheet: President Biden Takes Executive Actions to Tackle the the Climate Crisis*, Jan. 27, 2021, <https://www.whitehouse.gov/briefing-room/statements-releases/2021/01/27/fact-sheet-president-biden-takes-executive-actions-to-tackle-the-climate-crisis-at-home-and-abroad-create-jobs-and-restore-scientific-integrity-across-federal-government/>

executive orders are not judicially enforceable, much like the statutory provisions explored above, they create norms around best practices and provide agencies with guidance on how to exercise their discretion when their choices are not constrained by statute. As a result, agencies will be on firmer footing when they ground their selection of discount rates in the best available data and literature.

II.A.3. Statutes Often Require Consideration of Future Generations

The discount rate determines how much weight is given to future costs and benefits; in the context of analyzing the inter-generational effects of climate change, the discount rate determines how much weight is given to the welfare of future generations. When agencies justify their overall choice of discount rates—or, more specifically, their calibration of the pure rate of time preference, their approach to future growth uncertainty or future project risk, their consideration of future scarcity of non-market goods, or any adjustments made for inter-generational equity—it will be helpful to know that such choices are consistent with (or at least do not violate) legal requirements to consider the welfare of future generation.

Multiple key statutes explicitly reference the interests of future generations. In many other key statutes without such explicit references, the statutory structure and legislative history also provide strong evidence that future generations are an important factor for agencies. Indeed, Congress rarely, if ever, forbids agencies from considering future generations.¹⁵⁹ Thus, agencies will typically retain some degree of discretion in how they consider the needs of future generations. That discretion will be guided by important Executive Orders that supplement agencies' statutory authority, as explored below.

Though many explicit references to future generations are contained in statutory sections on general findings and purposes that are hard to enforce, these direct references strongly indicate that Congress intended agencies to think about the interests of future generations. A few notable examples include:

- NEPA, which establishes a federal policy to “to create and maintain conditions under which man and nature can exist in productive harmony, and fulfill the social, economic, and other requirements of present and future generations of Americans”;¹⁶⁰
- the Federal Land Policy and Management Act, which instructs agencies to manage public lands consistent with “multiple use,” defined as “a combination of balanced and diverse resource uses that takes into account the long-term needs of future generations for renewable and nonrenewable resources”;¹⁶¹
- the Natural Gas Act, which requires an assessment of the “present or future public convenience and necessity”;¹⁶² and

¹⁵⁹ Though Congress has in at least a few instances specified a relatively short timeframe for analysis, *see, e.g.*, 42 U.S.C. § 8254 (specifying the Department of Energy determine a discount rate to apply in calculating the energy lifecycle costs of federal buildings over a period of either 40 years or the expected life, whichever is shorter), even this does not foreclose considering how events transpiring during such a timeframe may impact the needs of future generations.

¹⁶⁰ 42 U.S.C. § 4331(a).

¹⁶¹ 43 U.S.C. § 1702(c).

¹⁶² 15 U.S.C. § 717f(e).

- the National Energy Conservation Policy Act, which stresses the relevance of conservation to being “able to provide energy to meet future needs.”¹⁶³

The absence of an explicit reference to future generations in other statutes should not be interpreted to indicate agencies can ignore the needs of future generations.¹⁶⁴ Congress has at least once removed an explicit statutory reference to both the “present and future” public health and welfare as an unnecessary “surplus,”¹⁶⁵ suggesting that Congress may have often believed that general references to the “public” implicitly included future generations as well.

The histories of other key statutes confirm that Congress often had future generations in mind when legislating to protect the public welfare. For example, the Senators instrumental in drafting and passing the Clean Air Act of 1970 spoke often of the “health and welfare of this and future generations,”¹⁶⁶ and Congress expressed its overall goal for the Clean Air Act Amendments of 1977 was to “insure the protection of the public health and the environment, both of this *and future generations*, while at the same time considering the energy and economic needs of this Nation.”¹⁶⁷

¹⁶³ 42 U.S.C. § 8201(3). The Energy Policy and Conservation Act also expresses Congress’s desire “to deal with the short-, mid-, and long-term energy problems of the Nation.” *Id.* § 7112(3); *see also id.* § 5801 (“Congress hereby declares that the general welfare and the common defense and security require effective action to develop, and increase the efficiency and reliability of use of, all energy sources to meet the needs of present and future generations. . . . to advance the goals of restoring, protecting, and enhancing environmental quality.”).

¹⁶⁴ *See generally Shook v. District of Columbia Fin. Responsibility & Mgmt. Assistance Auth.*, 132 F.3d 775, 782 (D.C. Cir. 1998) (describing limits of the *expression unius* canon).

¹⁶⁵ In 1972, the Federal Aviation Administration was given authority to regulate aircraft noise and sonic booms to protect both “present and future . . . public health and welfare.” Pub. L. 92-574, 86 Stat. 1239 (Oct. 27, 1972). But in 1994, Congress changed the language to refer generally to “public health and welfare,” Pub. L. 103-272, 108 Stat. 1196 (July 5, 1994)—evidently believing the reference to both “present and future” was obviously implied and therefore was removable “surplus.” H.R. Rep. 103-180 at 352, 103rd Cong., 1st Sess. (July 15, 1993) (to accompany H.R. 1758) (explaining that in the text of 49 App.: 1431(a), re-designated at 49 U.S.C. § 44715(a)(1), “[t]he words ‘present and future’ . . . are omitted as surplus”); *id.* at 1 (explaining that the purpose of the bill was to “revise, codify, and enact *without substantive change* certain general and permanent laws related to transportation”) (emphasis added); S. Rep. 103-265 at 4-5, 103rd Cong., 2nd Sess. (May 19, 1994) (to accompany H.R. 1758) (explaining that language was simplified while preserving “legal effect,” and confirming that the “mere changes in terminology” make “no substantive change in the law”); *see also* 49 U.S.C. § 44715 (revision notes, explaining the same).

¹⁶⁶ Legislative History of the 1970 Clean Air Act vol. 1, Senate Debate on S. 4358, p.268 (Sept. 21, 1970) (statement of Sen. Baker regarding Section 202’s standards for motor vehicle emissions); *accord. id.* at p.144 (statement of subcomm. chair Sen. Muskie) (“I think that to a greater extent than we might have in past legislation, we are undertaking to deal with the long-term aspects as well as the short term”); *id.* (statement of Minority Leader Sen. Scott) (“Unless this outpouring of contaminants is controlled, scientists tell us we may very well experience irreversible atmospheric and climatic changes To guarantee that future generations of Americans can live without fear of the destruction of the very air they breathe, I urge immediate passage.”); *id.* at p.106, President Nixon’s Remarks upon Signing the Clean Air Act Amendments of 1970 into Law (Dec. 31, 1970) (“ . . . for the future generations of America.”).

¹⁶⁷ H.R. Rep. No. 95-294, 34, 1977 U.S.C.C.A.N. 1077, 1112.

Thus, when interpreting a statutory charge to protect “public welfare,” agencies should use their discretion to consider the needs of future generations, and can when appropriate justify their calibration of the discount rate on these grounds.

II.A.4. Executive Orders Require Consideration of Future Generations

Executive orders confirm that agencies should generally consider future generations when acting to protect the public welfare. For instance, President Clinton’s Executive Order 12,866 instructs agencies to “assess *all* costs and benefits” in weighing the “well-being of the American people.”¹⁶⁸ No distinction is drawn between present or future costs and benefits, or between current and future generations of Americans.

A few days after his inauguration, President Obama signed a *Memorandum on Regulatory Review*, which directed OMB to produce recommendations for a new Executive Order on regulatory policy.¹⁶⁹ OMB was specifically instructed to “address the role of distributional considerations, fairness, and concern for the interests of future generations.”¹⁷⁰ Later that same year, in December 2009, OMB summarized the memorandum as calling attention to “three factors that are not always fully included in cost-benefit analysis: *the interests of future generations*; distributional considerations; and fairness. If regulation is to be *data-driven and evidence-based*, it must include, rather than neglect, the concerns of future generations.”¹⁷¹ OMB’s summary continued on to describe the recent development in 2009 of the Working Group’s first interim estimates of the social cost of carbon, which recognized “the well-established view that a high discount rate for long-term damage could lead to action that might harm future generations.”¹⁷²

Just over a year after that, President Obama signed Executive Order 13,563, which directed agencies “to use the best available techniques to quantify anticipated *present and future* benefits and costs as accurately as possible,” reminding agencies also to consider “equity, human dignity, fairness, and distributive impacts.”¹⁷³ The explicit mention of “future benefits and costs” was surely meant to ensure, as OMB had previewed, that agencies would “include, rather than neglect, the concerns of future generations” and not select discount rates that were so “high” as to “harm future generations.”

Similarly, in the immediate hours after his inauguration, President Biden issued a series of orders and memoranda that should further inform how agencies exercise their discretion in selecting discount rates. In a *Memorandum on Modernizing Regulatory Review*, President Biden called for OMB to consult with agencies on “concrete” steps to ensure regulatory policies “promote...social welfare...equity, and the interests of future generations.”¹⁷⁴ In particular, the Memorandum recommended considering revisions

¹⁶⁸ Exec. Order No. 12,866 § 1(a) (emphasis added).

¹⁶⁹ 74 Fed. Reg. 5977 (signed Jan. 30, 2009; published Feb. 3, 2009).

¹⁷⁰ *Id.*

¹⁷¹ Unified Agenda, 74 Fed. Reg. 64,131 (Dec. 7, 2009) (emphases added).

¹⁷² *Id.*

¹⁷³ Exec. Order No. 13,563 § 1(c).

¹⁷⁴ Memorandum on Modernizing Regulatory Review, 86 Fed. Reg. 7223, 7223 (signed Jan. 20, 2021, published Jan. 26, 2021).

to *Circular A-4* to “reflect new developments in scientific and economic understanding.”¹⁷⁵ And Executive Order 13,990, titled Protecting Public Health and the Environment and Restoring Science to Tackle the Climate Crisis, specifically calls for agencies to use methodologies that “adequately take account of . . . intergenerational equity” to estimate the social cost of greenhouse gases, to “reflect the interests of future generations in avoiding threats posed by climate change.”¹⁷⁶

Agencies should fulfill these executive instructions by picking discount rates that are grounded in the best available evidence and that also give all due weight to inter-generational equity.

II.A.5. Courts Will Give Agencies Considerable, But Not Unlimited, Discretion on Discount Rates

Since most statutes do not directly discuss discounting much less require a specific rate, an agency’s choice of the discount rate will normally be reviewed under the Administrative Procedure Act’s “arbitrary and capricious” standard that applies to final agency actions.¹⁷⁷

Under that standard, as the Supreme Court set forth in *Motor Vehicles Manufacturers Association. v. State Farm*, rulemakings are vacated as “arbitrary and capricious” if the agency “entirely failed to consider an important aspect of the problem, offered an explanation for its decision that runs counter to the evidence before the agency, or is so implausible that it could not be ascribed to a difference in view or the product of agency expertise.”¹⁷⁸ But courts tend to defer to an agency’s judgments on complex technical or economic issues, such as discount rates. As administrative law scholar Cass Sunstein has argued, because discounting is a “highly technical area, courts should generally adopt a posture of deference, requiring agencies only to produce a reasonable explanation for their choice and to show a degree of consistency.”¹⁷⁹

Although there are few cases addressing an agency’s discount rate in a cost-benefit analysis, courts have usually been reluctant to second-guess an agency’s discounting choice in the instances where it has been challenged. In one case, for example, the U.S. Court of Appeals for the District of Columbia Circuit deferred to an agency’s discount rate selection as “first and foremost a policy choice,” and explained that the agency was free to revisit its discount rates in future rulemakings “so long as it sets forth a reasonable justification for doing so.”¹⁸⁰ This decision fits squarely within the judiciary’s deferential approach to reviewing the more technical aspects of an agency’s cost-benefit analysis.¹⁸¹

But while judicial review in this area is deferential, there are limits to this deference, and courts may step in if certain key parameters are not followed. In particular, there are three types of circumstances where

¹⁷⁵ *Id.*

¹⁷⁶ Exec. Order No. 13,990 § 5(b)(ii)(E) & (iii), 86 Fed. Reg. 7037, 7040-41 (signed Jan. 20, 2021, published Jan. 25, 2021).

¹⁷⁷ 5 U.S.C. § 706(2).

¹⁷⁸ 463 U.S. 29, 43 (1983).

¹⁷⁹ Cass R. Sunstein, *Cost-Benefit Default Principles*, 99 MICH. L. REV. 1651, 1711 (2001).

¹⁸⁰ *State of Ohio v. U.S. Dep’t of the Interior*, 880 F.2d 432, 465 (D.C. Cir. 1989). See also *N. Cal. Power Agency v. FERC*, 37 F3d 1517, 1522–23 (D.C. Cir. 1994) (deferring to agency’s discount-rate selection).

¹⁸¹ See, e.g., *Am. Petroleum Inst. v. EPA*, 862 F.3d 50, 69 (D.C. Cir. 2017), *decision modified on reh’g*, 883 F.3d 918 (D.C. Cir. 2018) (explaining that an agency “is free to rely on theoretical or model-based approaches, as long as that reliance is reasonable in context” and there is “some indication of a reasonable concurrence between model and reality”).

courts have shown greater willingness to overturn a rulemaking based on inadequate consideration of technical aspects of a cost-benefit analysis.

First, an agency has the burden of explaining its discount-rate selection and its rejection of alternative discount rates proposed by commenters, particularly if the selected discount rate differs from the rates that have informed prior agency policies.¹⁸² In one case, *Natural Resources Defense Council v. Herrington*, the D.C. Circuit found the Department of Energy's use of a 10 percent discount rate "fatally unexplained" after the agency summarily rejected lower discount rates offered through the notice-and-comment process and adopted its chosen rate taken from an OMB Circular that "d[id] not explain the reasoning behind the discount rate it recommend[ed]."¹⁸³ Courts will not defer to agencies' technical expertise if they do not adequately explain their choices. Another case, not on the discount rate but another technical aspect of an economic analysis, may also be instructive: last year, the U.S. Court of Appeals for the Fourth Circuit, acting *en banc*, vacated a Department of Health and Human Services rule in part because the agency provided "no justification" for its cost estimate, and its cost projections appeared to be "pulled from thin air."¹⁸⁴

Generally speaking, an agency's explanatory burden is positively correlated with the importance of the input to the analysis. As the D.C. Circuit stated in *Herrington*, the agency's failure to explain its discount rate selection in that case was especially problematic because "use of a 5 or even 7 percent real discount rate [as opposed to the 10 percent rate the agency used] would have substantially increased life cycle benefits from standards for many appliances. The major consequences of the discount rate made it particularly important that [the agency] fix the rate carefully and explain its decision intelligibly."¹⁸⁵ Thus for analyses with long time horizons, where the discount rate selection is especially critical to assessing costs and benefits, the reasoned explanation requirement is particularly robust.

Second, a court may step in if the agency selects a technical valuation that is wildly inconsistent with the available evidence. For instance, the U.S. Court of Appeals for the Fifth Circuit vacated a regulation that relied on an estimate of the value of a statistical life (*i.e.* the monetary value of mortality risk) that was roughly ten times higher than the valuations supported by the economic literature and previously applied by agencies in cost-benefit analysis.¹⁸⁶ As the court explained, the agency's high estimate represented "cavalier treatment of [its] duty to consider the economic effects of its decisions."¹⁸⁷ Similarly, just last year a federal district court struck down a deregulatory rule relying on an "interim" valuation of the social cost of methane that was nearly ten times lower than estimates that were supported by the economic

¹⁸² See, e.g., *FCC v. Fox Television Stations, Inc.*, 556 U.S. 502, 16 (2009) ("a reasoned explanation is needed for disregarding facts and circumstances that underlay or were engendered by the prior policy."); see also *id.* at 537 (Kennedy, J., concurring) ("An agency cannot simply disregard contrary or inconvenient factual determinations that it made in the past, any more than it can ignore inconvenient facts when it writes on a blank slate.").

¹⁸³ *Nat. Res. Def. Council, Inc. v. Herrington*, 768 F.2d 1355, 1412–14 (D.C. Cir. 1985).

¹⁸⁴ *Mayor of Baltimore v. Azar*, 973 F.3d 258, 282 (4th Cir. 2020) (*en banc*).

¹⁸⁵ *Herrington*, 768 F.2d at 1414 (citation omitted).

¹⁸⁶ *Corrosion Proof Fittings v. EPA*, 947 F.2d 1201, 1222–23 (5th Cir. 1991). Specifically, the agency applied implicit VSL estimates of \$43 million–\$76 million, whereas available VSL estimates generally fell between \$3.8 million–\$9 million.

¹⁸⁷ *Id.* at 1223.

literature and previously endorsed as the Working Group’s central estimate (in this case, the court struck down the agency’s use of a domestic-only rather than global estimate; the case did not address the choice of discount rates).¹⁸⁸ Because the agency disregarded “the best available science about monetizing the impacts of greenhouse gas emissions,” the court held, its regulation was arbitrary and capricious.¹⁸⁹ A similar standard could apply to the choice of discount rates.

And third, a reviewing court may strike down an agency action if the agency does not consistently apply its analytical assumptions. Indeed, the Fifth Circuit has noted that when an agency discounts costs, it “should discount benefits to preserve an apples-to-apples comparison.”¹⁹⁰ And in something of an outlier decision from nearly fifty years, a federal district court applied a particularly un-deferential review and struck down an agency’s determination in part because it used supposedly “unrealistic” discount rates that were inconsistent with the rates applied in other recent regulatory analyses.¹⁹¹

Case law on other regulatory impacts is also instructive. For instance, in *Center for Biological Diversity v. National Highway Traffic Safety Administration*—the seminal case leading to the creation of the Working Group—the U.S. Court of Appeals for the Ninth Circuit vacated the fuel-efficiency rule in question because the defendant agency “put a thumb on the scale by undervaluing the benefits and overvaluing the costs of more stringent standards.”¹⁹² Specifically, the court explained that because the agency quantified employment and sales impacts but did not “include in its analysis the benefit of carbon emissions reduction in either quantitative or qualitative form,” it improperly tipped the scales and did not fairly weigh regulatory costs against benefits.¹⁹³ Likewise, the D.C. Circuit has explained that an agency cannot “inconsistently and opportunistically frame[] the costs and benefits” of regulatory action.¹⁹⁴ On a more granular level, courts have similarly held that an agency acts arbitrarily when it applies an assumption when assessing one regulatory but a different and inconsistent assumption to analyze another regulatory impact.¹⁹⁵

The fact that agencies should assess impacts fairly and consistently, however, does not mean that they must assess all regulatory impacts identically. Rather, courts have recognized that certain impacts may present unique challenges with respect to cost-benefit analysis that could justify different regulatory treatment. Climate change, given its long time horizon, is a prime example. For instance, the U.S. Court of Appeals for the Seventh Circuit upheld a cost-benefit analysis that quantified climate benefits over hundreds of years while assessing employment impacts over only thirty years after the defendant agency concluded that the rule “would have long-term effects on the environment but . . . would not have long-

¹⁸⁸ *California v. Bernhardt*, 472 F. Supp. 3d 573, 608–14 (N.D. Cal. 2020).

¹⁸⁹ *Id.* at 611.

¹⁹⁰ *Corrosion Proof Fittings*, 947 F.2d at 1218.

¹⁹¹ *Montgomery v. Ellis*, 364 F. Supp. 517, 529 (N.D. Ala. 1973).

¹⁹² 538 F.3d 1172, 1198 (9th Cir. 2008).

¹⁹³ *Id.*

¹⁹⁴ *Bus. Roundtable v. S.E.C.*, 647 F.3d 1144, 1148–49 (D.C. Cir. 2011).

¹⁹⁵ See, e.g., *Gen. Chem. Corp. v. United States*, 817 F.2d 844, 857 (D.C. Cir. 1987) (deeming agency conclusion arbitrary and capricious where supporting analysis was “internally inconsistent”).

term effects on employment.”¹⁹⁶ Likewise, a reviewing court could defer to an agency’s finding that the long time horizon of climate change justifies a lower discount rate than the rate applied to short-term regulatory impacts. However, it is also possible that a court could in the future find the inconsistent application of discount rates to be arbitrary, especially if the agency has not adequately explained the special economic, legal, and ethical principles that may justify a different treatment of climate effects.

II.B. Legal Considerations for Selecting Central Discount Rates and a Sensitivity Range

In the past, when agencies were sometimes reluctant to apply the social cost of greenhouse gases in their environmental impact statements,¹⁹⁷ they often argued that range of values adopted by the Working Group in 2010 showed that there was no consensus on the appropriate discount rate and, as a result, that the social cost estimates were too variable and uncertain to be useful in analysis. Courts sometimes deferred to agencies on this point and agreed that the range of discount rates suggested there was perhaps “no consensus” on the appropriate values.¹⁹⁸

Other litigants have adopted similar arguments. In the March 2021 challenge in the U.S. District Court for the Eastern District of Missouri against the Working Group’s interim estimates, the complaint highlighted that “[t]he indeterminacy and value-laden nature of choosing a discount rate results in a wide range of potential values of the ‘social costs’ of gases,” and concluded that “[t]his wide range . . . reflects the inherently speculative, indeterminate, and policy-laden nature of the task.”¹⁹⁹ The argument went on to assert that states, industry, and other stakeholders had developed “legitimate reliance” on the prior administration’s use of 3% and 7% discount rates, and complained that the Working Group had failed to adequately explain the change in the choice of discount rates as compared to the prior administration.²⁰⁰

The April 2021 challenge in the U.S. District Court for the Western District of Louisiana made similar claims, arguing that the Working Group had failed to explain why “the fundamentals of economics have changed” in a way that would justify not using the 7% rate based on returns to capital.²⁰¹ Failing to use a 7% discount rate, the complaint went on, “ignor[es] the private sector” and will so “crowd[] out private investments with a higher rate of return.”²⁰² Furthermore, the lawsuit argues that the Working Group has

¹⁹⁶ *Zero Zone, Inc. v. United States Dep’t of Energy*, 832 F.3d 654, 679 (7th Cir. 2016).

¹⁹⁷ See Policy Integrity’s separate report submitted to this docket, which argues that agencies should broadly incorporate the social cost of greenhouse gas metrics into their environmental impact statements and other relevant analyses: Max Sarinsky et al., *Broadening the Use of the Social Cost of Greenhouse Gases in Federal Policy* (Policy Integrity Report, 2021).

¹⁹⁸ *350 Montana v. Bernhardt*, 443 F.Supp.3d 1185 (D. Mont. 2020) (citing Dr. Thomas Power as saying “there is no consensus on the appropriate social discount rate,” and implying that the resulting range of social cost of carbon estimates was too wide); accord *EarthReports v. FERC*, 828 F.3d 949 (D.C. Cir. 2016) (deferring to FERC on conclusion that lack of consensus on appropriate discount rates leads to “significant variation”).

¹⁹⁹ Complaint, *Missouri v. Biden*, No. 4:21-cv-00287-AGF at 20-21 (E.D. Mo. filed Mar. 8, 2021).

²⁰⁰ *Id.* at 26.

²⁰¹ Complaint, *Louisiana v. Biden*, No. 2:21-cv-01074 at 37-38 (W.D. La. filed Apr. 2021).

²⁰² *Id.* at 38 (citing Susan Dudley’s work).

“usurp[ed] the authority vested in agencies” by determining the discount rates and so “dictat[ing] a specific number” be used by all agencies.²⁰³

Though such claims are unfounded and, hopefully, should not survive long before the courts, the Working Group and agencies can take several steps to help minimize such legal risks. To begin, the Working Group should ground its choice of discount rates in the best available data, expert elicitations, and literature, and should thoroughly justify its choices as consistent with both legal principles and the best available economics. The Working Group should respond adequately to all public comments and suggestions that it use alternate rates, and should bolster its defense for not using the capital-based rate (see Section I.A for additional arguments to incorporate). It may also be helpful to note, in justifying the change from the prior administration’s approach, that even agencies during the prior administration acknowledged that the 7% capital rate did not adequately account for “tradeoffs between improving the welfare of current and future generations,” and that discount rates of 3% or lower would be more appropriate in the inter-generational context.²⁰⁴

If the Working Group does not incorporate all the recommendations outlined above in Section I on lowering the discount rate, the Working Group should explain the omissions and note that making such additional adjustments in the future, which are supported by evidence and the literature, would further lower the discount rate. This will help insulate the Working Group’s selections as conservative, consensus-based, upper-bound choices. In that same vein, the Working Group should avoid making statements that could be taken out of context to suggest its discount rate choices are somehow controversial. For example, the Interim Technical Support Document says that the “choice of a discount rate also raises highly contested and exceedingly difficult questions of science, economics, ethics, and law.”²⁰⁵ Though that statement is of course true, it could be taken out of context to suggest that the choice of discount rate is more controversial than it actually is. Indeed, the Interim Technical Support Document notes also a “surprising degree of consensus among experts” about the appropriate discount rate.²⁰⁶ The Working Group should emphasize such statements: there is, in fact, a strong consensus both about which discount rates would be unreasonably high and about the most appropriate range of rates for use in climate analysis.

Individual agencies should incorporate arguments developed by the Working Group into their policy proceedings as appropriate, to build the record to defend against possible legal challenges. When applicable, agencies should cite to relevant legal standards for considering the best available data and the welfare of future generations. When agencies’ policies will have costs that are primarily borne through reduced consumption rather than displaced investment; when the costs and benefits of their policies are long-run; or when their policies might induce rather than displace private investment, agencies should consider citing these additional justifications for not using capital-based discount rates (see Section I.A.2). When use of updated discount rates is important to the agency’s ultimate policy decision, the agency

²⁰³ *Id.* at 30.

²⁰⁴ The Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule for Model Years 2021–2026 Passenger Cars and Light Trucks, 85 Fed. Reg. 24,174, 24,735 (Apr. 30, 2020) (explaining that the central analysis focused on a 3% rate, and the 7% rate was used only for sensitivity analysis).

²⁰⁵ 2021 Interim TSD, *supra* note 1, at 17.

²⁰⁶ *Id.* at 20 (citing Drupp et al.).

should acknowledge the change in rates, justify its reliance on the newly recommended rates,²⁰⁷ and substantively respond to any comments proposing alternative discount rates.²⁰⁸

A final policy consideration that the Working Group should keep in mind when selecting its central discount rate. The Working Group's estimates have been copied by multiple U.S. states, other countries, and international decisionmakers,²⁰⁹ but some of these other jurisdictions have focused largely or only on the central rate, rather than adopting the full range of values. Similarly, some federal agencies may apply only the central value, particularly when using the social cost of greenhouse gas estimates in decision contexts that do not typically include sensitivity analysis (such as procurement decisions). Consequently, the Working Group should be sure that its selection of a central discount rate on its own will adequately account for all of the most important adjustments discussed above, including appropriate consideration of inter-generational equity, and should not rely exclusively on a recommended range for sensitivity analysis to address key factors.

II.C. Legal Considerations for Consistency in Discounting

As noted above, courts have sometimes cautioned agencies against inconsistent approaches to discounting in their analyses. Economic principles similarly recommend internally consistent discounting, as both the Working Group and the National Academies of Sciences have recognized.²¹⁰ There are multiple kinds of consistency to consider and multiple policy contexts, as detailed next. The Working Group and agencies should aim for consistency, but if the use of different discount rates remains necessary in some contexts, agencies should be prepared to justify any such differences.

One set of considerations is the different points within a single analysis during which discount rates are applied. To illustrate, consider a policy adopted in 2021 that creates compliance costs in 2022, resulting in carbon dioxide emission reductions in 2023, with those emissions reductions benefiting the climate over the course of centuries. The discount rate comes into play at three different but related points in an analysis of this policy. First, the carbon dioxide emission reduced in 2023 will generate climate benefits over the course of centuries, and all those climate benefits must first be discounted back to the year of emissions in 2023—this is the discount rate or discount schedule that serves as the basis for calculating the social cost of greenhouse gases. Second, the net climate benefits achieved from that emissions reduction in 2023 must still be discounted back to the present value in 2021, at the time when the analysis

²⁰⁷ The Supreme Court has held that “an unexplained inconsistency in agency policy is a reason for holding an interpretation to be an arbitrary and capricious change from agency practice.” *Encino Motorcars, LLC v. Navarro*, 136 S. Ct. 2117, 2126 (2016) (internal quotation marks omitted).

²⁰⁸ Under the Administrative Procedure Act, agencies must respond to substantive comments received during the notice-and-comment period. See, e.g., *N.C. Growers' Ass'n v. United Farm Workers*, 702 F.3d 755, 769 (4th Cir. 2012) (“[D]uring notice and comment proceedings, the agency is obligated to identify and respond to relevant, significant issues raised during those proceedings.”).

²⁰⁹ See Policy Integrity's separate report submitted to this docket: Jason A. Schwartz, *Strategically Estimating Climate Pollution Costs in a Global Environment* (Policy Integrity Report, 2021) (listing jurisdictions that have copied the Working Group's estimates).

²¹⁰ 2021 Interim TSD, *supra* note 1, at 22; NAS, *supra* note 18, at 170, 182.

is conducted. Optimally, the discount rate or discount schedule applied for this present-day valuation should be the same as the discount rate selected for the calculation of the social cost of greenhouse gases, so that all climate effects are discounted consistently.²¹¹ Third, other non-climate costs and benefits in the same analysis, such as the 2022 compliance costs, must also be discounted to present value in 2021, to the time when the analysis is conducted.

For this third discounting, existing guidance may already suggest default rates. Notably, OMB's *Circular A-4* currently recommends that agencies should typically use default rates of 3% and 7% for regulatory analyses, though OMB recognized in 2015 that *Circular A-4* "is a living document" and that default discount rate should be adjusted in the context of climate change.²¹² Moreover, President Biden has instructed OMB to revise *Circular A-4*,²¹³ and it is possible that this guidance may change in the near future in light of recent market data and the other justifications for lower discount rates and the frequent inapplicability of the capital-based rate discussed above (see Sections I.A-I.B).

Other decisionmaking contexts in which the social cost of greenhouse gases should be applied²¹⁴ may have their own guidance on default discount rates. For example, OMB's *Circular A-94* advises that in cost-effectiveness analysis of government programs, analysis of internal government investments (including, for example, energy-efficiency upgrades for federal buildings), and other contexts like lease-purchase analysis, agencies should generally use Treasury interest rates.²¹⁵ OMB updates *Appendix C to Circular A-94* every year to show the latest Treasury interest rates; in recent years, the rates have fallen to 0% or even into negative territory.²¹⁶ *Circular A-94* also advises that if a federal action "provides a mix of both Federal cost savings and external social benefits," and if the action's costs cannot be clearly allocated into a portion that leads to federal savings versus a portion that generates social benefits, then the entire investment can

²¹¹ See 2021 Interim TSD, *supra* note 1, at 25 ("[T]he monetized value of future emission changes should be discounted at the same rate used to calculate the initial SC-GHG to ensure internal consistency—i.e., future damages from climate change using the SC-GHG at 2.5 percent should be discounted to the base year of the analysis using the same 2.5 percent rate.").

²¹² 2015 Response to Comments, *supra* note 3, at 36.

²¹³ Memorandum on Modernizing Regulatory Review, 86 Fed. Reg. 7223, 7223 (signed Jan. 20, 2021, published Jan. 26, 2021).

²¹⁴ See Sarinsky et al., *supra* note 197 (recommending additional contexts for application of the social cost metrics). In some contexts for applying the social cost of greenhouse gases—such as when internalizing damages into royalty rates or administrative penalties, or to assess the significance of climate damages in environmental impacts statements that may otherwise forgo a formal cost-benefit analysis—comparison against other future costs and benefits may not be relevant. When the agency needs to present only the net present value of climate damages from a ton of emissions emitted in the future, agencies should simply discount the monetized value of future emission changes at the same rate as used to calculate the underlying social cost of greenhouse gas metric.

²¹⁵ OMB, *Circular A-94: Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs* 8-10 (1992)

²¹⁶ OMB, Table of Past Years Discount Rates from Appendix C of OMB Circular No. A-94 (Dec. 21, 2020), <https://perma.cc/5VYS-LAFH>.

be evaluated with a discount rate appropriate for discounting the social benefits.²¹⁷ The Federal Acquisition Regulations also cite in at least one part to *Circular A-94*.²¹⁸

Meanwhile, OMB's *Circular A-11* on budgeting says "discount rates for the budget are provided by OMB in the online Credit Subsidy Calculator,"²¹⁹ and cites to the Federal Credit Reform Act, which says "the discount rate shall be the average interest rate on marketable Treasury securities of similar maturity to the cash flows of the direct loan or loan guarantee for which the estimate is being made."²²⁰ On capital asset acquisitions, *Circular A-11* refers to *Circular A-94*, while for asset sales, OMB recommends an additional adjustment to the base discount rates.²²¹

Both the Working Group and individual agencies will need to address the issue of internal consistency in their analyses in light of any such background guidance on discounting other kinds of costs and benefits in various policy contexts. Agencies additionally may need to consider addressing consistency issues if they adopt different discount rates in their analyses of climate policies than in their analyses of other policies with similarly long-run effects (such as policies about persistent toxic pollutants, food and product safety, or even education, all of which can have effects over multiple decades or centuries, spanning future generations).

The most straightforward resolution to issues of consistency is to simply make all discounting choices consistent. A declining discount rate schedule should likely resolve the matter by prescribing an internally consistent schedule of rates, even as the rates will appropriately decline over time. Though the Working Group has in the past been reluctant to move to a declining discount rate schedule, such schedules have been estimated for use in U.S. policy (see Section I.D.1), and the goal of analytical consistency weighs strongly in favor of this approach.

Another option for achieving consistency would be to select and justify the constant discount rate that is most appropriate given all the costs and benefits under analysis. Note, for example, that *Circular A-94* advised that agencies could select a single discount rate to use even when an agency action would generate both internal government benefits and external social benefits. Because it would be inappropriate to apply a very high discount rate to climate effects (see Section I.A.2), while a lower discount rate may well be appropriate for non-climate effects as well (see Section I.B), this approach should involve applying the same discount rate selected for calculating the social cost of greenhouse gases to use for discounting all other costs and benefits. In adopting such an approach, agencies should be prepared to justify why using a lower discount rate for all costs and benefits is justified, drawing from the economic and legal principles

²¹⁷ *Circular A-94* at 10 (recommending that "[t]he net present value of such investments should be evaluated with the 7 percent real discount rate," because when *Circular A-94* was drafted in 1992, a 7% discount rate was thought appropriate for investments with external social benefits; updated data and more recent understandings suggest that rate would be inappropriate).

²¹⁸ FAR § 32.205 (on commercial item purchase financing).

²¹⁹ OMB, *Circular A-11: Preparation, Submission, and Execution of the Budget*, p.7 of Section 185 (2016).

²²⁰ See also 2 U.S.C. § 661a(5)(E).

²²¹ *Circular A-11* at App.A, p.5 ("The discount rate used to estimate the net present value shall be the average interest rate on marketable Treasury securities of similar maturity to the expected remaining useful life of the asset for which the estimate is being made, plus 2 percentage points to reflect the economic effects of continued ownership by the Government.").

described above. Agencies could still also assess non-climate costs and benefits with alternate discount rates in a sensitivity analysis, and doing so may help minimize legal risk.

Indeed, yet another option is to try to make different discount rate choices as harmonized as possible, while using sensitivity analyses to explore how different discount rates may affect the overall policy outcome. The National Academies of Sciences explored this option in their 2017 report. That report acknowledged the potential tension between applying different discount rates to climate damages versus other regulatory costs and benefits, but still strongly emphasized the need for agencies to base the social cost of greenhouse gases on evidence-based discount rates that account for the specific concerns that arise in the context of intergenerational impacts and long time horizons.²²² As one possible solution, the National Academies suggested trying to match discount rates as closely as possible, such as by “combining other cost and benefit estimates with the [social cost of greenhouse gas] estimate whose near-term discount rate most closely matches that particular discount rate” or “combining other costs and benefits based on a high discount rate with the [social cost of greenhouse gas] estimate based on its highest discount rate, and analogously combining the low discount rate estimates.”²²³ Assume, for example, that the Working Group recommends social cost of greenhouse gas estimates based on a discount rate range of 0.5%-2.5%, and also that agencies continue to use the default recommendations from the 2003 version of *Circular A-4* to discount non-climate costs and benefits. In this scenario, agencies could combine climate effects discounted at their lowest rate (0.5%) with other effects discounted at the lowest rate from the current version of *Circular A-4* (3%), and similarly match high discount rates. The use of sensitivity analysis could help show the influence of the discount rate on the ultimate policy choice.

As a final option, if it is not feasible or appropriate for agencies to use the same discount rate for all effects, agencies should thoroughly justify their choice to apply different rates in different contexts. This is, in fact, what many agencies have done to date in applying the social cost of greenhouse gases in regulatory analysis. In such analyses, agencies have often focused on the Working Group’s prior central estimates calculated at a 3% discount rate and compared those climate effects to other costs and benefits discounted at both the 3% and 7% rates.²²⁴ Another useful precedent for this option is the Seventh Circuit’s ruling in *Zero Zone v. Department of Energy*. In that case, the litigants argued that the Department of Energy had

²²² NAS, *supra* note 18, at 170, 182.

²²³ *Id.* at 181-82.

²²⁴ E.g., 85 Fed. Reg. 24,174, 24,735 (Apr. 30, 2020) (“Throughout the NPRM central analysis, costs resulting from increased emissions of CO₂ were also discounted from the year when those increases in emissions occurred to the present using a 3 percent rate, even when all other future costs and benefits were discounted at a 7 percent rate. Thus the agencies’ central analysis for the NPRM did not use SC-CO₂ values for future years that were constructed by applying a 7 percent rate to discount distant future climate-related economic damages, and did not use a 7 percent rate to discount costs of increased CO₂ from the years when they were projected to occur to 2018 (the base year used in the analysis).”); Dept. of Energy, Technical Support Document: Energy Efficiency Program for Consumer Products: Residential Central Air Conditioners and Heat Pumps at 1-3 (2016), <https://perma.cc/PDA2-Y2WK> (presenting the full range of the Working Group’s four social cost of carbon values, but then in tallying net benefits, explaining that “Total Benefits for both the 3% and 7% [discount rate] cases are derived using the series corresponding to average SCC with a 3-percent discount rate”); Bureau of Land Mgmt., Regulatory Impact Analysis for: Waste Prevention and Resource Conservation 6-7 (2016), <https://www.regulations.gov/document/BLM-2016-0001-9127> (presenting social benefits only “using model averages of the social cost of methane with a 3% discount rate,” and comparing those climate benefits to other costs and benefits discounted at both the 3% and 7% rates).

arbitrarily considered hundreds of years of climate benefits while limiting its assessment of employment impacts and other effects to just a thirty-year time horizon. The court upheld the regulatory analysis, concluding that the difference in time horizons was justified because the rule “would have long-term effects on the environment but . . . would not have long-term effects on employment.”²²⁵ The choice of time horizons is related to the choice of discount rate: any cost or benefit occurring beyond the end of the analytical time horizon is effectively discounted at an infinitely high rate.²²⁶ Analogizing from this precedent, a future court may similarly defer to an agency’s finding that the long time horizon of climate change justifies a lower discount rate than the rate applied to shorter-term costs and benefits. However, this approach may entail some legal risk, and so agencies taking this route should thoroughly explain the special economic, legal, and ethical considerations that justify selecting a different discount rate for climate effects than for other costs and benefits.

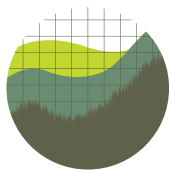
Besides the immediate adoption of an internally-consistent declining discount rate schedule, all of the above options could apply to agencies’ use of the Working Group’s current interim values as well as to their use of any future updated values. In other words, agencies using the February 2021 interim values could select and justify a single discount rate for application to all costs and benefits; could match high rates with high rates and low rates with low rates, as the National Academies explored; or could continue to justify any remaining differences in the selection of discount rates for different kinds of costs and benefits. But again, for the January 2022 update, moving toward a declining discount rate schedule would be preferred.

Conclusion

The discount rate is a key input into the calculation of the social cost of greenhouse gases. This report had made the case for why the Working Group should move to an internally-consistent, declining discount rate schedule, by calibrating the extended Ramsey formula using expert elicitations, the most updated market data, and the best, most recent literature on appropriate adjustments for uncertainty, the scarcity of non-market goods, inter-generational equity, and other key factors. Whatever updates the Working Group makes by January 2022, the Working Group should also continue to refine its estimates of the discount rate over time. To that end, the Working Group should identify the top priority research needs to help calibrate the discount rate, so that the academic community can support the Working Group in estimating the most accurate, most socially efficient, and fairest discount rate possible.

²²⁵ *Zero Zone, Inc.*, 832 F.3d at 679.

²²⁶ See Arden Rowell, *Time in Cost-Benefit Analysis*, 4 U.C. IRVINE L. REV. 1215, 1237-38 (2014) (noting time inconsistencies in different regulatory analyses and advising agencies to identify a temporal break-even point by which a proposed policy will pay for itself).



Institute *for*
Policy Integrity

NEW YORK UNIVERSITY SCHOOL OF LAW

Institute for Policy Integrity
New York University School of Law
Wilf Hall, 139 MacDougal Street, New York, New York 10012
policyintegrity.org