CLIMATE CHANGE AND FUTURE GENERATIONS

RICHARD L. REVESZ*

MATTHEW R. SHAHABIAN†

ABSTRACT

Efforts to reduce greenhouse gases and control climate change implicate a wide range of social, moral, economic, and political issues, none of them simple or clear. But when regulators use cost-benefit analysis to evaluate the desirability of climate change mitigation, one factor typically determines whether mitigation is justified: the discount rate, the rate at which future benefits are converted to their present value. Even low discount rates make the value of future benefits close to worthless: at a discount rate of three percent, ten million dollars five hundred years from now is worth thirty-eight cents today. Thirty-eight cents is therefore more than we would be willing to pay now to save a life in five hundred years. Discounting over very long periods, like in the context of climate change, has long perplexed economists, philosophers, and legal scholars alike.

This Article evaluates the four principal justifications for intergenerational discounting, which are often conflated in the literature. It

* Dean and Lawrence King Professor of Law, New York University School of Law.

† J.D., 2011, New York University School of Law; B.S., 2008, New York University. We are grateful to the following individuals for helpful discussions, suggestions, and comments on prior drafts: Oren Bar-Gill, Lily Batchelder, Norman Dorsen, Rochelle Dreyfuss, John Ferejohn, Clayton Gillette, Roderick Hills, Mitchell Kane, Lewis Kornhauser, Mattias Kumm, Michael Levine, Michael Livermore, Liam Murphy, Burt Neuborne, Daniel Shaviro, Seana Shiffrin, Richard Stewart, David Weisbach, Jeremy Waldron, Tobias Wolff, and Kenji Yoshino. We would also like to thank the faculty, students, and staff of the Furman program, as well as Brett Davenport, Dan Deacon, Jon Grossman, and Martha Roberts for excellent research assistance. This Article was produced, in part, with support from the D'Agostino/Greenberg Fund. A version of this Article was presented to the faculty workshop at New York University School of Law and to the 21st Annual Meeting of the American Law and Economics Association at Columbia Law School.

shows that none of these justifications support the prevalent approach of discounting benefits to future generations at the rate of return in financial markets and, more generally, that discounting cannot substitute for a moral theory setting forth our obligations to future generations.

I. INTRODUCTION

The Supreme Court's decision in *Massachusetts v. EPA*[1] led the U.S. Environmental Protection Agency ("EPA") to determine that greenhouse gas emissions ("GHGs") endanger the "public health and the public welfare of current and future generations" and to begin regulating accordingly.[2] In April 2010, the EPA issued a regulation together with the National Highway Traffic Safety Administration limiting GHG emissions from automobiles.[3] Congress, in turn, has attempted to respond to the threat posed by climate change, passing emissions trading legislation in the House.[4] Yet in the four years since *Massachusetts v. EPA*, Congress has not enacted a comprehensive climate bill, and seems unlikely to do so in the near future.[5] Until then, the federal government's primary response to climate change is likely to be through regulatory action.

Regulations that are considered "economically significant" by having

1. Massachusetts v. EPA, 549 U.S. 497 (2007).

2. *Id.* at 534–35 (holding the EPA's refusal to determine whether GHGs contribute to climate change arbitrary and capricious, remanding for further consideration); EPA, Endangerment and Cause or Contribute Findings for Greenhouse Gases Under Section 202(a) of the Clean Air Act, 74 Fed. Reg. 66,496 (Dec. 15, 2009) (to be codified at 40 C.F.R. ch. 1).

3. EPA & NHTSA, Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards; Final Rule, 75 Fed. Reg. 25,324 (May 7, 2010) (to be codified in scattered parts of 40 C.F.R. and 49 C.F.R.).

4. *See* American Clean Energy and Security Act of 2009, H.R. 2454, 111th Cong. (2009).

5. *See, e.g.*, Ian Talley, *Comprehensive 2010 Climate Bill Highly Unlikely, Murkowski Says*, WALL ST. J. (Mar. 11, 2010, 2:10 PM), http://online.wsj.com/article/SB10001424052748703625304575115803550688146.html.

an annual impact on the economy of $100 million or more—like the automobile emissions rule or any other major climate regulation—are subjected to cost-benefit analysis under Executive Order 12,866 and Executive Order 13,563.[6] Because most of the benefits of climate change regulation will accrue to future generations, the cost-benefit analysis of any regulation will turn in large part on the discount rate used to convert future dollars to their present value. A high discount rate means those future benefits will count for little, and climate change regulation will appear unjustifiable. A low discount rate, on the other hand, justifies more extensive action to mitigate the damage climate change will do to future generations. Comments to the EPA on the automobile emissions rule pointed out that the variation in the EPA's calculation of the social cost of carbon—the "present value of the economic benefits from avoiding [GHG] emissions"—which ranged from $5 per metric ton to $56 per metric ton in the proposed rule,[7] was "due entirely to different assumptions about the discount rate."[8] As Martin Weitzman has said, "the biggest uncertainty of all in the economics of climate change is the uncertainty about which interest rate to use for discounting."[9]

This Article argues the current approaches to discounting the benefits that accrue to future generations are deeply flawed. In Part II, we attempt to cut through the fog and confusion in the academic literature by classifying the justifications for discounting into four conceptually different categories that are often conflated: (1) prescriptive pure time preference discounting, (2) descriptive pure time preference discounting, (3) opportunity cost discounting, and (4) growth discounting. Part III addresses prescriptive time preference discounting, and argues that discounting the interests of future generations merely because they live in the future is ethically indefensible. Part IV turns to the descriptive time preference argument for discounting. It criticizes using the choices people make about saving for

6. *See* Final Rule, 75 Fed. Reg. at 25,539; Exec. Order No. 12,866, 3 C.F.R. § 638 (1994); Exec. Order No. 13,563, 76 Fed. Reg. 3821 (Jan. 21, 2011) (supplementing but not replacing Exec. Order No. 12,866).

7. *See* EPA & NHTSA, Proposed Rulemaking To Establish Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards, 74 Fed. Reg. 49,454, 49,477 (Sept. 28, 2009). In the final rule, the social cost of carbon estimates ranged from $5 to $65. *See also* Final Rule, 75 Fed. Reg. at 25,520–22. The difference in the estimates from $5 to $35 entirely reflects differences in the discount rate, and the $65 rate reflects higher estimates of damage caused by GHGs.

8. Inst. for Policy Integrity, N.Y.U. School of Law, Comments Regarding Proposed Rulemaking to Establish Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards 2 (Nov. 27, 2009).

9. Martin L. Weitzman, *A Review of* The Stern Review on the Economics of Climate Change, 45 J. ECON. LITERATURE 703, 705 (2007) [hereinafter Weitzman, *Stern Review*].

their own future to determine the amount that should be spent on the protection of future generations. We argue that this approach inappropriately uses an intrapersonal choice about consumption to make intergenerational decisions.

Part V separates opportunity cost discounting from time preference discounting. It shows that calls for opportunity cost discounting generally ignore the potentially irreversible nature of the problem and the rising costs of mitigation measures, as well as the difficult question of whether the resources harmed by climate change are substitutable with other resources. Part VI discusses the problems with discounting for economic growth, which argues that because future generations will be wealthier than the current generation, more resources should be allocated to the current generation since that generation will value those resources more as a result of the declining marginal utility of consumption. We show that the developed countries of the current generation, which will pay the bulk of the costs to reduce GHGs, are likely to be wealthier now than the developing country beneficiaries of climate change mitigation will be in the future. We also show that growth discounting, by conflating environmental goods with traditional consumption goods, assumes wealthy generations care less about the environment than poor generations. Part VII concludes.

II. APPROACHES TO INTERGENERATIONAL DISCOUNTING

Our goal in this part is to clarify the debate surrounding intergenerational discounting by separating the different arguments made to justify discounting. Without clarifying the issues, it is virtually meaningless to say that one is either for or against discounting in an intergenerational context. We start in Section A by introducing the most influential approach to discounting, which was developed by Kenneth Arrow in a study for the Intergovernmental Panel on Climate Change. From this approach and the subsequent literature we can discern four independent, conceptually different justifications for discounting: (1) discounting for pure time preference on the basis of ethical norms ("prescriptive pure time preference discounting"); (2) discounting for pure time preference because that is how people actually treat the future ("descriptive pure time preference discounting"); (3) discounting because future generations will be richer than our own ("growth discounting"); and (4) accounting for opportunity costs ("opportunity cost discounting"). It is important for us to separate the justifications for intergenerational discounting; commentators often fail to explicitly state which justification they are defending or criticizing, leading to confusion.[10] After untangling these disparate concepts, in Section B we introduce the added complexity of declining-rate, or "hyperbolic," discounting, a concept that Cass Sunstein, Administrator of the Office of Information and Regulatory Affairs ("OIRA"), described in 2009 as so critical that an agency that does not consider it "should be legally vulnerable on the grounds that it has acted arbitrarily."[11] In Section C, we then turn to how these concepts play into two highly publicized, diametrically opposed approaches to discounting in climate change: *The Stern Review*, prepared by Sir Nicholas Stern on behalf of the British government, advocating a low discount rate and aggressive steps to stop climate change,[12] and William Nordhaus's *A Question of Balance*, advocating a relatively high discount rate and a more measured response to climate change.[13]

10. *See, e.g.*, Sir Nicholas Stern, *The Economics of Climate Change*, 98 AM. ECON. REV. 1, 12 (2008) [hereinafter Stern, *Economics*] (describing "pervasive confusion about the basic theory of discounting"); *Value Judgments, Welfare Weights and Discounting: Issues and Evidence*, *in* AFTER THE STERN REVIEW: REFLECTIONS AND RESPONSES 10 (2007) (addressing confusion between pure time preference discounting justification and the discount rate); WILLIAM NORDHAUS, A QUESTION OF BALANCE: WEIGHING THE OPTIONS ON GLOBAL WARMING POLICIES 169–70 (2008) [hereinafter NORDHAUS, BALANCE] (same); David Weisbach & Cass R. Sunstein, *Climate Change and Discounting the Future: A Guide for the Perplexed*, 27 YALE L. & POL'Y REV. 433, 434 (2009) ("The resulting debates about the proper method of discounting have been heated, with Stern finally accusing Nordhaus and others of plain ignorance."); Kenneth J. Arrow et al., *Intertemporal Equity, Discounting, and Economic Efficiency*, *in* CLIMATE CHANGE 1995: ECONOMIC AND SOCIAL DIMENSIONS OF CLIMATE CHANGE 130 (James P. Bruce, Hoesung Lee & Erik F. Haites eds., 1996) [hereinafter Arrow et al., *IPCC Report*] ("The debate is often confusing."). *Compare* Dexter Samida & David A. Weisbach, *Paretian Intergenerational Discounting*, 74 U. CHI. L. REV. 145, 147 (2007) (explicitly addressing only opportunity cost discounting while setting aside other justifications), *with* Douglas A. Kysar, *Discounting . . . on Stilts*, 74 U. CHI. L. REV. 119 (2007) (accusing Samida and Weisbach of "smuggl[ing] back into their argument the pure rate of time preference argument that they attempted to disclaim at the outset of their piece"). Indeed, scholars have admitted to being "baffled" by discounting justifications different from the one they address, highlighting the need for a comprehensive evaluation of the different justifications. Richard N. Cooper, *International Approaches to Global Climate Change*, 15 WORLD BANK RES. OBSERVER 145, 152–53 (2000) (addressing only opportunity cost discounting). *See also* Louis Kaplow, Elisabeth Moyer & David A. Weisbach, *The Social Evaluation of Intergenerational Policies and Its Application to Integrated Assessment Models of Climate Change*, 10 B.E.J. ECON. ANALYSIS & POL'Y no. 2, 2010 at 1, 1, 19 (describing discussion as "confusing and sometimes misleading"); David F. Burgess & Richard O. Zerbe, *Appropriate Discounting for Benefit-Cost Analysis*, 2 J. BENEFIT-COST ANALYSIS no. 2, 2011 at 1, 1 ("[P]roponents of different approaches to discounting are frequently unclear about what they are maximizing, or what function the discount rate is supposed to perform.").

11. Weisbach & Sunstein, *supra* note 10, at 443–44.

12. SIR NICHOLAS STERN, THE STERN REVIEW: REPORT ON THE ECONOMICS OF CLIMATE CHANGE (2006) [hereinafter STERN REVIEW].

13. NORDHAUS, BALANCE, *supra* note 10, at 50.

A. KENNETH ARROW AND THE TRADITIONAL APPROACH

Kenneth Arrow and a number of other distinguished academics, as part of a contribution to the Intergovernmental Panel on Climate Change ("IPCC"), published in 1996 the most influential article on the treatment of future generations.[14] In their report, the authors distinguish between two major approaches to calculating the discount rate: What they term the "prescriptive approach" asks the question: "How (ethically) should impacts on future generations be valued"?[15] What they term the "descriptive approach" asks instead: "What choices involving trade-offs across time do people actually make"?[16]

According to Arrow and his coauthors, both approaches share a common theoretical framework to calculating the discount rate, which is described by the following equation:

$$d = \rho + \theta g$$

"where d is the discount rate, ρ is the rate of pure time preference[17] . . . θ is the absolute value of the elasticity of marginal utility [of consumption] . . . and g is the growth rate of per capita consumption."[18] This rate is then used to discount future costs and benefits, for example, the damage caused by climate change to future generations, into their present value, allowing us to compare the cost of mitigating climate change now to the benefits experienced in the future.[19]

The first term, ρ, reflects that "one cares less about tomorrow's consumer than today's, or about one's own welfare tomorrow than today."[20] The second term, θg, reflects that "one believes tomorrow's consumer will be better off than today's,"[21] and thus we should shift more

14. Arrow et al., *IPCC Report*, *supra* note 10, at 129.

15. *Id.*

16. *Id.*

17. In the context of intergenerational discounting, ρ is referred to as the "social rate of pure time preference," as opposed to an *individual's* rate of pure time preference. *Id.* at 141 n.4.

18. *Id.* at 130. Other scholars use different symbols to represent these concepts. For consistency's sake, we will use the Arrow notation.

19. The present value formula for a constant discount rate is an exponential formula, given by: $PV = FV/(1 + d)^n$, where PV is the present value, FV is the future value, and n is the number of periods.

20. Arrow et al., *IPCC Report*, *supra* note 10, at 130. This statement encompasses both an intergenerational pure rate of time preference and an interpersonal pure rate of time preference, respectively. These concepts are distinct and should not be conflated. *See infra* Part IV (discussing intrapersonal versus intergenerational discounting as it applies to descriptive pure time preference discounting).

21. *Id.*

resources to earlier, poorer generations that will benefit more from extra resources. This section starts by focusing on the first term, ρ, the pure rate of time preference, and discusses its treatment under the "prescriptive" and "descriptive" approaches in subsections 1 and 2. Subsection 3 then turns to the second term, θg, and discusses growth discounting as an independent justification to discount future benefits. Subsection 4 discusses how Arrow and his coauthors address the subtle point of distinguishing opportunity cost discounting from time preference and growth discounting.

1. Prescriptive Pure Time Preference Discounting

Arrow and his coauthors indicate that the prescriptive approach constructs a discount rate from ethical principles.[22] These principles "reflect[] discounting of the utility of future generations" and "society's views concerning trade-offs of consumption across generations."[23] The main choice is whether ethical principles tell us ρ should be zero or some value greater than zero. A ρ of zero represents no discounting of the utility of future generations, where a ρ greater than zero says we value our own utility greater than the utility of future generations. As an ethical choice, however, "[e]conomic analysis gives no guidance as to the correct value [of ρ]."[24]

Setting the prescriptive pure rate of time preference to zero has a long historical pedigree.[25] In 1928, Frank Ramsey, writing a paper on the optimal savings rate, argued there was no moral or ethical justification to give more weight to the welfare of the current generation than to that of future generations.[26] According to Ramsey, any $\rho > 0$ is "ethically indefensible and arises merely from the weakness of the imagination."[27] In

22. *Id.* at 131.

23. *Id.*

24. Leslie Shiell, *Descriptive, Prescriptive and Second-best Approaches to the Control of Global Greenhouse Gas Emissions*, 87 J. PUB. ECON. 1431, 1439 (2003) ("The actual value of ρ which is used as the basis for policy is a purely ethical choice, which must be made by policy makers. Economic analysis gives no guidance as to the correct value."). *See also* U.S. ENVTL. PROT. AGENCY, GUIDELINES FOR PREPARING ECONOMIC ANALYSES 6-14 (2010) [hereinafter EPA GUIDELINES] ("[E]conomics alone cannot provide definitive guidance for selecting the 'correct' social welfare function or the social rate of time preference.").

25. Arrow et al., *IPCC Report*, *supra* note 10, at 136 (citing Frank P. Ramsey, *A Mathematical Theory of Saving*, 38 ECON. J. 543, 543–59 (1928)).

26. *Id.*

27. *Id. But see* Wilfred Beckerman & Cameron Hepburn, *Ethics of the Discount Rate in the Stern Review on the Economics of Climate Change*, 8 WORLD ECON. 187, 197 & n.21 (2007) (citing FRANK P. RAMSEY, *Truth and Probability*, *in* THE FOUNDATIONS OF MATHEMATICS AND OTHER LOGICAL ESSAYS 156, 291 (1931)) ("[E]ven Ramsey accepted a positive pure rate of time preference when his

their report to the IPCC, Arrow and his coauthors do not attempt to construct an ethical theory that would justify redistribution to earlier generations.[28] Indeed, they acknowledge the arguments surrounding the ethical judgment Ramsey made have "advanced only slightly."[29] Many prominent scholars (philosophers and economists alike) including John Broome,[30] William Cline,[31] Tyler Cowen,[32] Partha Dasgupta,[33] Roy Harrod,[34] Geoffrey Heal,[35] Tjalling Koopmans,[36] Derek Parfit,[37] Cédric

guard was down.").

28. Arrow and his coauthors briefly discuss the arguments that ρ should be adjusted to account for the probability of the extinction of the human race, and also to avoid the mathematical problem of attempting to maximize the sum of infinite future utilities in the absence of discounting. But because the adjustment for either of these problems would be so small as to be almost nonexistent, the authors dismiss them as lacking any practical significance. Arrow et al., *IPCC Report*, *supra* note 10, at 136.

29. *Id.*

30. JOHN BROOME, COUNTING THE COST OF GLOBAL WARMING 95–96, 108 (1992).

31. William Cline has held this position for many years. *Compare* WILLIAM R. CLINE, THE ECONOMICS OF GLOBAL WARMING 8 n.3 (1992) [hereinafter CLINE, ECONOMICS] ("There is no allowance [in the rate of time preference] for pure myopia . . . an effect that is particularly inappropriate over an intergenerational horizon."), *with* William R. Cline, *Meeting the Challenge of Global Warming*, *in* HOW TO SPEND $50 BILLION TO MAKE THE WORLD A BETTER PLACE 1, 5 (2006) ("In [the prescriptive approach], the discount rate for 'pure time preference' . . . is set at zero.").

32. *See* Tyler Cowen, *Caring About the Distant Future: Why It Matters and What It Means*, 74 U. CHI. L. REV. 5, 8–10 (2007). *See also* Richard L. Revesz, *Environmental Regulation, Cost-Benefit Analysis, and the Discounting of Human Lives*, 99 COLUM. L. REV. 941, 1002 (1999) (agreeing with distinction between intrapersonal and intergenerational pure time preference).

33. *See* Partha Dasgupta, *Discounting Climate Change*, 37 J. RISK & UNCERTAINTY 141, 157 (2008) (conceding ethical argument is "hard to rebut").

34. ROY F. HARROD, TOWARD A DYNAMIC ECONOMICS: SOME RECENT DEVELOPMENTS OF ECONOMIC THEORY AND THEIR APPLICATION TO POLICY 40 (1966) ("[P]ure time preference [is] a polite expression for rapacity and the conquest of reason by passion.").

35. Geoffrey Heal, *The Economics of Climate Change: A Post-Stern Perspective*, 96 CLIMATIC CHANGE 275, 281 (2009) [hereinafter Heal, *Post-Stern*] ("I personally find it difficult to see any reason for valuing future people differently from present people just because of their futurity."); Geoffrey Heal, *Discounting: A Review of the Basic Economics*, 74 U. CHI. L. REV. 59, 72 (2002) [hereinafter Heal, *Basic Economics*] ("The positions of Ramsey, Harrod, von Weizsäcker, and indeed of most economic theorists and philosophers who have written on this, is that the utility discount rate should be zero. Such a position is an ethical rather than an economic judgment, and there is no obvious ethical reason why future people should be considered less valuable than present people.").

36. Tjalling C. Koopmans, *On the Concept of Optimal Economic Growth*, 28 PONTIFICAE ACADEMIAE SCIENTIARUM SCRIPTA VARIA 225, 239 (1967) [hereinafter Koopmans, *Concept*] (expressing an "ethical preference for neutrality as between the welfare of different generations"). Koopmans, however, generally favors discounting, based on the apparent mathematical paradoxes from refusing to discount he outlined in a series of articles. *See, e.g.*, Kenneth J. Arrow, *Discounting, Morality, and Gaming*, *in* DISCOUNTING AND INTERGENERATIONAL EQUITY 13, 13–15 (Paul R. Portney & John P. Weyant eds., 1999) [hereinafter Arrow, *Gaming*] (citing Koopmans, *Concept*, *supra*; Tjalling C. Koopmans, *Stationary Ordinal Utility and Impatience*, 28 ECONOMETRICA 287 (1960)) (describing Koopmans as giving a "crushing answer" to reject zero time preference based on mathematical paradox of infinite generations).

37. Tyler Cowen & Derek Parfit, *Against the Social Discount Rate*, *in* JUSTICE BETWEEN AGE

Philibert,[38] Arthur Pigou,[39] John Quiggin,[40] John Rawls,[41] Henry Sidgwick,[42] and Robert Solow,[43] concur with the proposition that, as far as the ethical judgment is concerned, ρ should equal zero.[44]

On the other hand, Arrow,[45] Wilfred Beckerman, and Cameron Hepburn[46] suggest that while objectively one can argue that ρ should be zero, the structure of societal ties may mean that our moral decisions are (and should be) relative to our position in life—we favor family, friends, and community over strangers.[47]

GROUPS AND GENERATIONS 144, 154–55 (Peter Laslett & James S. Fishkin eds., 1992) (describing pure time preference as "irrational" and unable to justify intergenerational discount rate).

38. Cédric Philibert of the International Energy Agency wrote, "If a . . . 'prescriptive' position [is] adopted for ethical reasons, it is of course logical to give the pure time preference a nil value." Cédric Philibert, *The Economics of Climate Change and the Theory of Discounting*, 27 ENERGY POL'Y 913, 917 (1999) (citing CLINE, ECONOMICS, *supra* note 31).

39. ARTHUR C. PIGOU, THE ECONOMICS OF WELFARE 25 (4th ed. 1932) (suggesting pure time preference "implies . . . our telescopic faculty is defective").

40. John Quiggin, *Stern and His Critics on Discounting and Climate Change: An Editorial Essay*, 89 CLIMATIC CHANGE 195, 200 (2008) (arguing positive rate of pure time preference is ethically indefensible as it represents "selfishness" that harms future generations, and should not be used for developing social policy).

41. JOHN RAWLS, A THEORY OF JUSTICE 259 (1st ed. 1999) ("There is no reason for the parties to give any weight to mere position in time.").

42. HENRY SIDGWICK, THE METHOD OF ETHICS 412 (4th ed. 1890) ("[T]he time at which a man exists cannot affect the value of his happiness from a universal point of view; and that the interests of posterity must concern a Utilitarian as much as those of his contemporaries, except in so far as the effect of his actions on posterity—and even the existence of human beings to be affected—must necessarily be more uncertain.").

43. Robert M. Solow, *The Economics of Resources or the Resources of Economics*, 64 AM. ECON. REV. 1, 9 (1974) ("In solemn conclave assembled, so to speak, we ought to act as if the social rate of time preference were zero.").

44. *See* Louis Kaplow, *Discounting Dollars, Discounting Lives: Intergenerational Distributive Justice and Efficiency*, 74 U. CHI. L. REV. 79, 97 (2007) ("[A]lthough this Article is not primarily concerned with political considerations, it is worth some reflection on the plausibility of distribution neutrality. A conjecture is that, if one had to predict a priori the most likely long-run distributive impact of a policy change, distribution neutrality would be the best guess."). *See also id.* at 112, 116 (taking no firm position on actual value of ρ); Eric A. Posner, *Agencies Should Ignore Distant-Future Generations*, 74 U. CHI. L. REV. 139, 139–41 (2007) (accepting ρ could equal zero as an ethical and moral judgment, though not a political judgment); Samida & Weisbach, *supra* note 10, at 151–52 & nn.20–21 (2007) (explaining that they "do not discount well-being," i.e. no positive pure time preference).

45. Arrow, *Gaming*, *supra* note 36, at 16–17.

46. Beckerman & Hepburn, *supra* note 27.

47. *See id.* at 198–201 (citing 2 HUME, A TREATISE OF HUMAN NATURE 462 (Penguin Books 1969) (1740)); Arrow, *Gaming*, *supra* note 36, at 16–17 (describing as "agent-relative" ethics). *See also* EPA GUIDELINES, *supra* note 24, at 6–19 (arguing "importance of other people's welfare . . . appears to grow weaker as temporal, cultural, geographic, and other measures of 'distance' increase"); Matthew W. Wolfe, Note, *The Shadow of Future Generations*, 57 DUKE L.J. 1897, 1906–07 (2008) (arguing person's interest in direct descendants does not explain "why people should care about future

2. Descriptive Pure Time Preference Discounting

According to Arrow and his coauthors, the descriptive approach is the more commonly employed method for calculating a discount rate to evaluate the effects of climate change.[48] Where the prescriptive approach attempts to break down the components of a discount rate in order to reach the "correct" rate, the descriptive approach infers *d* from the savings rate and current rates of return.[49] By looking to choices people actually make in saving and investing for the future, the descriptive approach attempts to calculate the implicit weight we place on the future.[50] A person who saves very little implicitly does not care about her future as much as her present consumption, but a person who saves a relatively high amount of her income implicitly cares greatly about her future welfare. As Arrow further elaborated in his subsequent work, the primary problem with assuming ρ is zero is that it implies a savings and investment rate far above and beyond what actually occurs in any country now.[51] Arrow also argues that a zero ρ means the infinite number of future generations will receive more value from our investment than the one current generation, and that consumption should fall to near-starvation levels in order to save for those future generations.[52]

---

generations"). Beckerman and Hepburn do not argue that agent-relative ethics is necessarily the "correct" ethical theory, but suggest it should be considered equally valid alongside the theory that ρ should not be positive. Beckerman & Hepburn, *supra* note 27, at 201.

48. Arrow et al., *IPCC Report*, *supra* note 10, at 132. *See also* Cass R. Sunstein & Arden Rowell, *On Discounting Regulatory Benefits: Risk, Money, and Intergenerational Equity*, 74 U. CHI. L. REV. 171, 177–78 (2007) ("[The descriptive approach] is the standard approach of those who advocate discounting.").

49. Arrow et al., *IPCC Report*, *supra* note 10, at 132–33. The typical descriptive approach is focused more on observing *d*, the final discount rate, and less on observing its component parameters ρ and θ. *See* Shane Frederick, *Valuing Future Life and Future Lives: A Framework for Understanding Discounting*, 27 J. ECON. PSYCH. 667, 675 (describing how researchers "rarely attempt to isolate or assess the relative effects of . . . different considerations" when determining implicit discount rates). *See also* NORDHAUS, BALANCE, *supra* note 10, at 50 (explaining how he lowered ρ in his descriptive approach but raised θ in order to maintain a *d* that approximated market data).

50. *See* Frank Ackerman & Ian J. Finlayson, *The Economics of Inaction on Climate Change: A Sensitivity Analysis*, 6 CLIMATE POL'Y 509, 512–13 (2006) ("The descriptive approach, in contrast, bases the discount rate on market interest rates because those rates represent consumers' revealed preference for future versus present rewards.").

51. Arrow et al., *IPCC Report*, *supra* note 10, at 133; Arrow, *Gaming*, *supra* note 36, at 14–16.

52. For an investment opportunity available only to the current generation, the argument goes, because any investment now will give a stream of benefits to an infinite number of generations in the future, any investment short of sacrificing all current income will be preferred to the status quo. This implies a savings rate of close to 100%. If the opportunity is available in every period, following Ramsey's optimal savings ratio of 1/θ, the implied savings rate is two-thirds at a θ of 1.5. Arrow, *Gaming*, *supra* note 36, at 14–15 (citing Ramsey, *supra* note 25, *as reprinted in* FRANK P. RAMSEY,

Rather than affect the ethical theory and appropriate ρ chosen in the prescriptive approach, these concerns are seen as arguments against using the prescriptive approach at all, and instead favor the descriptive approach.[53] By focusing solely on people's revealed preferences, the descriptive approach attempts to bypass the ethical concerns addressed in the prescriptive approach and reveal a positive discount rate.[54] As Arrow and his coauthors point out, Ramsey's analysis focused on what society *should* do, but "this does not exclude the possibility that, as a matter of *description*, the current generation gives less value to consumption of future generations."[55]

Some argue, however, that we cannot simply bypass those ethical concerns by looking to revealed preferences. David Pearce and his coauthors point out, "the social discount rate is a *normative* construct—it tells us what we should do. Deriving a normative rule from an empirical observation contradicts Hume's dictum that 'ought' cannot be derived from 'is'."[56] Thus, a serious problem with the descriptive approach is that it necessarily makes the prescriptive judgment that revealed preferences

FOUNDATIONS: ESSAYS IN PHILOSOPHY, LOGIC, MATHEMATICS, AND ECONOMICS 261, 276 (D.H. Mellor ed., 1978)); Arrow et al., *IPCC Report*, *supra* note 10, at 137.

53. Arrow et al., *IPCC Report, supra* note 10, at 132–33; Posner, *supra* note 44, at 141 ("Intertemporal egalitarianism may be ethically correct, but it is surely false as a matter of human psychology, and hence people's choices, voting behavior, and electoral politics.").

54. *See* Arrow, *Gaming*, *supra* note 36, at 13, 16–17 ("[I]ndividuals are not morally required to subscribe fully to morality at any cost to themselves."); Arrow et al., *IPCC Report*, *supra* note 10, at 133 (arguing overriding revealed preferences on ethical grounds creates irreconcilable inconsistencies between climate policy and other forms of cost-benefit analysis). *See also* Ackerman & Finlayson, *supra* note 50, at 512 (citing Arrow, *Gaming*, *supra* note 36) ("Most economists working in this field, though, have argued that pure time preference should be positive; in theory, zero pure time preference could lead to implausibly high optimal rates of savings and sacrifice for the future."); W. Kip Viscusi, *Rational Discounting for Regulatory Analysis*, 74 U. CHI. L. REV. 209, 209 (2007) ("[D]istant benefits and costs should be recognized fully in the policy analysis process, but . . . should be weighted based on the same discount rate methodology that is applied to effects on the current generation."); *id.* at 210–11 (suggesting that the welfare of future generations should perhaps enter our calculations only as it affects *our* welfare—altruistic utility).

55. Arrow et al., *IPCC Report*, *supra* note 10, at 136.

56. David Pearce et al., *Valuing the Future: Recent Advances in Social Discounting*, 4 WORLD ECON. 121, 126 (2003). *See also* John Broome, *The Ethics of Climate Change: Pay Now or Pay More Later?*, SCI. AM. MAG., May 19, 2008 (arguing it is doubtful markets "reveal people's ethical judgments about the value of future well-being"); Heal, *Post-Stern*, *supra* note 35, at 282 (arguing violating Hume's dictum "seem[s] to me to sink the whole endeavor of linking [ρ] to [market returns]"); Heal, *Basic Economics*, *supra* note 35, at 67, 73–75 (explaining that ρ is an exogenous variable that must be chosen in order to drive the social discount rate (*d*), and criticizing Nordhaus and Weitzman for avoiding the choice of ρ by using historical rates of return to infer ρ); Kysar, *supra* note 10, at 121 (criticizing reliance on revealed consumer preferences that government is often charged to correct for).

should drive how society should make public policy choices.[57]

3. Growth Discounting

The second term in the traditional discounting framework, θg, ostensibly provides a third justification for discounting intergenerational future benefits. Even if we assume that future generations should be treated equally from an ethical viewpoint ($\rho = 0$), if we expect future generations to be wealthier than our own, θg discounts for the fact that an extra unit of consumption is worth relatively more now to the poorer present than it will be to the wealthier future.[58] A future millionaire would not particularly care if she received an extra $100, but a current subsistence-level farmer could greatly improve his utility with that same $100, and so, in this example, we should adjust the allocation of resources to give it to the farmer who would benefit more.

Breaking apart the second term into its components, this rising consumption discount rate reflects the rate at which per capita consumption grows, g, and is multiplied by the elasticity of marginal utility gained from an extra unit of consumption, θ, which is a measure of society's "aversion to consumption inequality."[59] The higher θ is, the more we would sacrifice the consumption of a rich person to help a poor person. The IPCC estimates a growth rate of 1.6% per capita, with an elasticity of marginal utility of 1.5, leading to a discount rate of 2.4%.[60] Thus, even with $\rho = 0$, growth discounting implies we would be indifferent between saving 1 life now,

57. Sunstein & Rowell, *supra* note 48, at 178 ("[A]ny descriptive approach must ultimately be defended in prescriptive terms.").

58. Arrow et al., *IPCC Report*, *supra* note 10, at 131. *See also* Cowen, *supra* note 32, at 6 n.2 (separating growth discounting from pure time preference discounting); Heal, *Basic Economics*, *supra* note 35, at 60–61 (arguing growth discounting distinguishes between rich and poor generations, not necessarily future and current—an interpersonal distinction, not intergenerational); Viscusi, *supra* note 54, at 217 (arguing that if people value their lives more in the future because they are richer, we must discount that economic growth in order to treat present and future lives the same).

59. *See* Dasgupta, *supra* note 33, at 157. A θ of one "insist[s] that any proportionate increase in someone's consumption level ought to be of equal social worth to that same proportionate increase in the consumption of anyone else who is a contemporary, no matter how rich or poor that contemporary happens to be." *Id.* at 150. To the extent future growth is uncertain, θ also represents an index of risk aversion: the higher the θ, the more we would save now to avoid the risk of uncertain future consumption. *Id.* at 164; Stern, *Economics*, *supra* note 10, at 15 (describing θ as playing three roles: "(a) intratemporal distribution, (b) intertemporal distribution, and (c) attitudes to risks"). *See also infra* Part II.B (describing hyperbolic discounting as response to uncertainty of growth). θ as a measure of risk aversion is irrelevant as Arrow and his coauthors describe the framework, however, as he assumes by relying on "certainty equivalents" of risky consumption, we already capture risk aversion. Arrow et al., *IPCC Report*, *supra* note 10, at 130 & n.5.

60. Arrow et al., *IPCC Report*, *supra* note 10, at 132.

10.7 lives in 100 years, and 141,247 lives in 500 years.[61]

4. Opportunity Cost Discounting

Arrow and his coauthors recognize the important distinction between discounting for opportunity costs and discounting for a pure rate of time preference. They note that "the cost of a greenhouse mitigation project must include the foregone benefits of other competing investments not undertaken."[62] For example, if we want to benefit future generations through a climate change project, we need to consider the effects to the same future generations of diverting resources from projects that would also have generated other types of benefits to those generations. Those foregone benefits are the opportunity cost of choosing the climate change project.

Within a generation, Arrow and his coauthors note: "If a mitigation project would displace private investment, and returns to both projects accrue to the same generations, then it is appropriate to use the opportunity cost of capital—the return that the private investor would have received from the forgone capital investment."[63] This point is the standard, noncontroversial argument that assigning resources to one project forecloses using those resources for a different project and therefore the cost of a project includes the opportunity cost of not being able to undertake the competing project.

But accounting for opportunities lost now is not the same as discounting the utility of future generations.[64] By discounting the value of the utilities of future generations, society determines the level of benefit to convey to the future generation. On the other hand, opportunity cost discounting simply determines the cheapest way to convey a chosen benefit to a future generation. We explore the relationship between these concepts more thoroughly in Parts III and V.

B. HYPERBOLIC DISCOUNTING

Whether an economist adopts the prescriptive or descriptive approach

61. Revesz, *supra* note 32, at 1003.
62. Arrow et al., *IPCC Report*, *supra* note 10, at 131.
63. *Id.*
64. *See* Frederick, *supra* note 49, at 671 (citing Cowen & Parfit, *supra* note 37, at 153) ("'[M]ay be transformed into' should not be confused with 'is as good as' . . . one may be able to transform a frog into a prince, but that does not mean that a frog *is* a prince, or that a frog who remains a frog is as good as a prince.").

to discounting, the Arrow/Ramsey formula, $d = \rho + \theta g$, assumes the discount rate remains constant over time. Hyperbolic discounting challenges this assumption by employing a higher discount rate in the near term and a lower discount rate further into the future.[65] In traditional, "exponential" discounting, the constant discount rate exponentially decreases the present value of a good the further in the future we value it.[66] On the other hand, by using a declining discount rate, "hyperbolic" discounting changes the present value function to a hyperbola, increasing the value of future goods relative to traditional discounting.[67]

The literature provides two main rationales for hyperbolic discounting. First, empirical evidence suggests people (and animals[68]) actually discount the far-off future at a rate much less than the near future.[69] These studies observed this effect in different contexts. Some studies found that when asked to compare a small reward now to a large reward later, if discount rates are constant, people used a lower implicit discount rate for longer time horizons.[70] Other studies, when attempting to fit the empirical data

65. Hyperbolic discounting may be referred to as logarithmic discounting, Heal, *Basic Economics*, *supra* note 35, at 69, or declining discounting, STERN REVIEW, *supra* note 12, at 49–50. For ease of reference, we will refer to the general concept of using a variable discount rate as hyperbolic discounting.

66. This is clear from the present value formula: $PV = FV/(1 + d)^n$, where n creates the exponential effect when *d* remains constant over all periods n.

67. *See* Ackerman & Finlayson, *supra* note 50, at 514 (comparing effect of declining discount rate, "S," with constant discount rate, "Cline").

68. *See* Shane Frederick, George Loewenstein & Ted O'Donoghue, *Time Discounting and Time Preference: A Critical Review*, 40 J. ECON. LITERATURE 351, 361 & n.14 (2002) (citing George Ainslie & Richard J. Herrnstein, *Preference Reversal and Delayed Reinforcement*, 9 ANIMAL LEARNING BEHAV. 476 (1981)) (observing hyperbolic discounting in pigeons); Partha Dasgupta & Eric Maskin, *Uncertainty and Hyperbolic Discounting*, 95 AM. ECON. REV. 1290, 1298 (2005) (seeking to explain hyperbolic discounting observed in pigeons and starlings).

69. Geoffrey Heal compared the empirical evidence surrounding hyperbolic discounting to the Weber-Fechner law, which says that the response to a change in the intensity of a stimulus is inversely proportional to the initial level of the stimulus. Heal, *Basic Economics*, *supra* note 35, at 69. That is, "[t]he louder the sound initially, the less we respond to a given increase." *Id.* In discounting terms, time represents the stimulus. The longer the period of time, the less we care about (and discount) delaying a benefit one more year. *See id.* at 69–70.

70. Frederick, Loewenstein & O'Donoghue, *supra* note 68, at 360 (citing Richard H. Thaler, *Some Empirical Evidence on Dynamic Inconsistency*, 8 ECON. LETTERS 201 (1981); Uri Benzion, Amnon Rapoport & Joseph Yagil, *Discount Rates Inferred from Decisions: An Experimental Study*, 35 MGMT. SCI. 270, 282 (1989); Gretchen B. Chapman, *Temporal Discounting and Utility for Health and Money*, 22 J. EXPERIMENTAL PSYCH.: LEARNING, MEMORY, AND COGNITION 771, 771 (1996); Gretchen B. Chapman & Arthur S. Elstein, *Valuing the Future: Temporal Discounting of Health and Money*, 15 MED. DECISION MAKING 373, 374–75 (1995); John L. Pender, *Discount Rates and Credit Markets: Theory and Evidence from Rural India*, 50 J. DEVEL. ECON 257 (1996); Donald A. Redelmeier & Daniel N. Heller, *Time Preference in Medical Decision Making and Cost-Effectiveness Analysis*, 13 MED. DECISION MAKING 212, 214 (1993)). Some studies even showed "preference reversals," where

from these surveys to an explicit mathematical formula, found hyperbolic functions fit the data better than exponential (constant-rate) functions.[71]

Though there appears to be ample empirical evidence of hyperbolic discounting, scholars are cautious about the value of these findings. W. Kip Viscusi and his coauthors, for example, dismiss empirical evidence of hyperbolic discounting as a mere "empirical curiosity."[72] Shane Frederick and his coauthors suggest hyperbolic discounting may be explained by "subadditive discounting"—if you ask someone to discount two consecutive six-month periods and then ask them to discount once over one year, the compounded discount rate from the six-month periods will be larger than the one-year discount rate, suggesting some cognitive error.[73]

The second justification for hyperbolic discounting says, as a mathematical process, uncertainty about the future interest rates suggests

people switched to preferring the earlier reward if they would receive it sooner, even if the time interval between the two rewards remained the same. Frederick et al., *supra* note 68, at 360–61 & n.14 (citing Leonard Green et al., *Temporal Discounting and Preference Reversals in Choice Between Delayed Outcomes*, 1 PSYCHONOMIC BULL. REV. 383 (1994); Kris N. Kirby & R. J. Herrnstein, *Preference Reversals Due to Myopic Discounting of Delayed Reward*, 6 PYSCH. SCI. 83, 83 (1995); Andrew Millar & Douglas Navarick, *Self-Control and Choice in Humans: Effects of Video Game Playing as a Positive Reinforcer*, 15 LEARNING & MOTIVATION 203, 213–16 (1984); Jay Solnick et al., *An Experimental Analysis of Impulsivity and Impulse Control in Humans*, 11 LEARNING & MOTIVATION 61, 74–76 (1980); Ainslie & Herrnsetin, *supra* note 68, at 477–78; Leonard Green et al., *Preference Reversal and Self Control: Choice as a Function of Reward Amount and Delay*, 1 BEHAV. ANALYSIS LETTERS 43, 43 (1981)).

71. W. Kip Viscusi, Joel Huber & Jason Bell, *Estimating Discount Rates for Environmental Quality from Utility-Based Choice Experiments*, 37 J. RISK & UNCERTAINTY 199, 212–13 (2008); Frederick, Loewenstein & O'Donoghue, *supra* note 68, at 360 & n.13 (citing Kris N. Kirby, *Bidding on the Future: Evidence Against Normative Discounting of Delayed Rewards*, 126 J. EXPERIMENTAL PSYCH: GEN. 54 (1997); Kris N. Kirby & Nino Marakovic, *Modeling Myopic Decisions: Evidence for Hyperbolic Delay-Discounting within Subjects and Amounts*, 64 ORG. BEHAV. HUM. DECISION PROC. 22, 28–29 (1995); Joel Myerson & Leonard Green, *Discounting of Delayed Rewards: Models of Individual Choice*, 64 J. EXPERIMENTAL ANALYSIS BEHAV. 263, 272 (1995); Howard Rachlin, Andres Raineri & David Cross, *Subjective Probability and Delay*, 6 J. EXPERIMENTAL ANALYSIS BEHAV. 233, 243–44 (1991)).

72. Viscusi et al., *supra* note 71, at 216. In their study measuring people's value of improvements to water quality, Viscusi and his coauthors found a more stable long-term discount rate (~5%), and thus argued the main effect of hyperbolic discounting with such a high initial rate "will be to disadvantage short-term environmental policies," with discounting still ignoring benefits in the very long-term. *Id.*

73. *See* Frederick, Loewenstein & O'Donoghue, *supra* note 68, at 361–62 & nn.16–17 (citing Daniel Read, *Is Time-Discounting Hyperbolic or Subadditive?*, 23 J. RISK & UNCERTAINTY 5 (2001)). These results are consistent with subadditive results in other fields. For example, if you ask people to judge the probability of "death by fire," "death by drowning," etc., the total probability of death by accident will be larger than if you simply ask them the probability of "death by accident." *Id.* at 361 n.16 (citing Amos Tversky & Derek Koehler, *Support Theory: Nonextensional Representation of Subjective Probability*, 101 PSYCH. REV. 547 (1994)).

we should average discount factors—the factors used to multiply future outcomes to turn them into present values. Martin Weitzman has pushed strongly for a declining discount rate, arguing that the key to calculating the certainty-equivalent discount rate is averaging those discount *factors*, rather than the discount *rates*.[74] Since we are not sure what the discount rate will be in the very-distant future, by averaging discount factors, over time the lower discount rate will dominate, leading to a declining rate.[75]

A mathematical example may help illustrate this concept. Let us assume that the yearly discount rate over the next 10 years is equally likely to be either 10% or 2%. In order to calculate the certainty-equivalent discount rate, Weitzman argues that we should not simply average the discount rates and discount at 6%. Instead, we should average the expected values at each of those discount rates. $1 in 10 years is either worth $.39 (10% rate) or $.82 (2% rate) now. This gives us an expected (average) present value of $.60, and a corresponding certainty-equivalent discount rate of 5.2%,[76] less than our 6% average of the discount rates.

If we keep our 50-50 probability of either 10% or 2% into the future forever, the discount factor for the 10% rate declines faster than the 2% rate, meaning our certainty-equivalent discount rates moves closer to 2% the further into the future we go. So, in 10 years the discount rate would be 5.2%, in 100 years the discount rate would decline to 2.7%, and in 1000 years the rate would decline to 2.1%, eventually approaching 2%.[77]

Taking the idea of uncertainty one step further, Weitzman also suggests that even if every person believes there is no uncertainty about what the proper discount rate is and wishes to discount exponentially, the discount rates people advocate vary widely, and so uncertainty exists in the *aggregate*.[78] Surveying the "professionally considered gut feeling" of what

74. Martin L. Weitzman, *Why the Far-Distant Future Should Be Discounted at the Lowest Possible Rate*, 36 J. ENVTL. ECON. & MGMT. 201, 206 (1998) [hereinafter Weitzman, *Far-Distant Future*]. *See also id.* at 203–05 (explaining mathematical proof). The discount factor is calculated as $1/(1 + r)^t$.

75. Martin L. Weitzman, *Gamma Discounting*, 91 AM. ECON. REV. 260, 260 (2001) [hereinafter Weitzman, *Gamma Discounting*]; Martin L. Weitzman, *Just Keep Discounting, But . . .*, *in* DISCOUNTING AND INTERGENERATIONAL EQUITY, *supra* note 36, at 23, 29 [hereinafter Weitzman, *Just Keep Discounting, But . . .*]; Weitzman, *Far-Distant Future*, *supra* note 74, at 201, 203, 206.

76. The present value formula, $PV = FV/(1+r)^n$, calculated as $0.6 = 1/(1+r)^{10}$, yields a yearly r of 5.2%.

77. *See* Pearce et al., *supra* note 56, at 129 tbl.1 (listing numerical example of declining certainty-equivalent discount rate).

78. Weitzman, *Gamma Discounting*, *supra* note 75, at 264 & n.5 ("*Even if* everyone believes in a constant discount rate, the *effective* discount rate declines strongly over time.").

economists believe the proper discount rate should be,[79] Weitzman used the probability distribution from his responses to calculate a certainty-equivalent discount rate.[80] He recommends a declining discount rate of 4% for the first 5 years, 3% for years 6–25, 2% for years 26–75, 1% for years 76–300, and 0% for everything past year 300.[81]

According to Weitzman, the proper social discount rate for long-term projects is a rate that declines over time to the lowest plausible rate, that is, the lowest estimation of the expected long-term rate, to account for uncertainty.[82] Despite some objections,[83] much of the current economics and legal literature agrees with Weitzman.[84] Indeed, in its notice of

79. *Id.* at 266.

80. *See id.* at 264–69 (outlining mathematical formula modeling discount rate based on mean and variance of responses). Weitzman interpreted the results as aligning with a gamma probability distribution, i.e. roughly an early peak with a thin tail at right end of the distribution. *See id.* at 263 fig.1, 268. Hence Weitzman coined his approach "gamma discounting."

81. *Id.* at 269–71 & tbl.2.

82. Weitzman, *Far-Distant Future*, *supra* note 74, at 207; Weitzman, *Just Keep Discounting, But. . .*, *supra* note 75, at 29 ("I now think the moral of the story is 'just keep discounting, but . . .' at a declining interest rate for very long-term projects.").

83. The main objection to hyperbolic discounting is "time-inconsistency," that future generations using declining discount rates would rationally reverse the policies we set now. *See* Pearce et al., *supra* note 56, at 132. *See also* OFFICE OF MGMT. & BUDGET, EXEC. OFFICE OF THE PRESIDENT, OMB CIRCULAR A-4, REGULATORY ANALYSIS 35 (2003) [hereinafter OMB CIRCULAR A-4], *available at* http://www.whitehouse.gov/omb/circulars_a004_a-4/ ("Using the same discount rate across generations has the advantage of preventing time-inconsistency problems."). Others, however, argue that requiring discounting to avoid time inconsistency is a "most unnatural requirement," since people often reverse their own decisions, Pearce et al., *supra* note 56, at 132 (quoting GEOFFREY HEAL, VALUING THE FUTURE: ECONOMIC THEORY AND SUSTAINABILITY 110 (1998)), and that a "sophisticated" government policy will take into account future possible reversals in a way that avoids problems caused by "naïve" government decisions that ignore time inconsistency. *See* Pearce et al., *supra* note 56, at 133 (citing Cameron J. Hepburn, *Hyperbolic Discounting and Resource Collapse*, ROYAL ECON. SOC'Y ANNUAL CONFERENCE 2004, NO. 103, at 18–20 (2003)); Jiehan Guo et al., *Discounting and the Social Cost of Carbon: A Closer Look at Uncertainty*, 9 ENVTL. SCI. & POL'Y 205, 209–10 (2006) (citing Hepburn, *supra*).

84. *See* Weisbach & Sunstein, *supra* note 10, at 443–44; Christian Gollier & Martin L. Weitzman, *How Should the Distant Future Be Discounted When Discount Rates are Uncertain?* 10 (CESifo Working Paper No. 2863, 2009), *available at* http://www.ifo.de/pls/guestci/download/CESifo%20Working%20Papers%202009/CESifo%20Working%20Papers%20December%202009/cesifo1_wp2863.pdf ("When future discount rates are uncertain but have a permanent component, then the 'effective' discount rate must decline over time toward its lowest possible value."); Mark C. Freeman, *Yes, We Should Discount the Far-Distant Future at Its Lowest Possible Rate: A Resolution of the Weitzman-Gollier Puzzle*, 42 ECON. E-JOURNAL 2 (2010); Guo et al., *supra* note 83, at 206 (arguing declining discount rates are better suited to discounting climate change than constant discount rates); Robert S. Pindyck, *Uncertainty in Environmental Economics*, 1 REV. ENVTL. ECON. & POL'Y 45, 62 (2007) [hereinafter Pindyck, *Uncertainty*] ("[T]he correct rate should decline over the [time] horizon and . . . the rate for the distant future is probably well below two percent, which is lower than the rates often used for environmental cost-benefit analysis."); *id.* at 62 & n.15 (citing Robert J. Barro, *Rare*

proposed rulemaking on the GHG rule for automobile emissions, the EPA used a form of hyperbolic discounting in its sensitivity analysis.[85] This approach of declining discount rates applies to all the different justifications for discounting.[86] Whichever justification for intergenerational discounting one advances, if there is uncertainty about the discount rate, the hyperbolic approach argues that the rate should decline over time.

C. STERN AND NORDHAUS

Two studies of climate change policy, the *Stern Review* and William Nordhaus' *A Question of Balance*, apply very different discount rates and, largely for that reason, come to radically different conclusions regarding the gravity of the threat posed by global warming as well as the proper response to that threat. The *Stern Review*, a report commissioned by the British government on the economics of climate change, advocates a very low discount rate. This is largely due to its position that it is ethically indefensible to value the welfare of future generations less than that of our own simply because we exist prior in time—a rejection of prescriptive time preference discounting. Using a discount rate of 1.4%, the *Review* urges the immediate adoption of expensive measures designed to curb climate change, to the tune of 1% of the world's gross domestic product ("GDP") per year.[87]

In contrast, according to William Nordhaus, the proper way to value future benefits is to look at how people actually value the future based on the opportunity cost of capital—he advocates descriptive pure time preference discounting. Using this framework, Nordhaus adopts a discount

Disasters and Asset Markets in the Twentieth Century, 121 Q.J. ECON. 823 (2006)) (suggesting the risk of disasters such as war help explain market "puzzles" such as the near-zero risk free rate); Pearce et al., *supra* note 56, at 129–30 (citing Richard G. Newell & William A. Pizer, *Discounting the Distant Future: How Much Do Uncertain Discount Rates Increase Valuations?*, 46 J. ENVTL. ECON. & MGMT. 52, 54 (2003)) (simulating and supporting Weitzman's assumptions of persistent uncertainty in interest rates into the future based on historical data).

85. EPA & NHTSA, Proposed Rulemaking To Establish Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards, 74 Fed. Reg. 49,594, 49,613–16 (Sept. 28, 2009) (using Newell-Pizer "random walk" uncertainty model for declining discount rate). *But see* EPA & NHTSA, Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards; Final Rule, 75 Fed. Reg. 25,324, 25,522–23 (May 7, 2010) (not using declining discount rate in final rule).

86. *See, e.g.*, Heal, *Post-Stern*, *supra* note 35, at 285 (accepting Weitzman's calculations as "technically" correct but not "totally certain of its philosophical foundations and implications").

87. STERN REVIEW, *supra* note 12, at 284–88.

rate of 5.5% and discounts future benefits accordingly. Largely because of this he comes to policy conclusions much more modest than those advanced by the *Stern Review*, advocating spending no more than $2 trillion on climate mitigation efforts, or 0.1% of the world's income,[88] approximately ten times less than the 1% of global GDP Stern recommends.[89]

1. The *Stern Review*

The *Stern Review* provides two possible justifications for discounting future consumption: pure time preference and growth discounting.[90] The *Review* rejects discounting for pure time preference on ethical grounds, at least in the context of future generations.[91] Finding no ethical justification for treating the welfare of future generations as less important than our own, the *Review* concludes, "if a future generation will be present, we suppose that it has the same claim on our ethical attention as the current one."[92]

This prescriptive approach to discounting would therefore appear to justify setting a ρ value of zero. But rather than set ρ as zero, the *Review* allows for the possibility that, at any given point in the future, the human race will not exist, and that therefore there will be no welfare effects about which we should be concerned. In fixing the probability of an extinction event, the *Review* is careful to note that it is only taking account of events exogenous to climate change, for example a massive meteor strike.[93] The *Review* settles on a ρ of 0.1% to take into account the yearly probability of

88. *See* NORDHAUS, BALANCE, *supra* note 10, at 195.

89. *Id.* at 186 ("[The Stern Review's] number is more than 10 times the DICE-model [Nordhaus] result."); STERN REVIEW, *supra* note 12, at 284–88 (advocating 1% of global GDP spent on climate change mitigation).

90. The *Review* notably does not discuss discounting for opportunity costs. In a follow-on article to the publication of the *Review*, however, Sir Nicholas Stern criticizes opportunity cost discounting using market rates. *See* Stern, *Economics*, *supra* note 10, at 12–13; *infra* Part V (discussing Stern's argument against opportunity costs in detail).

91. STERN REVIEW, *supra* note 12, at 47 ("[The] intertemporal allocation by [an] individual has only limited relevance for the long-run ethical question associated with climate change.").

92. *Id.* at 31–32 (citing Ramsey, *supra* note 25, at 543); CLINE, ECONOMICS, *supra* note 31; HARROD, *supra* note 34, at 37–40; PIGOU, *supra* note 39, at 24–25; Solow, *supra* note 43, at 9; Sudhir Anand & Amartya Sen, *Human Development and Economic Sustainability*, 28 WORLD DEV. 2029, 2030 (2000). *See also* STERN REVIEW, *supra* note 12, at 48 ("[I]f you care little about future generations you will care little about climate change. As we have argued, that is not a position which has much foundation in ethics and which many would find unacceptable.").

93. STERN REVIEW, *supra* note 12, at 46.

such an event, a value which the *Review* itself says "seems high."[94]

The authors of the *Review* also consider it entirely uncontroversial to discount future benefits in order to take account of future changes in consumption, that is, growth discounting.[95] Citing empirical evidence, the *Review* adopts a θ of 1,[96] and calculates an expected growth rate of 1.3%.[97] Taking, then, the ρ value of 0.1 and the θ and g values of 1 and 1.3, the *Review* adopts an overall discount rate of 1.4% per year.[98]

2. William Nordhaus's *A Question of Balance*

In place of the *Stern Review*'s prescriptive approach to the discount rate, Nordhaus adopts a rate that is explicitly calibrated to reflect observed market interest rates. Much of Nordhaus' justification for such an approach

94. *Id.* at 47 & tbl.2A.1. At the *Review's* yearly rate of a .1% chance of extinction, they calculate there is a 10% chance of extinction in 100 years. *Id.* Extending even further, the probability that the human race exists in 700 years is less than a coin flip. The *Review* defends its rate by defining "extinction" to include not only the possibility of the world ending and complete destruction of the human race through events completely out of our control, such as a meteor strike, but also events like nuclear war or a pandemic that kills off a substantial portion of the human race. *Id.*

95. *See id.* at 48 ("[W]e should emphasise that using a low [ρ] does not imply a low discount rate. . . . Growing consumption *is* a reason for discounting.").

96. *See id.* at 161 & n.39 (citing David W. Pearce & David Ulph, *A Social Discount Rate for the United Kingdom*, *in* ENVIRONMENTAL ECONOMICS: ESSAYS IN ECOLOGICAL ECONOMICS AND SUSTAINABLE DEVELOPMENT (David W. Pearce ed., 1999)). The *Review* does not discount the possibility that future empirical work could point toward a broader range of values for θ, including something higher than 1. *Id.* at 161 & n.40 (citing Pearce & Ulph, *supra*; Nicholas Stern, *The Marginal Valuation of Income*, *in* STUDIES IN MODERN ECONOMIC ANALYSIS (Michael J. Artis & Avelino Romeo Nobay eds., 1977)). Although the *Review* uses empricial evidence for θ, it previously discussed θ as representing a "value judgment" about how much less utility we gain from consumption when we are richer. *See id.* at 46. It is unclear how this aligns with a descriptive approach to calculating θ.

97. *See id.* at 161–62 (using the PAGE2002 model for an annual average projection for growth in a world without climate change).

98. After the publication of the original *Review*, Stern, responding to academic critiques, modified his assumption of θ upwards to 2. *See* Stern, *Economics*, *supra* note 10, at 23 (citing Dasgupta, *supra* note 33; Weitzman, *Stern Review*, *supra* note 9; Martin L. Weitzman, *On Modeling and Interpreting the Economics of Catastrophic Climate Change*, 91 REV. ECON. & STAT. 1 (2009)). Stern did not recalculate his overall discount rate, *d*, but Weisbach and Sunstein point out this adjustment means Stern now advocates a discount rate of 2.7%. Weisbach & Sunstein, *supra* note 10, at 448. Additionally, although these are the values the *Review* uses for its modeling, its authors acknowledge that it is unlikely a constant discount rate for growth is correct, as growth rates change and could even point toward a negative discount rate if the economy contracts. *See* STERN REVIEW, *supra* note 12, at 48. This leads to a brief discussion in the *Review* of hyperbolic discounting based on the uncertainty of future growth rates. *See id.* at 49–50 (citing Cameron Hepburn, Discounting Climate Change Damages: Overview for the Stern Review (2006) [hereinafter Hepburn, Stern Review] (unpublished manuscript), *available at* http://www.cameronhepburn.com/Hepburn%20(2006)%20Stern%20review%20discounting.pdf) (using the nomenclature "declining discounting"). Aside from this tangent, the *Review* does not discuss how their model could account for hyperbolic discounting.

is implicit in his criticism of the *Stern Review* for adopting a particular ethical posture toward discounting.[99] Dismissing the philosophical justifications for a zero pure rate of time preference, Nordhaus argues the appropriate focus is on actual revealed preferences—the descriptive approach to calculating ρ.[100] But Nordhaus appears indifferent toward the precise values of ρ and θ*g*, as long as together they approximate the real return on capital.[101] As he states:

> To match a real interest rate of, say, 4 percent and a growth in per capita consumption of 1.3 percent per year requires some combination of high time discounting and high consumption elasticity. For example, using the *Stern Review*'s economic growth assumptions, a zero time discount rate requires a consumption elasticity of 3 to produce a 4 percent rate of return. If we adopt the *Stern Review*'s consumption elasticity of 1, then we need a time discount rate of 2.7 percent per year to match the observed rate of return.[102]

In his model, Nordhaus chooses a pure time preference rate of 1.5% with a consumption elasticity of 2, which, paired with his calculation of the growth rate of 2%, yields an overall discount rate of 5.5% to match his calculation of the real return on capital.[103]

99. *See* NORDHAUS, BALANCE, *supra* note 10, at 174, 176 (arguing *Review* arbitrarily adopts a certain ethical view, "British utilitarian[ism]," without discussing competing ethical perspectives that would lead to radically different results). *See also* Weitzman, *Stern Review*, *supra* note 9, at 707, 709 (criticizing prescriptive approach as "a decidedly minority paternalistic view" and Stern's parameters as reflecting "extreme taste[s]").

100. NORDHAUS, BALANCE, *supra* note 10, at 175, 177 (criticizing Stern for ignoring "real return on capital"). *See also* William D. Nordhaus, *Discounting and Public Policies that Affect the Distant Future*, *in* DISCOUNTING AND INTERGENERATIONAL EQUITY, *supra* note 36, at 145, 150 ("The discount rate on goods is chosen to be consistent with observed returns on capital, or revealed social time preference . . . ."); Weitzman, *Stern Review*, *supra* note 9, at 708–09 ("For most economists, a major problem with *Stern's* numbers is that people are not observed to behave as if they were operating [according to the Stern discount rate]."). *But see* Quiggin, *supra* note 40, at 201–02 (rebutting Nordhaus's descriptive criticism by arguing Stern's discount rate is consistent with observed real return on risk-free bonds).

101. This is consistent with many empirical studies that attempted to calculate individual's implicit discount rates without separately calculating how its components, ρ and θ, drove that implicit rate of time preference. *See* Frederick, *supra* note 49, at 675.

102. NORDHAUS, BALANCE, *supra* note 10, at 178. *See also* Dasgupta, *supra* note 33, at 156–59, 163–64 (agreeing with Stern that ρ may equal zero but suggesting values of 2 or 3 for θ to calibrate *d* to the savings rate through growth discounting).

103. NORDHAUS, BALANCE, *supra* note 10, at 178–79. As Nordhaus explains, his calculation of the real return on capital attempts to match historical market data. *See, e.g.*, *id.* at 186–87 ("One of the problems with [using Stern's assumptions in Nordhaus's model] is that it generates real returns that are too low and savings rates that are too high compared with actual market data."). *But see* STERN REVIEW, *supra* note 12, at 47 (arguing Ramsey formula does not account for all possible factors that could influence the optimum savings rate, and that "solution" of increasing ρ to reflect the observed

In addition to defending his discount rate on descriptive pure time preference grounds, Nordhaus also justifies his approach using opportunity cost discounting. He argues that the real rate of return "enters into the determination of the *efficient* balance between the cost of emissions reductions today and the benefit of reduced climate damages in the future."[104] In criticizing the *Stern Review*, he argues that the policies it advocates are inefficient because the future would be "worse off" without the "efficient strategy" of investing in conventional capital.[105] He also combines the descriptive justification with the opportunity cost justification, arguing that he uses historical interest rate because that is what *nations* use when they are negotiating climate change to compare the "actual gains" on climate abatement policies relative to the returns on other investments.[106] This appeal to opportunity cost discounting is rather brief, as Nordhaus does not delve into whether the historical interest rate is the correct rate for opportunity cost discounting.[107]

Stern and Nordhaus represent two of the most influential discussions of how we should respond to the threat posed by climate change. Stern advocates immediate action on climate change, while Nordhaus's conclusion is to take a more measured approach. As Nordhaus points out, the central point of contention between these two positions is not how

savings rate is "very ad hoc"). Interestingly, although some scholars disagree with Stern's methods, they believe Stern's rate may be closer to correct than Nordhaus's higher rate, due to the uncertainty rationale for hyperbolic discounting. *See* Weitzman, *Stern Review*, *supra* note 9, at 709 ("[T]he interest rate we should be using to discount a dollar of costs or benefits a century from now is in between the *Stern* value of $r = 1.4$ percent and the more conventional [Nordhaus] value of $r = 6$ percent, but . . . is a lot closer to the *Stern* value and is not anywhere near the arithmetic average of $r = 3.7$ percent."); Weisbach & Sunstein, *supra* note 10, at 16.

104. NORDHAUS, BALANCE, *supra* note 10, at 59 (emphasis added). *See also id.* at 174–75 ("The calculations of changes in world welfare arising from efficient climate-change policies examine potential improvements within the context of the existing distribution of income and investments across space and time. Because this approach relates to discounting, it requires that we look carefully at the returns on *alternative investments*—at the *real* real interest rate—as the benchmark for climatic investments.") (emphasis added).

105. *See id.* at 179–81.

106. *Id.* at 174–75. This argument appears to beg the question, as these nations "revealed preferences" are based on their own decisions about these same issues surrounding choosing the appropriate discount rate, which they often rely on academic literature to answer. *See, e.g.*, OMB CIRCULAR A-4, *supra* note 83, at 20–21.

107. Specifically, A QUESTION OF BALANCE ignores opportunity cost issues such as the effectiveness of intergenerational transfers, how to maximize resources for future generations, and whether the historical interest rate represents a realistic alternative investment to mitigating climate change. Further, if accounting for opportunity costs represented Nordhaus's primary defense of his model, the discussion surrounding the Arrow/Ramsey formula and the appropriate values of ρ of θ would be irrelevant to calculating the opportunity cost of capital.

much damage will occur from climate change, or, as the current media frenzy suggests, whether climate change is causing damage right now.[108] Rather, the driving force between their different conclusions is the seemingly minor technical detail of the discount rate.[109] Where Stern's rejection of both prescriptive and descriptive pure time preference discounting leads to his low discount rate and call to arms, Nordhaus's embrace of descriptive pure time preference discounting pushes for a much higher discount rate and informs his response to tackle climate change slowly.

III. PRESCRIPTIVE PURE TIME PREFERENCE DISCOUNTING

Now that we have laid out the various elements in the debate on intergenerational discounting, it will be helpful to disassemble the machinery of discounting to evaluate each of the approaches. In this part, we will work out a number of simple hypotheticals to test our moral intuitions about prescriptive pure time preference discounting. Section A starts by explaining why it is appropriate to develop ethical theories from moral intuitions, using John Rawls' process of reaching "reflective equilibrium."[110] Section B works through hypotheticals that test our intuition to reject a positive pure time preference discount rate. More generally, Section C presents examples demonstrating the proper treatment of future generations cannot be determined simply by the choice of a discount rate.

A. DEVELOPING MORAL INTUITIONS

Our intuition, shared by many others,[111] is that we should not treat future generations as less valuable than the current generation merely because they live at a later time. That is, we should reject a positive rate of pure time preference. To wrestle with the complexities of this issue, we use a set of examples in an effort to develop a set of moral intuitions. John Rawls described a similar process in his famous *A Theory of Justice*, where

108. *See, e.g.*, Elisabeth Rosenthal, *Skeptics Find Fault With U.N. Climate Panel*, N.Y. TIMES, Feb. 8, 2010, at A1 (accusing IPCC of exaggerating rate of climate change).

109. *See* NORDHAUS, BALANCE, *supra* note 10, at 168–69 ("[T]he *Stern Review*'s radical view of policy stems from an extreme assumption about discounting. . . . If we substitute more conventional discount rates used in other global-warming analyses, by governments, by consumers, or by businesses, the *Stern Review*'s dramatic results disappear, and we come back to the climate-policy ramp described earlier.").

110. *See* RAWLS, *supra* note 41, at 42–45.

111. *See supra* notes 30–41.

he argued that through this method of inductive reasoning we can strive to reach "reflective equilibrium"—where the theory describing our intuitions matches up with the facts on the ground.[112] According to Rawls, "the best account of a person's sense of justice is not the one which fits his judgments prior to his examining any conception of justice, but rather the one which matches his judgments in reflective equilibrium."[113]

How do we reach a reflective equilibrium? Rawls urges us to explore whether our general moral theory matches up with our moral intuitions in specific situations. These specific situations, or "considered judgments," should be free of circumstances that can cloud our judgment—fear, coercion, hesitation.[114] When our considered judgments do not comport with our moral theory, we must either adjust the judgments or the theory.[115] Through this dynamic process of reflection, we attempt to reach an equilibrium in which our judgments and theory are no longer in tension.[116]

We are not the first to use Rawls' ideas to wrestle with the dimensions of the Ramsey formula and intergenerational discounting.[117] Previous thought experiments, however, have focused on the appropriate value for the elasticity of marginal utility of consumption, θ;[118] we focus instead on the ramifications of a positive rate of pure time preference, ρ. We are also not the first to acknowledge that there are weaknesses to this approach. As Rawls describes it, intuitions drawn from our considered judgments are necessarily personal.[119] But the choice of an intergenerational discount rate

112. RAWLS, *supra* note 41, at 46–53. *See also* T.M. Scanlon, *Rawls on Justification*, *in* THE CAMBRIDGE COMPANION TO RAWLS 139, 139–53 (Samuel Freeman ed., 2003) (discussing alternative interpretations of Rawls' method of reflective equilibrium, describing as "intuitive" and "inductive" method).

113. RAWLS, *supra* note 41, at 43.

114. *See id.* at 42 ("Considered judgments are simply those rendered under conditions favorable to the exercise of the sense of justice, and therefore in circumstances where the more common excuses and explanations for making a mistake do not obtain.").

115. *Id. See also* Scanlon, *supra* note 112, at 140–41 (outlining process of reflective equilibrium in three stages: (1) developing set of considered judgments; (2) formulating principles to explain judgments; and (3) resolving tension between judgments and principle).

116. RAWLS, *supra* note 41, at 43 ("[Reflective equilibrium] is reached after a person has weighed various proposed conceptions and he has either revised his judgments to accord with one of them or held fast to his initial convictions (and the corresponding conception)."). *Id.* This equilibrium, Rawls acknowledges, may be merely theoretical. *Id.* ("To be sure, it is doubtful whether one can ever reach this state [of equilibrium]."). *See also id.* at 44 ("I wish to stress that . . . a theory of justice is precisely that, namely, a theory.").

117. *See* Dasgupta, *supra* note 33, at 148 (wrestling with proper value for θ); Stern, *Economics*, *supra* note 10, at 17 (same).

118. *See* Dasgupta, *supra* note 33, at 144; Stern, *Economics*, *supra* note 10, at 17.

119. *See* RAWLS, *supra* note 41, at 44 ("I shall not even ask whether the principles that

is not a personal judgment; it is a societal judgment that "contains an irremediably democratic element."[120] We adopt the same caveat as Partha Dasgupta: to the extent that others are not persuaded by these examples, they should go through the process of reaching their own reflective equilibrium.[121] Nonetheless, this approach will help us highlight the moral judgments inherent to intergenerational discounting, and also that our ethical concerns cannot be resolved merely by choosing a discount rate.

B. MORAL INTUITIONS ABOUT PRESCRIPTIVE PURE TIME PREFERENCE DISCOUNTING

This section explores our moral intuitions about whether ρ should equal zero in an intergenerational context. We will start with Revesz's original example in a prior article of a simple, two-person, two-generation, no growth world.[122] From there, we will use more complex examples to illustrate the difference between intrapersonal pure time preference and intergenerational pure time preference, and then distinguish opportunity cost discounting.

1. The Original Example—Pure Time Preference Between Two Generations

As Revesz's original formulation posited:

> Consider an exceedingly simple economy with 100 units of resources. Two individuals, with identical utility functions, live in this economy: one from year 1 to year 50 and the other from year 51 to year 100. There is no possibility for productive activity; thus, the individuals will be able to derive utility only from the existing 100 units of resources.
>
> In the absence of discounting for time preference, each individual would be allocated 50 units of resources. In the face of a positive rate of time preference, however, even a relatively modest one, the first

characterize one person's considered judgments are the same as those that characterize another's. . . . [E]veryone has in himself the whole form of a moral conception. . . . The opinions of others are used only to clear our own heads.").

120. Dasgupta, *supra* note 33, at 158.

121. *Id.* at 157. *See also* RAWLS, *supra* note 41, at 44 ("[F]or the purposes of this book, the views of the reader and the author are the only ones that count.").

122. *See* Revesz, *supra* note 32, at 998–99. Note that all of our examples use the perspective of two, nonoverlapping generations. This admittedly is an oversimplification that avoids some theoretical problems caused by overlapping generations. *See id.* at 1002–03 n.302. But for our purposes, using separate generations will more clearly demonstrate the ethical implications of discounting the utility of future generations.

> individual would get the bulk of the resources. It would be difficult to construct an attractive ethical theory that privileged the first individual in this manner merely because she lived fifty years earlier than the second individual.[123]

Since this thought experiment was published almost a decade ago, Revesz has asked students and professional audiences to play the role of social decisionmaker[124]: how many resources should each individual receive? The overwhelming response has been to split the 100 units of resources equally between the two individuals. This pattern of responses supports the strong intuition that there is no attractive ethical theory to justify privileging the first individual.

The same question was posed to Kenneth Arrow when he visited a class co-taught by Revesz and David Bradford.[125] Arrow indicated to the class that his intuition also was to allocate the resources equally between the individuals. He acknowledged that this intuition was inconsistent with his support of discounting for pure time preference.[126]

2. Intrapersonal Pure Time Preference vs. Intergenerational Pure Time Preference

Let us dig deeper into the original example and start by focusing on Person 1. Hewing to our original intuition, Person 1 will receive 50 units of resources. But in this slightly more complex world, she can decide how to allocate those units for consumption throughout her life. For simplicity's sake, let us assume she can make only one choice: how many resources to allocate for the first half of her life, years 1–25, with the remaining resources available for her to use in years 26–50. Let us say she chooses to allocate 30 units of resources to years 1–25, leaving 20 units for years 26–50.

123. *Id.* at 998.

124. We, along with others in the literature, evaluate the ethics of discounting from the perspective of a social decisionmaker. *See, e.g.*, David Anthoff, Cameron J. Hepburn & Richard S.J. Tol, *Equity Weighting and the Marginal Damage Costs of Climate Change*, 68 ECOLOGICAL ECON. 836, 836, 839 (2009) (using "global decisionmaker" in social welfare function).

125. This class on environmental policy was held at the Woodrow Wilson School at Princeton University in Spring 2002.

126. *See, e.g.*, Kenneth J. Arrow, Discounting Climate Change: Planning for an Uncertain Future, Lecture given at Institut d'Économie Industrielle, Université des Sciences Sociales, Toulouse, 7–8 (Apr. 24, 1995) [hereinafter Arrow, Lecture], *available at* http://idei.fr/doc/conf/annual/paper_1995.pdf ("I conclude therefore that our ethical and empirical conclusions strongly lead to the existence of a pure time preference which is greater than zero, perhaps about 1%.").

Person 1's welfare will be derived solely from the utility she receives from consuming resources. We assume that her utility function is concave to reflect diminishing marginal utility from an extra unit of consumption.[127] Let us say that her utility, U(c), is equal to the natural logarithm of the resources she has consumed, ln(c), which is a commonly used function.[128] Assuming Person 1 is rational, she will try to maximize her aggregate utility across years 1–25 and years 26–50. Her utility is maximized where her marginal rate of utility from years 1–25 (MRU_{t1}) is equal to her marginal rate of utility from years 26–50 (MRU_{t2}); if MRU_{t1} is greater than MRU_{t2}, she could increase her total welfare by taking one unit of resources from years 26–50 and allocating it to years 1–25.[129]

If Person 1 had no positive rate of pure time preference, she would have equally allocated 25 units to each time period. But she did not split the resources equally; she chose to allocate 30 units to years 1–25, and only 20 to years 26–50. Since she could otherwise have gained more utility from shifting five units from the first time period to the second,[130] it must be that she values her future consumption less than her present consumption, thereby exhibiting a pure time preference. From this allocation we know she values the future only 2/3 as much as the present, and that her choice reflects a yearly intrapersonal discount rate of 1.635%.[131]

Whatever the foibles of intrapersonal discounting,[132] there appears to be no ethical dilemma if Person 1 values resources in the first half of her life more than in the latter half and discounts accordingly.[133] Revesz also addressed this issue in his previous article on discounting, where he discussed how intrapersonal discounting simply relies on the values people

127. *See* Dasgupta, *supra* note 33, at 147–48 (using "felicity function" to describe utility at given consumption level); Heal, *Basic Economics*, *supra* note 35, at 61 (using "concave increasing function of consumption"). We also assume the typical economic assumptions for discounting such as isoelastic utility and an additively separable utility function. *See, e.g.*, THE STERN REVIEW, *supra* note 12, at 44–46.

128. *See* Dasgupta, *supra* note 33, at 148.

129. For a natural log utility function, the marginal rate of utility is the derivative of c with respect to U = 1/c, and thus elasticity of her marginal utility, θ, is 1. *Id.*

130. More formally, the MRU_{t2}, 1/20, is greater than the MRU_{t1}, 1/30.

131. Person 1's implicit discount factor is given by the formula 1/30 = D*1/20; D = 2/3. In other words, Person 1 considers future consumption only 2/3 as valuable as present consumption. Solving for ρ, the discount *rate* per year, $D = 1/(1+\rho)^{25}$; ρ ~ 1.635%.

132. *See* PIGOU, *supra* note 39, at 24–26 (describing intrapersonal discounting as implying a defective "telescopic faculty"). *But see generally* Revesz, *supra* note 32, at 941–87 (arguing intrapersonal discounting in context of latent harms raises no ethical dilemma).

133. *See* Revesz, *supra* note 32, at 984, 999 & n.282.

place on their own future.[134] Though there may be ethical questions associated with how regulators conduct cost-benefit analysis and measure the value of human life,[135] once those questions are answered there is no independent ethical argument against discounting intrapersonal pure time preference.[136]

Now assume that Person 1 actually lived for all 100 years, and received all 100 units of resources at the outset. If she exhibits the same time preference we calculated in the example above, for each 25-year period she will decide to allocate only 2/3 of the resources she allocated to the prior period. For years 1–25, she will allocate 41.54 units of resources; for years 26–50, 27.69 units of resources; for years 51–75, 18.46 units of resources; and for years 76–100, 12.31 units of resources.[137]

Let us now return to our original example, where Person 1 lives in years 1–50 and Person 2 lives in years 51–100. Does the fact that Person 1 would have allocated only 30.77[138] units to years 51–100 if she lived all 100 years imply that Person 2 should only receive this many units because she lives only in years 51–100? Our moral intuition is no. When we considered simply how to split resources between two generations in Section B.1, our intuition was to divide them equally.[139] As Rawls would ask us to do, we must reflect on why discounting for pure time preference in the intergenerational context is different from the intrapersonal context.

In the intrapersonal context, Person 1's choices simply decided how she would allocate the units of resources she received to maximize her utility. But in the intergenerational context, Person 1's choices would now directly decide how many units of resources, and therefore utility, Person 2 will receive. Giving fewer resources to Person 2 simply because Person 2 lives in the future seems morally problematic in this example.[140]

134. *See id.* at 984–87.

135. *Id.* (discussing objections that people may undervalue their future and regulators aggregating individual preferences to make social policy choices).

136. *Id.* ("If [cost-benefit analysis and valuation of human life] survive ethical scrutiny, no substantial independent ethical argument should be raised against the role played by discounting in an intragenerational setting.").

137. $100 = x + x/(1+\rho)^{25} + x/(1+\rho)^{50} + x/(1+\rho)^{75}$; x = 41.54.

138. In years 51–75, Person 1 allocated 18.46 units; in years 76–100, 12.31. 18.46 + 12.31 = 30.77.

139. *See supra* Part III.B.1 (discussing original example).

140. *See* Revesz, *supra* note 32, 1002–03 ("The confusion surrounding the issue stems, at least in part, from equating intragenerational discounting, which ought not to be considered particularly controversial, with intergenerational discounting, which raises a different set of issues.").

3. Role of Opportunity Costs

With some modifications, we can use a similar example to illustrate that the concept of opportunity costs does not affect our intuition about the appropriate pure rate of time preference. Rather than one social decisionmaker allocating our 100 units of resources between Persons 1 and 2, let us assume we have two decisionmakers, Impatient Ian, who believes the utility of future generations should be discounted by 1.635% to reflect pure time preference, and Neutral Nancy, who believes present and future generations should receive the same amount of utility. In a no-growth world, as previously discussed, Ian would allocate approximately 70 units to Person 1 and 30 units to Person 2; Nancy would allocate 50 units to each person.[141]

In this example, the social decisionmaker, in allocating our 100 units of resources between Person 1 and Person 2, can choose among three projects. In project 1 the units allocated to Person 2 get stuffed under a mattress and do not grow; in project 2 those units double in value by the time Person 2 receives them; and in project 3 they triple in value. Project 3 is clearly the best choice. Both Ian and Nancy should choose project 3—the opportunity cost of choosing any other project is the lost resources from not choosing project 3.

But this opportunity cost choice does not tell us how many resources Ian and Nancy would allocate to Persons 1 and 2; it simply lets them choose the cheapest option available to provide the benefit they previously chose. In Ian's case, choosing project 3 means he can give 87 units of resources to Person 1 with the remaining 17 units to Person 2 growing to 51 units, the resulting division reflecting Ian's 1.635% time preference rate.[142] In contrast, stuffing Person 2's resources under the mattress would result in a 70-30 split between the two people—both would be worse off. In Nancy's case, using project 3 she can allocate 75 units to Person 1, leaving 25 units that will grow into 75 units for Person 2, rather than 50 units for each person if she stuffs Person 2's resources under the mattress.

Indeed, pure time preference discounting and opportunity costs are so distinct that one could adopt both concepts to evaluate a climate change policy. For example, our social decisionmaker could discount for pure time preference because she determines society should (prescriptively) or does

141. *See supra* notes 134–37 and accompanying text.

142. *See supra* note 128 and accompanying text; Kaplow, Moyer & Weisbach, *supra* note 10, at 24–25 (separating ethical "distributive" questions from "efficiency" of providing chosen benefit level).

(descriptively) value the benefits to future people less than the benefits to current people; and she could account for opportunity costs because regardless of what she decides to allocate to a future generation, she should do so in the most efficient way possible. Alternatively, she could reject pure time preference discounting altogether yet still account for opportunity costs in the name of efficiency. The two concepts are therefore additive and not mutually exclusive.

This example illustrates that discounting for pure time preference is conceptually different than accounting for opportunity costs. The pure rate of time preference defines our obligation to the future. Accounting for opportunity costs, in contrast, merely lets us decide the cheapest way to provide the benefit level we have already chosen.[143]

When we separate out opportunity costs, our intuition remains that there is no ethical justification for pure time preference discounting. If we wish to maintain intergenerational equality, and we can think of no moral reason to treat future generations worse than our own, ρ must equal zero in this example, despite the presence of opportunity costs.

C. OUR MORAL INTUITIONS CANNOT BE FULLY REFLECTED IN THE DISCOUNT RATE

The intuitions we developed above support our belief that we should reject prescriptive time preference—that ρ should not be positive. But to reach true reflective equilibrium, we cannot simply look to limited factual situations that confirm our beliefs—we must try to consider all possible situations about equality between generations.[144] In the following hypotheticals, we find that rejecting a positive rate of pure time preference does not give us the answer to every moral question surrounding intergenerational discounting. By considering the size of generations, growth discounting, and distributions within generations, we see that some of these ethical questions must be answered by means other than through

143. *See* David Weisbach & Cass Sunstein, *Climate Change and the Rights of Future Generations*, at 15 (Presentation to Reg-Markets Ctr.) (Oct. 3, 2008) (separating "ethical" arguments about "how much we need to leave to the future" from "positive" argument discussing, "given how much we have chosen to leave to the future, which projects should we choose"). What opportunity costs we actually consider, for example whether we restrict ourselves to other climate change projects, other public goods, or the market rate opportunity cost of capital, depends on a wealth of issues that we explore more thoroughly in Part V.

144. *See* RAWLS, *supra* note 41, at 43 (describing how moral philosophy is concerned with all possible situations implicating moral theory, not just "those descriptions which more or less match one's existing judgments except for minor discrepancies").

the choice of a discount rate.[145]

1. Size of the Generations

Let us return to our original example of a two-generation, no growth economy. But instead of two people, one in each generation, let us assume a three-person economy. Person 1 lives in years 1–50, and Persons 2 and 3, comprising Generation 2, live in years 51–100. Our original intuition was to allocate the resources equally between Generation 1 and Generation 2, rejecting giving more resources to Person 1 simply because she lived earlier.

But how should we allocate resources in this example? Should we allocate half the resources to each of the generations, so that Person 1 gets 50 units of resources and Persons 2 and 3 get 25 each? The same intuition that had us reject giving Person 1 more resources because she lived in an earlier generation would probably lead us to reject privileging Person 1 because she lived in a smaller generation. This intuition would lead us to divide the resources into thirds, giving each person one third of the initial allocation.

But perhaps we need to know more information before making our decision in this case. What if Person 1 was a couple that chose not to have a child, and Person 2 was a couple that decided to have a child: Person 3. Might that change our intuition? Perhaps the allocation of resources to each generation should be affected if the size of a generation is a product of choices made by that generation? Although our examples attempt to justify our belief that we should treat future and current generations the "same," our rejection of a positive ρ will not answer the question of how to deal with population growth.[146]

2. Role of Growth Discounting

Let us return to our original example in Section B.1, where we must

145. *See also* Sunstein & Rowell, *supra* note 48, at 188–90 (arguing ethical problems in intergenerational equity must be solved outside of choosing discount rate); Kaplow, *supra* note 44, at 99 (same); Kysar, *supra* note 10, at 119–21 (arguing discounting must be rejected because it will not allow us to consider ethical objections outside of discounting).

146. *See also* Koopmans, *Concept*, *supra* note 36, at 254 ("There seems to be no way, in an indefinitely growing population, to give equal weight to all individuals living at all times in the future."); Tjalling C. Koopmans, *Objectives, Constraints, and Outcomes in Optimal Growth Models*, 35 ECONOMETRICA 1, 12–13 (1967) [hereinafter Koopmans, *Objectives*] (describing population growth issue as hardest discounting issue conceptually and practically).

decide how many units to allocate to Person 1 and how many to Person 2. Let us assume from the outset that there is no pure rate of time preference. In addition, as in Section B.3, our social decisionmaker can invest resources into productive activity. We will focus on Project 3, where the units allocated to Person 1 will not grow over time, but the units allocated to Person 2 can triple if they are untouched by Person 1 over the 50 years of her lifetime.[147]

If our goal was to only maximize consumption, ignoring utility entirely, we would allocate all of our resources to the second generation. Setting aside all 100 units of resources to grow gives our economy (that is, Person 2) a total of 300 units of resources—Person 1 is left with zero units to consume. In our original example, we rejected the view that Person 1 should get more simply because she lived earlier. Our intuition also leads us to conclude that Person 2 should not get all of the units of resources at the expense of Person 1 simply because we can maximize productivity. After all, even if Person 2 gets 3 units of resources for every unit Person 1 sacrifices, our now impoverished Person 1 will likely benefit more from gaining 1 unit of resources than wealthy Person 2 will hurt from losing 3 units.

Our desire for equality may lead us to believe that our social decisionmaker should behave like Neutral Nancy from Section B.3—allocate 75 units of resources to Person 1, leaving 25 units for Person 2 that grow to 75 units in year 50. Our intuition is an even distribution. This is the conclusion Dexter Samida and David Weisbach reached when they analyzed a similar thought experiment.[148] But, contrary to the assertion of Samida and Weisbach,[149] this moral intuition for equality does not maximize aggregate welfare in a utilitarian framework. At this even distribution, we could take just one unit of resources from Person 1 and

147. Unlike Section B.3 where our social decisionmakers debated which of the three available projects made the most sense to invest in and had already determined how to split the available resources between the generations, here we evaluate how growth discounting causes us to *change* the distribution between generations even in the absence of pure time preference.

148. Samida and Weisbach explore a similar situation where resources allocated to the future grow in value. They conclude, "If equality is valued, there are welfare gains from transferring resources from the second generation to the first until the marginal utility of consumption of each generation is the same . . . ," that is, we split 75-75. *See* Samida & Weisbach, *supra* note 10, at 153.

149. Although Samida and Weisbach claim this maximizes "absolute utility, depending on our social welfare function," *id.* at 153–54, this does not hold for the typical utilitarian function that simply adds the total utility of generations. *E.g.* Arrow, *Gaming*, *supra* note 36, at 15; Dasgupta, *supra* note 33, at 146 (discounting for pure time preference); Heal, *Basic Economics*, *supra* note 35, at 61; Koopmans, *Concept*, *supra* note 36, at 230.

give three to Person 2, and the welfare gain of three additional units to Person 2 will outweigh the welfare loss of one unit to Person 1. In this sense, Neutral Nancy may be egalitarian, but she is not welfare maximizing.

In fact, maximizing aggregate utility would require us to allocate 50 units to the first generation, leaving 150 units for the second generation.[150] In our Ramsey formula, we reach this distribution by discounting the future consumption of Person 2 by θg, the elasticity of marginal utility of consumption multiplied by the increase in the wealth of Person 2 measured by the growth rate.[151] In our logarithmic utility function,[152] the decreasing marginal utility of consumption leads us not to seek to maximize *consumption* by leaving 300 units for the second generation and nothing for the first, but the tripling of the resources set aside for the second generation leads us not to divide the resources equally.[153]

150. argmax(ln(x) + ln(3*(100 – x))) where x is bound between 0 and 100 = 50.

151. That is, argmax(x + 3(100 – x)), after discounting future consumption, becomes argmax(x + 3(100 – x)/3); x = 50. Note that we only discount consumption, not utility, by θg. This is because decreasing marginal utility is already taken into account by our utility function, ln(x), and discounting that function by θg, where θ is the elasticity of the derivative of the utility function, would double count decreasing marginal utility.

152. *See supra* note 129 and accompanying text.

153. Tjalling Koopmans termed this paradox the "indefinitely postponed splurge." Koopmans, *Objectives*, *supra* note 146, at 8–9. *See also* Emmett B. Keeler & Shan Cretin, *Discounting of Life-Saving and Other Nonmonetary Effects*, 29 MGMT. SCI. 300, 306 (1983) (arguing discounting benefits at a lower rate than costs, so-called "differential discounting," leads to an infinitely postponed splurge paradox). *But see* Melissa J. Luttrell, *The Case for Differential Discounting: How a Small Rate Change Could Help Agencies Save More Lives and Make More Sense* 8–21 (Working Paper 2010) (citing Revesz, *supra* note 32, at 989–92) (criticizing Keeler-Cretin paradox's applicability to real-world regulations). Many commentators have attempted to reconcile our intuition for equality with the mathematical problem of maximizing welfare. Koopmans suggested an arbitrary discount rate, with "no basis in a priori ethical thought" that tracks changes in productivity. Koopmans, *Concept*, *supra* note 36, at 257. Arrow argues we should reject our moral intuition of treating generations equally in favor of *descriptive* pure time preference. *See* Arrow, *Gaming*, *supra* note 36, at 16–17 ("[T]he strong ethical requirement that all generations be treated alike, itself reasonable, contradicts a very strong intuition that it is not morally acceptable to demand excessively high savings rates of any one generation."); Arrow, Lecture, *supra* note 126, at 6–8 ("[I]n the absence of pure time preference, the savings rates are . . . much higher than I think most people would judge reasonable."). Dasgupta argues for higher values of θ to further decrease marginal utility of consumption for rich generations. Dasgupta, *supra* note 33, at 156–59. *See also* Geir B. Asheim & Wolfgang Buchholz, *The Malleability of Undiscounted Utilitarianism as a Criterion of Intergenerational Justice*, 70 ECONOMICA 405, 417 (2003) (arguing a more concave utility function reflecting technology avoids paradox); Cameron J. Hepburn, *Valuing the Far-Off Future: Discounting and Its Alternatives*, *in* HANDBOOK OF SUSTAINABLE DEVELOPMENT 112–13 (Giles Atkinson, Simon Dietz, Eric Neumayer eds., 2007) [hereinafter Hepburn, *Valuing*] (concluding "excessive sacrifice" argument for pure time preference is refutable). Parfit, Rawls, and Solow argue for changing the social welfare function entirely. *See* DEREK PARFIT, REASONS AND PERSONS (1984); RAWLS, *supra* note 41, at 72 (describing "difference principle" where social utility is

To this point, we have assumed the resources set aside for Person 2 grow without any extra effort expended by Person 1. Instead, what if we now say that economic growth is a product of Person 1's effort, and Person 2 can live a life of leisure based on 1's hard work? Our intuition now is that Person 1 should receive a greater share resource allocation. Even if Person 1 deserves more because he created the resources available to Person 2, we cannot adjust for this intuition by discounting for pure time preference—pure time preference is a constant rate, and our intuition here depends on the amount of growth Person 1 provides from his effort. If Person 1 provides no benefit, there is no reason "effort" should still count for anything through a positive ρ. Our intuition may be that Person 1 should be able to reap benefits he creates,[154] but we cannot reduce this intuition to the simple choice of a discount rate.

What if we complicate this scenario further? If Person 2 has to work to maintain the resources he received, does this change our intuition? It would appear that it would, but does it matter that Person 1 is working for Person 2's welfare, where Person 2 is working only for himself? What happens when we have multiple generations, each of whose work contributes to the welfare of the next generation?

We could also flip this scenario on its head; instead of creating a benefit, what if we are dealing with a *harm* that Person 1 is responsible for? This, after all, seems to be the more appropriate comparison when we discuss climate change mitigation. Our moral intuition here suggests that if Person 1's actions or failure to act will directly harm Person 2, there is more of an obligation to reduce the harm Person 2 receives than if the harm was caused by neither person. The moral issues of climate change mitigation and our responsibility to future generations are complex, and it is clear that we cannot adequately answer our questions simply through the choice of a discount rate.[155]

measured based on worst-off member of society); *id.* at 254–58 (arguing certain "just institutions" and cultural capital belong to all generations and must be preserved for future generations); Robert Solow, *An Almost Practical Step Toward Sustainability*, RESOURCES POL'Y 162, 167–72 (1993) (advocating policy of "sustainable development" that maximizes growth for all generations).

154. We may ascribe this to a theory of "just desert." *See, e.g.*, Owen McLeod, *Desert*, *in* STANFORD ENCYCLOPEDIA OF PHILOSOPHY (Edward N. Zalta ed., 2008), http://plato.stanford.edu/entries/desert/. Rawls would remove morality from this equation and simply describe it as a person's "legitimate expectations" based on effort and contribution. *See* RAWLS, *supra* note 41, at 267–72.

155. *Cf.* Koopmans, *Objectives*, *supra* note 146, at 11 (expressing "uneasiness" with mathematical framework to resolve ethical questions).

3. Distributional Effects

Let us go back to our original, two-generation, no-growth example once more. But let's change the scenario a bit. Instead of determining the initial allocation between the two generations, let us assume it is already predetermined—50 units for each generation. Instead of one person per generation, let's assume two; in generation 1 each person gets 25 units of resources, but in generation 2 one person gets 40 units of resources and the other gets 10 units.

Now that the initial allocation is set, our policymaker has to determine how to allocate a new windfall of 10 units of resources between the two generations. Should she allocate all 10 units to the impoverished person in the second generation? It may seem like she should, as this person has the highest marginal utility of consumption and stands to gain the most from the extra 10 units. Or should she instead maintain only inter*generational* equity and allocate 5 units to each generation? After all, the *other* person in the second generation is considerably richer than anyone else in our scenario—should he not share his wealth with his impoverished colleague?

One might argue that it is our responsibility to ensure equality only between the generations and to let each generation take care of its own. Our intuition may also depend on whether there are feasible redistribution mechanisms both across generations and within a single generation. This is not a simple question, and from this example we can draw no definitive moral intuition. What we can see, however, is that the ethical question is not solved simply by a choice of ρ.

By working through these thought experiments, we accomplished two goals in our attempt to wrestle with the complexities of intergenerational discounting. First, our intuition is that it is unwarranted to discount the welfare of the future generation simply because they live in the future. Therefore, we reject the prescriptive argument for a positive pure rate of time preference. Second, the ethical questions surrounding intergenerational discounting cannot be answered through a dichotomous choice of whether ρ is zero or positive. These stylized hypotheticals, while admittedly incomplete, help us begin to understand the moral complexities of intergenerational discounting as we strive to reach reflective equilibrium.

IV. DESCRIPTIVE PURE TIME PREFERENCE DISCOUNTING

While many agree that discounting for pure time preference is not ethically justified, the descriptive approach to discounting—which is the prevalent approach—looks to market rates of return on investments to determine the value that the current generation places on future generations. In Section A, we begin by explaining how the existing literature links people's savings and investment decisions with the discount rate. We focus on the first-order question: what do savings rates tell us about how people value future generations? Our answer is not much. We discuss four problems with descriptive time preference discounting. Building on Revesz's previous article on discounting[156] and Part III.B, Section B discusses how descriptive time preference discounting conflates people's *intrapersonal* choices (their savings rate) with an *intergenerational* discount rate. Section C critiques the use by descriptive time preference discounting of savings and investment rates as a way to determine revealed preferences about how to treat future generations. In addition to this conflation problem, Section D discusses how the public goods nature of climate change prevention renders suspect revealed preference studies of the current generation's preferences concerning future generations. In Section E, we discuss how stated preference studies cast further doubt on the credibility of descriptive time discounting's use of revealed preferences to determine the discount rate. By focusing participants directly on our obligations to future generations and trying to work around the public goods problem, these studies suggest that we do not actually significantly discount the welfare of future generations.

A. CONNECTING THE SAVINGS RATE AND THE DISCOUNT RATE

Why does the descriptive approach use savings and investment rates to tell us how to treat future generations? As we previously discussed in Part II.A.2, most economists use the descriptive approach on the grounds that if we really valued the future generation as highly as the prescriptive approach suggests, then we should be saving significantly more money for them than we currently are. Money saved grows—if one saves $40 from a $100 paycheck and invests it earning 4% interest, in ten years that $40 becomes $59.21. Since saving money always gives us more in the future, why would we not save *everything* (above a minimum level for survival)? For one, an extra dollar benefits our rich future self less than our impoverished current self, and further, impatience, or pure time preference, suggests we prefer consumption now over consumption later.

156. Revesz, *supra* note 32, at 1016–17.

So how precisely do we connect the savings rate with the discount rate? The classic explanation comes from Ramsey's optimum savings formula.[157] Ramsey noted the relationship between the two concepts—the larger the discount rate, the less value we place on future consumption, and so the less we should be saving. How much less can be approximated using a formula for the implied savings rate, $(r - \rho)/\theta r$, where r is the average market return on investment.[158] Using the *Stern Review*'s numbers of ρ as .1% and θ of 1, with an r of 4%, Dasgupta argues the *Stern Review* suggests we should be saving 97.5% of our current output for future generations.[159] In other words, for every $100 we earn, we should sock away $97.50 for future generations. Comparatively, current estimates of the savings rate suggest we save 13.4% of our income in the United States, and 22.2% globally.[160] To get to a more realistic assumption—say, 22.5%[161]—using Dasgupta's approximation, if we left θ unchanged at 1, we would need a ρ of approximately 3%.

This asserted need for a positive pure rate of time preference to justify the observed savings rate, however, is dependent on the assumptions embedded in the Ramsey formula.[162] In particular, Stern and Bradford DeLong take issue with the fact that the Ramsey formula assumes no technological change. For example, DeLong points out that the Ramsey formula relies on a very specific model of economic output that assumes any increase in productivity, and therefore growth, can come only from increasing the amount people save.[163] More complex models, however,

157. *See* Ramsey, *supra* note 25.

158. *See* Dasgupta, *supra* note 33, at 153–54 (approximating from optimum savings rate formula, $s^* = (1+r)^{-(\theta-1)/\theta}/(1+\rho)^{1/\theta}$). *See also* Arrow, *Gaming*, *supra* note 36, at 15 (deriving implied savings rate with *no* pure rate of time preference as 1/θ from difference equation of $K_{t+1} = \alpha(K_t - c_t)$).

159. Partha Dasgupta, *Commentary: The Stern Review's Economics of Climate Change*, 199 NAT'L INST. ECON. REV. 4, 6 (2006) ("To accept [the *Stern Review*'s numbers] would be to claim that the current generation in the model economy ought literally to starve itself so that future generations are able to enjoy ever increasing consumption levels."). *See also* Weisbach & Sunstein, *supra* note 10, at 450 ("Another way to describe the problem . . . is that if the correct social discount rate is 1.4%, we should be saving vastly more than we do today to leave the ethically appropriate legacy for the future.").

160. THE WORLD BANK, WORLD DATABANK (2010), http://databank.worldbank.org/ddp/home.do?Step=12&id=4&CNO=2 (rates based on 2007 Gross National Income figures).

161. *See, e.g.*, Bradford DeLong, *Partha Dasgupta Makes a Mistake in His Critique of the Stern Review*, GRASPING REALITY WITH BOTH HANDS (Nov. 30, 2006, 1:18 PM), http://delong.typepad.com/sdj/2006/11/partha_dasgaptu.html (describing a savings rate of 22.5% as "far from absurd").

162. *See* Weisbach & Sunstein, *supra* note 10, at 452 & n.43 (arguing Ramsey formula is nearly century old and has been "supplanted by vastly more sophisticated models," citing *e.g.*, ROBERT J. BARRO & XAVIER SALA-I-MARTIN, ECONOMIC GROWTH 59–90 (1995)).

163. *See* DeLong, *supra* note 161 (describing Haig-Simons output).

acknowledge that productivity and growth increase from changes in technology and accumulated knowledge, not merely by saving more.[164] If we assume, as DeLong does, that technological changes accounts for 3% growth per year, then the implied savings rate plummets from Dasgupta's calculation of 97.5% to only 22.5% of GDP without any rate of pure time preference.[165]

Stern expands on this argument in his response to critics of the *Stern Review*. Based on an article of his from the 1970s,[166] Stern assumes a typical economic production function with no population growth, and also assumes no pure time preference, a marginal elasticity of utility with respect to consumption (θ) of 2, share of capital for production of .375, and exogenous technological growth (not based on savings) of 3%.[167] By merely adding the technological growth rate and adjusting the share of output attributed to capital, the implied optimal savings rate is between 19% and 29%—a reasonable rate—without pure time preference discounting.[168]

We can therefore conclude that attempts to argue that ρ needs to be greater than zero because of observed savings rates are highly dependent on particular assumptions.[169] Under other reasonable assumptions, a positive pure time preference rate is not necessary for a discount rate that aligns with observed savings rates. Rather than delve further into the debate on the appropriate assumptions, we instead focus on the first-order question: does the savings rate really tell us anything about our intergenerational obligations? Based on the conceptual and practical problems we outline in the rest of Part IV, we argue that it does not.

164. *See id.*

165. *Id*. *See also* Hepburn, *Valuing*, *supra* note 153, at 112–13 (describing mathematical arguments as "refutable" through technological progress); *Value Judgments*, *supra* note 10, at 13 (arguing as long as $(1 - \theta)g - \rho < 0$, which holds for $\rho = .1$ & $\theta = 1$, we avoid infinitely postponed splurge problem); *supra* note 147.

166. J.A. Mirrlees & N.H. Stern, *Fairly Good Plans*, 4 J. ECON. THEORY 268, 284–85 (1972).

167. Stern, *Economics*, *supra* note 10, at 16.

168. *Id.*

169. *See* Heal, *Post-Stern, supra* note 35, at 282 ("[W]e need very strong assumptions for this equation [linking the discount rate to descriptive market rates] to hold, assumptions that seem to be particularly out of place in a discussion of climate change."). *See also id.* at 283 (arguing that linking savings rate to ρ depends on assuming equivalency between market rates and the social discount rate); EPA GUIDELINES, *supra* note 24, at 6-14 to 6-15 (describing Ramsey formula as merely "first order approximation" given it "excludes numerous real-world departures from the idealized assumptions of perfect competition and full information").

B. CONFLATING INTRAPERSONAL AND INTERGENERATIONAL CHOICES

As we previously discussed in Part III.B, descriptive time preference discounting suffers from a serious conceptual problem: an *individual's* choice in how much to save, primarily for his or her own lifetime,[170] is not the same as determining how society should treat *future* generations. When we considered the different scenarios in Part III, we saw that the decision to allocate resources across one's own life raises no ethical concerns, but our ethical intuition changes when we instead focused on how many resources future generations should receive. The justifications for descriptive time preference themselves conflate these concepts by referring to individual psychological characteristics like myopia and impatience used to justify intrapersonal time preference discounting.[171]

Advocates of descriptive time preference attempt to take shortcuts through this intergenerational/intrapersonal fog, for example, by building economic models that assume there is only a single generation that lives forever.[172] By using a single, infinite generation, these models avoid answering whether the preferences of the current generation should determine the resources we leave to the future generation, and whether market rates accurately reflect an intergenerational discount rate.

But collapsing intergenerational discounting with intrapersonal discounting does not eliminate the ethical distinctions between the two; it simply makes a judgment that intrapersonal and intergenerational discounting should be treated in the same way.[173] By using an infinite generation approach, descriptive time preference discounting ducks the question of whether we should look to the preferences of the current generation to determine how many resources to leave for future generations.[174] As we argued in Part III, using the time preference rate of

170. *See infra* Part IV.C.

171. *See id.*; Arrow et al., *IPCC Report*, *supra* note 10, at 131. *See also* Revesz, *supra* note 32, at 999 n.285 (criticizing Arrow's justification for time preference discounting as conflating intergenerational and intrapersonal problems).

172. Revesz, *supra* note 32, at 999 & nn.284–86 (citing Richard Dubourg & David Pearce, *Paradigms for Environmental Choice: Sustainability versus Optimality*, *in* MODELS OF SUSTAINABLE DEVELOPMENT 21, 24 (Sylvie Faucheux et al. eds., 1996); Robert C. Lind, *Intergenerational Equity, Discounting, and the Role of Cost-Benefit Analysis in Evaluating Global Climate Policy*, 23 ENERGY POL'Y 379, 385 (1995)). *See also* John E. Roemer, *The Ethics of Distribution in a Warming Planet*, 48 ENVTL. RES. ECON. 363 (2011) (claiming single, infinite generation is only way to justify descriptive time preference discounting).

173. Revesz, *supra* note 32, at 999.

174. *See* Kysar, *supra* note 10, at 122 (criticizing use of single generation).

the current generation for intergenerational discounting is inappropriate. Other commentators reach similar conclusions. Broome, for example, argues that using market rates is inappropriate for discounting in the context of climate change mitigation because they completely ignore the interests of future generations.[175] Sunstein and Rowell argue that the preferences of the current generation are self-interested.[176] Stern states that even if the current generation actually places less weight on future generations, "it is hard to see any ethical justification for [discounting at this rate]."[177] Beckerman and Hepburn suggest "ethical decisions are not appropriately decided in the market place."[178] Descriptive time preference discounting simply hides the conceptual problems by conflating the discount rate the current generation should apply to projects affecting future generations with the rate the current generation uses for its own preferences.[179]

C. REVEALED PREFERENCES—SAVINGS JUSTIFICATIONS AND INTERGENERATIONAL DISCOUNTING

Though models simplifying descriptive rates of pure time preference generally ignore multiple generations,[180] savings rates may still tell us

---

175. *See* John Broome, *Discounting the Future*, 23 PHIL. & PUB. AFF. 128, 151 (1994).

176. Sunstein & Rowell, *supra* note 48, at 178 (arguing there is no reason to believe preferences of current generation shed light on future generations).

177. STERN REVIEW, *supra* note 12, at 35. *See also* Stern, *Economics*, *supra* note 10, at 13 ("There is no market-determined rate that we can read off to sidestep an ethical discussion.").

178. Beckerman & Hepburn, *supra* note 27, at 203 ("One would not, for example, want to allow policy concerning the death penalty or abortion to be influenced by the *incomes* of voters."). *See also* Anthoff, Hepburn & Tol, *supra* note 124, at 839 (discussing how "many economists and philosophers argue that an ethical approach based solely on individual preferences revealed on markets is flawed" in discussion of θ). On the other hand, other commentators argue, based on democratic theory, that only the current generation's preferences are relevant to what the current generation will invest in. *See* Posner, *supra* note 44, at 141–43 ("[P]olicies that benefit non-voting future generations [will only be supported] to the extent that they are supported by voting members of the current generation."); Viscusi, *supra* note 54, at 209 ("Intergenerational discounting should be no different than within-generation discounting."). *See also* Stephen A. Marglin, *The Social Rate of Discount and the Optimal Rate of Investment*, 77 Q.J. ECON. 95, 97 (1963) (arguing decisions should be driven by current generation's preferences, but rejecting use of market rates for discount rate based on public goods problem further described in Part IV.D). *But see* Sunstein & Rowell, *supra* note 48, at 178 n.32 (citing Cowen & Parfit, *supra* note 37, at 146) ("When those affected have no vote, the appeal to democracy provides no answer.").

179. *See* Beckerman & Hepburn, *supra* note 27, at 203 ("[S]ome features of people's preferences . . . imply that the social discount rate . . . would be below the market rate. For example . . . at best, markets only reflect individual preferences and growth expectations over relatively short periods of time. They provide little information about people's preferences over generations.").

180. *See* Shiell, *supra* note 24, at 1439 (explaining economic models generally ignore bequest as a

something about future preferences based on the bequest motive for saving—leaving money for our heirs. As this section shows, however, using revealed preferences from the savings rate to determine the current generation's *actual* preferences for the treatment of future generations is problematic for two reasons. First, savings do not tell us much about how we feel about future generations. Savings are primarily motivated by one's own personal desire to consume, and how to appropriately spread that consumption over one's own life. Moreover, scholars are undecided if bequests (leaving money for heirs) are actually driven by concern for future generations. Second, transfers made from parents to children during life, or inter vivos transfers, represent a much more significant indicator of concern for future generations than bequests—one not reflected in the savings rate.

1. Bequest, Savings, and Altruism?

Saving for one's own consumption does not fully explain why people often leave significant inheritances for their heirs. Research on savings patterns by the elderly suggests that savings above and beyond consumption are driven by three different motives: precautionary, as retirees are unsure how long they will live and err on the side of having enough money for their lifespan and guarding against future unforeseen expenses like medical care;[181] status from holding money;[182] and bequest, a desire to leave wealth for heirs.[183]

Determining the influence of the bequest motive seems key to establishing how well the savings rate may actually reveal descriptive pure time preference as it applies to future generations. People, however, often save for more than one reason. A person could put $10,000 aside now both because she may need it if she lives long enough and because if she does not need it, her children will inherit it.[184] Given this difficulty in

simplifying assumption); Alan S. Manne, *Equity, Efficiency, and Discounting*, *in* DISCOUNTING AND INTERGENERATIONAL EQUITY, *supra* note 36, at 111, 114–15 (same).

181. *See* Wojciech Kopczuk & Joseph P. Lupton, *To Leave or Not to Leave: The Distribution of Bequest Motives*, 74 REV. ECON. STUDIES 207, 208 (2007) (citing Michael G. Palumbo, *Uncertain Medical Expenses and Precautionary Saving Near the End of the Life Cycle*, 66 REV. ECON. STUDIES 395 (1999); Karen E. Dynan, Jonathan Skinner & Stephen P. Zeldes, *The Importance of Bequests and Life-Cycle Saving in Capital Accumulation: A New Answer*, 92 AM. ECON. REV. 274 (2002) [hereinafter Dynan, Skinner & Zeldes, *Importance of Bequests*]; Karen E. Dynan, Jonathan Skinner & Stephen P. Zeldes, *Do the Rich Save More?*, 112 J. POL. ECON. 397 (2004)).

182. *Id.* (citing Christopher D. Carroll, *Why Do the Rich Save So Much*, *in* DOES ATLAS SHRUG? THE ECONOMIC CONSEQUENCES OF TAXING THE RICH (Joel B. Slemrod ed., 2000)).

183. *Id.*

184. Dynan, Skinner & Zeldes, *Importance of Bequests*, *supra* note 181, at 274 (2002) ("A dollar

determining why precisely someone chooses to save a dollar, there is widespread disagreement over the importance of the bequest motive.[185] Further, even to the extent this research identifies bequest as a motive for intergenerational transfers and debates its importance relative to other motives, it does not tell us *why* people choose to leave money for their heirs.[186] Many scholars argue any bequest motive is driven by egoistic desires to leave a legacy and exert control over family, rather than any altruistic concerns for providing benefits to future generations.[187]

2. Inter Vivos Transfers

The financial support we provide for our children throughout their lives implies that the savings rate *undervalues* the weight we place on future generations. We provide our children with food, shelter, education, and financial support. None of these consumption expenses are reflected in the savings rate, but their measure demonstrates concern for the future. To

saved today simultaneously serves both a precautionary life-cycle function (guarding against future contingencies such as health shocks or other emergencies) and a bequest function because, in the likely event that the dollar is not absorbed by these contingencies, it will be available to bequeath to children or other worthy causes.").

185. *See id.* at 277 (arguing bequest only has "modest" impact on savings and that it is not possible to parse savings into different justifications because a dollar can serve more than one purpose); Michael D. Hurd, *Mortality Risk and Bequests*, 57 ECONOMETRICA 779 (1989) (challenging economic value of bequest motive as trivial); Michael D. Hurd, *Savings of the Elderly and Desired Bequests*, 77 AM. ECON. REV. 298, 306–08 (1987) (finding elderly people with children spend their wealth *faster* than people without children); Kopczuk & Lupton, *supra* note 181, at 209, 210–17 (finding, based on survey responses to saving practices, that 53% of net wealth bequeathed is accounted for by bequest motive); Lee M. Lockwood, The Importance of Bequest Motives: Evidence from Long-term Care Insurance and the Pattern of Saving 2 (Jan. 6, 2010) (unpublished manuscript), *available at* http://www.chicagofed.org/digital_assets/others/research/research_calendar_attachments/seminars_200/sem_lockwood011110.pdf (explaining debate between bequest and precautionary motives remains unresolved because of problems identifying specific motives for savings).

186. Kopczuak & Lupton, *supra* note 181, at 208 ("Little is known regarding why individuals desire to leave a bequest, if they do at all.").

187. *See id.* at 210 ("[T]here is little evidence that individuals leave bequests for altruistic reasons.") (citing John Laitner & Henry Ohlsson, *Bequest Motives: A Comparison of Sweden and the United States*, 79 J. PUB. ECON 205 (2001); James Poterba, *Estate and Gift Taxes and Incentives for Inter Vivos Giving in the US*, 79 J. PUB. ECON. 237, 261 (2001); Kathleen McGarry, *Inter Vivos Transfers and Intended Bequests*, 73 J. PUB. ECON. 321, 349 (1999); Joseph G. Altonji, Fumio Hayashi & Laurence J. Kotlikoff, *Parental Altruism and Inter Vivos Transfers: Theory and Evidence*, 105 J. POL. ECON. 1121 (1997); John Laitner & Thomas F. Juster, *New Evidence on Altruism: A Study of TIAA-CREF Retirees*, 86 AM. ECON. REV. 893 (1996); Mark O. Wilhelm, *Bequest Behavior and the Effect of Heirs' Earnings: Testing the Altruistic Model of Bequests*, 86 AM. ECON. REV. 874, 874, 890 (1996)); *id.* at 208 & n.1 (citing Altonji, Hayashi & Kotlikoff, *supra*; Laitner & Juster, *supra*; Wilhelm, *supra*; Michael Kuehlwein, *Life-Cycle and Altruistic Theories of Saving with Lifetime Uncertainty*, 75 REV. ECON. & STAT. 3 (1993)); *id.* at 231 (describing empirical results as consistent with egoistic bequest motive).

the extent these financial transfers are not reflected in the savings rate, the savings rate's relevance as a measure of actual preferences for helping future generations is diminished. Some studies suggest that these inter vivos transfers are more important than bequests to measure what we leave for future generations.[188] It is, however, difficult to measure the magnitude of these transfers.[189]

The rising importance of inter vivos transfers was first noted by John Langbein in his seminal 1988 article on the subject.[190] The foundation of Langbein's article, based more on theoretical analysis than empirical evidence, is that education—with its rising costs and higher rate of return than physical property—has become the "main occasion for intergenerational wealth transfer."[191]

---

188. *See* JACQUELINE L. ANGEL, INHERITANCE IN CONTEMPORARY AMERICA: THE SOCIAL DIMENSIONS OF GIVING ACROSS GENERATIONS 17 (2008) (noting the "desire and need to obtain a high-quality education . . . has replaced [bequests] . . . as the pathway by which Americans convey their wealth to their children."); J. Bradford DeLong, *Bequests: A History of Bequests in the United States*, *in* DEATH AND DOLLARS 33 (Alicia H. Munnell & Annika Sunden eds., 2003) (suggesting there is a broad consensus that bequests have decreased in importance, and now account for approximately 40% of aggregate wealth accumulation); Claudine Attias-Donfut, Jim Ogg & Francois-Charles Wolff, *Financial Transfers*, *in* HEALTH, AGEING AND RETIREMENT IN EUROPE: FIRST RESULTS FROM THE SURVEY OF HEALTH, AGEING, AND RETIREMENT IN EUROPE 179 (Axel Börsch-Supan ed., 2005) ("[R]esearch has begun to show that the bulk of private money transfers between the generations occurs inter vivos."). *See also* Martin Kohli, *Intergenerational Transfers and Inheritance: A Comparative View*, 24 ANN. REV. GERONTOLOGY & GERIATRICS 266, 276 (2004) (suggesting that bequest transfers are four times more valuable than inter vivos financial gifts). Kohli's measure of inter vivos transfers, however, excludes spending on education, health expenses, and basic support needs. It is also difficult to identify whether these transfers reflect an altruistic motivation or an "exchange" motivation (e.g. a parent investing in a child with the expectation they will take care of the parent in old age). Attias-Donfut, Ogg & Wolff, *supra*, at 182.

189. Precise estimates of the relative size of inter vivos transfers are limited—stemming largely from disagreement over what constitutes a gratuitous transfer, *see, e.g.*, Kerry A. Ryan, *Human Capital and Transfer Taxation*, 62 OKLA. L. REV. 223, 242 (2010), and the difficulty of obtaining inter vivos data because so much is excluded from wealth transfer tax reporting. The lack of direct data has caused economists to turn to surveys, which, coupled with the debates over what constitutes a gratuitous transfer, has limited the drive to conduct comprehensive empirical studies in the area. For a discussion of the merits of looking at more than taxable inter vivos transfers, see Kathleen McGarry, *Inter Vivos Transfers or Bequests? Estate Taxes and the Timing of Parental Giving*, 14 TAX POL'Y & ECON. 93 (2000). There are reasons to suspect underreporting bias depending on whether the inter vivos transfer is viewed from the perspective of the donor or recipient. Jeffrey R. Brown & Scott J. Weisbenner, *Intergenerational Transfers and Savings Behavior*, *in* PERSPECTIVES ON THE ECONOMICS OF AGING 189 (David A. Wise ed., 2004).

190. John Langbein, *The Twentieth-Century Revolution in Family Wealth Transmission*, 86 MICH. L. REV. 722 (1988).

191. *Id.* at 732. *See also id.* at 736–38, 750 (listing other factors contributing to shift to inter vivos transfers such as increased life expectancy, rising healthcare costs, and belief that wealth need not be passed down).

Empirical studies support the conclusions drawn by Langbein. The most widely cited estimate of the relative size of intergenerational wealth transfers comes from a 1994 empirical study by William Gale and John Karl Sholz, who estimated that 31% of intergenerational wealth transfers are transmitted inter vivos, with the estimate rising up to 43% after accounting for possible underreporting bias.[192]

In conclusion, individual savings rates, therefore, have no value in determining our obligation to future generations. The savings rate is primarily a choice about individual consumption, and to the extent bequest enters into the savings decision, it does not clearly appear to reflect much concern for future generations. On the other hand, studies on wealth transfers suggest that inter vivos transfers, not reflected in the savings rate, are more important to measuring how we treat our obligations to future generations. Given these complexities, using the savings rate to determine a pure rate of time preference is inappropriate in the case of intergenerational discounting.[193]

D. MARKET RATES AND THE PUBLIC GOODS PROBLEM OF CLIMATE CHANGE MITIGATION

Additionally, even assuming that intrapersonal rates could determine our responsibility to future generations, using the market rate of return as the discount rate does not tell us how individuals actually value social investment.[194] Market rates are imperfect, and because climate change

192. The authors note that this amount is adjusted from their finding that 31% of wealth is transferred inter vivos, accounting for possible underreporting. William G. Gale & John Karl Scholz, *Intergenerational Transfers and the Accumulation of Wealth*, 8 J. ECON. PERSP. 145, 156 (1994). *See also* Brown & Weisbenner, *supra* note 189, at 185 (supporting Gale & Scholz with empirical study estimating one-third of transfers made inter vivos). Subsequent scholars have commented that this estimate may even be on the low side considering the survey data, which came from the Survey of Consumer Finances over the period from 1983 to 1986, does "not include the value of medical expenses gratuitously paid on another's behalf." *See, e.g.*, Ryan, *supra* note 189, at 243.

193. In their article on measuring preferences, John Beshears and his coauthors highlight "red flags" for studies that use people's revealed preferences to infer their actual preferences that include decisions involving long-time horizons and intertemporal choices. *See* John Beshears et al., *How Are Preferences Revealed?*, 92 J. PUB. ECON. 1787, 1788–90 (2008) (using discounting as example of "red flag" studies). *See, e.g.*, Robert N. Stavins, *The Cost of Carbon-Sequestration: A Revealed-Preference Approach*, 89 AM. ECON. REV. 994, 994–95 (1999) (describing problems with using opportunity cost of alternative land uses as revealed preferences to determine cost of carbon sequestration). *See also* Simon Dietz, Cameron Hepburn & Nicholas Stern, Economics, Ethics, and Climate Change 9 (Jan. 13, 2008) (unpublished manuscript), *available at* http://ssrn.com/abstract=1090572 (describing problems with using market data for "revealed ethics").

194. As Stern describes it, the multiple levels of conflation problems can be summed as follows: one's private discount rate is not equivalent to the social discount rate which is not equivalent to the

mitigation is a public good, collective action problems need to be taken into account when discussing the extent of saving for future generations.[195]

Without enforcement mechanisms to ensure compliance across society, people (or nations) 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.[196] As a result, market rates cannot tell how we actually value benefits provided to future generations through climate change mitigation.[197] This public goods problem points to another reason to believe preferences "revealed" by the savings rate that reflect only individual savings should be given less weight when we compare them to contradictory stated preference studies that ask the participant to choose a *public* benefit program and consider societal interests.[198]

---

social rate of return on investment which is not equivalent to the private rate of return on investment. *See* Stern, *Economics*, *supra* note 10, at 12–13.

195. *See id.* at 13 ("[Market rates] have only limited usefulness. . . . [P]roblems that prevent [equating the market rate with the social discount rate], such as missing markets, unrepresented consumers, imperfect information, uncertainty, production, and consumption externalities are all absolutely central for policy toward the problem of climate change."); Philibert, *supra* note 38, at 915–16 (evaluating the "isolation paradox" of people's individual preferences reflected in markets not reflecting their preferences for collective action). *See also* Jean Drèze & Nicholas Stern, *Policy Reform, Shadow Prices, and Market Prices*, 42 J. PUB. ECON. 1, 34–36 (1990) (conducting formal analysis of how market imperfections cause market rates to differ from social discount rates and how "shadow prices" can be used to convert market prices to social discount rates).

196. Philibert, *supra* note 38, at 916. *Cf.* Robert B. Cialdini, *Hotel Room Psychology*, *in Rethinking Laundry in the 21st Century*, N.Y. TIMES ROOM FOR DEBATE BLOG (Oct. 25, 2009, 7:00 PM), http://roomfordebate.blogs.nytimes.com/2009/10/25/rethinking-laundry-in-the-21st-century/ (describing study that showed informing hotel guests that majority of guests reused towels increased towel reuse by 34%). For an extended treatment of the intergenerational savings rate as a public good, see Cédric Philibert, The Isolation Paradox and the [sic] Climate Change (1998) (unpublished manuscript), *available at* http://philibert.cedric.free.fr/Downloads/isolat.pdf [hereinafter Philibert, *Isolation Paradox*]; Amartya K. Sen, *Approaches to the Choice of Discount Rate for Social Benefit-Cost Analysis*, *in* DISCOUNTING FOR TIME AND RISK IN ENERGY POLICY 325 (Robert C. Lind ed., 1982). This "isolation paradox" argument has been described as "controversial," as the well-being of future generations may not be a public good to the extent society makes long-term investments that benefit the current generation and overlapping future generations. *See* Hepburn, Stern Review, *supra* note 98, at 3 (citing Sen, *supra*); Philibert, *Isolation Paradox*, *supra*, at 18–20 (citing Gordon Tullock, *The Social Rate of Discount and the Optimal Rate of Investment: Comment*, 78 Q.J. ECON. 331 (1964); Robert C. Lind, *Further Comment*, 78 Q.J. ECON. 336 (1964)).

197. *See* Stern, *Economics*, *supra* note 10, at 16–17 ("We cannot really interpret actual saving decisions as revealing the collective view of how society acting together should see its responsibilities to the future in terms of distributional values . . . . Observed aggregate savings rates are sums of individual decisions, each taken from a narrow perspective. This is not the same thing as a society trying to work out responsible and ethical collective action—the crucial issue for climate change.").

198. *See, e.g.*, Maureen L. Cropper, Sema K. Aydede & Paul R. Portney, 80 AM. ECON. REV. 469, 469 (1992) (asking participants to choose between pollution mitigation investments).

Many scholars have identified this public goods issue as a key problem with descriptive pure time preference discounting, including Stern,[199] Heal,[200] Philibert,[201] Amartya Sen,[202] Stephen Marglin,[203] Beckerman, and Hepburn.[204] As Dasgupta points out, "For all we know, social rates of return on [climate change mitigation] are negative today. But the market economy wouldn't tell us they are, because private rates of return would perforce be positive (why else would anyone invest?)."[205] Considering that our preference for climate change mitigation may depend on the actions of everyone else in our generation, looking to individual market rates to determine the social discount rate is flawed.[206]

199. *See* Stern, *Economics*, *supra* note 10, at 13 (arguing private discount rates (PDRs) do not reflect the social discount rate (SDR)). *See also* Dietz, Hepburn, & Stern, *supra* note 193, at 9 ("Market data does not reflect an answer to the question of what citizens of a society should do when considering together what they would regard as the right or responsible action.").

200. *See* Heal, *Post-Stern*, *supra* note 35, at 282 (arguing because of public goods problem, market return on capital is not relevant to discount rate).

201. Philbert, *supra* note 38.

202. Amartya K. Sen, *Isolation, Assurance, and the Social Rate of Discount*, 81 Q.J. ECON. 112 (1967).

203. Marglin, *supra* note 178.

204. *See* Beckerman & Hepburn, *supra* note 27, at 203 (citing Amartya K. Sen, *On Optimizing the Rate of Saving*, 71 ECON. J. 479 (1961)) ("[M]any people may prefer, in their capacity as citizens, to discount the future less than they would do in making choices that affect only their personal allocation of resources.").

205. Dasgupta, *supra* note 33, at 158–59 (concluding, based on climate change involving "a massive global commons problem," there is "a serious possibility that observed [savings] behaviour offers a wrong basis for calibrating [the discount rate]"). *See also* Partha Dasgupta, Karl-Goran Maler & Scott Barrett, *Intergenerational Equity, Social Discount Rates and Global Warming*, *in* DISCOUNTING AND INTERGENERATIONAL EQUITY, *supra* note 36, at 52 (arguing social discount rates can be zero even if private discount rates are positive).

206. We reiterate that, although we focus on critiquing descriptive pure time preference discounting (ρ), the descriptive approach is often unconcerned with separating the values for ρ and θ so long as the overall discount rate, *d*, approximates market rates. *See supra* note 47. Thus, to the extent proponents of the descriptive approach would accept our criticisms of descriptive pure time preference and simply shift the market rate to rest solely in θg by increasing θ, *see, e.g.*, Dasgupta, *supra* note 33, at 163–64 (engaging in thought experiment for values of θ from 2–4 to compensate for low ρ); NORDHAUS, BALANCE, *supra* note 10, at 184–90 (rerunning climate change model with zero ρ but higher θ to approximate market rates); *but see* Stern, *Economics*, *supra* note 10, at 15–17 (rejecting vastly higher θ suggested by Dasgupta and Nordhaus), the same criticisms of using market rates to determine our obligations to future generations still apply. *See, e.g.*, Stern, *Economics*, *supra* note 10, at 15–17 (engaging in thought experiment for proper value of θ in light of near-zero ρ and rejecting empirical evidence as conflating intrapersonal values with intergenerational values). For a further discussion of growth discounting, see Part VI.

E. STATED PREFERENCES—EMPIRICAL STUDIES OF INTERGENERATIONAL DISCOUNTING

Stated preference studies cast further doubt on the validity of using the savings rate for a descriptive claim about pure time preference. These studies suggest that people value future generations at a much lower discount rate than the descriptive approach typically recommends. These stated preference studies try to solve the problems we identified with the revealed preference approach by focusing participants on future generations and by avoiding individual judgments that give rise to the public goods problem.

As Revesz discussed in his previous article, empirical studies have shown discount rates tend to fall as time horizons grow, and the rates for the far-distant future often approach zero.[207] Maureen Cropper and her coauthors offer a typical example of these stated preference studies.[208] In it, the questionnaire asked participants to choose between two government programs that would save 100 people in the present or, depending on the specific questionnaire the participant received, some varying number of people from 5 to 100 years in the future.[209] Based on the responses, the authors calculated people's mean discount rates as 8.6%, 6.8%, and 3.4% for time horizons of 25, 50, and 100 years, respectively.[210] In one Swedish study, participants were asked to compare the seriousness of nuclear fuel leaking from a storage facility between one thousand and two million years in the future.[211] "Almost one third of the respondents did not discount future consequences at all."[212] Out of those who did discount, the mean discount rate was so small as to be practically zero.[213] These studies "reveal an essentially unanimous opposition to the core component of the traditional discounting model: that future consequences should be discounted at a constant rate and that the rate of discounting should be set

207. Revesz, *supra* note 32, at 994–96 (citing Cropper et al., *supra* note 198, at 469; Magnus Johannesson & Per-Olov Johansson, *The Discounting of Lives Saved in Future Generations—Some Empirical Results*, 5 HEALTH ECON. 329, 331 (1996); Ola Svenson & Gunnar Karlsson, *Decision-Making, Time Horizons, and Risk in the Very Long-Term Perspective*, 9 RISK ANALYSIS 385, 398 (1989)). *See also supra* Part II.B (discussing empirical evidence for hyperbolic discounting).

208. Cropper et al., *supra* note 198.

209. *Id.* at 469.

210. *Id.* at 471 tbl.1. *See also* Johannesson & Johansson, *supra* note 207, at 331 (finding similar declining discount rate).

211. Revesz, *supra* note 32, at 995 (citing Svenson & Karrison, *supra* note 207).

212. *Id.*

213. *Id.*

by reference to the rate of return on particular investments."[214]

Of course, there are problems with relying on stated preference studies to determine discount rates. Studies that measure people's stated preferences—what people say their discount rate is—may be less reliable than measuring revealed preferences—what people's savings decisions reveal their implicit discount rate to be.[215] Nonetheless, in an additional review, Kenneth Arrow, Robert Solow, and Paul Portney concluded that stated preferences, when measured correctly, were reliable enough to give a starting point for estimating the environmental damage caused by the Exxon Valdez oil spill.[216] At the very least, given the wide disparity between people's stated preferences and their preferences revealed through the savings rate, we should not rely blindly on "descriptive" claims based on revealed preferences as justifying discounting at a higher rate the welfare of future generations.[217]

V. OPPORTUNITY COST DISCOUNTING

The opportunity cost rationale for discounting argues that we should invest resources in climate change mitigation only if the return from that investment is greater than the return on any other investment for those resources. Many scholars, including OIRA Administrator Cass Sunstein, argue that this rationale alone is sufficient to justify intergenerational discounting.[218] We agree at the outset that accounting for opportunity costs

214. *Id.*

215. Beshears et al., *supra* note 193, at 1792 ("Historically, economists have rejected self-reports on the grounds that behavior has real consequences and self-reports are (usually) only cheap talk."). *See also* RICHARD L. REVESZ & MICHAEL A. LIVERMORE, RETAKING RATIONALITY 127–29 (2008) (outlining criticism and defense of stated preference studies).

216. *See* Report of the NOAA Panel on Contingent Valuation, 58 Fed. Reg. 4601, 4610 (Jan. 15, 1993) (concluding stated preference studies "convey useful information").

217. *See* Beckerman & Hepburn, *supra* note 27, at 203–04 (citing Frederick et al., *supra* note 68) ("[E]mpirical studies of people's discount rates whether by 'revealed preferences' or 'contingent valuation' studies show such monumental inconsistencies in individual rates of time preference that it is virtually impossible to base any policy-relevant estimate on these preferences."); Beshears et al., *supra* note 193, at 1792 ("Self-reports may provide a natural tool for discovering when revealed preferences diverge most from [actual] preferences.").

218. *See* Weisbach & Sunstein, *supra* note 10, at 436–38. *Accord* Cooper, *supra* note 10; Kaplow, *supra* note 44, at 86, 99 (describing government as a "guardian, seeking to maximize the overall well-being of the future generation . . . guided solely by considerations of intergenerational efficiency"); Samida & Weisbach, *supra* note 10, at 147 ("The . . . arguments made here relate only to opportunity costs . . . we do not consider pure time-preference arguments for discounting, such as impatience, uncertainty, and the like."); Viscusi, *supra* note 54, at 221, 240 (citing Kenneth J. Arrow & Robert C. Lind, *Uncertainty and the Evaluation of Public Investment Decisions*, 60 AM. ECON. REV. 364, 377–78 (1970)) (arguing discount rate should be risk-free opportunity cost of capital). *But see* Kysar, *supra* note

is a critical step in any analysis weighing the costs and benefits of climate change mitigation. We do not argue that we should ignore opportunity costs in climate change analysis, nor do we argue that current discount rates are too "low." But, in the climate change context, using a market rate of return (the opportunity cost of capital) as an intergenerational discount rate poses significant problems, conceptually and practically. This part evaluates those problems.[219] Section A discusses the commensurability problem in climate change discounting—we might be willing to trade off some environmental resources like any other economic investment, but we are not willing to do so for other environmental resources. Section B then addresses how the irreversibility of climate change cuts against the opportunity cost rationale: we can always set aside money for future generations, but by doing so instead of investing it in mitigation measures, we may leave future generations with irreversible damage. Finally, Section C discusses the circularity problem raised by discounting the costs and benefits of climate change at the current opportunity cost of capital—by choosing not to mitigate climate change we may actually change the resources available and thus change the opportunity cost of capital. Though accounting for opportunity costs is clearly important, as we demonstrated through our example in Part III.B.3, the opportunity cost rationale does not justify discounting intergenerational benefits at a market rate of return. A far more complex inquiry is needed.

A. COMMENSURABILITY OF MONEY AND ENVIRONMENTAL BENEFITS

Opportunity costs represent a trade-off. If you choose to invest in one project, you necessarily give up investing those same resources in other projects. For financial investments, there is no reason to invest your money in an asset that returns only 1% risk-adjusted if you have the opportunity to invest that money in an asset that returns 5% risk-adjusted (or really, anything greater than 1%). But if we are making a trade off, we must be able to legitimately compare the things we are trading off—apples to

10, at 135 ("Nothing in the foregoing discussion is intended to suggest that analysts are not right to be focusing on opportunity costs, only that such costs should not be compounded into the cost-benefit exercise in a mechanical fashion without first asking important normative questions about intergenerational justice."); *id.* at 137–38 (rejecting discounted cost-benefit analysis as a whole because it "den[ies] its own incompleteness").

219. We do not attempt to address every issue with opportunity cost discounting in this Article, particularly those that have been already extensively discussed in the literature. For example, we do not address the issue of whether we can actually transfer investments now in other projects to future generations through some intergenerational bank account.

apples. This idea of "commensurability" is relatively simple in the everyday economy—money and market pricing allows us to make trade off decisions and compare opportunity costs.[220] When we attempt to price climate change, however, the comparison is not so simple.

How much is clean air worth? If two countries produce the same amount of goods in their economy, but one conserves its natural resources (and clean air) and the other wastes them with no regard to their replacement, it is obvious the conservationist country is more efficient.[221] But determining how much more efficient is not an easy calculation. As Robert Solow and others have suggested, the true price of climate change depends on the "shadow value" of the resources lost.[222] This is an economist's way of saying the value of clean air is the cost of replacing it with other resources.[223]

Our earth has a stock of finite, nonrenewable resources. Some of these resources, like minerals, arable land, and fossil fuels, have no value besides their economic value and thus by properly calculating their "shadow price" we can compare them to other opportunity costs and make trade-offs.[224]

220. *See* Joan Martinez-Alier, Giuseppe Munda & John O'Neill, *Commensurability and Compensability in Ecological Economics*, *in* VALUATION AND THE ENVIRONMENT: THEORY, METHOD AND PRACTICE 37, 37–40 (Martin O'Connor & Clive L. Spash eds., 1999) (describing history of commensurability theory in context of socialist economies that lack effective pricing mechanisms).

221. Solow, *supra* note 153, at 163.

222. *Id.* at 170. *See also* Kenneth J. Arrow, *Discounting and Public Investment Criteria*, *in* WATER RESEARCH: ECONOMIC ANALYSIS WATER MANAGEMENT, EVALUATION PROBLEMS, WATER REALLOCATION, POLITICAL AND ADMINISTRATIVE PROBLEMS HYDROLOGY AND ENGINEERING, RESEARCH PROGRAMS AND NEEDS 13, 17–19 (Allen V. Kneese & Stephen C. Smith eds., 1966) (discussing the hypothesis that consumption is a function of wealth and the interest rate); KENNETH J. ARROW & MORDECAI KURZ, PUBLIC INVESTMENT, THE RATE OF RETURN, AND OPTIMAL FISCAL POLICY 117–18 (1970) (same); David F. Bradford, *Constraints on Government Investment Opportunities and the Choice of Discount Rate*, 65 AM. ECON. REV. 887, 889 (1975) (explaining consumption patterns in relation to government investments); Heal, *Basic Economics*, *supra* note 35, at 77 & n.28 (citing Kenneth J. Arrow, *The Rate of Discount on Public Investments with Imperfect Capital Markets*, *in* DISCOUNTING FOR TIME AND RISK IN ENERGY POLICY 115, 118 (Robert C. Lind et al. eds., 1982)) (outlining how to mathematically predict consumer behavior for discounting purposes); Robert C. Lind, *A Primer on the Major Issues Relating to the Discount Rate for Evaluating National Energy Options*, *in* DISCOUNTING FOR TIME AND RISK IN ENERGY POLICY, *supra*, at 21, 23 (using concept of shadow price of private capital to account for opportunity cost of financing public investments).

223. This shadow price adjustment is technically not part of the discount rate, as it is an adjustment made to the actual value of the goods *before* discounting. Considering, however, how closely connected shadow pricing adjustments are to deriving a discount rate, *see, e.g.*, Dasgupta, *supra* note 33, at 156 (explaining how discounting in an imperfect economy must be paired with shadow-price adjustments), this slight expansion of the scope of our paper is appropriate to place our criticisms of discounting in context.

224. *See* Revesz, *supra* note 32, at 1011 n.337 (quoting Solow, *supra* note 153, at 162–63, 168) ("Most routine natural resources are desirable for what they do, not for what they are.").

But not everything can be so easily replaced. If the Grand Canyon is filled and becomes a parking lot, we cannot substitute its splendor by taking many little trips to visit locations that are not quite as wondrous. We cannot say the replacement value of killing off the panda bear is 2.5 grizzly bears per panda bear.

But our argument is not simply that because certain things cannot be traded off, discounting must be flawed. As we previously discussed in Part III.B.3, accounting for opportunity costs is an important part of evaluating any climate change policy. Rather, if we wish to properly consider opportunity costs in debating climate change, policymakers must affirmatively determine what it is that can be traded off.[225] This concept is related to the idea of sustainable development, advocated by a broad group of theorists, including both Robert Solow and Edith Brown Weiss, which states that we must limit our use of nonrenewable resources to a sustainable level that allows future generations to maintain a similar standard of living.[226] Brown Weiss argued that certain kinds of environmental damage violate "intergenerational rights" and require additional effort to safeguard such rights.[227] Even Solow, a traditional economist and Nobel Prize laureate, when suggesting that certain resources can be depleted if there are adequate substitutes, also stated there were unique, irreplaceable environmental resources that should be protected for future generations.[228] Making this affirmative decision about what should and should not be traded off is necessary to avoid applying the market rate opportunity cost of capital to environmental goods we do not want to trade off in a market context.

---

225. *See* Solow, *supra* note 153, at 171 ("The claim that a feature of the environment is irreplaceable, that is, not open to substitution by something equivalent but different, can be contested in any particular case, but no doubt it is sometimes true. Then the calculus of trade-offs does not apply.").

226. *Id.* at 167–68; Edith Brown Weiss, *Intergenerational Equity: A Legal Framework for Global Environmental Change*, *in* ENVIRONMENTAL CHANGE AND INTERNATIONAL LAW: NEW CHALLENGES AND DIMENSIONS 385 (Edith Brown Weiss ed., 1992). Though both scholars are often mentioned in the context of "sustainable development," their approach to what is encompassed in our obligations to future generations differs. Solow focuses on sustainable economic growth, while Brown Weiss focuses on intergenerational equity. Revesz, *supra* note 32, at 1010–12. *See also* Roemer, *supra* note 172, at 376–88 (arguing for abandoning utilitarianism as basis for intergenerational ethics and toward model of sustainable development).

227. *See* Brown Weiss, *supra* note 226, at 408. These "rights" include "destruction of cultural monuments that countries have acknowledged to be part of the common heritage of mankind," "destruction of specific endowments established by the present generation for the benefit of future generations, such as libraries and gene banks," and "damage to soils such that they are incapable of supporting plant or animal life." *Id.*

228. Solow, *supra* note 153, at 168.

One potential objection to this argument is that economic analysis has already made environmental benefits commensurable to financial investments through willingness-to-pay studies.[229] If we ask society how much the Grand Canyon is worth and they say $100 billion, then when we discount the impact of climate change, we are merely comparing money to money, and there is no commensurability problem. There is an extensive debate on willingness-to-pay studies, and this debate stretches beyond intergenerational discounting to traditional cost-benefit analysis and valuing any noneconomic resource (e.g., our health). We will not be able to do this issue justice in this Article.[230] What we can say, however, is that determining which environmental goods can and cannot be traded off is a necessary prerequisite to evaluating the opportunity costs of undertaking measures to protect against climate change.

B. IRREVERSIBILITY, UNCERTAINTY, AND CATASTROPHE

Opportunity cost discounting argues that if we invest resources in climate change mitigation now, we may be missing better opportunities that will allow us to have more resources to address climate change in the future. But traditional opportunity cost discounting—discounting at a constant rate determined by the return on financial instruments—ignores

229. *See, e.g.*, Sunstein & Rowell, *supra* note 48, at 181–82; Viscusi, *supra* note 54, at 230. *But see* Luttrell, *supra* note 153, at 30–31 (arguing that incommensurability poses a problem to the usefulness of cost-benefit analysis for nonfungible health and environmental goods).

230. Though outside the scope of incommensurability and moving towards valuation problems, one example may shed light on why using willingness-to-pay studies in the context of intergenerational climate change represents a problem of a different kind than traditional cost-benefit analysis, rather than merely a problem of degree. South Brother Island, a small, seven acre island, lies in the East River nestled between Rikers' Island, Queens, and the Bronx. The island has been uninhabited since the summer house of Jacob Ruppert (owner of the New York Yankees who acquired Babe Ruth from the Red Sox) burned down in 1909. The island changed hands a few times, and was purchased by a Long Island investment company in 1975 for the measly sum of $10. *See* Timothy Williams, *City Claims Final Private Island in East River*, N.Y. TIMES, Nov. 20, 2007, at B1. The land remained undeveloped and slowly became a natural sanctuary for herons, ibises, oyster catchers, and egrets. Joseph Berger, *So, You Were Expecting a Pigeon?; In City Bustle, Herons, Egrets and Ibises Find a Sanctuary*, N.Y. TIMES, Dec. 4, 2003, at B1. Based on the development of this natural refuge, New York City agreed to purchase South Brother Island as a wilderness sanctuary in 2007 for a reported two million dollars. Williams, *supra*. Not a bad return; but probably not what the investment company was expecting when it purchased the island for ten dollars. Willingness to pay may tell us how much particular environmental resources are worth at a specific moment in time, or even possibly for a generation or two. But attempting to extrapolate that value over generations, across a changing environment and changing tastes, seems significantly more problematic as our time horizon lengthens. *See* Edith Brown Weiss, *supra* note 226, at 403 ("To the extent that a hydroelectric dam or mine will destroy a unique natural resource, however, we must proceed extremely cautiously, if at all, because future generations might be willing to pay us handsomely to conserve it for them.").

the irreversibility of certain kinds of damage caused by climate change. Though many opportunity costs, such as investing in the financial markets, will continue to be available for future generations, the choice to protect against certain kinds of damage may be made up to only a certain point before species go extinct, land becomes fallow and flooded, or the polar ice caps melt.[231] To the extent that we are uncertain about when these irreversible events occur, or how future generations will value their loss, the optimal climate change policy will err more on the side of taking action now.[232] On the other hand, to the extent mitigation requires high sunk costs in technology and other investments, those sunk costs represent an "irreversibility" that cuts toward a more lax climate change policy.[233]

We do not know what kinds of damage climate change will cause for future generations, nor do we know their preferences for which actions they would prefer we take now.[234] Because of these different kinds of uncertainty, the sunk costs that justify opportunity cost discounting must be balanced against the "sunk benefit" of early action—if we invest in climate change mitigation now, we may prevent the damage caused by irreversibility before we have better information on either the extent of the damage that would be caused or the preferences of those now not-so-future generations.[235] This value of preventing the danger from uncertainty is also described more generally as the "precautionary principle"—better to spend it and not need it than need it and not spend it.[236] For example, investments

231. *See* Stern, *Economics*, *supra* note 10, at 2–3 (describing many of the damages associated with climate change as irreversible).

232. Pindyck, *Uncertainty*, *supra* note 84, at 55–57.

233. *Id.* at 57.

234. *Id.* at 54–55.

235. Robert S. Pindyck, *Irreversibilities and the Timing of Environmental Policy*, 22 RES. & ENERGY ECON. 233, 234 (2000) [hereinafter Pindyck, *Irreversibilities*]; Pindyck, *Uncertainty*, *supra* note 84, at 54–56; Geoffrey Heal & Bengt Kristrom, *Uncertainty and Climate Change*, 22 ENVTL. & RES. ECON. 3, 10–11 (2002); Alistair Ulph & David Ulph, *Global Warming, Irreversibility, and Learning*, 107 ECON. J. 636, 649 (1997).

236. Heal & Kristrom, *supra* note 235, at 11; Pindyck, *Uncertainty*, *supra* note 84, at 57 (calling the "bad-news principle"). *See also* Samida & Weisbach, *supra* note 10, at 168–69 (arguing the correct approach to dealing with irreversibility is using "real option theory" to account for lost opportunities). Real option analysis in the context of climate change involves spending a smaller sum of money now to "freeze" current climate conditions in order to wait for more information and preserve the "option" of mitigating those same climate conditions later. This information could be about either the uncertain damage caused by climate change or about whether technological innovation will make it cheaper to mitigate in the future. Real option theory has generated some theoretical discussion in the economics literature on climate change, though scant empirical studies of actual valuation. *See* Heal & Kristrom, *supra* note 235, at 24–28, 35 (surveying literature on real option analysis in context of climate change); Heal, *Post-Stern*, *supra* note 35, at 286 (arguing real option analysis in climate context is "not one that we can easily evaluate in quantitative terms").

in infrastructure may produce a higher return than climate change mitigation. If, however, there is a danger that an increase in sea levels would flood those investments, the future generation would need to spend much more on protecting against rising sea levels than the present generation would have spent mitigating climate change in the first instance. In this example, we have forfeited the "sunk benefit" of cheaper climate change mitigation before it became absolutely necessary.

This danger is particularly high in the context of climate change, where we do not know at what point our failure to mitigate will cross the line into catastrophic damage,[237] and where it is difficult to accurately value many of our nonrenewable resources.[238] Opportunity cost discounting using the market rate of return as the discount rate does not take into account irreversibilities, since markets only reflect individual choices, which do not affect aggregate-level changes like irreversibility.[239]

On the other hand, there are also uncertainty and irreversibility benefits that operate in the other direction. In a more nuanced discussion of opportunity cost discounting, not only do we need to consider the potential alternate investments that could generate a higher return than climate change mitigation, but we must also consider that investing in climate change mitigation with high sunk costs means we could be wasting a lot of money now if the uncertainties resolve in a way where climate change causes little damage, or if our knowledge increases to the point where we can mitigate damage incredibly cheaply.[240] It is difficult to calculate

It is important to note, however, that real option analysis is simply an analytical tool to address uncertainty, and does not address the fundamental problems with justifications for discounting we evaluate in this Article. If the option will be exercised by the current generation, that is, we only delay more comprehensive decisions for a short time, then no discounting problem exists. If, however, the option continues across generations, real option analysis poses the same discounting problem as traditional cost-benefit analysis: where the future generation that *exercises* the option is separate from the current generation *paying* for the option, the option's present value will be undervalued due to discounting the benefit provided to the future generation. *See* Pindyck, *Irreversibilities*, *supra* note 235, at 241–42 (explaining that an increase in the discount rate leads to a corresponding increase in the price the option must reach before it should be exercised). Real option theory simply hides the discounting question a level deeper in cost-benefit analysis.

237. Pindyck, *Uncertainty*, *supra* note 84, at 47.

238. *See, e.g.*, Eric Neumayer, *A Missed Opportunity: The Stern Review On Climate Change Fails to Tackle the Issue of Non-Substitutable Loss of Natural Capital*, 17 GLOBAL ENVTL. CHANGE 297, 299 (2007) (arguing discounting must account for "non-substitutable" loss of natural resources that affect consumption growth).

239. *See* Dietz, Hepburn, & Stern, *supra* note 193, at 9 ("[M]arkets are unable to capture the ethical issues associated with non-marginal and irreversible change at the global level, since any one individual's action will not affect the set of aggregate circumstances.").

240. *See* Heal & Kristrom, *supra* note 235, at 24 (citing Charles D. Kolstad, *Fundamental*

precisely how these "sunk benefits" and "sunk costs" interact, but Pindyck notes that the higher the uncertainty level, the higher the threshold to actually adopt mitigation policies.[241]

This complex interaction carries over to the greatest possible "irreversibility" from climate change: the end of civilization. If there is a risk that the world would end from climate change, common sense might dictate that we do more to stop it. But, if those future generations cease to exist, then why worry about spending money on helping people who will not be around to appreciate it? That is, though the argument for mitigation becomes stronger as the damage gets worse, at a certain catastrophic level there is *no* point in spending money on climate change.[242] This complexity makes it difficult to discern a clear policy statement from irreversibilities. As Pindyck describes, "we have a good understanding of the economic theory, but a poor understanding of its implementation in practice."[243]

Opportunity cost discounting using a market rate, however, does not consider irreversibility, as it focuses only on maximizing the total resources available for future generations, not the damage caused by that single-minded focus. Setting aside catastrophe and uncertainty, irreversibility matters for the simple reason that climate change put off until tomorrow may be radically more expensive than if we take action today.[244] Opportunity cost discounting ignores that, as we dedicate more resources to goods other than climate change mitigation, the cost of protecting environmental resources might greatly increase in relative terms.[245]

Irreversibiltiies in Stock Externalities, 60 J. PUB. ECON. 221 (1996); Charles D. Kolstad, *Learning and Stock Effects in Environmental Regulation: The Case of Greenhouse Gas Emissions*, 31 J. ENVTL. ECON. & MGMT. 1 (1996)); Alan Manne & Richard Richels, *The Impact of Learning-by-Doing on the Timing and Costs of CO_2 Abatement*, 26 ENERGY ECON. 603 (2004).

241. *See* Pindyck, *Irreversibilities*, *supra* note 235, at 242. This difficulty extends to valuing any real option that preserves a set level of climate change in order to allow the uncertainties to resolve. If the uncertainty surrounding "sunk benefits" of the damage caused by climate change dominates the valuation, real option analysis may point toward spending *more* on mitigation now. *See, e.g.*, Heal, *Post-Stern*, *supra* note 35, at 286**.** If, however, the uncertainty surrounding "sunk costs" and future technological innovation dominates, real option analysis may point toward spending *less* on mitigation now. *See, e.g.*, Pindyck, *Irreversibilities*, *supra* note 235, at 242 (describing how greater levels of uncertainty cut toward delay of adopting any mitigation program).

242. *See* Pindyck, *Uncertainty*, *supra* note 84, at 59. Whether or not we should lend a hand to a generation hanging off a cliff depends on how closely the risk of catastrophe is correlated with an increase in pollution, that is, how much of the cliff-dangling is because we pushed the future off in the first place. *Id.*

243. *Id.*

244. *Id.* at 56.

245. Stern, *Economics*, *supra* note 10, at 14 & n.12. *See also id.* at 4–11 (describing costs of climate change costs of delay); *infra* Part VI.B.

C. CLIMATE CHANGE AND PATH DEPENDENCY

There is also a significant theoretical problem with opportunity cost discounting based on the opportunity costs *currently available*. An extreme example may help illustrate this slippery concept. Imagine you have the choice of two adjacent properties for your home, Greenacre and Blackacre, and enough resources to invest in only one. Thus, each property is the opportunity cost of the other. Greenacre is on a bluff overlooking a lake, and as more people move into the area, its value is expected to increase significantly. The value of Blackacre, which does not have as good a view of the lake, will increase less significantly. Blackacre, however, operates a pump that allows water and plumbing to reach all the way up the bluff. If you do not purchase Blackacre, no one else will either. Clearly, the opportunity cost of Blackacre, that is, *not* purchasing Greenacre, is not as high as it appeared at first glance—without someone operating Blackacre's water pump, Greenacre is worthless as a home.

This example illustrates the problem of opportunity cost discounting in intergenerational climate change. The investment opportunities currently available depend on the capital stock currently available—our natural resources. If we choose *not* to invest in climate change mitigation, that capital stock may be depleted, thus lowering the value of the available set of opportunities. In our example, climate change mitigation is Blackacre—natural resources serve as the "pump" that drives our economy. If that pump starts to run dry, our economy may become less productive, both because we will need to use other, more inefficient resources to drive growth, and because we may need to spend more resources to mitigate climate change. As a result, without the "pump" of our current stock of natural resources to drive growth, growth may plummet, and perhaps even turn negative.[246]

To put it in economics terms, climate change mitigation represents a "nonmarginal" choice, an event that actually changes the economy's entire growth path.[247] As we discussed in Section A, the appropriate way to discount opportunity costs is to convert trade-offs using "shadow prices," that is, determining how many additional resources we need to make up for the losses from climate change and keep the same growth rate.[248] But both

246. *See* Heal, *Post-Stern*, *supra* note 35, at 280 (pointing out that estimates of productivity growth based on historical records omit depletion of natural resources and thus bias discount rate upwards).

247. Stern, *Economics*, *supra* note 10, at 13.

248. *See supra* notes 216–17 and accompanying text; Hepburn, Stern Review, *supra* note 98, at 2–

shadow prices and discount rates using the market rate of return[249] are "marginal" concepts that depend on the current path.[250] A constant growth path provides the baseline that allows us to make meaningful comparisons between resources and determine the shadow price. If, due to climate change, the entire panoply of available resources changes, it is impossible to break out one individual resource, like clean water, and determine what its value is in terms of other resources. Using the current opportunity cost of capital as the discount rate in this situation is incorrect because the opportunity cost of capital *changes* as the growth path changes.[251] In this situation, there is no alternative to making an ethical choice about the pure rate of time preference.[252]

We do not know currently whether damage from climate change will be marginal or nonmarginal.[253] It could be that while certain areas of the globe (e.g., low-lying coastal areas) are devastated, others benefit from increased temperatures and increased arable land. But by using the current opportunity cost of capital as the discount rate, opportunity-cost discounting grossly oversimplifies the complexity by assuming the choices we make on climate change will not affect the consumption growth path.

4 ("[S]hadow discount factors are only applicable *along a particular path*."). *See also* Heal, *Basic Economics*, *supra* note 35, at 63–68 (explaining why "consumption discount rate," i.e. Ramsey formula, only applies in "partial equilibrium" model, i.e. a marginal choice).

249. *But see* Hepburn, Stern Review, *supra* note 98, at 3 (citing Robert C. Lind, *A Primer on the Major Issues Relating to the Discount Rate for Evaluating National Energy Options*, *in* DISCOUNTING FOR TIME AND RISK IN ENERGY POLICY 21 (Robert C. Lind ed., 1982)) (criticizing use of market rates as discount rate for ignoring shadow pricing problem, stating "real risk-free *market* interest rates provide an inappropriate conceptual basis for social discounting"); Kaplow, Meyer & Weisbach, *supra* note 10, at 25 (noting "market rate of return is endogenous to climate policy"); Beckerman & Hepburn, *supra* note 27, at 203 (same).

250. Stern, *Economics*, *supra* note 10, at 13 ("[I]t is simply wrong to look at rates as currently observed, or in historical terms, which refer to existing paths. A choice among paths means also choosing the implied set of discount rates associated with the paths.").

251. *See, e.g.*, Luttrell, *supra* note 153, at 30 ("When the best action *actually* available is worse than the best action *theoretically* available . . . agencies may often be taking no action when they should be regulating to protect public health and/or the environment.").

252. *See* Cowen & Parfit, *supra* note 37, at 151 (criticizing opportunity cost argument for ignoring that "the choice of discount rate determines the marginal productivity of capital"); Heal, *Post-Stern*, *supra* note 35, at 281 ("More generally, if you are working with a general equilibrium model of the entire economy . . . in which case consumption is clearly endogenous, you have to pick [ρ].").

253. *But see* Joseph H. Guth, *Resolving the Paradoxes of Discounting in Environmental Decisions*, 18 TRANSNAT'L L. & CONTEMP. PROBS. 95, 108–12 (2009) (criticizing "endless growth" assumption in discounting models and arguing climate change will affect economy's growth path profoundly).

VI. GROWTH DISCOUNTING.

Growth discounting argues that if future generations will be wealthier than our own, we should not give them as much of our resources. A rich person benefits less from an extra dollar than a poor person, and utilitarianism demands the dollar should go to the person who benefits from it the most: the poorer current generation. Growth discounting calculates the wealth of future generations through the growth rate and determines how much less a rich person benefits from an increase in income through θ, the elasticity of the marginal utility of consumption.

Section A addresses the distribution problems traditional growth discounting ignores. The likely beneficiaries of climate change mitigation, third-world countries, may still be poorer in the future than the developed countries that will bear most of the cost of climate change mitigation now. Section B turns to the second component of growth discounting, θ. By focusing only on the elasticity of marginal utility of *consumption* through θ, growth discounting ignores other relevant factors. In particular, wealthy generations may value environmental benefits more than typical consumption goods, reducing the growth discounting effect. This feature casts doubt on the accuracy of utilitarian calculations based on growth discounting.

A. GROWTH DISCOUNTING, PRESENT RICH, AND FUTURE POOR

In his previous article, Revesz argued that growth discounting makes a gross oversimplification by comparing the "richer" future generation to the relatively "poorer" current generation.[254] The reality is considerably more complex. The countries most likely to benefit from climate change mitigation in the future—developing countries located in the tropics—may still be significantly poorer than the rich countries in the present generations that would shoulder the brunt of the costs associated with mitigation.[255]

Bangladesh, for example, is likely to be disproportionately affected by

254. *See* Revesz, *supra* note 32, at 1004 ("More fundamentally, the growth discounting account assumes implicitly that the benefits of environmental activities are distributed in the same manner as the costs.").

255. *Id.*; Carolyn Kelly, How Intragenerational Distributions of Wealth (Should) Affect Discussions of Intergenerational Distributions of Wealth Under Climate Change Mitigation Policy Proposals 4–7 (Mar. 11, 2009) (unpublished manuscript) (on file with authors).

climate change as sea levels rise.[256] In 2008, the per capita gross national income ("GNI") of Bangladesh was $520, compared to $47,930 in the United States, an amount ninety-two times greater.[257] We can fairly assume that Bangladesh's GNI will not catch up to the United States' in one hundred years time. In fact, as Revesz points out, it is entirely possible that Bangladesh's *future* GNI will be less than America's *current* GNI, which would imply negative growth and negative discounting.[258] Thus, to the extent discounting seeks truly to maximize utilitarian welfare, using one growth rate exaggerates both the wealth of the future beneficiaries of climate change and the poverty of the current generation that would invest in mitigation.[259]

Some commentators have suggested there are ways to adjust the discounting model to attempt to account for these distributional problems.[260] David Anthoff, Cameron Hepburn, and Richard Tol, for example, suggest that we can use a global discount rate if we first adjust damage estimates as applied to specific regions by a factor that represents the differences in that region's marginal utility of consumption.[261] By adjusting aggregate damages by differences in marginal utility, we can partially correct undervaluing the damage climate change causes to the welfare of future generations by traditional discounting models. Anthoff and his coauthors point out that equity weighting does not answer what to do about distributional concerns—it just makes those concerns explicit.[262]

Our argument that the poverty of the major climate change beneficiaries would thus call for relatively higher mitigation expenditures is at odds with the perspective of Nobel Prize laureate Thomas Schelling, who argues that climate change mitigation is a form of foreign aid, and

256. Revesz, *supra* note 32, at 1004 (citing CLINE, ECONOMICS, *supra* note 31, at 110–12).

257. Figures from World Bank Global Development Indicators Database, *supra* note 160 (calculating per capital GNI in US dollars using Atlas method).

258. Revesz, *supra* note 32, at 1004–05. *See also* Kelly, *supra* note 255, at 13–16 ("It is quite likely that the future poor will be poorer than the present rich.").

259. *Id*. *See also* Sunstein & Rowell, *supra* note 48, at 188–90 (acknowledging growth discounting may raise distributional problems).

260. *See, e.g.*, Anthoff, Hepburn & Tol, *supra* note 124 (proposing equity weighting of marginal utility calculations based on regional income); Christian Azar, *Weight Factors in Cost-Benefit Analysis of Climate Change*, 13 ENVTL. & RES. ECON. 249 (1999); David W. Pearce, *The Social Cost of Carbon and Its Policy Implications*, 19 OX. REV. ECON. POL'Y 362 (2003); Shiell, *supra* note 24 (calculating optimal GHG emissions using different weights for different regions).

261. *See* Anthoff, Hepburn & Tol, *supra* note 124, at 839–41.

262. *Id.* at 847. *But see* Kaplow, *supra* note 44, at 112–15 (arguing explicit social weightings lead to inefficient selection of projects).

should be evaluated on those terms.[263] Schelling presents two major critiques of climate change mitigation. He argues that if people are unwilling to greatly support foreign aid in the *intra*generational context, why should we assume they are more willing to support it in the intergenerational context?[264] Additionally, he argues, on opportunity cost grounds, that to the extent we have decided to help developing countries, we should determine whether they would benefit more from climate change mitigation or direct investment in their economies.[265]

There are at least two arguments we can make to distinguish climate change mitigation from traditional foreign aid. First, current foreign aid is plagued by enormous corruption: only a very small proportion of aid channeled through governments in developing countries tends to reach its beneficiaries.[266] In contrast, when developed countries invest in reducing greenhouse gases, they convey a benefit to future generations in developing countries that cannot be compromised by corruption in those countries.

Second, once we have shifted from the pure utilitarian context of discounting to a debate over the merits of foreign aid, we can acknowledge other ethical theories, like corrective justice, that suggest we have a responsibility to mitigate the damage we cause.[267] Arguably, the present-day developed countries did not cause the problem of poverty in developing countries.[268] In contrast, the present-day developed countries are responsible for the bulk of greenhouse gases in the atmosphere.[269]

The broader point, however, is that traditional growth discounting

263. Thomas C. Schelling, *Intergenerational Discounting*, 23 ENERGY POL'Y 395, 398–400 (1995).

264. *See id.* at 397–400. *See also* Revesz, *supra* note 32, at 1005–06 (arguing justifying discounting on basis of foreign aid argument requires using an ethical theory other than utilitarianism).

265. Schelling, *supra* note 263, at 400–01.

266. *See, e.g.*, PAUL COLLIER, THE BOTTOM BILLION: WHY THE POOREST COUNTRIES ARE FAILING AND WHAT CAN BE DONE ABOUT IT (2007); DAMBISA MOYO, DEAD AID: WHY AID IS NOT WORKING AND HOW THERE IS A BETTER WAY FOR AFRICA (2009) (arguing foreign aid breeds corruption).

267. *See* Stephen M. Gardiner, *Ethics and Global Climate Change*, 114 ETHICS 555, 579 (2004) (noting philosophers are "virtually unanimous" that developed countries should bear cost of climate change mitigation, based on various ethical justifications).

268. On the other hand, some might argue that the legacy of colonialism in the developing world is the responsibility of the current developed nations.

269. Heal, *Post-Stern*, *supra* note 35, at 291 ("The great majority of the greenhouse gases currently in the atmosphere were put there by the rich countries, and the biggest losers will be the poor countries—though the rich will certainly lose as well. Because of this, a stronger preference for equality will make us more concerned to take action to reduce climate change."); Revesz, *supra* note 32, at 1005.

does not adequately address these issues.[270] Absent the kind of explicit equity weighting Anthoff and his coauthors propose, growth discounting conflates the issues posed by distributive justice and efficiency. Though this is not a serious problem in the intragenerational context, where the tax and transfer system is used to adjust for distribution problems, we cannot conduct a cost-benefit analysis of discounting and simply leave distribution for a nonexistent intergenerational tax system.[271]

B. ENVIRONMENTAL GOODS VS. TRADITIONAL CONSUMPTION

The elasticity of the marginal utility of consumption, θ, tells us that the value we attach to getting more consumption is a function of our wealth. The wealthier we are, the less we benefit from an extra dollar.[272] Since future generations will likely be wealthier than our own, growth discounting redistributes more resources to our current poorer generation, which we would expect to benefit more from extra resources. This assumes, however, that the value we derive from a better environment functions the same as the value derived from getting more of any other good. It assumes that wealthy generations care less about the environment than poor generations.

As Shane Frederick points out, "The presumption that the utility . . . of a consequence depends on wealth is questionable. Why, for example, would the extinction of the polar bear be assumed to affect wealthier people less?"[273] Using θ to capture how wealth affects the marginal utility of consumption ignores that climate change involves more than just consumption. Indeed, there are two separate arguments that cut against this presumption. First, if we shunt resources towards projects other than

270. *See* Heal, *Post-Stern*, *supra* note 35, at 290–91 (arguing current discounting models do not adequately capture the complexity of our preferences for equality); Samida & Weisbach, *supra* note 10, at 151 ("Utilitarianism and other forms of consequentialist reasoning do not answer this [distribution] question directly. A broader ethical framework is needed.").

271. Hepburn, *Valuing*, *supra* note 153, at 110; Robert C. Lind, *Analysis for Intergenerational Decisionmaking*, *in* DISCOUNTING AND INTERGENERATIONAL EQUITY, *supra* note 36, at 173; Revesz, *supra* note 32, at 1005–06; Sunstein & Rowell, *supra* note 48, at 194–95.

272. Technically, declining marginal utility tells us that a rich person benefits less from an extra dollar than a poor person. The *elasticity* of marginal utility, θ, expresses this relationship in terms of percentages. An elasticity of 1 says that an extra *percentage* increase in consumption affects the utility of a rich and poor person the same. Thus if our poor person has $10 and receives an extra dollar, our rich person with $100 would need to receive $10 to get an equivalent increase in utility. When elasticity is greater than one, a rich person benefits less from an extra percentage increase in consumption than a poor person.

273. Frederick, *supra* note 49, at 670.

climate mitigation, we will cause damage to the environment, reducing the environmental goods available to future generations. As environmental goods become scarcer, future generations will value them more than our own.[274] As Pearce and his coauthors point out, "[t]hink of disappearing rain forests: the value of those that remain is likely to rise over time as there are fewer of them."[275] Second, commentators suggest that willingness to pay to preserve natural resources may actually increase with wealth.[276] As societies become wealthier, the argument suggests they value environmental resources more—communities become less willing to sacrifice environmental quality for economic gain.[277]

Though θ tells us that as we get wealthier we derive less utility from an extra dollar, it ignores that as we get wealthier we are willing to spend more of the dollars we have on protecting the environment. Thus, if we wish to properly weigh the value of climate change mitigation to future generations' welfare, we would have to modify the growth discounting formula to account for the income elasticity of willingness to pay for environmental goods. Where θ tells us how a person's wealth affects the value they attach to more consumption, the income elasticity of willingness to pay for environmental goods (let us use η to represent this term) would tell us how their wealth affects the value they attach to higher

274. *See* Heal, *Post-Stern*, *supra* note 35, at 284 (citing Thomas Sterner & U. Martin Persson, *An Even Sterner Review: Introducing Relative Prices into the Discounting Debate*, 2 REV. ENVTL. ECON. POL'Y 61 (2008)) (arguing as environmental goods become scarce due to climate change, their value "may be rising over time, and the consumption discount rate on environmental services may thus be negative").

275. Pearce et al., *supra* note 56, at 126.

276. There is a vigorous debate on whether environmental benefits are "luxury" goods, that is, whether wealthy people value environmental resources more than poor people. *See id.* (citing JOHN V. KRUTILLA & ANTHONY C. FISHER, THE ECONOMICS OF NATURAL ENVIRONMENTS (1975); Robert Porter, *The New Approach to Wilderness Conservation Through Benefit–Cost Analysis*, 9 J. ENVTL. ECON. & MGMT. 59 (1982)); Revesz, *supra* note 32, at 1003–04 (citing FRANK S. ARNOLD, ECONOMIC ANALYSIS OF ENVIRONMENTAL POLICY AND REGULATION 177 (1995); Lisa Heinzerling, *Regulatory Costs of Mythic Proportions*, 107 YALE L.J. 1981, 2051 (1998)). *But see* Bengt Kristrom & Pere Riera, *Is the Income Elasticity of Environmental Improvements Less Than One?*, 7 ENVTL. & RES. ECON. 45, 52 (1996) (conducting empirical survey of European willingness to pay that "gives no support to the 'folklore' that the income elasticity for environmental goods is at least one").

277. An interesting and paradoxical example of this correlation is the concept of "petro-states": resource–rich countries that remain poorer than their nonresource rich neighbors and suffer from environmental degradation. *See* Terry Lynn Karl, *The Perils of the Petro-State: Reflections on the Paradox of Plenty*, 53 J. INT'L AFF. 31, 32 (1999). *See also* Steven Mufson, Op-Ed, *Oil Spills. Poverty. Corruption. Why Louisiana is America's Petro-State*, WASH. POST, July 18, 2010, at B01 (arguing BP oil spill is just the latest in a series of environmental disasters to befall Louisiana, one of the nation's poorest states with the highest oil production).

environmental quality.[278]

Because the discount formula does not account for this increased willingness to pay, using θ alone overdiscounts the value of climate change mitigation to future generations. As Pearce has pointed out, "A survey of the literature . . . suggests that this adjustment is not one that is made."[279] As some have suggested, we can incorporate η in our existing discount formula to create a "net discount rate."[280] Though θ is actually a negative number, the Ramsey formula uses the absolute value of θ to *increase* the discount rate. Here, we need to do the opposite and subtract η to decrease the discount rate. We also would need to adjust our discount rate based on expected future growth, resulting in a new discount formula of $d = \rho + g^*(\theta - \eta)$. Using the IPCC's estimates for g and θ (1.6% and 1.5),[281] we can see the magnitude of η can have a large impact on growth discount rates. Empirical studies suggest η ranges from .3 to .7.[282] If we use a η of .5, then the growth discount rate drops from 2.4% to 1.5%. If η is equal to θ, growth discounting disappears entirely.[283]

There are objections to this approach. For example, adding η to the discount rate may decrease the discount rate too much by lumping together true "environmental goods" (clean air, parks, endangered species, etc.) with pure economic goods affected by climate change (agricultural productivity). Additionally, David Pearce and his coauthors argue that

278. As an elasticity measure, η tells us how much more of our income we would be willing to pay for environmental improvements if we were 1% wealthier. A η of one means we would always be willing to increase the amount we would pay for environmental improvements to spend the same *percentage* of our income on environmental improvements. A η between zero and one, as is commonly suggested by the literature, *see* David Pearce, Conceptual Framework for Analysing the Distributive Impacts of Environmental Policies 33–35 & tbl.4 (Apr. 2003) (unpublished manuscript), *available at* http://www.ucl.ac.uk/~uctpa36/oecd%20distribution.pdf (surveying empirical literature and concluding most studies suggest elasticity between .3 and .7), means that though the wealthier we are the more money we would be willing to pay, our wealth increases faster than our willingness to pay.

279. David Pearce, *What Constitutes a Good Agri-Environmental Policy Evaluation?*, *in* EVALUATING AGRI-ENVIRONMENTAL POLICIES: DESIGN, PRACTICE AND RESULTS 71, 80 (2005). *See also* Heal, *Post-Stern*, *supra* note 35, at 278 (discussing how elasticities differ depending on type of good, and how cross-elasticities between environmental goods and consumption goods depend on whether the goods are complements or substitutes, "an issue that has [not] been discussed in the literature").

280. *See, e.g.*, Pearce, *supra* note 279, at 79–80; Pearce et al., *supra* note 56, at 126–27.

281. *See supra* note 58 and accompanying text.

282. *See* Pearce, *supra* note 278, at 33–35 & tbl.4 (surveying empirical literature and concluding most studies suggest elasticity between .3 and .7).

283. *See* Revesz, *supra* note 32, at 1004 ("If the valuation of all the components of the damage of climate change increased at the rate of economic growth, this factor would either completely cancel out any discounting as a result of greater wealth (when θ is equal to one), or greatly reduce the extent of such discounting (when θ is somewhat greater than one).").

including η in the discount formula "confuses relative valuation of costs and benefits with the valuation of time. For analytical and didactic reasons, it is best to keep the two separate."[284] However we account for η, though, it is clear that θ is not enough—we cannot assume that future generations benefit less from climate mitigation simply because they will be wealthier. Our arguments do not undermine the fundamental justifications for growth discounting—that we need to adjust our calculations based on the different relative positions of future and present generations. The current approach to growth discounting, however, risks papering over the distributive and valuation questions we need to grapple with to determine our obligations to future generations.

VII. CONCLUSION

There are no easy answers to our obligation to future generations. But what this Article has shown is that we cannot solve these difficult questions merely through the choice of a discount rate. By examining prescriptive time preference discounting, we have argued that discounting is not a substitute for an ethical theory. We show that prescriptive pure time preference discounting is inconsistent with moral intuitions and has little support even among economists.[285] Though some commentators have argued that the question of discounting should be separated from the question of ethics,[286] the dominant approach in the climate change debate is to allow the discount rate to swallow entirely any ethical concerns. Our obligations to future generations are more complex than a choice of zero percent, two percent, or five percent for the discount rate.

Descriptive pure time preference discounting, by deriving the discount rate from the savings rate, makes the category mistake of extrapolating from intrapersonal decisions to the intergenerational context. Though proponents argue the amount society sets aside for investments in future consumption shows how we feel about future generations,[287] the choice to save is primarily intrapersonal. Additionally, we have shown the revealed preference argument does not save descriptive time preference discounting. The savings rate is not useful as revealed preferences for how society sees its obligations to the future—both because the savings rate does not capture

284. Pearce et al., *supra* note 56, at 127.

285. *See supra* notes 29–45 and accompanying text.

286. *See, e.g.*, Sunstein & Rowell, *supra* note 48, at 188–90; Kaplow, *supra* note 44, at 99.

287. Ackerman & Finlayson, *supra* note 50, at 512–13; Arrow et al., *IPCC Report*, *supra* note 10, at 136.

all intergenerational transfers and because of its wide disparity with stated preferences of our obligations to future generations. Further, as climate change mitigation represents a global public good, individual rates of saving do not represent social preferences for public goods. Descriptive time preference discounting, as it is currently performed, is no more than arithmetic artifact with no defensible connection to the value that the current generation might be willing to accord future generations.

Opportunity costs are an important consideration when evaluating climate change mitigation. If our interest is to confer a benefit to future generations, we should not choose a particular means to that end if another way of accomplishing the same objective is less expensive. But opportunity cost discounting, as it is currently performed, ignores complications posed by the nature of the climate change problem. While for a private investor the only relevant consideration is which investment generates a higher return, when considering the opportunity costs of climate change we must determine whether the costs and benefits are commensurable with each other. Changes in agricultural yields from climate change are comparable with other economic investments like infrastructure or education, but would we trade the Grand Canyon for a faster computer chip? Irreversibility also adds a layer of complexity to the opportunity cost problem. Investing in infrastructure may make mitigation cheaper for future generations by generating a higher return, but that may be more than offset if future generations are stuck with irreversible, catastrophic damage, or are even forced simply to spend significantly more on climate change mitigation in the future because current generations decided not to. Taking opportunity costs into account is crucial to evaluating any mitigation efforts, but simple discount rates abstract away from what is distinct about the problem of climate change.

Growth discounting presents another example of complexity masked by the simple choice of the discount rate. Though the growth rate, *g*, represents that the entire world will be richer in the future, the main beneficiaries of climate change mitigation, developing countries, will likely continue to be poorer than the developed countries that would currently invest in mitigation. Thus, as Thomas Schelling has pointed out, our debate over climate change is to a large extent a debate over foreign aid.[288] Climate change mitigation may be a way of transferring resources to poorer countries that avoids problems of corruption. Additionally, even within the growth discounting formula, simply assuming that future generations will

288. Schelling, *supra* note 263, at 398–400.

value increased consumption less than current generations ignores the uniqueness of climate change: future generations are likely to value environmental improvements *more* than current generations, and the discount formula would need to be adjusted accordingly.

By explicitly wrestling with the individual justifications for discounting, we have shown why traditional approaches to discounting are inappropriate in the intergenerational context. Indeed, several of our arguments against these individual justifications have also been made by mainstream economists in isolated instances.[289] By considering the sum of the implications raised by each justification, this Article shows that we cannot simply reduce all of our ethical qualms to the choice of a discount rate and then mechanically discount future benefits of climate change mitigation at the market rate of return. Rather, we have tried to move the discussion on discounting and climate change towards what is truly at stake: what obligations we owe to future generations to mitigate climate change.

289. *See, e.g.*, *supra* note 225 and accompanying text (describing Solow's support of commensurability argument against opportunity cost discounting).