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# Equalizing the Intergenerational Burdens of Climate Change–An Alternative to Discounted Utilitarianism

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Energy use contributes to both short-term and long-term human benefits by allowing infrastructural and capital investments, which may raise living standards into the future.[1] The use of fossil fuels in particular has short-term costs in the form of pollution, but even more importantly long-term costs through an increase in the concentration of greenhouse gases in the atmosphere. Much of the debate about climate change concerns the degree to which policy should shift the costs of climate change onto people in the present and the near future through investments in mitigation and adaptation and the extent to which these costs should be passed on to possibly wealthier people in the more distant future. Those who have been following the theoretical debates among economists know that there is no consensus about this matter, even though there is very little disagreement about either the impact of climate change or about

1. Earlier versions of this article were presented at the Symposium on the Ethics and Economics of Climate Change, organized by Kian Mintz-Woo, at Karl-Franzen-Universität Graz, at a practical philosophy colloquium, organized by Stephan Gosepath, at Freie Universität Berlin, and at a workshop, organized by David Schmidtz, at the University of Arizona. We are grateful to the organizers for the opportunity to present the paper and to the audiences for their helpful feedback. The article benefited especially from thorough and tough comments by Ben Hale at the Arizona workshop. We would also like to thank Sebastian Brun for his assistance with the modeling.

the principle according to which costs should be distributed. Rather, the disagreement is due to the employment of different social discount rates in the optimization calculus. The higher the social discount rate employed, the less the future benefits of present policy count, and the more important the present and medium term cost are to intergenerational optimization. By now this is a well-rehearsed debate and one without any resolution in sight.

Standard economic models employ the framework of Discounted Utilitarianism (DU), which by simplification (and not at all noncontroversially) takes the multifarious damages of climate change to be costs in the sense of reductions in consumption. In the utilitarian tradition of welfare economics DU aims for optimization, in particular for maximum intergenerational consumption (or minimum costs) over an infinite time horizon. Typically, the framework requires employing a social discount rate, which standardly contains three factors. Economists and moral philosophers have discussed the social discount rate extensively, laying most attention on the factor that discounts future benefits because they are in the future, the rate of pure time preference. This turns out, however, often not to be the most important factor in generating the differing policy proposals among discounted utilitarians. The elasticity of the utility of marginal consumption can be much more significant in that regard.

In this article we are not interested in coming down on one side or the other of the debate among economists about the appropriate values for the factors in the social discount rate. Instead we propose an alternative to DU, one that departs from the standard welfare economics aim of optimization. For the sake of limiting the scope of the argument, we accept the controversial claim that a primary moral aim of climate change policy is to distribute properly the intergenerational costs of climate change, where the costs are taken as diminutions of consumption. As an alternative to DU, we propose Intergenerational Equality (IE). IE seeks equality in the ratio of global climate change costs to the global gross domestic product across generations. If one thinks of burdens as costs in proportion to the ability to bear them, then IE is an equal burden-sharing principle. For technical reasons that we clarify in the article, IE as just stated cannot be well-modeled. We approximate it by modeling the minimization of the accumulated differences between the proportional costs across generations, rather than the strict equality of the ratio of costs to GDP across generations.

We offer merely a pairwise comparison of IE to DU. We are not attempting an all-things-considered justification of IE. It is possible that there is a better principle for distributing the intergenerational costs of climate change. Our claim is merely that IE is superior to DU. But given the importance of DU in the economics literature and in policy discussions, this limited claim is significant nonetheless. We argue for the superiority of IE by way of defending four claims. First, the aim optimizing intergenerational consumption suffers from familiar worries about the fairness of aggregating costs and benefits in order to optimize them (across generations). Second, although the employment of a social discount rate might mitigate these problems somewhat, it introduces other likely intractable problems regarding rational agreement about the factors in the social discount rate, in particular in setting the elasticity of the utility of marginal consumption. Third, modeling the distribution of the costs reveals that fairness problems persist for DU, on either of two well-known proposals for the social discount rate, in comparison with IE. And finally, modeling also reveals that IE is superior to DU on precautionary grounds.

## 1. FAIRNESS AND INTERGENERATIONAL OPTIMIZATION

Accounts of the proper distribution of the costs and benefits of climate change across generations might differ according to their understanding of the costs and benefits. Classical utilitarianism seeks to maximize the subjective state of utility and to minimize disutility. Contemporary versions of utilitarianism often seek to maximize preference satisfaction. Welfare economics stands in this tradition of optimization. But the current practice of economists employing DU is to avoid difficult questions of how to measure and compare utility across individuals and generations.[2] Instead, the practice is to model different paths of consumption. Consumption rather than utility or preferences is, then, the maximand among economists who employ DU for purposes of modeling different climate change policies. As economist Partha Dasgupta expresses it, contemporary economists assume that "a generation's felicity can be aggregated from individual felicities in such a way that it depends solely on the generation's average consumption level."[3] According to John Broome, felicity falls out of the picture altogether: "Economists have ended up taking a short cut that leads them to deal in commodities rather than wellbeing."[4] This has the pragmatic advantage of easing comparisons of future scenarios, by measuring, aggregating, and then comparing the forecasted intergenerational (discounted) consumption of different policy paths.

Supposing we have sufficient reason to care about consumption and its reductions, a principle that would require optimization is nonetheless morally dubious. Imagine an original position type thought experiment as a heuristic for deliberating fairly about the distribution of intergenerational costs and

2. A short, but illuminating, summary of the literature on the problems of interpersonal utility comparisons can be found in Daniel M. Hausman and Michael S. McPherson, *Economic Analysis, Moral Philosophy, and Public Policy*, 2nd ed. (Cambridge: Cambridge University Press, 2006), 104–07. Not every one finds the problem of making interpersonal utility comparisons staggering. An optimistic voice to be found in J. A. Mirrlees, "The Economic Uses of Utilitarianism," in *Utilitarianism and Beyond,* ed. Amartya Sen and Bernard Williams (Cambridge: Cambridge University Press, 1982), 63–84. But Mirrlees's optimism is based on the heroic assumption that "effective identity" or "isomorphism" between individuals is for practical purposes possible.

3. Dasgupta, "Discounting Climate Change," 4 (of the printout from the online version).

4. John Broome, "Discounting the Future," in *Ethics Out of Economics* (Cambridge: Cambridge University Press, 1999), 48.

benefits. Representatives of generations consider distributive principles with the aim of maximizing the consumption of their own generations. But they are required to deliberate under constraints. They do not know which generation they represent, apart from not representing the first or last ones, and any principle applied to other generations would be applied to theirs as well. A principle that required optimizing consumption would be deeply troubling in light of the possibility that the consumption of any one generation might be allowed to be very low because doing so could be offset by tiny gains to a sufficient number of other generations.[5] The familiar fairness problem of optimization takes on special salience in the intergenerational context of an infinite time horizon. If the collection of generations over which a principle optimizes extends infinitely into the future, then benefits, no matter how small, could accumulate to justify the imposition of huge costs.

Many economists employing DU are aware of the fairness problem. One justification offered for discounting future gains is precisely to mitigate the problem of debilitating costs falling on any one generation for the sake of miniscule gains to an infinite number of others.[6] Economist William Nordhaus repeats this justification of discounting when, by invoking an imaginary example of the climate system wrinkle, he argues against the comparatively low social discount rate employed by fellow economist Nicholas Stern:

> Suppose that scientists discover a wrinkle in the climate system that will cause damages equal to 0.1 percent of net consumption starting in 2200 and continuing at that rate forever after. How large a one-time investment would be justified today to remove the wrinkle that starts only after two centuries? If we use the methodology of the *Stern Review*, the answer is that we should pay up to 56 percent of one year's world consumption today to remove the wrinkle. In other words, it is worth a one-time consumption hit of approximately $30,000 billion today to fix a tiny problem that begins in 2200.[7]

Discounting future gains would mitigate that problem in practice by reducing the importance of the benefits to future generations such that they approach zero. But employing any social discount rate brings with it the burden of justifying the specific rate employed. And that is the source of much confusion and mischief.

5. The fairness argument is made more fully in Darrel Moellendorf, "Justice and the Intergenerational Assignment of the Costs of Climate Change," *Journal of Social Philosophy* 40 (2009): 204–24.

6. This argument for discounting originates in Tjalling C. Koopmans, "Stationary Ordinal Utility and Impatience," *Ecomentrica* 28 (1960): 287–309, esp. 306. It is made in an intuitive way by Kenneth J. Arrow, "Discounting, Morality, and Gaming," in *Discounting and Intergenerational Equity*, ed. Paul R. Portney and John P. Weyant (Washington, DC: Resources for the Future, 1999), 14. It is critically discussed by John Broome in *Counting the Costs of Climate Change* (London: White Horse Press, 1992), 104–06.

7. William Nordhaus, *A Question of Balance: Weighing the options on global warming policies* (New Haven, CT: Yale University Press, 2008), 182.

## 2. THE SOCIAL DISCOUNT RATE

One of the most sophisticated models for projecting and aggregating climate change costs is the well-known integrated assessment model DICE, developed by Nordhaus and upgraded in 2013 (as DICE 2013R) by Nordhaus and Paul Sztorc.[8] The projections of this model inform Nordhaus's prescription that the optimal mitigation policy requires beginning with relatively modest investments in mitigation, which increase continually over time. Nordhaus refers to this policy as the "climate-policy ramp."[9] The reasoning in support of the climate-policy ramp is based on the idea that returns on even modest investments in mitigation and adaptation techniques would continuously increase because in the absence of such investments forecasted damages would multiply over an infinite time horizon. In other words, modest investments now would reap continually greater benefits in the form of costs averted far into the future. Although the initial emission reductions called for by Nordhaus are not great, they are substantially larger than have been recently been pursued.

The initial reductions of greenhouse gas emissions endorsed by Nordhaus are less than that called for by the PAGE model designed by Chris Hope and applied by Nicholas Stern in the *Stern Review on the Economics of Climate Change*. Stern calls for comparatively strong immediate mitigation measures.[10] The opposing recommendations of Nordhaus and Stern strike the uninitiated as curious because they both assume the scientific consensus regarding the impacts of climate change. Moreover, they both employ versions of DU. It is by now well appreciated in the literature that the most significant reason for the competing policy recommendations of Nordhaus and Stern is the different social discount rate that each applies, and in particular the different values that each applies to two parameters of the social discount rate, namely the elasticity of the utility of marginal consumption and the rate of pure time preference.[11]

Frank Ramsey's pioneering work on the optimal savings rate over time employs a canonical formula for the social discount rate that has come to

8. For an early presentation of DICE see William Nordhaus, *Managing the Global Commons: The Economics of Climate Change* (Cambridge, MA: MIT Press, 1994). For the recent upgrade see William D. Nordhaus and Paul Sztorc, *DICE 2013R: Introduction and User's Manual*, 2nd ed. Available online at http://www.econ.yale.edu/~nordhaus/homepage/documents/ DICE_Manual_103113r2.pdf (accessed August 9, 2014).

9. The climate-policy ramp is explicated and defended by Nordhaus in a variety of works. See for example William Nordhaus, "An Optimal Transition Path for Controlling Greenhouse Gases," *Science* 258(1992): 1315–19; William Nordhaus, "Global Warming Economics," *Science* 294(2001): 1283–84; and Nordhaus, *Balance*.

10. Nicholas Stern, *The Economics of Climate Change: The Stern Review* (Cambridge, UK: Cambridge University Press, 2007).

11. This by now widely appreciated, but for good explanation of this see Partha Dasgupta, "Discounting Climate Change," *Journal of Risk and Uncertainty* 37 (2008): 141–69.

be called "the Ramsey equation."[12] The Ramsey equation can be stated succinctly as follows: $\rho \approx \delta + \eta g$. The social discount rate, $\rho$, is the sum of the rate of pure time preference, represented as $\delta$, and the product of the elasticity of the utility of marginal consumption, $\eta$, and the rate of growth of consumption, $g$. The rate of pure time preference has been much discussed. We focus instead on the disagreement between Nordhaus and Stern over the numeric value to assign to the variable $\eta$. The mathematical role of $\eta$ within the Ramsey formula is as follows. Assuming a positive rate of growth, that is, $g > 0$, a value for $\eta > 1$ would serve as a positive multiplier, increasing the discount rate. Such a positive multiplier discounts the value of the consumption of those who consume more (due to growth) by some multiple of the growth of consumption. Because of the potential of $\eta$ to function as a positive multiplier in the Ramsey equation, differences in its value can play a bigger role than differences in $\delta$ in producing different social discount rates.

Since $\eta$ is multiplied by $g$ in the social discount rate, a word about the role of $g$ is in order. Discounting for growth can be justified on grounds that technology-driven productivity gains increase average consumption and reduce the replacement costs of goods. The idea is that, due to technological development and savings through infrastructural investment, a higher quantity of commodities (of the same quality) can be produced and consumed in the future. Consequently, commodities (of the same quality) would be cheaper (relative to household income) in the future. Major studies in the field of climate economics converge on a rate for $g$ of about 0.02 in the near future but declining over time to about 0.01.[13]

Correctly setting the value of $g$ involves an empirical projection, but there is an often overlooked moral reason for including $g$ in the social discount rate. Accounting for the lower future replacement cost of a good (due to growth) is necessary to preserve impartiality between generations when counting costs. To fail to discount for growth would be to count the value of future costs as too high and therefore to give undue weight to the costs of future generations. This would be in tension with a fundamental commitment of the utilitarian tradition to give equal regard to the utility of all sentient beings. John Stuart Mill refers to the fundamental commitment that a utile is to count for one, no more and no less, regardless of the subject of the experience, as "Bentham's dictum."[14] Getting the value for $g$ right is

12. The focus on utility follows Frank Ramsey, "A Mathematical Theory of Savings," *Economic Journal* 38 (1928): 543–59. Ramsey focuses on subjective utility or enjoyments, which when maximized he refers to as "bliss." Dasgupta endorses a focus on well-being rather than utility in "Three Conceptions," 151.

13. See Stern, *The Economics of Climate Change* and William Nordhaus, "The 'Stern Review' on the Economics of Climate Change," NBER Working Paper Series, No. w1274.

14. John Stuart Mill, *On Liberty,* quoted in book 5 of J. M. Robinson, ed., *Essays on Religion, Ethics, and Society* (Toronto: University of Toronto Press, 1969), 257.

important, then, in light of the utilitarian understanding of, and commitment to, impartiality.[15]

It is illuminating to contrast the elasticity of the utility of marginal consumption with decreasing marginal utility in the classical utilitarian tradition. Utility for classical utilitarians is taken to be a positive state of a person (or sentient being) that is caused by various activities, including the consumption and the possession of goods. A discount factor for marginal increases in utility is necessary just insofar as an additional unit of a good or activity brings less utility than the previous. Attention to the relationship between utility and its causal antecedent (the good or activity) is required because utility might be falsely measured and aggregated without awareness of how much less the marginal utility gain is for an additional unit of a good. This could lead to a failure to optimize utility by over-counting the gains of a particular distribution. In this account the causal relation between the good or activity and the utility it produces is crucial. Depending on prior holdings, an optimal assignment often requires an unequal distribution of goods in order to maximize utility.

Recall, however, that DU seeks to optimize consumption. That requires measuring and aggregating intergenerational consumption rather than utility. What role can $\eta$ play in those sorts of quantitative exercises? Often it is taken to express some kind of elasticity in the value of consumption. But unlike the case of classical utilitarianism, in DU diminished *utility* from increased consumption is not counted and aggregated in order to get the optimization calculus correct, because it is only consumption that is optimized. Instead the idea would seem to have to be that marginal consumption increases are simply considered less valuable, but not because of an elastic causal relation to utility since utility is not counted. Why is it less valuable then and at what rate of discount? Alternatively, $\eta$ is sometimes taken to register an aversion to inequality. By decreasing the value of future consumption by a multiple of a positive rate of growth, we may signal our judgment that it is better to distribute more to relatively poorer earlier generations than to the relatively richer later ones. But how strong should such an aversion be? Is this a matter of how much we are in fact averse to inequality or of how averse, morally speaking, we should be? The economics literature is replete with discussions about the appropriate value to assign to $\eta$. These are not idle debates; rather, they have important implications for the amount of money that should be spent (as a quasi-savings) to mitigate and adapt to climate change over the medium term. In the next section we present the outcomes of a modeling exercise that clarifies these implications.

15. This argument is made more fully in Darrel Moellendorf, *The Moral Challenge of Dangerous Climate Change: Values, Poverty, and Policy* (New York: Cambridge University Press, 2014), chap. 4.

## 3. NORDHAUS VS. STERN

The different social discount rates employed by Nordhaus and Stern result from the differences in the values assigned to two of the three parameters, the elasticity of the utility marginal consumption and the rate of pure time preference. Stern takes the classical utilitarian requirement of equal regard seriously, but nonetheless employs a positive rate for δ of 0.001. His rationale is not that future consumption should be discounted because it is in the future, rather it should be discounted because it might not occur. There is a risk of the extinction of the human species, for example, by means of a huge meteor crash. In effect, Stern redeploys δ so that it states a risk factor rather than a pure time preference. In the context of the economic debate about the social discount rate for climate change Stern's value for δ is quite low. Additionally, he assigns η a low value of 1. Stern's approach is in that respect inegalitarian; he does not discount future consumption on grounds that future people will be wealthier. Nordhaus's DICE 2005 model takes δ to be 0.03 and η to be 1. But his DICE 2013R employs a smaller rate for δ of 0.015 and a higher rate for η of 2.0.[16] In comparison with Stern, Nordhaus deviates from the utilitarian norm of equal regard by discounting future consumption simply because it is in the future, but the later Nordhaus stands closer to the egalitarian tendency in classical utilitarianism by assigning a value to η of >1.[17] Assuming an identical value for *g*, the discount rate for Nordhaus (especially the later Nordhaus) is higher than for Stern. Although the different values assigned to δ get a lot of attention, the later Nordhaus's assignment of a value for η > 1 is especially significant because, unlike δ, η plays a multiplier role.

We use the DICE 2013R model to present the differences between Nordhaus and Stern. As Figures 1 and 2 indicate, significantly different public policy recommendations derive from the different values of the parameters of the social discount rate. Figure 1 represents emissions under a business-as-usual scenario and according to the recommendations of Nordhaus and Stern.

Figure 1 reveals that both total emissions and those at most time points in time vary with the social discount rates employed. Hence, the optimal policy depends crucially on the social discount rate. Unsurprisingly, then, as Figure 2 shows, prescribed emission reductions also depend on the social discount rates employed.

16. See Nordhaus and Sztorc, *DICE 2013R* and William Nordhaus, *The Climate Casino: Risk, Uncertainty, and Economics for a Warming World* (New Haven, CT: Yale University Press, 2013).

17. For a discussion of the relation of assigning η a value >1 to egalitarianism see Partha Dasgupta, "Commentary: The Stern Review's Economics of Climate Change," *National Institute Economic Review* 199 (2007): 5. See A.C. Pigou, "Some Aspects of Welfare Economics," *American Economic Review* 41 (1951): 287–302 for a statement of the egalitarian tendency in classical utilitarianism.

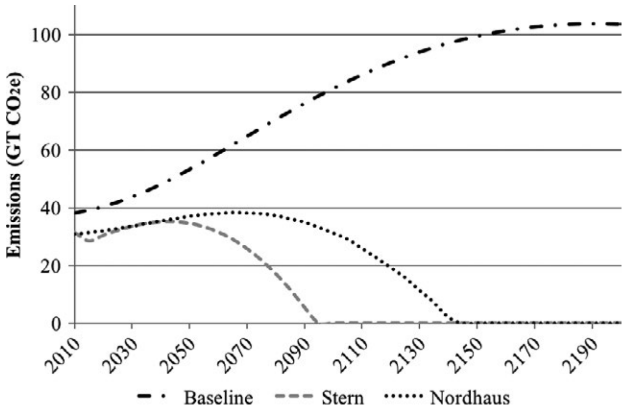


**Figure 1.** Greenhouse gas emissions between 2005 and 2205, business-as-usual baseline and Nordhaus and Stern optimal policy scenarios.
Source: Own calculations based on DICE 2013R (Nordhaus 2013, Nordhaus and Sztorc 2013).

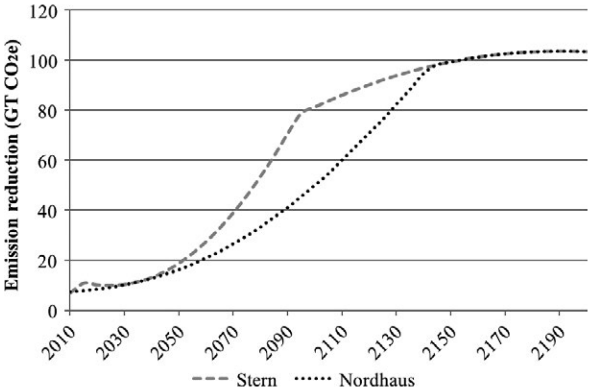


**Figure 2.** Mitigation of greenhouse gas emissions between 2005 and 2205 for Nordhaus and Stern. Source: Own calculations based on DICE 2013R (Nordhaus 2013, Nordhaus and Sztorc 2013).

Stern urges immediate action aiming at rapid, large reductions in $CO_2$ emissions by 2050 and even more by the end of the century. In comparison Nordhaus's policy ramp is more gradual. The emission reductions that he recommends only catch up with Stern's prescriptions well into the next century.

These figures show that different values assigned to the parameters of the social discount rates employed by versions of DU result in very different policy recommendations. Mitigation policies will result in households spending less on consumption goods, and more on energy and infrastructural development, which amounts to a kind of savings plan on behalf of future generations to reduce the costs that are damage caused by climate change. At stake in the different policy prescriptions of Nordhaus and Stern is a nontrivial sum of private consumption. How much savings for the future should policy require? Optimism about DU in general might recommend that a reasonable basis for agreement regarding that question is in principle available so that, as the debate between the followers of Nordhaus and Stern continues, policy convergence on the basis of good reasons can be expected. In the next section we argue that that is not likely to be the case. Such optimism is probably unwarranted.

## 4. LIMITS TO RATIONAL NORMATIVE AGREEMENT

Dasgupta takes the value assigned to η to express a psychological state, which he calls "inequality aversion." Presumably, the more averse one is to inequality the higher value one sets for η since that renders a marginal increase in consumption to high consumers less valuable than an equal marginal increase to low consumers. Now, in some cases there might be reasons to believe that a particular aversion, say to stepping on cracks in the sidewalk, is misplaced. Such aversions express fears that are ill-founded, in which case the holder of the fear can in principle be reasoned with. But in other cases aversions seem insensitive to reasons. For example, aversions to the feel of a clothing tag on the neck or to the color yellow may vary across persons, with no basis in argument or fact that could convince a person to adopt them or not. A common biology might yield approximate convergence in some cases. But convergence of that sort is caused (presumably) by some kind of biological adaptation, not by being convinced by reasons. Aversions of these sorts are a kind of bare preference not to have such tactile or visual experiences. Dasgupta does not discuss conditions under which the aversion to inequality could possibly be ill-founded. He could take it to be a bare preference. But then policy claims about how to direct a great deal of money would be insensitive to argument. And any hope of rationally reconciling the competing proposals of Nordhaus and Stern would be misplaced.

Perhaps in an effort to avoid that unsatisfactory implication, Dasgupta suggests that we consider our feelings and attitudes *vis-à-vis* the inequality across time produced by the various rates of savings that are derived from different values assigned to η.[18] This is to treat the matter of the appropriate value to set for η as in principle resolvable on the basis of surveying analogous preferences and inferring from them. The appropriate rate by which the value of a marginal increase in consumption should decline as people consume more is seen as the product of something like a social choice based on the aversion that people have to inequality.

Fellow economist Martin Weitzman refers to η as a "taste-parameter." That language suggests that claims about the value to assign η express bare preferences. In what seems like an effort similar to Dasgupta's to make disagreements about η resolvable, Weitzman advocates setting η with reference

18. Partha Dasgupta, "Commentary: *The Stern Review*'s Economics of Climate Change," *National Institute Economic Review* 199 (2007): 5.

to observed behavior.[19] The idea seems to be that the appropriate value for $\eta$ should track the response of the population. It seems that we are to base $\eta$ either on the average of peoples' tastes regarding whether marginal increases in consumption should be valued less as a person consumes more or simply on peoples' tastes for inequality.

Dasgupta and Weitzman are advocating a sort of empirical survey for purposes of setting a value for $\eta$. If we were interested in an empirical generalization about what people were averse to or what their tastes were, investigations of the kind that they urge would certainly be relevant. But the question to answer is not whether in fact we value less a marginal increase in consumption for those who already consume a great deal more, but whether we should. The parameter $\eta$ is normative. Treating it as resolved by empirical surveys would be like seeking an answer to the question of whether poverty is unjust by trying to figure out whether in fact people's attitudes to poverty are that it is unjust.

The survey approach to setting a value for $\eta$ is not appropriate for determining values generally, but it is also at odds with the practice of the utilitarian tradition. The survey-approach to setting the value of $\eta$ bears a resemblance to the method by which goods are discounted in classical utilitarianism on grounds of decreasing marginal utility, but the resemblance is superficial and can be misleading. In the pursuit of maximizing the aggregate of individual states of utility, the classical utilitarian is interested in knowing how much utility an additional unit of a good brings a person. The classical utilitarian takes it to be the case that there is some psychological fact of the matter for any particular person, which fact can be expressed in a law-like function, according to which a good or activity produces utility in inverse proportion to the amount already possessed or the number of times the person has acted. Surveying people might lead to an average discount rate for a particular good or activity. The more precise one can be about that discount rate for the people affected, the better epistemic circumstances the policymaker is in to optimize utility since it would be suboptimal to distribute a good equally that caused different utility to different people. The survey approach in DU is, however, importantly different from what the classical utilitarians are doing. The classical utilitarian is interested in measuring, aggregating, and optimizing utility. Knowing the causal relationship between goods and the utility caused to the people who would be affected by the distribution of the good is important for measuring. Discounted utilitarians in contrast are interested in measuring, aggregating, and optimizing consumption. Dasgupta and Weitzman discuss how much we disvalue inequality, or more precisely how much we differentially value an equal marginal increase of consumption for better- and worse-off individuals. That is not an interest in the causal relation between the good and a person's well-being, nor does discounting by $\eta$ promote accurate measuring of consumption since it has to be measured before

19. Martin Weitzman, "A Review of *The Stern Review on the Economics of Climate Change*," *Journal of Economic Literature* 45 (2007): 709.

it can be discounted. Even if the aim were to measure utility, insofar as η reflects merely our present attitudes, it would be irrelevant to the causal relation between utility and consumption for people in the future. What is more, if the aim is to measure consumption, how much we disvalue distributing equal marginal increases to high and low consuming person is simply irrelevant.

If the survey approach to setting a value for η is neither appropriate for determining values nor consistent with the practice of the utilitarian tradition, why do prominent discounted utilitarians employ it? The comparison to classical utilitarianism allows us to explain the strange predicament of discounted utilitarians disagreeing about the value to assign η. If theorists were to call upon a possibly law-like relation between consumption and the utility of a person, then they would be pursuing agreement about η in the same manner that classical utilitarians seek to set the rate of decreasing marginal utility. But they would also then be engaged in an activity that is relevant only to counting and optimizing the utility caused by consumption because the reason to discount marginal utility is simply to get the optimization of utility right. But optimizing utility would require confronting the difficulties of aggregating and comparing it across population groups, which difficulties the short cut of aggregating consumption allows them to avoid. The alternative pursued by contemporary economists is to value consumption *simpliciter*, but then there is no causal relation (between consumption and utility) that could possess the property of elasticity. If there is no interest in utility, why then value the marginal consumption of high-consuming and low-consuming persons differentially? The answer theorists seem to revert to is an aversion or distaste for inequality.[20] That either renders the matter entirely subjective or impels theorists to the survey approach.

Our focus has been on η. Different values assigned to η are often more important than different values assigned to δ in generating disagreements about the social discount rate. In the debates about the social discount rate, η is much less widely discussed, and apparently taken to be less controversial, than δ. We disagree. We have argued that the approach in DU to η is confused and that this is in large part because of the ambiguity of the short cut taken by DU in valuing consumption. There is of course good reason to believe that DU is also in trouble with respect to the value of δ, which, after all, it takes to represent the rate of pure time *preference*. Stern asserts that the preferences of the present generation should play no role in determining how we ought to value the costs of climate change for people in the future. Nordhaus suggests that by attending to the market return on capital we can discern what rate of pure time preference people in fact now employ.[21] This is just another version of the survey approach. Even if the market were indicative, as Nordhaus claims, it would only be indicative of our preferences regarding trade-offs between our own consumption and savings. That provides no insight into the

20. See also the criticism of the "psychological fallacy" in the economics of climate change in Moellendorf, *The Moral Challenge*, 87, 104, and 112.

21. Nordhaus, *Balance*, 61.

value of another population group's preferences in that regard. Moreover, the value to assign δ determines how much to load costs on others, and it is not at all an uncommon occurrence for people to prefer to do less for others than they should. Such a survey approach betrays a morally impoverished theory.

Our analysis suggests an important difference in how DU handles the matter of the values to assign to η and δ. In the case of η, if the project were to optimize utility, then we would need to know much more about how to compare utility across populations and generations. Those problems can be avoided by taking the short cut to consumption. When consumption is optimized, however, there is no objective causal relation between the good and utility that can fix the rate at which marginal increases in the good should be discounted. So, theorists consider our aversions or our tastes for inequality. An implication of DU, then, is that theorists are left surveying preferences and aversions. In the case of the value of δ, it is simply a stipulation of the theory that setting the value is a matter of preference. Presumably theorists could stipulate otherwise. When assessing the merits of a theory, its implication is more interesting than its stipulation since the latter is more easily avoided. In both cases, however, rather than disciplining our aversions, tastes, and preferences so that they align with the reasons we have regarding what we owe to others, DU has us taking the matter of what we owe to others to be determined in significant part by our preferences. The engine of implication seems stuck in reverse.

For someone seeking to salvage the project of guiding policy by the optimization of intergenerational consumption the obvious move to deflect the problems discussed above would be to abjure discounting on basis of η and δ. This would free the project from the apparently intractable debates about how to set the values of these variables. Doing so, however, allows the fairness problem to resurface. To appreciate this, we imagine a choice limited to consumption streams that include no economic growth. No discount rate would then apply to future costs. The task would be to identify the present and future savings rates that would constitute the optimal undiscounted sum of net consumption benefits over an infinite time horizon. This could permit massive costs being imposed on one or more generations if they were offset by minute consumption gains to a sufficiently large set of future generations. Discounting mitigates the fairness problem, but it also carries with it the problems of setting values for the factors of the discount rate. That is evidence of a significant problem internal to the account.

The problem for DU takes the form of the following dilemma:

1. If DU does not employ a discount rate in addition to the rate of growth, it suffers from the fairness problem familiar to optimization.
2. If DU does employ such a discount rate, the only means it has to fix the values for η (and perhaps δ) are empirical surveys that tell us nothing about how much we should value the consumption of richer (future) people.
3. Neither the consequent of 1 nor of 2 is satisfactory in an account that seeks to offer normative guidance to public policy in the assignment of the intergenerational costs of climate change.

4. Therefore, DU is not a satisfactory basis for an account that seeks to offer normative guidance to public policy.

Discounted utilitarians will seek to free the theory from the grips of the dilemma. Our interest is different. We suggest that at the very least the dilemma provides good reasons to consider an alternative to DU. The comparative virtue of IE is that rather than being an optimizing principle it is an equalizing one. It breaks from the tradition of welfare economics in that regard. The rest of this article is devoted to discussing model comparisons of DU and IE.

## 5. MODEL COMPARISONS

The use of the modeling tools available to project consumption for purposes of judging optimal intergenerational consumption gives us the possibility of comparing the results of prominent versions of DU with IE. In order to make such comparisons we assume the distribuand of consumption. But there are two complications involved in modeling IE. First, unlike the Nordhaus and Stern approaches, which both aim to identify a single optimal mitigation path, several mitigation paths with equal ratios of climate change costs to GDP exist depending upon the trajectory of growth. This is because, insofar as the aim is not the optimization of consumption, growth is exogenous on the IE model. Hence, IE can be variously instantiated depending on various assumptions about economic growth. To make the modeling of IE manageable we need to limit the examples. So, we simplify matters by modeling only two different growth scenarios consistent with IE. One scenario follows the investment path derived by Nordhaus. This scenario assumes robust economic growth and capital accumulation. It is based upon widespread assumptions about the direction and desirability of continued economic growth. We refer to this as "the growth scenario." A second scenario models a path of transition to a steady-state economy. Imagine that society elects to keep the capital stock constant and allows for investments up to the amount of annual depreciation. Though the growth of consumption is further driven by the fertility of technology, the assumption of a constant capital stock softens economic growth. There is a long tradition of support for a steady-state economy, including in the writings of Mill.[22] Ecological economists also often argue that global economic growth must flatten out sooner rather than later in order to avert massive ecological

22. Mill: "I confess I am not charmed with the ideal of life held out by those who think that the normal state of human beings is that of struggling to get on; that the trampling, crushing, elbowing, and treading on each other's heels, which form the existing type of social life, are the most desirable lot of human kind, or anything but the disagreeable symptoms of one of the phases of industrial progress. It may be a necessary stage in the progress of civilization … But it is not a kind of social perfection which philanthropists to come will feel any very eager desire to assist in realizing." John Stuart Mill, "Of the Stationary State," Book IV, Chapter VI in *Principles of Political Economy: With Some of Their Applications to Social Philosophy* (London: J. W. Parker, 1848). http://www.econlib.org/library/Mill/mlP61.html#Bk.IV,Ch.VI (accessed November 22, 2012).

destruction.[23] We refer to this as "the degrowth scenario." We employ these two scenarios merely for illustrative purposes; we take no position here on the relative merits of either of them or any others. Still, it is a noteworthy feature of IE that, because it rejects the aim of optimizing growth, it possesses no barrier to advocating steady-state economics.

A second complication arises specifically for the period of policy transition. Since currently both mitigation costs and climate-related damages are comparatively small, the actual ratio of costs to GDP will need some transition time to achieve a ratio equal to later generations. We permit this by modeling the minimization of the accumulated differences between the proportional costs across generations instead of the strict equality of the ratio of costs to GDP. The employment of a minimization aim in the modeling IE is fortuitous because it allows us to use the Nordhaus's DICE 2013R model environment, which requires some kind of optimization calculus. We use DICE 2013R to compare the two instances IE with the two most prominent version of DU offered by Nordhaus and Stern.

The total costs of climate change vary according to mitigation strategy. So, modeling the accumulated absolute climate costs (defined as the sum of consumption reduction due to mitigation and adaptation costs plus damages) of the four approaches provides a good way to appreciate significant differences in the approaches.

Figure 3 reveals that, while future damages clearly dominate current mitigation and adaptation costs for Nordhaus and Stern, the IE scenarios are more balanced. This is due to the relatively strong early emission reductions required by IE (see Figure 5), which reductions in turn result in significantly fewer later damages.

Given the aim of IE, an interesting comparison is that of the costs of climate change as a percentage of GDP. Figure 4 shows that ratio for all four scenarios.

The IE scenarios keep a ratio of costs to GDP that is nearly constant (the minimization of accumulated differences in ratios), while the DU scenarios allow for costs that are much higher as a percentage of GDP, at least for a period of time. According to the growth scenario of IE the share of climate-related costs to GDP (after a short period of transition) is approximately 2.1%, and according to the degrowth scenario it is only slightly less. So, although the modification of IE discussed in the previous section does not require strictly equal ratios across generations, the minimization of the accumulated differences in ratios very closely approximates equality. In the near future both IE scenarios require higher ratios of costs to GDP than either Nordhaus's or Stern's recommendations. Later, however, the ratios of costs

23. See for example Herman Daly, *Steady State Economics,* 2nd ed. (Washington, DC: Island Press, 1991). For recent discussions see D. W. O'Neill "Measuring Progress in the Degrowth Transition to a Steady State Economy," *Ecological Economics* 84 (2012): 221–31 and G. Kallis, C. Kerschner, and J. Martinez-Alier "The Economics of Degrowth," *Ecological Economics* 84 (2012): 172–80.

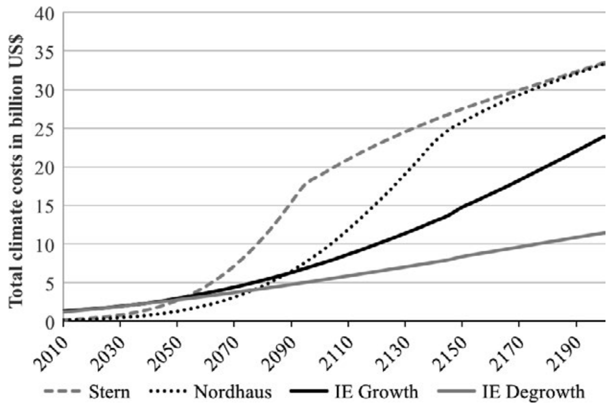


**Figure 3.** Total climate cost between 2005 and 2205.
Source: IE: Own calculations, Nordhaus and Stern Trend: based on DICE 2013R (Nordhaus 2013, Nordhaus and Sztorc 2013).

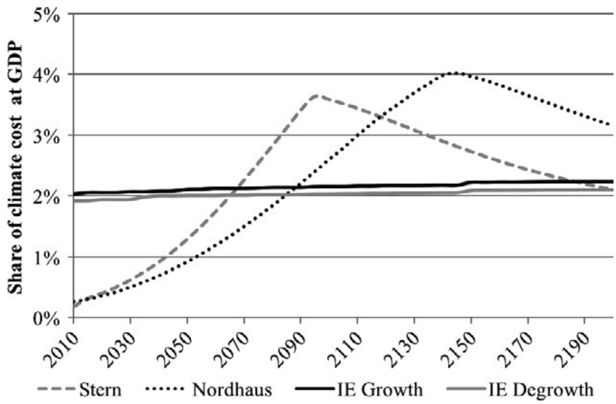


**Figure 4.** Development of shares of climate costs to GDP within the IE model.
Source: IE: Own calculations, Nordhaus and Stern Trend: based on DICE 2013R (Nordhaus 2013, Nordhaus and Sztorc 2013).

to benefits of both the growth and the degrowth scenarios are considerably lower than either the Nordhaus or the Stern approach. Since economic growth is about the same for Nordhaus, Stern, and the IE growth scenario, the differences in shares of costs to GDP among them reflect the higher initial expenditures on mitigation and lower subsequent climate-related damages in IE than in either the Nordhaus or Stern approaches.

Figure 4 suggests another concern about fairness. For Stern the share of climate costs to GDP peaks somewhere around 2090, for Nordhaus around 2150. Given the assumption of continued economic growth, richer generations who come after these years pay a smaller share of their GDP in climate change costs. There is then a regressive tendency after 2090 for Stern and

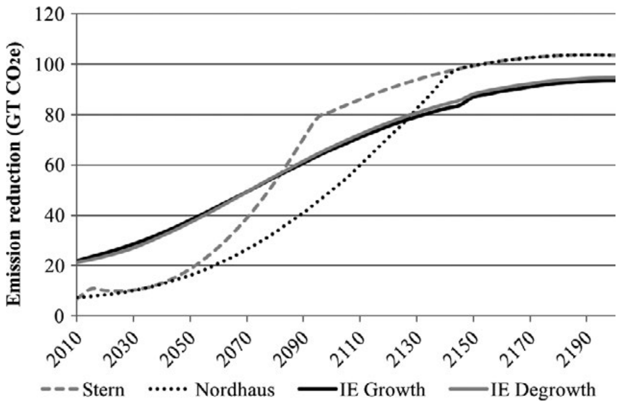


**Figure 5.** Mitigation of greenhouse gas emissions between 2005 and 2205.
Source: IE: Own calculations, Nordhaus and Stern Trend: based on DICE 2013R (Nordhaus 2013, Nordhaus and Sztorc 2013).

after 2150 for Nordhaus. In contrast, IE has no such regressive tendency. Hence, there is reason to think that IE has fairness advantages over prominent forms of DU. But even if IE has a fairer intergenerational distribution of costs, one might wonder whether the distribution could not be fairer still. Perhaps the share of the GDP devoted to climate change cost should rise as economic growth increases so as to produce a progressive intergenerational levy. The problem with this suggestion is that increasing the share of the GDP devoted to paying climate change costs is inconsistent with the generally accepted aims of mitigation, which are to effect an energy transition once and for all and to halt warming in an effort to take precaution against possible but uncertain catastrophes. Assuming continued economic growth, a progressive levy on the costs of climate change across generations would allow for ever-increasing damages, and that is inconsistent with the aims of mitigation.

## 6. PRECAUTION

One of the advantages of comparing the model results of DU and IE is that some features of the principles become apparent that otherwise would not be. Although without any modeling one might be critical in principle of optimization on grounds of the fairness problem and critical of the social discount rate because of the problems of setting the parameters, certain advantages and disadvantages of the principles are only apparent after comparing projected results. As discussed above, Figure 4 reveals that IE has fairness advantages over DU even with discounting. That's not all. Figure 5 compares the mitigation paths of the two IE scenarios to those of Nordhaus and Stern. The curve for emission reductions for the IE scenarios is more gradual than that of either Nordhaus or Stern. But it is noteworthy that both IE curves represent immediate, sharp reductions in emissions, more so than even Stern recommends. These are required by the IE scenarios because of the current low damage costs of climate change. Maintaining an approximately equal ratio of costs requires supplementing these damage costs with the assumption of high mitigation costs. If the economy were to follow the IE degrowth scenario, the reduction of emissions would only very slightly exceed those of the IE growth scenario. Those reductions would be primarily driven by the slowdown of the economy rather than additional active mitigation policies.

The modeling exercise reveals an additional advantage that IE has over DU, namely that IE is more consistent with a precautionary approach to climate change policy. A precautionary approach is warranted given the uncertain prospects of catastrophes. Climate change forecasts are replete with uncertain events; these are uncertainties in the technical sense, namely events for which no objective probability can currently be assigned. This is the sense of uncertainty developed in the important work of Frank H. Knight.[24] Uncertainty enters climate change forecasting very early on—at the estimate of equilibrium warming for a specific increase of $CO_2$ in the atmosphere. Climate sensitivity is the measure of increased warming due to a doubling of pre-industrial atmospheric $CO_2$ concentrations. The Intergovernmental Panel on Climate Change's (IPCC) *Fifth Assessment Report* states a range of uncertainty for climate sensitivity of 1.5–4.5°C.[25] The uncertainty about climate sensitivity is a base-level uncertainty in climate forecasts that effects countless other projections, including some processes that have additional uncertainties built in. For example, although projections of sea-level rise are subject to uncertainty due to warming uncertainty, the greatest contributor of sea-level rise could be from the dynamic land-based ice sheet collapse in Antarctica and Greenland. The processes of dynamic ice sheet collapse are not well understood and the IPCC attaches no probability to occurrence of such collapse because of its uncertainty.

If we merely had reason to believe that a harmful outcome were possible, but nothing more, then there would be insufficient reason to incur costs to protect against it. The sheer possibility of an alien attack does not justify developing expensive space weapons for defense of the Earth. In contrast to the mere possibility of a bad outcome, suppose the following four conditions were to obtain:

1. The harmful outcome could possibly come about by means that are in general terms understood by science.
2. Several of the understood causal antecedents are presently exercising influence on events.

24. Frank H. Knight, *Risk, Uncertainty, and Profit* (New York: Hart, Schaffner and Marx, 1921). See especially chapter 8.

25. IPPC, The Physical Science Basis, *Summary for Policymakers*, 16.

3. The harm is sufficiently grave that there is greater reason to avoid it than to pursue the opportunities that avoiding it excludes.
4. The costs of avoidance are comparatively minor.

In thinking about these conditions imagine first the circumstance of an individual choosing prudentially regarding costs. If under the above four conditions the individual were unwilling to assume the comparatively minor costs of precaution and instead leave herself exposed to what she considers a grave outcome, her refusal would seem imprudent. Now, imagine she were unwilling to assume comparatively minor costs to herself, and thereby exposed another person to the possibility of grave harm. Her attitude would seem morally blameworthy.[26]

These four conditions seem to apply to several catastrophes that might be caused by climate change, not only rapid sea-level rise as the result of dynamic ice sheet collapse, but also mass hunger due to crop pattern disruption and drought in the context of a rising global population and the massive release of methane from warming arctic waters and thawing tundra. None of these events would seem miraculous; several of the causal antecedents seem identifiable and are known to be causally effective; they all pose grave threats, which we have very good reason to avoid; and climate change mitigation to prevent them would be far less costly than the costs of their occurrence. Hence, a climate change mitigation regime that is precautionary with respect to these occurrences seems justified. The greater initial mitigation required by both IE scenarios is consistent with such a precautionary approach. Hence, on grounds of precaution IE also possesses an important advantage over DU.

## 7. CONCLUDING REMARKS

IE seeks an approximately equal ratio of climate change–related costs to GDP across generations. We have not argued that IE is the best of all plausible principles that seek to distribute the intergenerational costs of climate change. Our aim is more modest than that. We have argued that IE is superior to DU on grounds of fairness; IE avoids confused and probably irresolvable moral debates about discount factors; and that it better corresponds to the good reasons that we have to take a precautionary approach to climate change policy.

The policy implications of our alternative are significant. Due to comparatively low current damages, today's ratio of costs to GDP can only come close to equality with future ratios if mitigation efforts are increased significantly. According to the model results absolute climate costs increase disproportionately with economic output. As a consequence, the share of costs

26. See Stephen M. Gardiner, "A Core Precautionary Principle," *Journal of Political Philosophy* 14 (2006): 33–60; and Henry Shue, "Deadly Delays, Saving Opportunities: Creating a More Dangerous World?" in Henry Shue, *Climate Justice: Vulnerability and Protection* (Oxford: Oxford University Press, 2014), chap. 14.

increases with the proposed investment and growth path. A share of about 2% would be appropriate for the two versions of IE presented here. This requires significantly increasing current mitigation ambition.

We have used modeling to make part of our case. It is, of course, possible to criticize all modeling exercises as largely speculative. Given the multiple and massive uncertainties in the climate system, there are significant epistemic constraints on any modeling exercise. And all models are at best very rough guides to the future. People often argue that policy should abjure strict reliance on all modeling forecasts.[27] As our discussion of uncertainty evinces, we do not wish to reject that claim. Still, climate change mitigation involves redistributing some of the costs of climate change from the future to the present and the near future. In light of that, it is reasonable to ask what principle should guide us in deciding how much we should invest now, and how much we should leave to persons in the future to pay. This is a basic question of intergenerational distributive justice. And we believe that it is tremendously important to appreciate how much the answer to this question in DU is dependent on fairly poor understandings of the moral parameters of the social discount rate. Indeed, fundamental ambiguities seem to be built into the model of maximizing consumption. Moreover, regardless of the accuracy of the modeling—ours is no worse than any other, and we can only hope for continued improvement—if IE is better justified than DU, we make a serious moral mistake if we set out to follow, even if not strictly, either the approach of Nordhaus or Stern. The extent of current mitigation prescribed by their approaches is well below what is required to achieve approximately equal ratios of costs to benefits across generations. The danger of treating future generations unjustly is suggested by the outcome of these modeling exercises. This is an important reason to take IE seriously.

27. This objection was pressed forcefully on us by Paul Baer and Lauren Hartzell Nichols.