Rational Discounting for Regulatory Analysis

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This Article examines the economic basis for what is termed "rational discounting," which entails full recognition of policy effects over time and exponential discounting at a riskless rate of return. Policies often cannot be ranked unambiguously in terms of their present or future orientation. Both failure to discount and preferential intergenerational discounting generate inconsistencies and economic anomalies. Office of Management and Budget (OMB) discounting guidelines now stipulate more reasonable discount rates than earlier guidelines, but err in permitting open-ended preferential rates for intergenerational effects. This Article presents a methodology for monetizing the value of statistical life for people of different ages and at different points in time. Review of regulatory analyses indicates increased consistency of discounting practices. However, an examination of two policies with intergenerational effects, stratospheric ozone regulation and nuclear waste storage at Yucca Mountain, reveals failures to adopt a rational discounting approach. The influence of behavioral anomalies such as hyperbolic discounting may make full recognition of intertemporal effects in benefit-cost analysis more consequential than the use of preferential discount rates.

I. INTRODUCTION

Intergenerational discounting should be no different than within-generation discounting. The policy position I will advocate in this Article is that distant benefits and costs should be recognized fully in the policy analysis process, but that they should be weighted based on the same discount rate methodology that is applied to effects on the current generation.

The impetus for a preferential rate may stem in part from the dramatic mathematics of exponential discounting. Let the discount rate be r and policy benefits and costs at time t be weighted by the discount factor $1 / (1 + r)^{t}$.[1] Suppose the value of r is 3 percent. Then benefits a year from now will have a weight of 0.97, benefits two years from now will have a weight of 0.94, and so on. By the time one reaches twenty years in the future, which might well be the latency period for cancer risks from some environmental exposures, the discount factor is 0.55, or benefits and costs are weighted at just over half of their within-period value. Likewise, the discount factor becomes

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1   This formula can be found in a variety of basic texts. See, for example, Howell E. Jackson, et al, *Analytical Methods for Lawyers* 244 n 7 (Foundation Press 2003).

0.23 after fifty years, 0.05 after one hundred years, and 1.45×10^{-13} for effects one thousand years in the future. For the very distant future, all but the most consequential benefits and costs will drop out of the analysis.[2] The discount weight pattern is a straightforward consequence of valuing all policy effects using a consistent discounting approach and need not be a cause for alarm.

Thoughtful commentators who advocate a preferential discount rate for future generations have framed the issue in a manner that creates a bias toward thinking of what lower rate should be applied to effects on future generations.[3] Thus, the question that is posed is whether society should use the same discount rate for all policy benefits and costs, or whether a lower rate should be used in the future. Indeed, the main policy issue in their view is how much lower the discount rate should be for effects on future generations.

Rather than framing the intergenerational discounting question in terms of preferential lower rates, I would like to frame the policy evaluation question in a more fundamental way. Should effects on future generations even be considered in the policy evaluation process? Why not set their values equal to zero? Notwithstanding the possibility of constructing hypothetical social welfare functions in which the welfare of future generations matters, the current generation's policy choice task is much simpler. How do we make choices now to maximize our own discounted well-being? The well-being of future generations may enter our utility functions, or it might not. Some people may care about future generations in an altruistic manner, but perhaps not a great deal. Per capita income levels and living standards have risen over time, and if the past is any guide, future generations will be more affluent and better off economically than we are, just as we have had a higher standard of living than past generations. The current citizenry consequently may feel quite justified in taking a within-generation perspective and might not be too moved by the plight of their more affluent, distant descendants.

The degree to which personal self-interest may have profound consequences for future generations is reflected in the public's attitude toward climate change policies. Efforts to combat global warming through gas taxes will necessarily have a deferred impact on global

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2   See Frank Ackerman and Lisa Heinzerling, *Pricing the Priceless: Cost-Benefit Analysis of Environmental Protection*, 150 U Pa L Rev 1553, 1571 (2002) ("At a discount rate of five percent, for example, the death of a billion people 500 years from now becomes less serious than the death of one person today.").

3   See, for example, Richard L. Revesz, *Environmental Regulation, Cost-Benefit Analysis, and the Discounting of Human Lives*, 99 Colum L Rev 941, 1015–16 (1999) (advocating for intergenerational preferences).

climate change, which is a long-term environmental problem. To what extent will older age groups be willing to pay more for gasoline so that gasoline will be less harmful to the environment? My analysis with Joni Hersch of the Eurobarometer survey data found that concern with this environmental amenity declined steadily with age, which reflects the degree to which there is a strong component of self-interest governing the public's willingness to pay for environmental benefits over time. More specifically, in terms of the additional percent amount that respondents were willing to pay for gasoline, the average response was a high value of 2.8 percent among those age fifteen through thirty-four, 2.3 percent for those thirty-five through forty-four, 2.1 percent for those forty-five through fifty-four, 1.6 percent for those fifty-five through sixty-four, and 1.0 percent for those sixty-five and over.[4] This dramatic dropoff in valuation led the authors to conclude that there is a generational divide in support for environmental policies.[5]

If people are self-interested in the extreme, they might place no value whatsoever on the well-being of future generations. From the standpoint of their policy assessments, concern about what discount rate should be used to value effects on future generations is irrelevant. If the effects are treated as having zero value, the discounting of these consequences does not enter. By including intergenerational effects in our policy evaluation calculus, we have already made perhaps substantial headway toward placing a substantial value on interests subsequent generations have in today's policies.

Matters might of course be quite different if future generations could bribe us to make sacrifices now to advance their interests. But we do not know what their preferences are, and there is no mechanism by which they can transfer resources to us. Legislatures can run budget deficits to shift costs to the future, but these are not targeted to advance specific policies that future generations have selected. Thus, the extreme present-generation approach is to value future-generation effects at zero and to use conventional discounting for current-generation effects.

The reference point I will adopt for my Article does not embody intergenerational preference or intergenerational neglect. Rather, I will assume that we treat effects on future generations in a manner that is consistent with the discounting approach applied to outcomes within our own generation. These future effects will be recognized fully and brought back to present value with no deduction from the

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4   Joni Hersch and W. Kip Viscusi, *The Generational Divide in Support for Environmental Policies: European Evidence*, 77 Climatic Change 121, 125 table 1 (2006).

5   See id at 134.

benefits, even though current populations will not be directly affected. Benefits and costs to future generations will have the same standing as effects on the current generation. This symmetrical treatment already embodies a quite strong degree of altruism toward future generations that might greatly exceed the current citizenry's actual valuation of future generations' welfare. However, just as intergenerational discounting preferences will create anomalies and inconsistencies, it is easy to show that intergenerational discounting neglect will create parallel problems. Using the same discount rate r symmetrically for all policy benefits and costs will be my policy evaluation reference point.

Before considering the appropriate intergenerational policy, I will first examine how discount rates affect the future orientation and the environmental responsiveness of the policy. Each of these matters may be unclear unless sufficient structure is imposed on the policy choice. I then consider anomalies arising from failure to discount, which is perhaps the extreme example of intergenerational preference, and use of preferable discount rates for policies affecting future generations. These discounting practices and those currently in use for regulatory analysis will lead to irrational economic consequences and intertemporal inconsistencies. Finally, I examine the behavioral anomalies that affect people's discounting behavior. Because of the irrationalities of individual discounting, there is likely to be inadequate policy emphasis on efforts with deferred benefits. Thus, the major policy deficiency may be a failure to value policies with long-term effects by the same extent as people would do if they had rational intertemporal preferences.

II. Discounting and Temporal Orientation

A. The Ambiguity of Temporal Orientation

Increasing the discount rate necessarily reduces the discount weight placed on future costs and benefits.[6] Because costs and benefits that occur immediately are not discounted at all, higher discount rates necessarily place a lower relative value on future costs and benefits. Researchers often attempt to characterize policies as being more or less present oriented.[7] However, before getting into discounting issues in great detail, it is worthwhile to explore whether this simple intuition

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[6]   My analysis adopts the benefit-cost criterion for policy choice. But see Tyler Cowen, *Caring About the Distant Future: Why It Matters and What It Means*, 74 U Chi L Rev 5, 27–28 (2006) (offering a different approach for forecasting a discount rate based on growth maximization).

[7]   See, for example, Revesz, 99 Colum L Rev at 946 (cited in note 3).

of present or future orientation is always a useful way to categorize policies.

In many policy choice contexts, a higher rate of discount will generate calculations that are less favorable to judgments of the policy's net attractiveness. Suppose all policy costs occur at the outset, and that all benefits are deferred. Thus, the net policy effects have a negative value initially before turning positive thereafter. Consider the trajectory of net benefits less costs, where net benefits in year t equal the difference in the benefits b_t in year t and costs c_t in year t. The time path of $(b_t - c_t)$ is initially negative as c_t exceeds b_t and then is positive once b_t exceeds c_t. For this simple example, there is one sign reversal in the pattern of net benefits over time. In such situations, increasing the discount rate will decrease the present value of benefits by a greater relative amount than it will decrease costs, which are more immediate.

Within the set of possible policies that begin with negative net benefits followed by periods of positive net benefits, there will be differences in the timing and duration of the positive net benefit period. Policies in which the net benefits are more immediate will be viewed as present oriented, while policies with deferred net benefits might be termed future oriented. This simple characterization of policies is an apt description of very well-behaved trajectories of benefits and costs.

In more complex patterns of costs and benefits, the appealing logic of one policy being more future oriented than another does not hold up. To see how the ambiguity in the ranking of temporal orientation arises, consider the closely related concept of the internal rate of return,[8] which I will call i. The internal rate of return i is the rate of discount at which the present value of the difference between benefits and costs of the policy is zero. For a conventional regulatory policy, one might expect the present value of net benefits to be positive for low rates of discount and negative for high rates of discount that are above the value of i. For these payoff streams, the net payoffs are initially negative and then turn positive, so that there is one sign reversal. Support of a lower discount rate consequently pushes the policy discussion into a region in which the policy is more attractive, as there is no ambiguity in the temporal orientation of the policy.

Matters become more complicated in situations in which there is more than one sign reversal in the time problem of net benefits. In these instances, there can be multiple values of i that generate a zero present value.[9] The number of such values of i cannot be greater than

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8   See Jackson, et al, *Analytical Methods for Lawyers* at 247 (cited in note 1).
9   See Paul A. Samuelson, *Some Aspects of the Pure Theory of Capital*, 51 Q J Econ 469, 487 (1937). See also Paul A. Samuelson, *A Summing Up*, 80 Q J Econ 568, 571–73 (1966) (explaining why reswitching occurs).

the number of sign reversals in the payoff stream. As a consequence, for the simple payoff stream that begins with negative net benefits followed by positive net benefits, there is only one internal rate of return. With more than one sign reversal in the payoff stream, there can be multiple internal rates of return. The phenomenon of multiple internal rates of return is known as "reswitching." In such instances, there may be no simple way to assess the present orientation of the policy. Similarly, if one compares the difference in benefits and costs of two policies, there may well be multiple sign reversals in those differences. Thus, it may not be possible to employ a simple policy choice rule such as choosing policy A at low discount rates or choosing policy B at high discount rates.

The reswitching phenomenon may be particularly important in environmental contexts. In an early paper, Richard Zeckhauser and I showed that the presence of irreversibilities, which are endemic to environmental decisions, may induce situations of reswitching: policy B is preferred to policy A at low values of r and high values of r but not at intermediate values.[10] The presence of uncertainty of a possible environmental irreversibility, which is also a common characteristic of environmental choices, also may induce such reswitching.[11] Ranking policies in terms of the degree to which they are present oriented or future oriented consequently may not be a straightforward exercise, as it is complicated by the influence of crossing payoff streams, the effect of irreversibilities, and the role of uncertainty.[12] A preferable approach is to select the discount rate that is appropriate and determine which policies generate the greatest present value of the spread between benefits and costs.

As a result, there will be two principal features of my treatment of appropriate discounting policies. First, the focus will be on the choice of the appropriate discount rate irrespective of whether doing so should be characterized as being more present oriented or more future oriented. Second, before characterizing policies as being more or less future oriented, it is essential that the time pattern of payoffs meets the requisite criteria for such simple designations. When benefit and cost streams are complex, there may be no unambiguous ranking of policies in terms of their temporal emphasis.

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[10]   See W. Kip Viscusi and Richard Zeckhauser, *Environmental Policy Choice under Uncertainty*, 3 J Envir Econ & Mgmt 97, 103 n 12 (1976).

[11]   Id at 105–08.

[12]   See Dexter Samida and David A. Weisbach, *Paretian Intergenerational Discounting*, 74 U Chi L Rev 145, 168–69 (2006) (stating that irreversibilities are best handled by using real option theory).

B. Are Low Discount Rates Pro-Environment?

Whether a low or high discount rate is pro-environment is also not well-defined in general. Even if it is clear that a policy is more future oriented, that temporal orientation does not imply that the policy is more pro-environment. Current destruction of natural wilderness areas to provide longer-term timber production or oil and natural gas reserves will impose environmental costs now and in the future, with deferred intermediate financial gains. If there are negative net benefits in the near term, positive net benefits in the intermediate term, and negative net benefits in the distant future, such a pattern of costs and benefits fits the reswitching profile, with possibly two internal rates of return and no unambiguous temporal ranking.

Even with more well-behaved benefit and cost trajectories, a higher discount rate may be the pro-environment approach. My involvement with environmental issues began with a critique of the dam building operations by the Department of Interior's Bureau of Reclamation.[13] That agency, which is the Western counterpart of the Army Corps of Engineers, has built dams that are engineering marvels, such as the Hoover Dam. However, even after most of the good sites for dams had been used up, the agency continued to construct new dams and sought to build dams in the Grand Canyon.[14] Less catastrophic but actual environmental harms have resulted from dams that the Bureau has built, including the flooding of scenic areas, fish kills, and salinity problems.[15] The agency did not monetize these environmental effects, so that there was no environmental discounting issue to consider.

Dams are highly capital-intensive projects. As the rate of discount is increased, the present value of the benefits is reduced, while the costs are not much affected. As a result, the agency historically showed a preference for using low discount rates, such as 2.5 percent.[16] Because a higher discount rate would make its policies appear less attractive from a benefit-cost standpoint, the agency resisted efforts to bring the discount rate in line with rates recommended by the Office of Management and Budget (OMB).[17] Recommendations that a higher discount rate be used would lead fewer projects to pass a benefit-cost test, which in this instance would mean less environmental harm. Thus,

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[13] See generally Richard L. Berkman and W. Kip Viscusi, *Damming the West: Ralph Nader's Study Group Report on the Bureau of Reclamation* (Grossman 1973).

[14] Id at 75–76, 117–18 (using the Grand Canyon facts as an example in which accounting for ecological impacts would have ensured a more rational project evaluation).

[15] Id at 29–77.

[16] See id at 229 table 4-A (listing the discount rates used in reclamation feasibility studies during 1959–1971).

[17] Id at 88–89 (describing OMB's efforts to encourage agencies to use a higher discount rate).

for these public works projects with adverse environmental effects, use of a higher discount rate was a mechanism for deterring these efforts.[18] Advocacy of a higher discount rate was the pro-environment policy position.

A quite interesting intertemporal tradeoff arose with respect to the 1992 Food and Drug Administration (FDA) approval of the drug Taxol, which is used to treat ovarian cancer.[19] This drug, which was manufactured from the Pacific yew tree, would lead to the saving of lives in the near term. However, cutting down the trees now will lead to depletion of the stock of Pacific yew trees and long-term environmental harm. Is the more responsible risk-reducing policy the one that saves lives or trees, and if it is trees, what discount rate should be used to assess the future value of the trees? Fortunately, the availability of hybrid yews and semisynthetic Taxol diminished the controversy, but the fundamental point remains: often ranking policies that have environmental effects over time in terms of the degree to which they reduce risk or are pro-environment is not a simple matter, in this case because of competing risk concerns across time.

III. Discounting Anomalies

A. Problems with Failures to Discount[20]

If policy effects are not discounted, several anomalies arise,[21] and it is worthwhile to review them here. I will focus on four anomalies to give a sense of the fundamental problems that will be encountered. Subtler inconsistencies, such as those that I discuss with respect to intergenerational discounting, also may arise.

The first problem is what I have called the "permanent cost slam dunk."[22] Suppose that a development policy will lead to the permanent loss of some very inconsequential environmental amenity that has a value of $1 in each period. With that loss extended for an infinite time horizon, the present value of the environmental harm is infinite. No policy criterion with a finite payoff can ever offer great enough benefits to offset this infinite loss. In contrast, with discounting, the infinite

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18 Id at 89.

19 See W. Kip Viscusi, *Discounting Health Effects for Medical Decisions*, in Frank A. Sloan, ed, *Valuing Health Care: Costs, Benefits, and Effectiveness for Pharmaceuticals and Other Medical Technologies* 125, 126–28 (Cambridge 1995) (describing the debate surrounding Taxol's approval).

20 See Samida and Weisbach, 74 U Chi L Rev at 145–46 (cited in note 12) (arguing that discounting is required despite its problems).

21 See Viscusi, *Discounting Health Effects for Medical Decisions* at 134–36 (cited in note 19).

22 Id at 136.

stream of $1 losses has a present value of only $1/r$, or $33 with a 3 percent discount rate.[23]

The second problem with zero discount rates is that it is always desirable to defer policies if that same policy opportunity will be available in the future. Let Policy A save thirty-three statistical lives this year at a cost of $100 million, so that it costs just over $3 million to save a statistical life. Let Policy B take effect one year later. It too could save thirty-three statistical lives at a cost of $100 million. However, if we take our $100 million today and invest it at the rate of 3 percent, then we will have $103 million to spend on saving lives next year. At a cost per life saved of $3 million, we can now save thirty-four lives if we wait till next year. Whether our policy criterion is a benefit-cost test or simply saving lives, waiting is always the superior choice when there is no discounting and there is a positive interest rate.

Third, if there are technological changes that will make future policies more effective in saving lives, as with improved pollution control technologies for cars, waiting is always superior. Suppose Policy A saves thirty-three lives this year for $100 million, but Policy C entails expenditure of $100 million next year and will save thirty-four lives in one hundred years. Even without investing the $100 million to boost it to $103 million in year two, Policy C will dominate, despite having to wait a century for the life-saving benefits.

Fourth, benefits from any given policy action will rise as well. A positive income elasticity of demand for risk-reducing policies of various kinds will by definition lead to a higher willingness to pay for these same policy outcomes in the future. If benefit values grow at some finite growth rate g, then the unit benefit value in t years will be $(1 + g)^t$. As t goes to infinity, these unit benefit values likewise become infinite. As long as there is any positive annual growth rate in benefits, however small, the benefit value becomes infinite if there is no discounting.

Serious economic discussions do not suggest that zero discount rates are appropriate; however, particularly in policy contexts, there might be suggestions that we do not discount lifesaving benefits or effects on future generations. The anomalies that arise from not discounting are quite general. There are no special case exemptions from a rational discounting approach.

B.   The Problematic Mathematics of Intergenerational Discounting

Most discussions of the consequences of discounting for the environment focus on long-term policies, often including discounting of

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[23]   See Jackson, et al, *Analytical Methods for Lawyers* at 246 n 8 (cited in note 1) (providing a formula for valuing an infinite stream of payoffs).

effects on future generations. A higher discount rate necessarily gives effects on future generations a lower weight. In a paradigmatic case of benefits from activities now and in the near term with environmental damage being imposed on future generations, there will be no sign reversals of the environmental cost trajectory. A lower discount rate always enhances the weight placed on future-generation effects. Whether a preferential discount rate is desirable in such contexts is a quite different matter.

While it is seemingly simple to suggest that one might use a lower discount rate for policy benefits and costs for future generations, the possible policy consequences of doing so are problematic. At a more basic level, it is not even clear what might be meant operationally by using a lower rate of time preference for future generations. As the exploration of the various possibilities below will illustrate, none of the seemingly plausible interpretations of time-inconsistent discounting leads to reasonable behavior. For concreteness, I will assume that the appropriate discount rate for current-generation effects is r and that the opportunity cost of capital does not change over time.[24] Also, let the current generation live for fifty years. The timing of the arrival of these "future generations" and the duration of a generation is not well specified by advocates of the intergenerational preference approach. Are we talking about fifty years, one hundred years, one thousand years? I will leave aside this ambiguity and assume that the switch to future generations is well defined. For simplicity, I have assumed that there is only one future generation, but the discussion can easily be generalized to multiple future generations.

Appendix 1 summarizes four primary categories of different discounting possibilities. The first row designates policies that only have effects on the current generation. For these policies with benefits b_t and costs c_t in year t, the discount rate is r, as under current policy analysis practices. Then the present value of the policy is

$$\sum_{t=0}^{50}(b_t - c_t)/(1+r)^t . \qquad (1)$$

The second row of Appendix 1 pertains to policy decisions that future generations will make at the time when the future generation begins. As with current policy guidelines, these future generations will be making within-generation choices by discounting both benefits and costs at a rate r. For simplicity, let the future generation's time horizon be infinite, so that there are only two generations in the model. From

24 See Geoffrey Heal, *Discounting: A Review of the Basic Economics*, 74 U Chi L Rev 59, 64–65 (2006) (reviewing the conditions under which the utility discount rate is equal to the consumption discount rate).

their within-generation perspective, the future generation will place a value on policies given by

$$\sum_{t=0}^{\infty} (b_t - c_t)\big/(1+r)^t. \tag{2}$$

The first row of Appendix 1 pertains to the discounting practices of the current generation consistent with Equation (1), while the second row shows the future generation's counterpart decisions following the same standard discounting principles. Both the first and second rows of Appendix 1 are consistent with conventional discounting practices. Similarly, if one were to evaluate policies affecting both current and future generations using standard discounting practices, one would use a discount rate r for both periods.

The third policy row in Appendix 1 consists of policy decisions by the current generation that affect future generations. Under this approach, there is discounting of all effects on the current generation by a discount rate r, but future-generation effects receive a preferential discount rate $r' < r$. This approach provides for a policy preference for consequences affecting future generations.

Two variants of this future preference must be distinguished. The first variant is case 3*i* in Appendix 1, which has a preferential discount rate for effects starting when the future generation begins, which in my example is year fifty-one, but this shift in discount rates does not affect the within-generational values. The assumption that $r' < r$ will apply in year fifty-one in the future is of course quite arbitrary.

Thus, the policy criterion is

$$\sum_{t=0}^{50} (b_t - c_t)\big/(1+r)^t + \frac{1}{(1+r')^{51}} \sum_{t=0}^{\infty} (b_t - c_t)\big/(1+r)^t. \tag{3}$$

This approach creates undesirable effects at the year in which the current generation ends and the next generation begins. The policy effects at the last year of the current generation may have a value $(b_{50} - c_{50}) / (1 + r)^{50}$, whereas the first year of the next generation will have effects with a value $(b_{51} - c_{51}) / (1 + r')^{51}$. So if the value of $(b_{50} - c_{50})$ equals $(b_{51} - c_{51})$, then the policy effects in year fifty-one will have a greater present value than the effects in year fifty. Much of the same reasoning applies to other future-generation effects. This approach disadvantages distant members of the current generation relative to the future generation. The attractive feature of this approach is that the policy effects that occur within the future generation are being valued in the same way that future generations themselves would value these effects.

Policy 3*ii* also begins at preferential discount rate r' for the future generation and continues to use that rate thereafter. This policy criterion is

$$\sum_{t=0}^{50}(b_t - c_t)\big/(1+r)^t + \frac{1}{(1+r')^{51}}\sum_{t=0}^{\infty}(b_t - c_t)\big/(1+r')^t. \qquad (4)$$

The formulation in policy 3*ii* introduces a new problem not shared by policy 3*i*: the effects within the future generation are valued at a discount rate r', which is inconsistent with the future generation's own rate of time preference r.

   The final row in Appendix 1 illustrates what advocates of the preferential discount rate approach for future generations more typically have in mind and which is embodied in the policy practices discussed below. If a policy has consequences for the current generation and future generations, then all policy benefits and costs are discounted at a preferential rate r', leading to the criterion applied at the initial period given by

$$\sum_{t=0}^{\infty}(b_t - c_t)\big/(1+r')^t. \qquad (5)$$

   This approach does not create the across-generational inconsistencies as with the third discounting policy. However, it does create problems within generations. Suppose the policy has modest effects on future generations and that the preponderance of the benefits are to the current generation. Then the preferential discount rate r' may make the present value of the policy with future-generational effects greater than that of superior current policies valued using rate r. Similarly, suppose that all policy effects are to future generations and are discounted at a rate r'. Then the policy ranking obtained using policy 4 with discount rate r' may be quite different than what the future generations themselves would have chosen based on policy approach 2 using the rate r that is appropriate for their own decisions. Thus, use of the preferential rate r' in effect overrides the preferences that the future generation itself would have with respect to different time streams of benefits and costs.

   Problems also arise if we generalize these concerns to the very long term. There is also not just one future generation. If the next future generation gets a preferential discount rate of $r' < r$, should we not also give the subsequent future generation a preferential rate of $r'' < r'$? And so on. For much that same reason that $r' < r$ will create anomalous results for the current generation versus the next future generation, this approach of $r'' < r' < r$ will likewise create anomalous results for the next future generation compared to the subsequent future generation.

IV. OMB DISCOUNT RATE GUIDELINES

The guidelines for discounting issued by the OMB quite properly have emphasized the fundamental economic determinants of discounting. Although for decades economists have generated elegant models for proper discounting practices, such as explorations of the social rate of discount,[25] the dominant approach has been the private opportunity cost of capital.[26] Nevertheless, as I indicate below, the OMB has begun to show some ill-advised and ill-defined flexibility with respect to intergenerational effects.

The OMB has articulated the main principles for discounting policy effects. OMB Circular A-94 provides general guidance for the basic mechanics of discounting.[27] Although the OMB discount rate had long been set at 10 percent, this 1992 document issued the following requirement and OMB's justification for why the rate is reasonable: "Constant-dollar benefit-cost analyses of proposed investments and regulations should report net present value and other outcomes determined using a real discount rate of 7 percent. This rate approximates the marginal pretax rate of return on an average investment in the private sector in recent years."[28]

Although the OMB did not document the justification for the 7 percent rate, it appears to have been too high a rate even in 1992. If in fact the real, inflation-adjusted rate of return was 7 percent, it was presumably because analyses justifying that rate included investments that yielded a premium for risk. Such risk premiums should not be included, as returns for the riskiness of an asset are not a reflection of the intertemporal rate of tradeoff per se.

The discount rate I advocate is the riskless rate of return.[29] Doing so does not imply that uncertainty is irrelevant. Suppose that the benefits of a government policy are highly uncertain, as for example in the case of levees to protect New Orleans from floods due to future hurricanes. Proper analysis of program benefits based on the willingness of beneficiaries to pay for the uncertain benefits will reflect a risk premium for these uncertain benefits, which can then be discounted

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[25] See, for example, Stephen A. Marglin, *The Social Rate of Discount and the Optimal Rate of Investment*, 77 Q J Econ 95, 110 (1963) (suggesting a method for determining the social rate of discount by relating the rate of economic growth to the marginal rate of social time preference).

[26] See Heal, 74 U Chi L Rev at 61–62, 77 (cited in note 24) (reviewing various approaches to discounting).

[27] See generally Office of Management and Budget, Circular A-94, *Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs* 8 (1992), available at 57 Fed Reg 53519 (1992).

[28] Id at 53522–23.

[29] See Kenneth J. Arrow and Robert C. Lind, *Uncertainty and the Evaluation of Public Investment Decisions*, 60 Am Econ Rev 364, 377–78 (1970) (showing that publicly-borne costs should be discounted at a riskless rate).

using a riskless rate. While some observers have advocated using a discount rate that incorporates uncertainty,[30] doing so necessarily imposes the mathematical structure of the discounting process that may not track the effect of uncertainty over time. In general, there is no reason to assume that the risk premiums associated with regulatory benefit trajectories have the same mathematical structure as would emerge from the exponential discounting function.

A good measure of the riskless rate of return is the government bond rate. The 1992 three-month Treasury bill rate was 3.45 percent,[31] which is just above the inflation rate in 1992 of 3.0 percent.[32] The ten-year Treasury security interest rate was 7.01 percent, which is just 4 percent higher than the inflation rate.[33] Moreover, returns on longer-term bond issues for durations such as ten years will include a premium for possible increases in inflation as well as a liquidity premium to compensate investors for having their funds tied up for that long period. Regardless of what government bond reference point we use, OMB Circular A-94's 7 percent rate is too high.

In 2003, the OMB revised the guidance in its OMB Circular A-4.[34] The calculations provided by the OMB to justify its policy used average performance of ten-year Treasury notes and the rate of change in the Consumer Price Index (CPI). Subtracting the CPI increase from the bond rate yielded a real rate of return of 3.1 percent.[35] Why the OMB did not report a similar calculation in 1992 to justify the 7 percent rate is never explained. Despite providing the 2003 analysis in support of a 3 percent rate, the OMB concluded that agencies should use the earlier 7 percent rate as well as the 3 percent rate of discount.[36] In particular, OMB regarded the 3.1 percent rate as the social rate of time preference for projects that reallocate from consumption, with a 7 percent rate used otherwise. As a practical matter, most agencies perform regulatory impact analyses using both rates.

What useful purpose might be served by continuing to perform analyses using the inappropriate 7 percent rate? Using that rate may

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[30] See, for example, Louis Kaplow, *Discounting Dollars, Discounting Lives: Intergenerational Distributive Justice and Efficiency*, 74 U Chi L Rev 79, 106–07 (2006) (considering how the uncertainty in various factors affects the intergenerational efficiency analysis).

[31] Council of Economic Advisors, *Economic Report of the President* 296 (2005), online at http://www.gpoaccess.gov/eop/2005/2005_erp.pdf (visited Jan 22, 2007).

[32] Id at 283.

[33] Id at 296.

[34] Office of Management and Budget, Circular A-4, *Regulatory Analysis* (2003), online at http://www.whitehouse.gov/omb/circulars/a004/a-4.pdf (visited Jan 22, 2007).

[35] Id at 33–34.

[36] Id at 34 ("For regulatory analysis, you should provide estimates of net benefits using both 3 percent and 7 percent.").

enable policymakers to compare the efficacy of proposed new policies with earlier policies that were evaluated using the 7 percent discount rate. However, presumably past policy decisions have been completed and should be regarded as fixed costs. Should tradeoffs between current and past policies ever arise, the analysis should be done at a more meaningful 3 percent rate applied to all policies being considered.

A second possible function of the 7 percent rate may be strategic. That higher rate typically will reduce benefits compared to costs and consequently frame the policy debate in a manner that enables the OMB to impose more discipline on spending and regulations.

A third possibility is that the OMB is subject to a behavioral irrationality. Continued reference to a 7 percent rate may simply reflect an anchoring bias reflecting the earlier discount rate mindset. Historically, the OMB has used excessively high discount rates, so the movement to the pair of discount rates at 3 percent and 7 percent reflects a partial adjustment toward a rate that bears a plausible relationship to the real rate of return on capital.

The official OMB guidance regarding intergenerational discounting has evolved over time. The 1992 budget Circular A-94 does not make any explicit provision for intergenerational concerns. The 2003 Circular A-4 notes that inconsistencies may arise from using a preferential rate for intergenerational discounting, but nevertheless concludes by giving agencies leeway with respect to such discounting: "If your rule will have important intergenerational benefits or costs you might consider a further sensitivity analysis using a lower but positive discount rate in addition to calculating net benefits using discount rates of 3 and 7 percent."[37] In this single sentence, the OMB apparently has given carte blanche to a broad range of economically irrational discounting practices.

What form such a departure from standard discounting norms should take is not specified, nor does the OMB specify the extent of such a departure. Should all agencies use the same preferential discount rate for all effects on future generations? Does the timing of the effects influence the acceptable discount rate? None of these issues is resolved by the OMB guidelines. What is clear is that the OMB has given agencies the leeway to adopt the discounting policy approach 4 from Appendix 1, with all the attendant problems that deviation creates.

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37   Id at 36.

V. DISCOUNT RATE PERFORMANCE BY REGULATORY AGENCIES

While the OMB guidelines are clear, an interesting policy question is the extent to which agencies adhere to these guidelines and apply consistent discounting practices. Some agencies might use a very high rate to emphasize the importance of immediate payoffs and to decrease the salience of adverse distant policy effects, whereas other agencies might use a low rate to decrease the relative weight placed on immediate costs.

Less than a decade ago, an inventory of discounting practices found that there were wide disparities in the discount rates federal agencies used, notwithstanding official OMB guidance.[38] In light of the quite strong and explicit directive that the OMB now provides, do agencies continue to display widely varying choices in the rates of discount they select?

The set of regulations I chose in order to make this comparison was the list of all regulations from Table 1-4 of the OMB's Draft 2005 Report to Congress on the Costs and Benefits of Federal Regulation.[39] Thus, rather than selecting a few regulations at random, this assessment considers every regulation the OMB reported to Congress in 2005.

The results of this review appear in Appendix 2. The first column lists the rule, the second column lists its status, and the second-to-last column lists the discount rate used. Notably, the OMB guidance of 3 percent and 7 percent discount rates seems to have taken hold. Seven of the regulations are evaluated using both rates.

In some instances, the regulatory agency expresses a rationale for its choice or a preference between the two rates. For example, the interim final rule for Medicare Prescription Drug Discount Card cites OMB Circular A-4 and indicates a preference for the 3 percent rate: "The Office of Management and Budget has indicated that a 3 percent discount rate better approximates the individual rate of time preference."[40]

The next set of four regulations in Appendix 2 all used a 7 percent discount rate. Each of these regulations was a final rule, so there was continuing use of the earlier 7 percent rate that presumably had been adopted in analyses at earlier stages of the policy process. In

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[38] See Edward R. Morrison, Comment, *Judicial Review of Discount Rates Used in Regulatory Cost-Benefit Analysis*, 65 U Chi L Rev 1333, 1336 (1998) ("Agencies exhibit striking inconsistencies in their use of discount rates.").

[39] Office of Management and Budget, *Draft 2005 Report to Congress on the Costs and Benefits of Federal Regulations* 12–22 (2005), online at http://www.whitehouse.gov/OMB/inforeg/2005_cb/draft_2005_cb_report.pdf (visited Jan 22, 2007).

[40] Department of Health and Human Services Centers for Medicare and Medicaid Services (HHS–CMS), Medicare Program: Medicare Prescription Drug Discount Card, 68 Fed Reg 69840, 69913 (2003).

these instances, the agency presumably simply chose not to redo the earlier analysis once the policy review by the OMB was completed. It is, however, notable that the 7 percent rate does conform with the OMB Budget Circular A-94.

The next regulation did not indicate an explicit discount rate, but the Environmental Protection Agency (EPA) did use a discounting approach in its analysis. More specifically, EPA's discussion of Effluent Limitations Guidelines and New Source Performance Standards for the Meat and Poultry Products Point Source Category noted that there was use of a discount rate for costs and benefits, though the specific rates are not indicated.[41]

The final nineteen regulations in Appendix 2 did not include any discussion of discounting. This absence can be explained in four possible ways. First, the agency might claim that the regulation was issued to address an emergency situation, such as mad cow disease. Indeed, that claim was made for both USDA meat regulations: "The emergency situation surrounding this rulemaking makes timely compliance with Executive Order 12866 and the Regulatory Flexibility Act (5 U.S.C. 601 et seq.) impracticable."[42] Second, an analysis using discounting may have been undertaken, but the discount rates were not reported in the final rule, as with the EPA's National Emission Standards for Hazardous Air Pollutants for Stationary Reciprocating Internal Combustion Engines[43] and the EPA's National Emission Standards for Hazardous Air Pollutants: Surface Coating of Automobile and Light-Duty Trucks.[44] Indeed, most of the regulations in which discount rates are not reported are final rules, so that any analysis that was done presumably was an earlier stage. Third, in some contexts there may be no discount rate indicated because benefits and costs are annual events, so that if the regulation is worthwhile in any given year, it is desirable in

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[41] In particular, the EPA noted that "[its] closure analysis is a discounted cash flow analysis that compares the costs during a 16-year period from 2005 to 2020 to the earnings accumulated during that same period. This analysis discounts both costs and earnings with the facility-specific discount rate reported in the detailed questionnaire." EPA, Effluent Limitations Guidelines and New Source Performance Standards for the Meat and Poultry Products Point Source Category, 69 Fed Reg 54476, 54511 (2004).

[42] USDA Food and Safety Inspection Service (USDA–FSIS), Prohibition of the Use of Specified Risk Materials for Human Food and Requirements for the Disposition of Non-Ambulatory Disabled Cattle, 69 Fed Reg 1862, 1871 (2004); USDA Food Safety and Inspection Service, Meat Produced by Advanced Meat/Bone Separation Machinery and Meat Recovery (AMR) Systems, 69 Fed Reg 1874, 1883 (2004).

[43] Environmental Protection Agency, National Emission Standards for Hazardous Air Pollutants for Stationary Reciprocating Internal Combustion Engines, 69 Fed Reg 33474, 33498 (2004).

[44] Environmental Protection Agency, National Emission Standards for Hazardous Air Pollutants: Surface Coating of Automobiles and Light-Duty Trucks, 69 Fed Reg 22602, 22619 (2004).

all years.[45] Fourth, the agency may not have employed discounting because it was too difficult to accurately quantify costs or benefits.[46]

VI. DISCOUNTING AND THE VALUE OF STATISTICAL LIFE

A primary component of these regulations is the reduction of risks to life and to health. Using discounting in this context has been a prominent concern in the literature and may at first glance appear to be indefensible.[47] Are we not in effect saying that lives saved today are worth more than those saved in the future? And with very long-term effects on human life, are we not devaluing entire future generations' lives?

To clarify the issues at stake and to get our thinking straight, it is useful to examine the different contexts in which discounting enters in the valuation of morbidity risk reductions. Discounting takes on several different roles with respect to the valuation of regulatory efforts that reduce mortality risks. To clarify these different implications and functions of discounting, I examine discounting in three scenarios: i) discounting for the value of statistical life (VSL) for people of different ages at a point in time; ii) discounting the VSL for a person alive now and for that same person at some future time; and iii) discounting the VSL in the future for someone not already alive. Many of these scenarios have arisen in previous treatments, and it is useful to clarify how I would address each of them.[48]

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[45] See, for example, Department of Labor Wage and Hour Division, Employment Standards Administration (DOL–ESA), Defining and Delimiting the Exemptions for Executive, Administrative, Professional, Outside Sales and Computer Employees, 69 Fed Reg 22122, 22234 (2004) (listing costs to state and local governments in terms of annual expenditures).

[46] See, for example, Department of Transportation, Office of the Secretary, Computer Reservations System (CRS) Regulations, 69 Fed Reg 976, 1026 (2004) ("The analysis relied on a qualitative assessment of the costs and benefits of the proposed rules, because we did not have information of the kind and detail necessary for a quantification of those benefits and costs.").

[47] The role of discounting of human lives is a central theme in Revesz, 99 Colum L Rev 941 (cited in note 3). For further discussion, see generally, John A. Cairns and Marjon M. van der Pol, *Saving Future Lives: A Comparison of Three Discounting Models*, 6 Health Econ 341 (1997); Magnus Johannesson and Per-Olov Johansson, *Saving Lives in the Present versus Saving Lives in the Future—Is There a Framing Effect?*, 15 J Risk & Uncertainty 167 (1997); Maureen L. Cropper, Sema K. Aydede, and Paul R. Portney, *Preferences for Life Saving Programs: How the Public Discounts Time and Age*, 8 J Risk & Uncertainty 243 (1994); Maureen L. Cropper, Sema K. Aydede, and Paul R. Portney, *Rates of Time Preference for Saving Lives*, 82 Am Econ Rev 469 (1992); Maureen L. Cropper and Paul R. Portney, *Discounting and the Evaluation of Lifesaving Programs*, 3 J Risk & Uncertainty 369 (1990); Maureen L. Cropper and Frances G. Sussman, *Valuing Future Risks to Life*, 19 J Envir Econ & Mgmt 160 (1990); John K. Horowitz and Richard T. Carson, *Discounting Statistical Lives*, 3 J Risk & Uncertainty 403 (1990); Clifford S. Russell, "*Discounting Human Life" (Or, the Anatomy of a Moral-Economic Issue)*, 82 Resources for the Future 8 (1986).

[48] The most prominent treatment in the legal literature of scenarios such as these appears in Revesz, 99 Colum L Rev at 958 (cited in note 3).

Consider first the appropriate VSLs for people of different ages alive today. In particular, should we take a different approach to the VSL for someone age thirty at time 0, which I denote by VSL (30,0), versus a sixty-year-old at the current time, which I denote by VSL (60,0)? This simple starting point enables us to separate the life expectancy differences by age from the timing effects.

There are two possible economic approaches to answering this question, one of which I believe is correct. First, one could undertake a form of quantity adjustment for the VSL. Older people have shorter remaining life expectancies, so that mortality-reducing efforts are purchasing less of a quantity of life extension. Let the VSL be the sum of a series of annual value of statistical life year (VSLY) components, so that each year is equally valued apart from the influence of discounting. Although a coauthor and I introduced the quantity-adjusted value of life concept that is mathematically equivalent to VSLY, we never showed theoretically or empirically that each year of life has a constant value.[49] Rather, that formulation was an untested assumption of the model. After some manipulation, it can be shown that for life expectancy *L*,

$$\text{VSL} = \frac{\text{VSLY}}{r} - \frac{1}{(1+r)^L}\left[\frac{\text{VSLY}}{r}\right].^{[50]}$$

To implement this formula, one can take the VSL implied by wage-fatality-risk tradeoffs for the average worker and calculate the constant annual VSLY implied by the VSL estimates. Assuming individuals of all age groups have the same VSLY, which may even appear generous to older individuals given age-related declines in health status, one can calculate for the person at age sixty the VSL associated with the discounted stream of annual VSLY values that remain. In effect, all VSL amounts are simply the present value of the stream of VSLY levels, so that the VSL calculated using this approach always declines with age.

In a series of papers, my coauthors and I estimated rates of time preference with respect to years of life as revealed by decisions in the labor market and product market. These analyses shared a common approach. Each year of life was assumed to have the same value, and the rate of discount was assumed to be the same for all workers. Thus,

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[49]   See Michael J. Moore and W. Kip Viscusi, *The Quantity-Adjusted Value of Life*, 26 Econ Inquiry 369, 386 (1988) (analyzing data to show workers' implicit discount rate when making employment decisions and the implicit value per year of life).

[50]   Joseph E. Aldy and W. Kip Viscusi, *Age Variations in Workers' Value of Statistical Life* 23 (National Bureau of Economic Research Working Paper 10199, 2003), online at http://papers.nber.org/papers/w10199.pdf (visited Jan 22, 2007) (calculating VSLs based on age-specific years of life expectancy).

the focus was on averages across the population rather than the possible heterogeneity of these values for people of different ages.

Four of these studies dealt with labor market decisions involving fatality risks. The first of these studies found that workers discounted years of life at a rate of 10–12 percent, implying a value per year of life of $170,000 in 1986 prices.[51] A second article used a much more elaborate econometric model and found a rate of time preference with respect to future years of life of 11 percent.[52] Subsequent labor market studies using a variety of other econometric approaches yielded implicit rates of discount of 2 percent[53] and a range from 1 percent to 14 percent.[54]

My product market estimates of implicit rates of time preference were quite similar to the labor market results. The discount rate implied by auto safety choices involving used car preferences yielded discount rate estimates for fatality risks from 11 to 17 percent.[55]

There are a number of conclusions and cautionary observations that emerge from this set of studies. First, at least at some point the quantity of life at risk does matter. Otherwise, the estimated discount rate would be infinite. Second, the estimated rates of time preference across these studies vary from 1 percent to 14 percent, which is at least a plausible range given observed market rates of interest. Third, even if we accept these results at face value, they imply that the value of a statistical life does not plummet with age. Consider a discount rate of 7 percent, which is at the midpoint of the estimated discount rate range. A person with an infinite lifespan would lose (1/0.07) VSLY, or 14.3 VSLY. If there were only ten years of remaining life expectancy, there would be a loss of 7.0 VSLY, or almost half the value with an infinite lifespan.[56] Losing one year of life is worth 1/14 of a VSL. From the standpoint of individual preferences, short remaining lifespans are worth a great deal—much more than the proportion of life at risk.

Several caveats are also in order. The results of these studies do not imply that each life year has some VSLY value that is constant and that the VSL is the present value of these individual year amounts. Each of these features is an assumption of the models, not an empiri-

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[51]	See Moore and Viscusi, 26 Econ Inquiry at 386 (cited in note 49).

[52]	See W. Kip Viscusi and Michael J. Moore, *Rates of Time Preference and Valuations of the Duration of Life*, 38 J Pub Econ 297, 316 (1989).

[53]	See Michael J. Moore and W. Kip Viscusi, *Discounting Environmental Health Risks: New Evidence and Policy Implications*, 18 J Envir Econ & Mgmt S-51, S-61 (1990).

[54]	Michael J. Moore and W. Kip Viscusi, *Models for Estimating Discount Rates for Long-Term Health Risks Using Labor Market Data*, 3 J Risk & Uncertainty 381, 389 table 1 (1990).

[55]	Mark K. Dreyfus and W. Kip Viscusi, *Rates of Time Preference and Consumer Valuations of Automobile Safety and Fuel Efficiency*, 38 J L & Econ 79, 79 (1995).

[56]	For comparability with the infinite time horizon formula, I valued the first year of life at the end of the period, or 1/1.07.

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cal result. Second, the findings of these studies and similar investigations should be treated with caution because they did not allow for variations in risk levels with age. Moreover, the nature of the time variations that were permitted imposed considerable structure on the possible results. More recent studies, discussed below, recognize time variations in risk and permit VSL to vary across the life cycle. These new studies permit the VSL to rise and fall with age, whereas early studies required that VSL decline with age.

In ongoing research, I have taken advantage of the capabilities offered by more refined fatality-risk data and have written with coauthors a series of papers on age variations in the VSL.[57] Although the VSL displays an inverted-U-shaped relationship with respect to age, the curve is fairly flat. As a result, the VSL (60,0) exceeds the VSL (20,0). Going back to first principles, the VSL is simply the individual's wage-risk tradeoff. A person's reluctance to incur risks may be quite substantial even as life expectancy shortens, in part because of increases in wealth over time. As a result, the appropriate way to value VSL (60,0) compared to VSL (30,0) is to use the explicit VSL amounts pertinent to these age groups rather than to construct a VSL based on a discounted stream of VSLY values derived from VSL (30,0). Doing so takes the influence of discounting out of this VSL calculation.

The second discounting VSL situation involves assessing the VSL of the person who is now thirty years old thirty years from now, which is a situation that might arise when dealing with risks for which there is a substantial latency period or a delay before a policy is enacted.[58] The first component of this benefit value is the VSL for a similar sixty-year-old person at the current time, or VSL (60,0). The next step is to bring this amount back to present value, leading to VSL $(60,0)/(1 + r)^{30}$. Third, if income levels are expected to grow over time, given the positive income elasticity of VSL of about 0.5 to 0.6,[59] the VSL will grow at some positive growth rate g. Thus, the appropriate VSL (60,30) value for this situation is VSL $(60,0)(1 + g)^{30}/(1 + r)^{30}$, which is approximately

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[57]   See generally Joseph E. Aldy and W. Kip Viscusi, *Adjusting the Value of a Statistical Life for Age and Cohort Effects* (Resources for the Future Discussion Paper, 2006), online at http://www.rff.org/Documents/RFF-DP-06-19.pdf (visited Jan 22, 2007) (using an age-dependent fatal risk measure to estimate age-specific hedonic wage regression); Thomas J. Kniesner, W. Kip Viscusi, and James P. Ziliak, *Life-Cycle Consumption and the Age-Adjusted Value of Life*, 5 Contributions Econ Analysis & Policy Article 4 (2006); Aldy and Viscusi, *Age Variations in Workers' Value of Statistical Life* (cited in note 50).

[58]   For discussion of the policy concerns with latency periods, discounting, and the value of life, see Revesz, 99 Colum L Rev at 950–55 (cited in note 3).

[59]   See W. Kip Viscusi and Joseph E. Aldy, *The Value of a Statistical Life: A Critical Review of Market Estimates Throughout the World*, 27 J Risk & Uncertainty 5, 63 (2003) (analyzing mortality risk premiums to estimate income elasticity).

VSL $(60,0)/(1 + r - g)^{30}$, which is a formulation William Evans and I derived two decades ago.[60]

When I first introduced the VSL approach to government agencies in 1982, I was asked whether it is appropriate to discount lives at all.[61] I had two responses to this issue, which still appears to be a matter of controversy.[62] First, what is being discounted is not the number of lives, but a monetary amount equal to the willingness to pay to reduce risks to life.[63] Second, it is possible to avoid discounting altogether by changing our frame of reference. If we don't discount the VSL at year thirty, we could ask instead if it is worthwhile to incur some cost c to obtain the benefit of one VSL at that time. But after thirty years, the cost c will have a terminal value $c(1 + r)^{30}$, which leads to the same benefit-cost analysis requirement, as $VSL/(1 + r)^{30} > c$.[64]

Now consider the third case of someone who is not alive today but who will be saved in thirty years at age thirty. The appropriate value can be calculated using the same general approach as with the second situation, taking the VSL (30,0) as the reference point. Thus, in terms of our notation, we have

$$VSL(30,30) = VSL(30,0)(1 + g)^{30}/(1 + r)^{30},$$

which is approximately

$$VSL\ (30,30) = VSL(30,0)/(1 + r - g)^{30}.$$

If the growth rate in income is expected to be low, then the benefit assessment can be simplified by dropping g from the calculation.

VII. Policy Practices for Intergenerational Discounting

OMB guidance has given agencies leeway in how they discount effects on future generations. As a result, it is useful to examine how agencies have employed this discretion. Notably, none of the regulations in Appendix 2 involved intergenerational effects. There is currently a dearth of policies with truly long-term implications. The two examples I consider in this section are stratospheric ozone regulations and radioactivity exposure standards for nuclear waste storage at Yucca Mountain. A common feature of these regulations is that the

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[60] See generally W. Kip Viscusi and William N. Evans, *Utility Functions That Depend on Health Status: Estimates and Economic Implications*, 80 Am Econ Rev 353 (1990).

[61] See generally Pete Earley, *What's a Life Worth?*, Wash Post Magazine 11 (June 9, 1985).

[62] See Revesz, 99 Colum L Rev at 1016 (cited in note 3) ("With respect to harms to future generations . . . the use of discounting is ethically unjustified.").

[63] Much the same point is made in Cass R. Sunstein and Arden Rowell, *On Discounting Regulatory Benefits: Risk, Money and Intergenerational Equity*, 74 U Chi L Rev 171, 173 (2006).

[64] This example can easily be elaborated to incorporate a growth rate g in VSL.

VSL is of central importance, as is concern for future generations. What differs is the length of the time horizon captured by these future concerns, as the future extends to 2075 in the regulatory analysis of stratospheric ozone regulation and a million years in the analysis of nuclear waste storage at Yucca Mountain. Each of these examples yields a common lesson, which is that federal agencies need to develop a sounder economic approach to discounting intergenerational effects.

A. Stratospheric Ozone Regulations

The problem that very distant time periods create for regulatory analyses is apparent from the EPA's 1987 analysis of its proposed rule, Protection of Stratospheric Ozone.[65] That regulation would have controlled a wide range of applications of CFC and halons, such as refrigerants. The benefits, which were calculated to the year 2075, included reductions in skin cancer deaths, cataracts, crop damage, damage to fish, damage to polymers, and sea level rise damage.

For concreteness, consider how the EPA addressed the skin cancer mortality risks. The EPA undertook a sensitivity analysis with three scenarios: i) a high-benefits scenario of 1 percent discount rate, $4 million value of life, and 3.4 percent annual growth in the value of life; ii) a medium scenario with a 2 percent discount rate, $3 million value of life, and 1.7 percent annual growth in the value of life; and iii) a low scenario with a 6 percent discount rate, $2 million value of life, and 0.85 percent annual growth in the value of life. The idea of undertaking a sensitivity analysis is a desirable feature. The choice of the VSL was perhaps less well defined at that time than it is now, though I believe the $2 million figure was certainly too low even for that era.[66] The EPA's discussion of the final rule cited my work in the 1980s, which indicated that the appropriate VSL was much higher than the rate they had employed in the preliminary regulatory impact analysis.[67]

Setting aside the choice of the value of life number, consider the implications of their combination of discounting assumptions and growth rate assumptions. For the high benefits scenario, the present value PV(t) of a statistical life saved t years in the future is given by

$$PV(t) = \frac{\text{VSL}(1.034)^t}{(1.01)^t}, \qquad (6)$$

which is approximately

[65] See Environmental Protection Agency, Protection of Stratospheric Ozone, 52 Fed Reg 47489, 47513–14 (1987).

[66] See W. Kip Viscusi, *The Value of Risks to Life and Health*, 31 J Econ Lit 1912, 1912–13 (1993).

[67] See Environmental Protection Agency, Protection of Stratospheric Ozone, 53 Fed Reg 30566, 30596 (1988).

$$PV(t) = VSL(1.024)^t. \qquad (7)$$

Consequently, there is no net discounting at all, as instead the present value per life saved increases at a compound growth rate of 2.4 percent annually. To put this growth rate in perspective, after seventy-five years this approach makes the "discounted" VSL worth 5.9 times as much as the VSL for the current period. Saving one future life in seventy-five years will consequently count about as much as saving six lives today. There is no valid economic rationale for this preferential treatment of future generations. An exhaustive exploration of the different ways we could sacrifice now to make people better off in 2075 could easily divert all our risk-reducing resources to making our descendents' lives safer, given that their lives count about six times as much as lives in the current generation.

The middle benefits scenario developed by EPA is more modest, leading to

$$PV(t) = \frac{VSL(1.017)^t}{(1.02)^t}, \qquad (8)$$

or a value approximately equal to

$$PV(t) = VSL/(1.003)^t. \qquad (9)$$

The almost-identical choice of the growth rate and the discount rate fall short of being exactly offsetting, as perhaps the EPA wanted to have at least some net nonzero discounting. Using this approach, a statistical life saved in seventy-five years has a present value of 0.80 of its value today.

The final low-benefits scenario best captures the idea that there should be discounting. The relatively high 7 percent rate that was recommended by the OMB in that era is the starting point for the analysis. The approach leads to a net discount rate of 5.15 percent. A statistical life saved after seventy-five years will have a present value of 0.02 times a VSL today. Had the EPA used a more realistic base discount rate of 3 percent and coupled that assumption with its chosen low growth figure of 0.85 percent VSL growth, the net discount rate would be 2.15 percent, and the VSL in seventy-five years would be 0.20 times the value of saving a life today.

B.   Yucca Mountain Nuclear Waste Storage

One of the most consequential and bizarre regulatory analyses pertaining to future generations is the EPA's 2005 analysis of standards for storage of nuclear waste at Yucca Mountain, Nevada.[68] The standards involved criteria for proposed storage of nuclear wastes at an underground storage facility at Yucca Mountain, which is about one hundred miles northwest of Las Vegas.[69] The nuclear waste repository would be about three hundred meters underground, with an additional three hundred to five hundred meters between the repository and the water table. The purpose of the proposed regulation is to establish new health and safety standards for this repository of radioactive material.[70]

Before considering the details of the EPA's regulatory analysis, it is useful to ask what an ideal regulatory analysis might look like. Because Yucca Mountain does not create nuclear wastes but simply stores them, a pertinent question to ask is how much this site will reduce the risks from nuclear wastes as opposed to storage at current locations. This comparison never arises in the EPA analysis, as the mindset is with respect to incremental risks from a zero baseline risk. What the EPA should have done is explore the risk-risk tradeoffs involved rather than adopting the implicit fiction that we now live in a riskless nuclear-free world.

Using such a framework, the EPA should have analyzed the incremental cancer risk reductions associated with different standards, the populations affected by these risks, the value of the statistical lives saved by more stringent standards, and the discounted value of the costs and benefits for standards of different stringency. Somewhat strikingly, discounting of effects never even enters the analysis despite the use of a policy time horizon that goes well beyond that of science fiction fantasies.

The thought process underlying the proposed regulation bears a strong similarity to the methodology used by the EPA for deciding whether hazardous waste sites should be cleaned up by the Superfund program.[71] An individual risk approach guides the site cleanup decisions. If a current or hypothetical future individual subjected to a reasonable maximum exposure could be exposed to a lifetime cancer risk

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[68]   See generally Environmental Protection Agency, Public Health and Environmental Radiation Protection Standards for Yucca Mountain, NV, 70 Fed Reg 49014 (2005).

[69]   Id at 49018.

[70]   Id at 49014.

[71]   See James T. Hamilton and W. Kip Viscusi, *Calculating Risks? The Spatial and Political Dimensions of Hazardous Waste Policy* 26–29 (MIT 1999) (describing the risk assessment procedures used in the EPA Superfund program).

of 1/10,000, the site must be cleaned up. If the individual risk is between 1/10,000 and 1/1,000,000, cleanup is discretionary.[72] Note that nobody need be actually exposed to the risk. The number of people affected by the risk does not enter into the decision, so risks to populations are not the matter of concern but only the individual risk reference point. In contrast, a benefit-cost approach would multiply the cancer risk by the size of the exposed population, weight the values by the pertinent VSL, and then discount the result.

The EPA's Yucca Mountain analysis is similar, with one additional level of abstraction. It does not consider the cancer risk probability, only the level of the radioactive dose. In particular, the proposed standard is split into two parts. For the next ten thousand years the allowable dose is 15 millirems per year, while after ten thousand years and up to one million years the allowable dose is 350 millirems per year.[73] In each instance, the reference person is the reasonably maximally exposed individual,[74] just as the Superfund focuses on the reasonable maximum exposure for an individual.[75] The reasonably maximally exposed individual need not be a real person but instead is a "theoretical individual representative of a future population group."[76]

If we adopt the approach that only a single real or hypothetical individual matters, how much weight should a risk to one person carry in a benefit-cost assessment? Using a discount rate of 3 percent, one case of cancer ten thousand years from now has a discounted value of $(1/1.03)^{10,000}$, or 4.2×10^{-129}. Thus, even if the entire current United States population were crammed into Yucca Mountain and exposed to a lethal dose of radiation, there would be a negligible value for the number of discounted cases of cancer that could be prevented by eliminating this risk.

But even these minuscule discounted cancer risks overstate the actual risks for three principal reasons. First, the maximum possible risk to an individual greatly exceeds the average risk to an exposed individual, as documented for the Superfund.[77] Second, exposure to radioactive risks is a choice. People need not choose to build houses at the Yucca Mountain site or rely on drinking water contaminated by radioactive waste. Third, even taking the exposure limits at face value,

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[72]   Id at 63 (stating the thresholds of risk which determine remediation policy at potential sites).

[73]   70 Fed Reg at 49014 (cited in note 68).

[74]   See id at 49019.

[75]   See Hamilton and Viscusi, *Calculating Risks?* at 62 (cited in note 71).

[76]   See 70 Fed Reg at 49019 (cited in note 68).

[77]   See Hamilton and Viscusi, *Calculating Risks?* at 63 (cited in note 71) ("While the goal of Superfund risk assessment is to provide a plausibly conservative estimate of risk, a number of studies suggest that [reasonable maximum exposure] estimates may greatly exceed this target.").

my example above greatly overstates the severity of the risk. Exposure to radioactivity is not fatal at the 15 millirems per year level or even at the 350 millirems per year level.

To justify the exposure limits, the EPA does not calculate the exposed populations or risk probabilities but instead gives risk reference points. Consider, for example, the comparable background risk for residents of Colorado, which the EPA views as comparable to Nevada in terms of climatic features.[78] The average background radiation level is 700 millirems per year,[79] which is double the million-year exposure standard and almost fifty times the ten thousand-year standard. The current average background risk level in the U.S. is 300 millirems per year.[80] The incremental risks from Yucca Mountain will be far from lethal and in fact were designed to keep the total risk from background risks and Yucca Mountain to the maximally exposed person at or below 350 millirems per year,[81] which is half the background radiation dose Colorado residents currently experience. Even based on total risk levels, the standard is quite stringent and makes no apparent sense.

Moreover, total risk should not be the focal point of any benefit-cost analysis, however rudimentary it might be. What matters are the incremental risks and benefits associated with a policy. Background risks will be present with or without the risks of the Yucca Mountain site. To the extent that dose-response relationships are nonlinear, the risk calculations can account for any influence of background risks, but the focus will be on incremental risks associated with different regulatory options.

The EPA's fanciful time horizons of ten thousand years and one million years are temporal reference points that would have dropped out of any analysis had the agency engaged in any reasonable discounting of effects. To put these time periods in perspective, recorded human history spans about five thousand years, and homo sapiens first walked the earth about 120 thousand years ago.

How could the EPA have been led to propose a regulation for the next million years based on our current, certainly primitive technologies for dealing with risk that surely will be less effective than technologies that will emerge in the future? The agency cites approvingly the following guidelines offered by the National Academy of Public Administration (NAPA):

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78   See 70 Fed Reg at 49037 (cited in note 68).
79   Id.
80   Id at 49038.
81   Id.

To inform decision-making, NAPA defined four basic principles:

• Trustee: Every generation has obligations as trustee to protect the interests of future generations;

• Sustainability: No generation should deprive future generations of the opportunity for a quality of life comparable to its own;

• Chain of Obligation: Each generation's primary obligation is to provide for the needs of the living and succeeding generations. Near-term concrete hazards have priority over long-term hypothetical hazards;

• Precautionary: Actions that pose a realistic threat of irreversible harm or catastrophic consequences should not be pursued unless there is some countervailing need to benefit either current or future generations.[82]

It is useful to consider each of these principles in turn. The trustee obligation appears to be reasonable insofar as it implies that future-generation effects should matter when conducting regulatory analysis.

The second requirement of sustainability is less compelling. Is there no sufficiently large current benefit that would make a policy desirable if it imposed a very small risk that the quality of life for some future generation might be an infinitesimal amount lower than our own? Rigid requirements of sustainability do not permit any such tradeoffs and are antithetical to a balanced benefit-cost approach. "Sustainability" is also an ill-defined environmentalist battle cry. What does it mean for the future quality of life to be "comparable" to our own? Must they have access to the same natural resources, the same resources per capita, or sufficient resources to have the same life expectancy? How can we even tell if their quality of life is the same as our own? We cannot readily take ourselves forward in time to determine the utility future generations will experience within the context of their civilizations. Going back in time, at least from my vantage point, I believe we are better off today than we were before indoor plumbing and electricity even though there surely has been tremendous degradation of our natural resources. The task of ascertaining whether decisions today will lead people to have a lower quality of life in ten thousand years or a million years cannot ignore the role of technological progress and change in lifestyle that we are ill-equipped to predict. We don't know the absolute levels of their quality of life,

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82 Id at 49035, quoting NAPA, *Deciding for the Future: Balancing Risks, Costs, and Benefits Fairly across Generations* 7 (1997), online at http://www.eh.doe.gov/oepa/data/napa.pdf (visited Jan 22, 2007).

how much our decisions today will alter that quality, or how we might go about making a sensible intertemporal interpersonal comparison. The sustainability objective is both inefficient and inoperable.

The chain of obligation principle expands on the trustee notion and indicates that current effects are the primary obligation. Proper discounting practices will ensure that appropriate weight is given to current and future effects. The greater weight the principle urges be given to near-term hazards seems to be broadly consistent with some type of discounting.

Where I depart from that principle is with respect to the greater weight that should be given to concrete risks as opposed to long-term hypothetical risks. On the positive side, this guidance avoids the excessive attention to ambiguous risks that are not well understood.[83] However, suppose that we face two types of risks—a certain risk of 1/10,000 and a subjectively assessed risk of 1/1,000 based on scientists' best judgments. The mean level of the risk should be our guide, not the precision of the risk estimate. This basic principle of Bayesian statistical decision theory[84] will ensure that we address risks even when sample sizes are too small to support classical statistical testing. The antiterrorism effort is an example of active policy despite small sample size. Risks may be real, even when they cannot be precisely estimated.

The final precautionary principle is either innocuous or inefficient depending on its interpretation. No risk of any kind of harm, whether irreversible or not, should be undertaken unless there is some offsetting benefit. But irreversibilities per se need not be a barrier to action. In a series of papers, I have examined the role of environmental irreversibilities and found that they do not alter the decision analysis problem in a way that is too sweeping.[85] Moreover, the existence of irreversibilities sometimes leads to a need to overregulate

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[83] See W. Kip Viscusi, *Rational Risk Policy* 127 (Oxford 1998) (critiquing the institutionalization of risk biases through government programs).

[84] See generally Howard Raiffa, *Decision Analysis: Introductory Lectures on Choices under Uncertainty* (Addison-Wesley 1968).

[85] See W. Kip Viscusi, *Irreversible Environmental Investments with Uncertain Benefit Levels*, 15 J Envir Econ & Mgmt 147, 156–57 (1988) (concluding that investing fewer resources in irreversible policies is not always optimal); W. Kip Viscusi, *Environmental Policy Choice with an Uncertain Chance of Irreversibility*, 12 J Envir Econ & Mgmt 28, 37 (1985) (discussing when it is important to learn about potential irreversibilities); W. Kip Viscusi, *Frameworks for Analyzing the Effects of Risk and Environmental Regulations on Productivity*, 73 Am Econ Rev 793, 794–97 (1983) (analyzing the irreversible impacts on firms from regulations); Viscusi and Zeckhauser, 3 J Envir Econ & Mgmt at 103 (cited in note 10) (explaining why irreversibilities need not have a dramatic impact on the analysis of a policy).

risks and other times makes underregulation optimal.[86] How the irreversibilities affect the analysis or the appropriate policy decision is often ambiguous. What is clear is that there are threats to sound decisions that will emerge if we let our choices be guided by arbitrary commitments to precaution or sustainability rather than benefit-cost tests.[87]

The EPA's Yucca Mountain analysis embodies the kinds of inefficient policy prescriptions that emerge when policies are based on lofty but misguided principles of intergenerational equity rather than a sound benefit-cost approach. Had the agency assessed costs and benefits properly and discounted these values appropriately, the emphasis would have shifted from arbitrary exposure thresholds for hypothetical, maximally exposed individuals to the discounted economic value of the expected number of cancer cases that will be averted through more stringent standards.

VIII. THE CHALLENGE OF HYPERBOLIC DISCOUNTING

My discussion thus far has been normative. What discount rate should the government use in valuing regulatory benefits and costs over time? Whether policies are considered for such assessment will, of course, depend on political pressures exerted by the citizenry. If, for example, there is no constituency for attempting to reduce the risk of global climate change, then policies to combat global warming may not even be considered for evaluation. Thus, it is useful to explore what the behavioral aspects of intertemporal preferences are and whether the pressure these preferences exert on policy will lead to rational intertemporal political decisions.

The conventional discounting approach known as "exponential discounting" dominates economic theory. Whether people behave in a manner consistent with this theory is a quite different matter. Economists have long challenged the behavioral accuracy of the conventional discounting framework. In the usual exponential discounting case, the rate of discount for payoffs in year t is given by $1/(1 + r)^t$. Be-

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[86]   See Viscusi, 73 Am Econ Rev at 793 (cited in note 85) (concluding that not only does the current level of regulation affect firm output, but so does the future level of regulation and degree of uncertainty regarding this future level).

[87]   The precautionary principle has been subject to a variety of critiques. See, for example, Ragnar E. Löfstedt, *The Swing of the Regulatory Pendulum in Europe: From Precautionary Principle to (Regulatory) Impact Analysis*, 28 J Risk & Uncertainty 237, 246–48 (2004) (reviewing the current use of the precautionary principle in Europe and its effects); Christian Gollier and Nicolas Treich, *Decision-Making under Scientific Uncertainty: The Economics of the Precautionary Principle*, 27 J Risk & Uncertainty 77, 99 (2003) (discussing problems with the precautionary principle, including the fact that it may favor opportunistic behavior); Cass R. Sunstein, *Beyond the Precautionary Principle*, 151 U Pa L Rev 1003, 1020 (2003) (stating that the largest problem with the precautionary principle is that it paralyzes policy by forbidding both action and inaction).

ginning with the conjecture by Robert Strotz, economists have hypothesized that people behave in a myopic manner and put an inordinate weight on immediate rewards.[88] This phenomenon, which he termed hyperbolic discounting, has led to a considerable experimental literature documenting this form of intertemporal irrationality.[89] A useful simple formulation of this framework is the quasi-hyperbolic discounting model, in which the discount factor is 1 in the initial period, but thereafter is given by $\beta / (1 + r)^t$, where $0 \leq \beta < 1$.[90] Thus, all deferred payoffs are scaled down by some factor β.

Using a nationally representative sample, Joel Huber and I recently examined whether people exhibited hyperbolic discounting when valuing the environment.[91] The survey considered water quality improvements that could occur now, or with a delay of two, four, or six years. For delays of two years, people displayed an average rate of time preference ranging from 12.7 percent to 14.3 percent.[92] For delays of four years, the implicit rate of time preference range was 8.0 to 8.4 percent, while for six years it was 7.9 to 8.7 percent. Based on the responses that led to these estimates, it is possible to estimate the quasi-hyperbolic discounting parameter β, which was 0.48–0.53 for two-year delays and 0.58–0.61 for delays of six years. Thus, there is evidence of a substantial undervaluation of deferred benefits, which in effect receive a weight of about 50–60 percent of their correct discounted value that would prevail if people adhered to an exponential discount rate. People have a strong preference for policies that generate immediate benefits.

This form of intertemporal irrationality is not simply an intellectual curiosity of interest only to economists. Hyperbolic discounting has potentially far-reaching policy consequences because it indicates that people are displaying an irrationally substantial weight on current payoffs compared to the future. Public support for policies such as environmental policies with very long-term effects consequently are potentially strongly affected by hyperbolic discounting.

Given that people's revealed intertemporal preferences display hyperbolic discounting, should policy prescriptions for discounting

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[88]   See generally R.H. Strotz, *Myopia and Inconsistency in Dynamic Utility Maximization*, 23 Rev Econ Studies 165 (1955).

[89]   See generally Shane Frederick, George Loewenstein, and Ted O'Donoghue, *Time Discounting and Time Preference: A Critical Review*, 40 J Econ Lit 351 (2002) (reviewing intertemporal irrationality literature).

[90]   See David Laibson, *Golden Eggs and Hyperbolic Discounting*, 112 Q J Econ 443, 449 (1997) (describing the hyperbolic discount function used to calculate a time-additive utility function).

[91]   See generally W. Kip Viscusi and Joel Huber, *Hyperbolic Discounting of Public Goods* (National Bureau of Economic Research Working Paper 11935, Jan 2006), online at http://papers.nber.org/papers/w11935.pdf (visited Jan 22, 2007).

[92]   Id at 38 table 4.

practices reflect these preferences? My view is that this form of intertemporal irrationality should not be incorporated into official discounting practices, which instead should be based on the opportunity cost of capital rather than the irrational, myopic concerns embodied in hyperbolic discounting.

Nevertheless, hyperbolic discounting is of potentially substantial policy importance. The pressure the public exerts on government officials to promote policies they prefer will lead to policy outcomes that reflect the public's risk beliefs and preferences, to the extent that policy choices respond to the public's concerns. If people display an inordinate disregard for all future payoffs, then the political pressures on agencies will tilt policies toward efforts with immediate payoffs rather than longer-term benefits. This disregard of future effects is not a minor anomaly but may have a considerable effect if the public's hyperbolic discounting parameter β is on the order of 0.5, in which case they only count future payoffs at half their discounted value.

The question of whether we should respect the public's preference even if it is irrational is a recurring problem in policy contexts. For risk perceptions, the question of whether policies should address irrational fears has long been a matter of substantial debate.[93] In the risk belief context, I have long suggested that policies should be grounded on the actual risk levels rather than public misperceptions of the risk.[94] Just as we would not want to ignore risks because the public is not aware of the risk, we should not respond to hazards for which the public has exaggerated beliefs. This same principle should guide policies with respect to intertemporal irrationalities. The practical result of doing so will be more emphasis on policies that offer deferred benefits. How political support can be generated for efforts that involve current sacrifices to achieve these deferred rewards may be more problematic.

IX. CONCLUSION

My prescription for rational discounting is simple. The government should base the discount rate on the opportunity cost of capital. The same discount rate should be used for benefits and costs. Policy assessments should recognize the effects on future generations fully and discount those effects consistently with discounting practices for the current generation.

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[93] See, for example, Paul R. Portney, *Trouble in Happyville*, 11 J Pol Analysis & Mgmt 131, 132 (1992) (asking readers their willingness to pay to get rid of a contaminant with no risk of harm).

[94] See Viscusi, *Rational Risk Policy* at 85–86 (cited in note 83) (providing examples of government policies embodying individuals' biases in risk perception).

There are several reasons why this approach will not lead to neglect of future generations. Most important is that there should be increased consideration of policies with long-term consequences. In much the same way that choices under uncertainty may involve neglect of possible states of the world, policy choices may neglect consequences in future time periods. There should be a concerted effort to recognize that there are often important consequences of regulatory policies on future generations. Somewhat surprisingly, none of the major regulations OMB reported to Congress in 2005[95] included regulatory analysis of future-generation effects. It may be that distant effects do not play a major role in these policies. But perhaps it is also the case that regulations that protect the future do not make it onto the policy agenda. Even if there are potential benefits in the distant future, if the regulations that would generate these benefits are never proposed and issued, the policy process in effect neglects these concerns entirely. Those concerned with the well-being of future generations consequently may have overlooked the more fundamental policy problem. There will be no need to discount any future-generation effects at either a high discount rate or a low preferential rate if such policies are never considered.

Neglect of the well-being of future generations may be quite rational in many instances. If policies only have near-term effects, then the future consequences do not enter. However, if policies generate the bulk of their net benefits far into the future, then the influence of hyperbolic discounting will tend to relegate such efforts to lower-priority status in favor of those that generate immediate benefits due to the influence of behavioral anomalies in subjective rates of time preference.

Overcoming such intertemporal myopia may be extraordinarily difficult given the substantial uncertainties involved with very long time horizons. Waiting to take action may provide new information that potentially may resolve the uncertainties as to whether policy action is warranted. The existence of substantial uncertainties may provide a plausible basis for the inaction that stems from hyperbolic discounting, making it difficult to overcome intertemporal irrationalities. Once these policies with long-term consequences are evaluated using a consistent discounting approach, the effects will be reduced by the inescapable mathematics of discounting. While meaningful discounting will reduce the value of such effects, recognizing the positive income elasticity of benefits will be at least partially offsetting. Moreover, even if policy effects one hundred years from now only have a weight that is 0.05 that of current benefits, if the effects on future gen-

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[95]   See Appendix 2.

erations will be truly catastrophic, their discounted value will be consequential as well. If the effects will be minor and all but eliminated from concern by rational discounting, then there is no compelling rationale for the current generation to make sacrifices.

APPENDIX 1: TIME INCONSISTENCY EFFECTS OF DIFFERENT
DISCOUNT RATES FOR DIFFERENT GENERATIONS

Discounting Policy	Discount Rate (r)	
	Benefits to Current Generation	Benefits to Future Generation
Rational Discounting:		
1. Current Effects, Current Decisions	r	—
2. Future Effects, Future Decisions	—	r
Preferential Discounting:		
3. Current Decisions, Future Discounting Differential	r	$r' < r$
i. No change in within-generation discounting.	r	$r' < r$, but r within future generation
ii. Within-generation discounting changes as well	r	$r' < r$ including within future generations
4. Current Decisions, Continuous Differential Discounting	$r' < r$	$r' < r$

APPENDIX 2: DISCOUNT RATES USED FOR REGULATIONS FROM
TABLE 1-4 OF THE DRAFT 2005 REPORT TO CONGRESS ON THE COSTS
AND BENEFITS OF FEDERAL REGULATION

Rule	Status	Date	Agency	Rates Used	Cite
Bar Code Label Requirement for Human Drug Products and Biological Products	Final	2/26/04	HHS-FDA	3% & 7%	69 FR 9120, 9163
Prior Notice of Imported Food Under the Public Health Security and Bioterrorism Preparedness and Response Act of 2002	Interim final	10/10/03	HHS-FDA	3% & 7%	68 FR 58974, 59063
Registration of Food Facilities Under the Public Health Security and Bioterrorism Preparedness and Response Act of 2002	Interim final	10/10/03	HHS-FDA	3% & 7%	68 FR 58894, 589500–51
Final Rule Declaring Dietary Supplements Containing Ephedrine Alkaloids Adulterated Because They Present an Unreasonable Risk	Final	2/11/04	HHS-FDA	3% & 7%	69 FR 6788, 6847
Medicare Prescription Drug Discount Card	Interim final	12/15/03	HHS-CMS	3% & 7%	68 FR 69840, 69912
Control of Emissions of Air Pollution from Nonroad Diesel Engines and Fuel	Final	6/29/04	EPA	3% & 7%	69 FR 38958, 39107
National Pollutant Discharge Elimination System—Final Regulations to Establish Requirements for Cooling Water Intake Structures at Phase II Existing Facilities	Final	7/9/04	EPA	3% & 7%	69 FR 41576, 41662
Required Advance Electronic Presentation of Cargo Information	Final	12/5/03	DHS-CBP	7%	68 FR 68140, 68166
Area Maritime Security	Final	10/22/03	DHS-USCG	7%	68 FR 60472, 60479
Vessel Security	Final	10/22/03	DHS-USCG	7%	68 FR 60483, 60507
Facility Security	Final	10/22/03	DHS-USCG	7%	68 FR 60515, 60536
Effluent Limitations Guidelines and New Source Performance Standards for the Meat and Poultry Products Point Source Category	Final	9/8/04	EPA	Not Indicated	69 FR 54476
Reduced Vertical Separation Minimum in Domestic United States Airspace	Final	10/27/03	DOT-FAA	None	68 FR 61304

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Rule	Status	Date	Agency	Rates Used	Cite
Prohibition of the Use of Specified Risk Materials for Human Food and Requirements for the Disposition of Non-Ambulatory Disabled Cattle	Interim final	1/12/04	USDA-FSIS	None	69 FR 1862
Meat Produced by Advanced Meat/Bone Separation Machinery and Meat Recovery (AMR) Systems	Interim final	1/12/04	USDA-FSIS	None	69 FR 1874
General Order Implementing Syria Accountability and Lebanese Sovereignty Act of 2003	Final	5/14/04	DOC-BIS	None	69 FR 26766
United States Visitor and Immigrant Status Indicator Technology Program ("US-VISIT"); Authority to Collect Biometric Data from Additional Travelers and Expansion to the 50 Most Highly Trafficked Land Border Ports of Entry	Interim	8/31/04	DHS-BTS	None	69 FR 53318
Migratory Bird Hunting; Final Frameworks for Early-Season Migratory Bird Hunting Regulations	Final	8/30/04	DOI-FWS	None	69 FR 52970
Migratory Bird Hunting; Early Seasons and Bag and Possession Limits for Certain Migratory Game Birds in the Contiguous United States, Alaska, Hawaii, Puerto Rico, and the Virgin Islands	Final	9/1/04	DOI-FWS	None	69 FR 53564
Migratory Bird Hunting; Migratory Bird Hunting Regulations on Certain Federal Indian Reservations and Ceded Lands for the 2004–05 Early Season	Final	9/3/04	DOI-FWS	None	69 FR 53990
Migratory Bird Hunting; Final Frameworks for Late-Season Migratory Bird Hunting Regulations	Final	9/23/04	DOI-FWS	None	69 FR 57140
Migratory Bird Hunting; Late Seasons and Bag and Possession Limits for Certain Migratory Game Birds	Final	9/27/04	DOI-FWS	None	69 FR 57752
Migratory Bird Hunting; Regulations on Certain Federal Indian Reservations and Ceded Lands for the 2004–05 Late Season	Final	9/29/04	DOI-FWS	None	69 FR 58236
Defining and Delimiting the Exemptions for Executive, Administrative, Professional, Outside Sales and Computer Employees	Final	4/23/04	DOL-ESA	None	69 FR 22122
Pipeline Safety: Pipeline Integrity Management in High Consequence Areas (Gas Transmission Pipelines)	Final	12/15/03	DOT-RSPA	None	68 FR 69778

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Rule	Status	Date	Agency	Rates Used	Cite
Computer Reservations System (CRS) Regulations	Final	1/7/04	DOT-OST	None	69 FR 976
HIPAA Administrative Simplification: Standard Unique Health Identifier for Health Care Providers	Final	1/23/04	HHS-CMS	None	69 FR 3434
National Emission Standards for Hazardous Air Pollutants for Stationary Reciprocating Internal Combustion Engines	Final	6/15/04	EPA	None	69 FR 33474
National Emission Standards for Hazardous Air Pollutants: Plywood and Composite Wood Products; Effluent Limitations Guidelines and Standards for the Timber Products Point Source Category; List of Hazardous Air Pollutants, Lesser Quantity Designations, Source Category List	Final	7/30/04	EPA	None	69 FR 45944
National Emission Standards for Hazardous Air Pollutants for Industrial, Commercial, and Institutional Boilers and Process Heaters	Final	9/13/04	EPA	None	69 FR 55218
National Emission Standards for Hazardous Air Pollutants: Surface Coating of Automobiles and Light-Duty Trucks	Final	4/26/04	EPA	None	69 FR 22602