NOTE

NOW, LATER, OR NEVER: APPLYING ASYMMETRIC DISCOUNT RATES IN NUISANCE REMEDIES AND FEDERAL REGULATIONS

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* J.D. candidate, May 2008. I dedicate this Note to Professor Clopper Almon and Mrs. Joan Almon, whose wisdom, integrity, and devotion I greatly admire and whose generosity I deeply appreciate. I am grateful to Professor James E. Krier for introducing me to law and economics and advising me on this Note. Many thanks to Ilya Shulman, Jeremy Suhr, Krista Caner, Jeanne Long, and Joel Flaxman for helpful suggestions on previous drafts of this Note. Financial support from the John M. Olin Center for Law and Economics at the University of Michigan Law School is also gratefully acknowledged.

INTRODUCTION

Discounting, "[t]he procedure for determining the present value of a future dollar,"[1] has long been recognized as a crucial element in the calculation of tort damages. Following decades of application by state courts in the late nineteenth and early twentieth centuries,[2] the notion that future economic losses must be discounted to present-day value first received express endorsement from the U.S. Supreme Court in 1916.[3] In the ninety years that followed, the use of discount rates in computing tort damages became firmly established in American jurisprudence and widely practiced by courts.[4] More recently, discounting has also become indispensable to the executive branch of the federal government in the economic analysis of its regulations.[5] Since 1981, when President Reagan's Executive Order 12291 first mandated cost-benefit analysis for all major federal regulations,[6] federal agencies such as the Environmental Protection Agency, the Food and Drug Administration, and the Department of Housing and Urban Development have routinely discounted and compared future costs and benefits to study the impact and desirability of proposed regulations.[7]

Discounting has intuitive appeal. As Judge Posner writes, "To most people, a dollar today is worth a great deal more than a dollar ten years from now."[8] There are two reasons this is the case: opportunity cost, because a dollar today can be invested, and pure time preference, because individuals are generally impatient.[9] By converting a future dollar into its present-day equivalent, discounting enables us to aggregate and compare values across

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1. B. PETER PASHIGIAN, PRICE THEORY AND APPLICATIONS 552 (1995).

2. Chesapeake & Ohio Ry. Co. v. Kelly, 241 U.S. 485, 493–94 (1916) (noting that it was a common practice among state courts to discount future payments to present value when determining damage awards).

3. *Id.* at 490–92 (holding that, when computing a lump-sum award, lost future earnings of the deceased must be discounted to their present value).

4. *See* RESTATEMENT (SECOND) OF TORTS § 913A (1979) ("The measure of a lump-sum award for future pecuniary losses arising from a tort is the present worth of the full amount of the loss of what would have been received at the later time.").

5. Edward R. Morrison, Comment, *Judicial Review of Discount Rates Used in Regulatory Cost-Benefit Analysis*, 65 U. CHI. L. REV. 1333, 1333–34 (1998).

6. CASS R. SUNSTEIN, THE COST-BENEFIT STATE 10 (2002).

7. Morrison, *supra* note 5, at 1336–37.

8. Reynolds v. Beneficial Nat'l Bank, 288 F.3d 277, 284 (7th Cir. 2002).

9. SUNSTEIN, *supra* note 6, at 84.

different time periods.[10] In the classic model of discounting, the formula for making such a conversion from the future to the present is:

$$u_t = \frac{v_t}{(1+r)^t},$$

where v_t is the future value in year t, r is the discount rate, and u_t is the present value of v_t.[11] Cost-benefit analysis applies this formula to compute the present value of future costs and benefits of a proposed project or regulation.[12] Under the Net Present Value ("NPV") test, an activity is worthwhile if and only if it has a positive net present value, defined as the difference between the present value of benefits and the present value of costs.[13] A negative net present value indicates that the activity costs more than its benefits and therefore fails the cost-benefit analysis.[14]

Despite its intuitive appeal and simple mathematical formulation, the use of discounting in cost-benefit analysis remains a subject of heated academic debate,[15] at the center of which is the difficulty of determining the appropriate discount rate.[16] The classic model of discounting predicts a constant discount rate equal to the real market interest rate,[17] but scholars have since identified a number of other factors affecting the discount rate, such as risk premium, social preference, and ethical implications.[18] From a theoretical perspective, even though scholars generally agree that the discount rate depends on more than the interest rate alone, they disagree on the extent to

10. Coleman Bazelon & Kent Smetters, *Discounting in the Long Term*, 35 LOY. L.A. L. REV. 277, 277 (2001) ("Discounting addresses the problem of translating values from one time period to another.").

11. Daniel A. Farber & Paul A. Hemmersbaugh, *The Shadow of the Future: Discount Rates, Later Generations, and the Environment*, 46 VAND. L. REV. 267, 277–78 (1993). If the discount compounds continuously instead of annually, the formula becomes $v_t^{'} = v_t e^{-rt}$. EDWARD M. GRAMLICH, A GUIDE TO BENEFIT-COST ANALYSIS 113 (2d ed. 1990).

12. Farber & Hemmersbaugh, *supra* note 11, at 278.

13. *Id.* For a more detailed introduction to the NPV test, see MICHAEL FAURE & GÖRAN SKOGH, THE ECONOMIC ANALYSIS OF ENVIRONMENTAL POLICY AND LAW 116–19 (2003).

14. Morrison, *supra* note 5, at 1342.

15. *See, e.g.*, John J. Donohue III, *Why We Should Discount the Views of Those Who Discount Discounting*, 108 YALE L.J. 1901 (1999) (defending cost-benefit analysis); Lisa Heinzerling, *Regulatory Costs of Mythic Proportions*, 107 YALE L.J. 1981 (1998) (criticizing the use of regulatory cost-benefit analysis). For a review of the main critiques of cost-benefit analysis, see Robert W. Hahn, *The Economic Analysis of Regulation: A Response to the Critics*, 71 U. CHI. L. REV. 1021, 1024–31 (2004), and Amy Sinden, *Cass Sunstein's Cost-Benefit Lite: Economics for Liberals*, 29 COLUM. J. ENVTL. L. 191, 201–10 (2004).

16. Cass R. Sunstein, *Cost-Benefit Default Principles*, 99 MICH. L. REV. 1651, 1711 (2001) ("Perhaps the most difficult issue [in a cost-benefit analysis], from the theoretical point of view, involves the selection of the appropriate discount rate.").

17. IRVING FISHER, THE THEORY OF INTEREST 13–14 (1930).

18. *See infra* Part I.

which these other factors influence the discount rate.[19] Some contend that one should not discount nonmonetary "future enjoyments" such as human lives and environmental benefits,[20] essentially advocating a discount rate of zero for such assets.[21] Empirical analysis has not fared much better in producing a consensus. Various experimental studies observed a range of behavioral discount rates too wide to provide any practical guidance,[22] further confirming the challenge in obtaining an appropriate discount rate for use with cost-benefit analysis. In practice, federal agencies vary in selecting discount rates, and even within one agency discount rates may vary from regulation to regulation "for no apparent reason."[23] Because of the theoretical controversy and the practical difficulty in ascertaining the appropriate discount rate, as well as the "extremely erratic" government approach to choosing a discount rate,[24] some scholars have questioned the feasibility and credibility of cost-benefit analysis,[25] noting that even a minute discrepancy in the estimated discount rate can result in a substantial change in the present value of costs and benefits from the distant future.[26]

This Note does not attempt to resolve the controversy surrounding the choice of discount rates or the use of cost-benefit analysis. Instead, it builds on a substantial body of literature that advocates asymmetric discounting—the use of a lower discount rate when computing the net present value of benefits than when computing the net present value of the corresponding costs—and argues that a proper application of asymmetric discount rates will change the inquiry of cost-benefit analysis from "whether to adopt a proposed activity" to "when to adopt." Part I of this Note reviews recent literature on the need for asymmetric discount rates in cost-benefit analysis. It observes that even though scholars disagree on the precise value of the appropriate discount rate, many agree that future costs and benefits must be

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19. *See, e.g.*, Richard W. Parker, *Grading the Government*, 70 U. CHI. L. REV. 1345, 1373 (2003) (disagreeing with the 5% discount rate Dr. Hahn used in his studies and suggesting a discount rate between 2% and 3%). *See also* SUNSTEIN, *supra* note 6, at 83–86.

20. *E.g.*, F.P. Ramsey, *A Mathematical Theory of Saving*, 38 ECON. J. 543, 543 (1928) ("[D]iscount[ing] later enjoyments in comparison with earlier ones . . . is ethically indefensible and arises merely from the weakness of the imagination . . . ."); Richard L. Revesz, *Environmental Regulation, Cost-Benefit Analysis, and the Discounting of Human Lives*, 99 COLUM. L. REV. 941, 987–1009 (1999) (arguing that, in an intergenerational context, one should not discount future life years and environmental benefits).

21. Morrison, *supra* note 5, at 1338–39.

22. *See, e.g.*, Uri Benzion, Amnon Rapoport, & Joseph Yagil, *Discount Rates Inferred from Decisions: An Experimental Study*, 35 MGMT. SCI. 270 (1989) (estimating the discount rate to be between 7.5% and 60%, depending on the time horizon and dollar amount involved); Richard Thaler, *Some Empirical Evidence on Dynamic Inconsistency*, 8 ECON. LETTERS 201, 204 (1981) (finding discount rates ranging from 1% to 345%).

23. Sunstein, *supra* note 16, at 1711–12.

24. *Id.* at 1712.

25. *E.g.*, Amy Sinden, *In Defense of Absolutes: Combating the Politics of Power in Environmental Law*, 90 IOWA L. REV. 1405, 1428–29 (2005).

26. K.J. Arrow et al., *Intertemporal Equity, Discounting, and Economic Efficiency*, *in* CLIMATE CHANGE 1995: ECONOMIC AND SOCIAL DIMENSIONS OF CLIMATE CHANGE 125, 132 (James P. Bruce et al. eds., 1996).

discounted at different rates. Part II then constructs a simple model, consisting of two activities competing for the same resource, and analyzes the consequences of asymmetric discounting under this model. This Part proposes that, to maximize the joint social utility, the resource should be time divided between the competing activities rather than permanently allocated to one or the other. Part III applies this model to nuisance suits between polluters and victims of pollution. This Part argues that, when choosing how to allocate an entitlement to valuable resources between competing parties, courts should consider time dividing the remedy instead of permanently awarding entitlement to one side or the other, as courts traditionally have done. Likewise, the two categories of rules designed to protect entitlements, property rules and liability rules, may also be alternated over time to maximize social utility. Part IV extends the model to augment the traditional economic analysis of federal environmental regulations. It identifies two perhaps unintended consequences of applying asymmetric discount rates in the cost-benefit analysis of federal regulations. First, from a pure utility-maximizing point of view, many federal regulations to which asymmetric discounting is applicable should be adopted neither now nor never, but rather at some point in the future. Second, agencies should adopt progressively more stringent regulations over time in order to maintain a maximum level of social utility.

I. Discounting Benefits at Different Rates

In determining the appropriate discount rate to use with a cost-benefit analysis, the real interest rate approach serves as a starting point. Introductory economics and finance textbooks often illustrate the theory of discounting by using the real interest rate as the discount rate,[27] because under perfect market conditions, rational consumers will "equate their marginal rates of time preference to the rate of interest."[28] Based on this justification, and perhaps partially due to the relative ease in calculating the real interest rate from the return on long-term government bonds, many courts in this country and other common law jurisdictions have adopted the real interest rate approach to discounting future cash flows.[29] This Part provides a brief survey of the large volume of literature that suggests the real interest rate may not be the appropriate discount rate.

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27. *E.g.*, Harvey S. Rosen, Public Finance 240–41 (7th ed. 2005).

28. Agnar Sandmo & Jacques H. Drèze, *Discount Rates for Public Investment in Closed and Open Economies*, 38 Economica 395, 395 (1971).

29. Jones & Laughlin Steel Corp. v. Pfeifer, 462 U.S. 523, 541–42, 548–49 (1983) (noting that Australian and American courts have taken the "real interest rate" approach to discounting, and holding that the use of real interest rate discounting by the trial court cannot be a ground for reversal).

A. *Descriptive Approach*

The real interest rate approach described above is a simplified version of what is commonly referred to as the descriptive approach. "The descriptive approach," as defined by Professor Arrow in his influential 1996 article, "looks at investments in the real world, and sets the discount rate accordingly."[30] Advocates of the descriptive approach "begin[] with evidence from decisions that people and governments actually make" and infer the discount rate from such evidence.[31]

Under the descriptive approach, risky future payoffs must be discounted at a higher rate than risk-free ones. The basic financial principle that "[a] safe dollar is worth more than a risky one"[32] implies that, to be acceptable, risky projects must be able to earn a higher return than safe projects. Under this approach, a risk-adjusted discount rate, consisting of the risk-free discount rate plus a risk premium, is appropriate for evaluating uncertain future benefits.[33] The risk premium component of the risk-adjusted discount rate is further divided into specific risk, the risk associated with the unique characteristics of the future cash flow, and systematic risk, the risk associated with the market as a whole.[34] Because specific risk "stems from the fact that many of the perils that surround an individual company are peculiar to that company,"[35] the discount rate used in calculating the present value of a high-risk cash flow must account for the additional specific risk associated with that cash flow and is therefore higher than that of a low-risk income stream.[36]

Several prominent economists argue that government projects and regulations should be assessed at a low risk premium.[37] This argument has two aspects. First, for any individual government venture, risk is "inevitably pooled and averaged over the entire population of the country in some fashion, . . . without any cost of extra financial transactions."[38] Under proper assumptions, this reason alone implies that "the government should employ no risk premium."[39] Second, because the government is "involved with so

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30. Arrow et al., *supra* note 26, at 132.

31. *Id.* at 131.

32. Richard A. Brealey & Stewart C. Myers, Principles of Corporate Finance 18 (6th ed. 2000) (emphasis omitted).

33. *Id.* at 244.

34. *Id.* at 167 nn.19–20.

35. *Id.* at 167.

36. "The risk-adjusted discount rate adjusts for both time and risk." *Id.* at 244. Alternatively, one could make separate adjustments for risk and time. The certainty-equivalent method first converts a risky future cash flow into a certainty equivalent, then discounts the certainty equivalent flow by the pure time preference. *Id.*

37. *See, e.g.*, Joseph E. Stiglitz, Economics of the Public Sector 290–91 (3d ed. 2000); Kenneth J. Arrow, *Criteria for Social Investment*, 1 Water Resources Res. 1 (1965); Dale W. Jorgenson et al., Discussion, *Principles of Efficiency*, 54 Am. Econ. Rev. 86 (1964).

38. Jorgenson et al., *supra* note 37, at 89.

39. Stiglitz, *supra* note 37, at 291.

many risky ventures, the law of large numbers ensures an aggregate certainty."[40] As Professor Samuelson concludes, "[o]ften, government is one of the 'cheapest' ways of providing insurance against important risks."[41]

Another branch of the descriptive approach to discount rates focuses on distortions in the economy. Studies have shown that, under certain assumptions, distortions such as the corporate income tax "drive[] a wedge between" the discount rate facing consumers and the discount rate facing private investors.[42] As a result, the discount rate applicable to private investment is higher than that for consumption. The presence of distortions in the economy leads to yet another argument in favor of assigning a lower discount rate to government activities than to private investment. Because the discount rate under the descriptive approach is essentially the opportunity cost of capital, the discount rate of government projects should be equal to the opportunity cost of the private consumption and investment they displace.[43] The resulting government discount rate is thus a weighted average of the consumption discount rate and the tax-distorted investment discount rate, and therefore should be lower than that of the private investment discount rate.[44]

B. *Prescriptive Approach*

Unlike the descriptive approach, the prescriptive approach to discounting does not base the discount rate on the time preference revealed by individual and government actions.[45] Advocates of this approach argue that market imperfections and governmental intervention make market interest rates a poor indicator of marginal tradeoffs to society.[46] Instead, this approach begins with a social welfare function constructed from ethical principles to guide the selection of an appropriate discount rate and to reflect society's views concerning tradeoffs in evaluating public and private activities.[47]

Under the prescriptive approach, future benefits involving nonmonetary assets, such as human lives and the environment, generally enjoy a lower discount rate than financial assets. Neither of the two reasons for discounting

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40. Arrow, *supra* note 37, at 7.

41. Jorgenson et al., *supra* note 37, at 96. Such position, however, is not without opposition. For example, Professors Bailey and Jensen argue that the allowance for risk should be greater for government projects because efficient allocation of risk bearing is usually more difficult for government projects than it is for private ones. *See* Martin J. Bailey & Michael C. Jensen, *Risk and the Discount Rate for Public Investment*, *in* STUDIES IN THE THEORY OF CAPITAL MARKETS 269, 269 (Michael C. Jensen ed., 1972).

42. David F. Burgess, *Complementarity and the Discount Rate for Public Investment*, 103 Q.J. ECON. 527, 530 (1988).

43. ROSEN, *supra* note 27, at 247–48.

44. Arrow et al., *supra* note 26, at 135.

45. *See* Daniel A. Farber, *From Here to Eternity: Environmental Law and Future Generations*, 2003 U. ILL. L. REV. 289, 298 n.45 (2003).

46. Arrow et al., *supra* note 26, at 131.

47. *Id.*

future cash flows, opportunity cost of capital and pure time preference,[48] is relevant in a nonmonetary context.[49] As Professor Sunstein illustrates, one cannot extend the opportunity cost of capital argument to justify the discounting of a future human life, because "it cannot plausibly be urged that . . . a current life saved can be immediately 'invested.' "[50] Furthermore, discounting based on pure time preference in an intergenerational context presents serious moral problems, because "the death of a 35-year-old in 2004 does not seem worth more than the death of a 35-year-old in 2044."[51] For these reasons, Professor Revesz suggests that different discount rates should apply to two separate types of harms. When considering latent harms that will occur within an individual's lifetime, a positive discount rate is appropriate, but future benefits derived from the prevention of such latent harms should be discounted at a lower rate than the private rate of return.[52] On the other hand, when considering harms to future generations, the "use of discounting . . . is ethically unjustified."[53] If one generation imposes the externalities of its activities on the next, "[i]t would be difficult to construct an attractive ethical theory that privilege[s] [a person in an earlier generation] merely because she lived fifty years earlier."[54] Similarly, scholars have advocated adopting a lower discount rate when evaluating the benefits of environmental regulations, even though they do not agree on the appropriate extent of the downward adjustment.[55]

Despite the disagreement among scholars as to the correct approach for selecting a discount rate, they concur on one point. Advocates of both the prescriptive and descriptive approaches agree that there is not a single discount rate that applies universally to all future costs and benefits. The appropriate choice of discount rate should reflect a variety of factors, including risk and social preference. In sum, scholars generally agree that the discount rate should be adjusted upward when evaluating high-risk cash flows or private investment and downward when evaluating future consumption, benefits of government projects, and future nonmonetary assets such as human lives and the natural environment.

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48. *See supra* text accompanying note 9.

49. SUNSTEIN, *supra* note 6, at 84.

50. *Id.*

51. *Id.*

52. Revesz, *supra* note 20, at 947 ("[I]t is necessary to discount [latent harms] . . . . [However,] such discounting must be accompanied by countervailing upward adjustments . . . .").

53. *Id.*

54. *Id.* at 998.

55. *See, e.g.*, Donohue, *supra* note 15, at 1906 (agreeing with Professor Heinzerling, *supra* note 15, that the rate of return in the private sector is too high a discount rate for environmental regulations but disagreeing with her that environmental regulations should not be discounted at all); Heinzerling, *supra* note 15, at 2069.

II. Modeling Net Present Value over Time

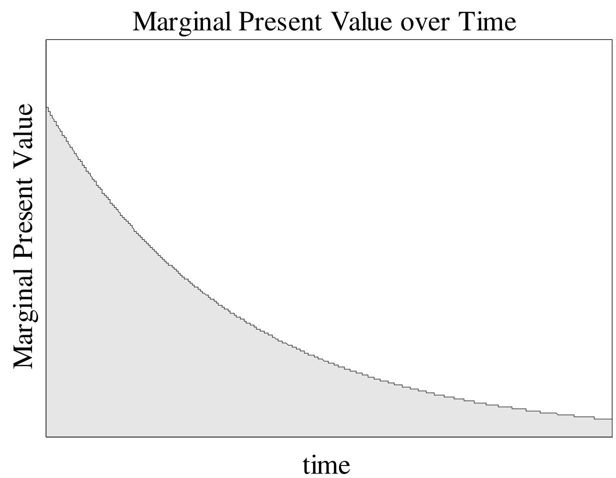
This Part proposes a novel approach, the Marginal Net Present Value ("M-NPV") model, to evaluate the implications of discounting competing activities at different rates. Section II.A introduces a simple model[56] of two activities that compete for the same resource and analyzes the utility-maximizing resource allocation resulting from the use of different discount rates when evaluating the future benefits of these activities. Section II.B generalizes the model in Section II.A into the M-NPV model, which, in evaluating the economic efficiency of adopting an activity, asks the question of "when" instead of "if." Section II.B identifies three possible utility-maximizing outcomes under the M-NPV model and outlines the conditions that would lead to each of these outcomes. Section II.C discusses and rejects the potential criticism that the M-NPV model will lead to an infinite series of postponements. It argues that the infinite postponement paradox is a result of an erroneous assumption that the relative prices of future benefits will remain unchanged over time. This assumption is fundamentally inconsistent with asymmetric discounting. Section II.C concludes by proposing an alternative formulation of the asymmetric discounting problem to make separate adjustments for pure time preference and changes in relative value.

A. *A First Model with Asymmetric Discount Rates*

For analytical simplicity, let us assume that an activity, once adopted, will generate a continuous and perpetual stream of constant annual benefits of b_1, unadjusted for risk, in an inflation-free economy ("Stream 1"). Given any constant discount rate r_1, we can compute the present value of this benefit stream, represented by the shaded region in Figure 1.

56. For a mathematical statement of this model, see *infra* Appendix.

FIGURE 1
THE MARGINAL PRESENT VALUE OF A SINGLE BENEFIT STREAM OVER TIME



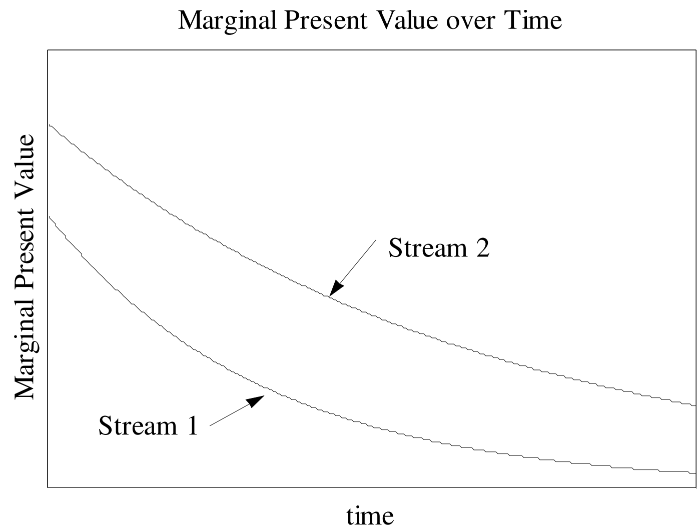
Further assume that another activity generates a second stream of benefits ("Stream 2"). In addition to applying to the second benefit stream the assumptions stated for the first benefit stream, we further assume that the appropriate discount rate for the second stream, r_2, is always lower than r_1.[57] We label the amount of recurring benefits of this stream as b_2.

Using the assumptions above, the rest of this Section attempts to answer the following question: if the two activities are mutually exclusive—that is, to pursue one we must forego the other—which one should we choose? Because the two benefit streams are mutually exclusive, one becomes the opportunity cost of the other, and we must perform a cost-benefit analysis to determine the utility-maximizing outcome.

To answer this question, we must first determine which stream generates a higher annual benefit. Because both streams generate a constant annual benefit, if Stream 2 generates a higher annual benefit and its future benefits are simultaneously discounted at a lower rate, that is, $b_2>b_1$ and $r_2<r_1$, then the present value of Stream 2 must be higher than that of Stream 1. Furthermore, Stream 2's marginal present value over time is always higher than the marginal present value of Stream 1, as shown in Figure 2. There is little doubt that Stream 2 is the preferred stream in this case.

57. $r_2<r_1$ if r_1 and r_2 are constant over time.

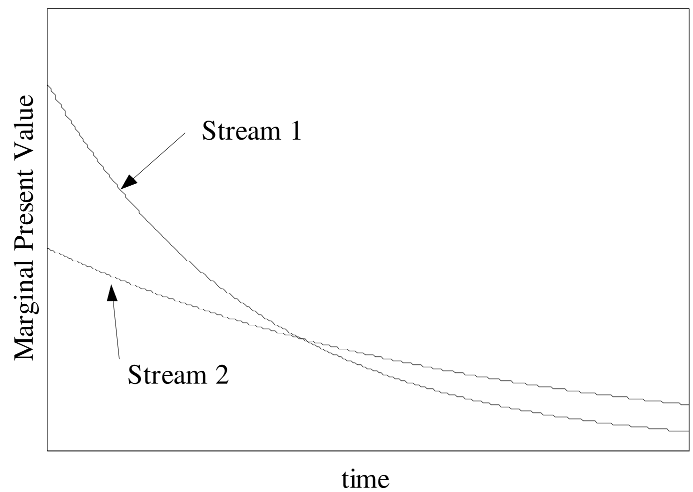
FIGURE 2
THE MARGINAL PRESENT VALUE OF TWO BENEFIT STREAMS OVER TIME. STREAM 2'S ANNUAL BENEFIT IS HIGHER THAN THAT OF STREAM 1 AND IS DISCOUNTED AT A LOWER RATE THAN STREAM 1.



But if Stream 1 generates a higher annual benefit than Stream 2, that is, $b_2<b_1$ and $r_2<r_1$, as shown in Figure 3, the optimal choice becomes less evident. The marginal present value of Stream 1 is greater than that of Stream 2 only until a certain point in the future, and it is not obvious which stream has a higher total present value.

The NPV approach to cost-benefit analysis appears to provide a solution: because the benefits generated by one stream are the opportunity cost of the other, we can simply compute the present value for each benefit stream and choose the one with the higher present value, such that the net present value of that stream, computed as its present value minus the present value of the opportunity cost, is positive.

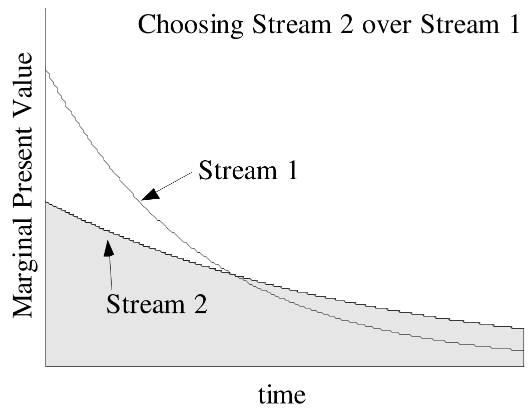
FIGURE 3
STREAM 2'S ANNUAL BENEFIT IS
LOWER THAN THAT OF STREAM 1 BUT IS ALSO
DISCOUNTED AT A LOWER RATE THAN IS STREAM 1.

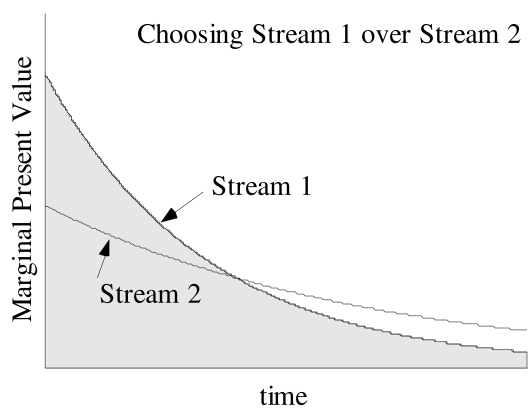


Given constant annual benefits, if the difference between the two discount rates is large enough, then the present value of Stream 2 will exceed the present value of Stream 1, and we should choose Stream 2,[58] as shown in Figure 4. Likewise, if the difference between the two discount rates is not as large as in the example above, then the present value of Stream 1 will exceed the present value of Stream 2, and we should choose Stream 1, as shown in Figure 5.

58. For a mathematical proof, see *infra* Appendix.

FIGURES 4 AND 5
CHOOSING ONE STREAM OVER ANOTHER

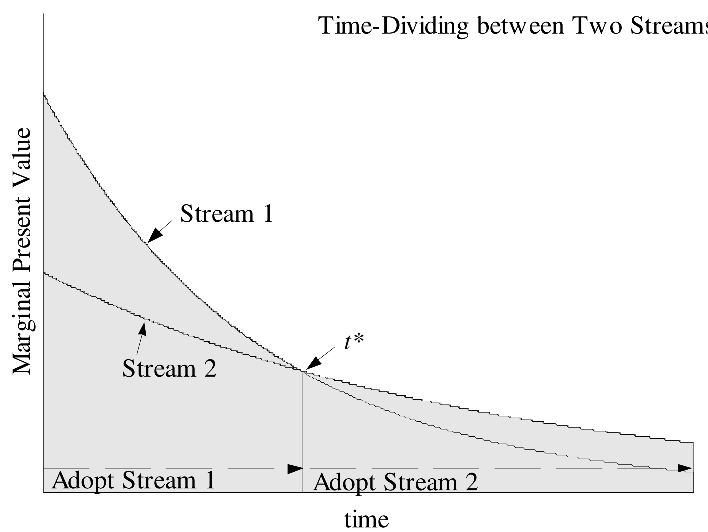




A closer look at the NPV approach reveals a problem. Because Stream 1 generates a higher annual benefit than Stream 2 but is also discounted at a higher rate, there is a certain point in the future, t^*, where the present value of the marginal benefit of Stream 1 becomes equal to that of Stream 2 and, beyond that point, smaller than that of Stream 2. This point is the intersection of the two curves in Figures 4 and 5. Assume that we have chosen Stream 1 over Stream 2 because this choice results in a positive net present value; we then notice that the positive net present value accrued up to t^* is partially offset by the negative net present value accrued after that point. In the extreme case where the net present value of adopting either stream is zero, the positive net present value accrued before the two curves intersect is entirely offset by the negative net present value accrued after the intersection.

A better solution under such circumstances is to adopt the two mutually exclusive activities in turn: first, Stream 1, up to the point t^*, followed by Stream 2. Adopting Stream 1 before t^* builds up a positive net present value: the marginal present value of Stream 1's benefits remains greater than that of Stream 2 before t^*. Following Stream 1 beyond t^*, however, will result in this positive net present value being gradually eroded by the negative buildup of Stream 1's net present value, as shown above in Figure 5. After t^*, the marginal present value of Stream 1's benefits is less than that of Stream 2, its opportunity cost. We therefore switch to Stream 2 at that point and continue the buildup of net present value, as shown in Figure 6.

FIGURE 6
THE OPTIMAL COURSE OF ACTION: ADOPT STREAM 1 UNTIL t^*, FOLLOWED BY STREAM 2



Thus, if the annual benefits of Stream 1 are higher than those of Stream 2, and if Stream 1's benefits are discounted at a higher rate, the utility-maximizing course of action is to adopt Stream 1 until the time at which the marginal net present value of each stream is equal and to switch to Stream 2 thereafter.

B. *Ask "When," Not "If": A Marginal Net Present Value Approach*

The simple model presented in Part A reveals an internal inconsistency inherent to the NPV approach of cost-benefit analysis as it is currently practiced. On one hand, the NPV approach looks into the future and discounts future costs and benefits over the time horizon. On the other hand, it disregards the time dimension completely when comparing the discounted values and considers only the question of "if," not "when." This dichotomy can lead to a variety of inefficient decisions. For example, an activity with a negative net present value, if adopted today, will not pass the NPV test under a cost-benefit analysis, but it can nevertheless produce a positive net present value if we defer it for a certain period of time instead of dismissing it altogether. Likewise, an activity with a positive net present value today may yield an even higher net present value if we defer it to the future. Adopting it today simply because it passes the NPV test foregoes the option of adopting it in the future and ultimately fails to maximize the net present value.

To remedy this deficiency in the traditional NPV test, this Note proposes the Marginal Net Present Value model, which asks the broader question of "when" instead of "if." The M-NPV model seeks to maximize the net present value by selecting the optimal point in time, t^*, to adopt the activity instead of determining whether the proposed activity will generate a positive net present value. This optimal time t^* may be zero, indicating that the time to adopt is now; some positive number, indicating that the activity should be deferred for a certain period of time; or infinity, indicating that the proposed activity should not be adopted.

As its name would suggest, the M-NPV model examines the marginal net present value as it changes over time rather than the aggregate net present value. Marginal analysis is a fundamental technique in the study of economics.[59] In the context of supply-demand analysis, economic efficiency occurs when "the marginal benefit associated with producing one more unit of any good equal[s] its marginal cost."[60] That situation produces efficiency because "if the marginal benefit exceeds the marginal cost, society would gain from producing more of the good; and if the marginal benefit was less than the marginal cost, society would gain from reducing production of the good."[61] This logic applies equally to marginal net present value analysis. Due to asymmetric discounting, the present value of the marginal cost ("PVMC") necessarily decreases at a faster rate than does the present value of the marginal benefit ("PVMB"). Thus, if the PVMC of an activity exceeds its PVMB at a certain point, the marginal net present value at that point is negative, and society can avoid accruing this negative value by deferring the activity to a later date. Likewise, if the PVMB of the activity exceeds its PVMC at some future point, society can capture the excess of PVMB over PVMC by adopting the activity at an earlier point. The optimal point at which to adopt the activity, therefore, is when PVMB equals PVMC, that is, when the marginal net present value is zero.

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59. Introductory macroeconomics and microeconomics textbooks typically present marginal analysis in the first chapter as a basic concept in the study of economics. *See, e.g.*, DAVID A. BESANKO & RONALD R. BRAEUTIGAM, MICROECONOMICS 9–11 (2d ed. 2005) (introducing "marginal reasoning" as first of the three key analytical tools in microeconomics); CAMPBELL R. MCCONNELL & STANLEY L. BRUE, MACROECONOMICS 4 (16th ed. 2004) ("The economic perspective focuses largely on *marginal analysis*—comparisons of *marginal benefits* and *marginal costs*.").

60. STIGLITZ, *supra* note 37, at 62.

61. *Id.*

A concrete example helps illustrate this point. Assume, given the model introduced in the previous Section, that Stream 1 represents the benefits derived from maintaining the status quo and Stream 2 represents the benefits derived from adopting a certain proposed activity. Further assume that the present value of future benefits from each stream are equal, so that either maintaining the status quo forever or adopting the proposed activity immediately will produce a net present value of zero. Under the traditional NPV approach, the regulator is indifferent between the two.

M-NPV analysis examines the relationship between the marginal net present value of the proposed activity and the time of adoption, as shown in Figure 7-1. Using M-NPV analysis, a decision maker can observe that there is a certain point in the future, t^*, where the present value of the marginal benefit of Stream 2 will be equal to the present value of the marginal cost, as shown in Figure 7-1. Before this point, the present value of the marginal benefit of maintaining the status quo is greater than the present value of the marginal cost. After this point, the situation is reversed: the marginal net present value of adopting Stream 2 becomes positive. Under M-NPV analysis, adopting Stream 2 at this point will maximize the net present value of the activity, as shown in Figure 7-2. The decision maker should therefore choose to maintain the status quo until t^*, at which point she should adopt the activity whose benefits are represented by Stream 2. NPV analysis, in contrast, only examines the two extreme ends of this curve and is indifferent between adopting Stream 2 now and maintaining the status quo, because both would produce a net present value of zero.

FIGURE 7-1
MARGINAL NET PRESENT VALUE OF STREAM 2 OVER TIME

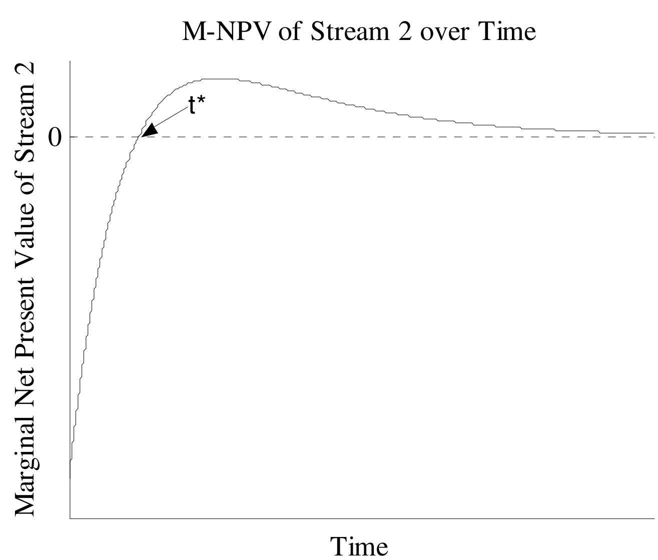
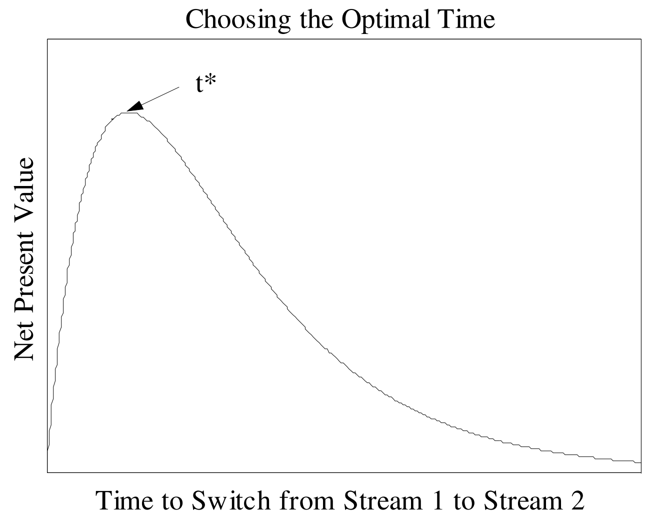


FIGURE 7-2
TOTAL NET PRESENT VALUE AS A FUNCTION OF TIME
FOR STREAM 2'S ADOPTION

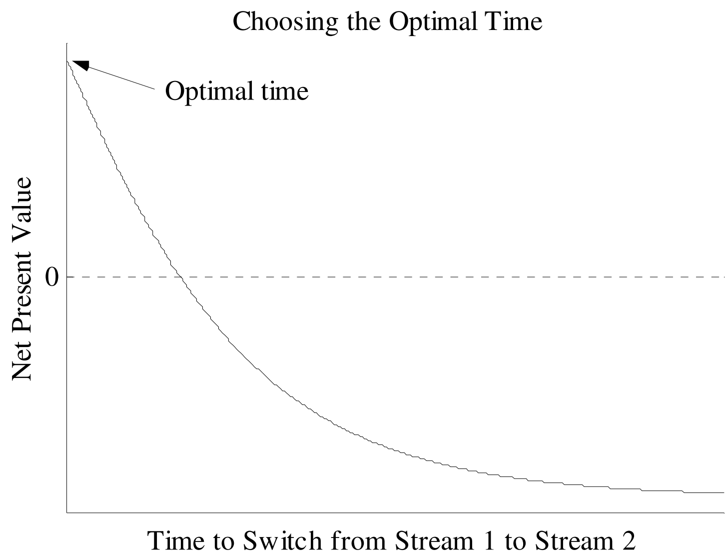


More generally, assuming that Stream 2 is discounted at a lower rate than Stream 1, such that $r_2<r_1$, a cost-benefit analysis applying the M-NPV model will produce one of the following three possible scenarios, depending on whether Stream 2's recurring benefit, b_2, is greater than the recurring benefit of Stream 1, b_1, and on which stream has a larger benefit-to-discount ratio, or *b/r*.[62]

Scenario 1. Immediate adoption of Stream 2 generates a positive net present value, and the net present value decreases as we postpone adoption, as shown in Figure 8-1. This occurs when the recurring benefit of Stream 2 is higher than that of Stream 1, such that $b_2>b_1$.

62. For a mathematical proof of this claim, see *infra* Appendix.

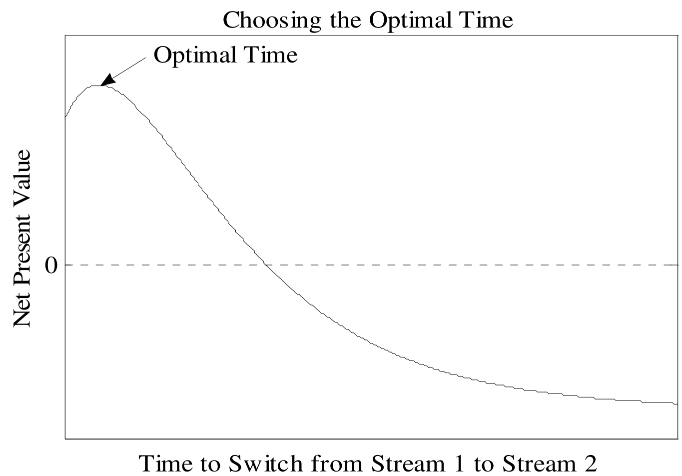
FIGURE 8-1
M-NPV SCENARIO 1: IMMEDIATE ADOPTION



Under the traditional NPV analysis, we should immediately adopt the activity because the net present value for immediate adoption is positive. M-NPV analysis reaches the same result, because immediate adoption yields the highest net present value.

Scenario 2. Immediate adoption of Stream 2 generates a positive net present value, but the net present value increases as we postpone adoption until it reaches a maximum, as shown in Figure 8-2. This occurs when the recurring benefit of Stream 2 is lower than that of Stream 1, such that $b_2 < b_1$, and the ratio between b_2 and r_2 is greater than the ratio between b_1 and r_1, such that $b_2 / r_2 > b_1 / r_1$).

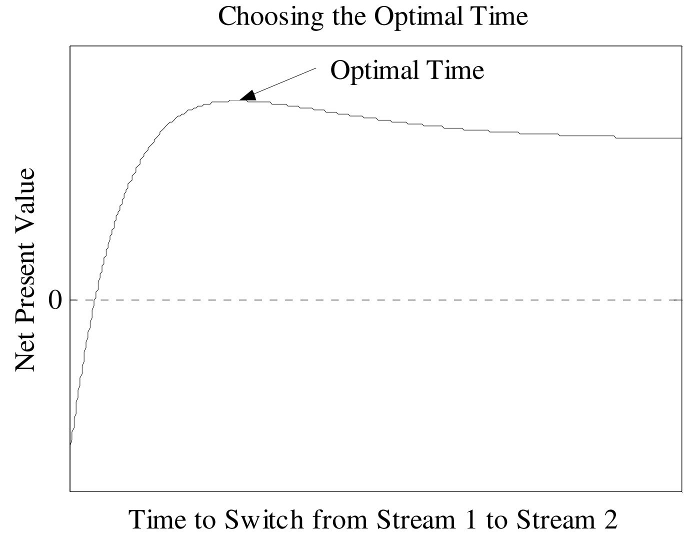
FIGURE 8-2
M-NPV SCENARIO 2: POSITIVE NPV, DEFERRED ADOPTION



The proposed activity passes the traditional NPV test and, therefore, will be adopted immediately. The M-NPV model, however, identifies a future date of adoption that would further increase the net present value. Accordingly, the activity will still be adopted under the M-NPV model but will be deferred until a future date.

Scenario 3. Immediate adoption of Stream 2 generates a negative net present value, but thereafter the net present value increases, reaching a positive maximum point before declining again, as shown in Figure 8-3. This occurs when the recurring benefit of Stream 2 is lower than that of Stream 1, such that $b_2 < b_1$, and the ratio between b_2 and r_2 is less than the ratio between b_1 and r_1 ($b_2 / r_2 < b_1 / r_1$).

FIGURE 8-3
M-NPV SCENARIO 3: NEGATIVE NPV, DEFERRED ADOPTION



Instead of treating the proposed activity as worthless because immediate adoption produces a negative net present value, M-NPV analysis suggests that the activity should be adopted at a certain time in the future, at which point the present value is both positive and maximized.[63]

C. *Achilles and the Tortoise: The Paradox of Infinite Postponement*

The simple intuition that one should postpone an activity until the time when it becomes more valuable than its alternative is hardly new. One reason that this intuition, as it relates to the theory and practice of asymmetric discounting, has not received the attention it deserves may lie in the fact that some scholars who previously discussed this intuition went on to conclude that the first postponement would set off a chain reaction, leading inevitably to an infinite series of postponements.[64] They criticized the theory of asymmetric discounting based on the "absurd consequences that would inexorably follow if discounting was not performed [on both sides of the cost-benefit analysis]."[65] Their reasoning, as summarized by Professor Revesz in the environmental law context, is that:

> [I]nstead of undertaking the environmental program, one could invest the funds in an alternative project, watch the investment grow, and then address the environmental problem at some time in the future. At this future

63. For a formal proof of this claim, see *infra* Appendix.

64. *See* Revesz, *supra* note 20, at 988–90 (summarizing the arguments of scholars who believe that an initial postponement will recursively lead to an infinite number of future postponements).

65. *Id.* at 988.

> time, moreover, one would engage in the same calculus and decide to postpone the environmental expenditure once more.[66]

Professor Revesz further observed that this argument turns the view that asymmetric discounting makes environmental programs more desirable "on its head" because asymmetric discounting would be environmentally undesirable if environmental programs must be postponed forever as a result.[67]

Stripped of its environmental context, the argument that asymmetric discounting will delay a project forever may also cast some doubt over the M-NPV model presented above. Given the simple model introduced in Section II.A, one might suggest that, instead of switching from Stream 1 to Stream 2 at time t^*, the decision maker should reapply the model at time t^* and decide to further delay the adoption of Stream 2 until time $2t^*$. At first glance, this argument seems logical. Assume that Streams 1 and 2 are constant and perpetually recurring benefit streams, that they yield annual benefits of $12 million and one human life saved, respectively, and that Stream 2 is discounted at a lower rate than Stream 1. Further assume that the value of a statistical human life is $6 million.[68] Suppose we decide in Year 1 that the utility-maximizing course of action is to adopt Stream 1 immediately and to switch to Stream 2 in Year 20. In Year 20, however, we are faced with the exact same utility-maximizing problem as in Year 1. The benefit streams are still assumed to be constant. Stream 1 will still produce $12 million each year and continue to appear more desirable than Stream 2. Stream 2 will still save one life per year and should still be postponed for another 20 years, now until Year 40. By repeating this process an infinite number of times, the decision maker will never adopt Stream 2. This exercise of *reductio ad absurdum* resembles "Achilles and the Tortoise," one of the well-known Zeno's paradoxes.[69] Each attempts to prove the nonoccurrence of an event by arguing that it will not happen within a limited time and applying this argument recursively for all future time frames. The fallacy in "Achilles and the Tortoise" has long been recognized and explained.[70] The fallacy in its modern incarnation will be explored in the remainder of this Section.

Working within the environmental context, Professor Revesz gave two explanations why environmental projects need not be postponed indefinitely under asymmetric discounting.[71] First, he observed that the costs and benefits of environmental programs in the real world will change over time and that "one cannot merely perform a static calculation of the magnitude of

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66. *Id.* at 989.

67. *Id.*

68. *See infra* note 145 and accompanying text.

69. Zeno's "Achilles and the Tortoise" paradox states that "the slowest thing will never be caught up by the quickest; for the pursuer has first to arrive at the point from which the pursued has started, so that the slower is always ahead." ARISTOTLE'S PHYSICS 416 (W.D. Ross ed., Oxford Univ. Press 1936).

70. "The claim that that which is ahead is not caught up is false; it is not caught up when it is ahead, but it *is* caught up, if one allows that a finite line can be traversed to the end." *Id.*

71. Revesz, *supra* note 20, at 990–92.

costs and damages on a particular date."[72] Instead, certain environmental projects must be adopted immediately to avoid irreversible damage to the environment or even catastrophic consequences.[73] Second, "difficulties concerning the transfer of resources across projects" favor adopting certain projects immediately rather than switching to them only after exhausting other higher-yield projects first.[74]

Professor Revesz's argument, while powerful, does not explain how the M-NPV model avoids the infinite postponement paradox. By arguing that many environmental projects should be adopted now rather than later, Professor Revesz stops the chain-of-postponement reasoning *before* its first iteration. The M-NPV model, in contrast, suggests that immediate adoption is desirable only under Scenario 1. For the other two scenarios, the M-NPV model suggests that there should be an initial postponement. A justification for the M-NPV model must explain how the seemingly infinite chain will be broken *after* its first link.

Nor do Professor Revesz's arguments imply that the M-NPV model reaches the wrong result in concluding that there should be an initial postponement in Scenarios 2 and 3. Professor Revesz argues that the costs and benefits of "many environmental problems" may change over time,[75] thereby negating one of the basic assumptions made by the M-NPV model. As an initial inquiry into the theory of asymmetric discounting, the M-NPV model assumes constant benefit streams in order to better understand these most basic cost-benefit structures. This assumption is both reasonable and necessary given that many environmental programs have a relatively stable cost and benefit structure in the long term. Second, the cost-to-transfer argument[76] implicitly assumes that postponing an activity until a later time will necessitate a transfer in the future, while immediate adoption does not require a transfer of resources at the present. This assumption may not hold for the type of problems the M-NPV model attempts to address. For example, if resources are initially located in the manufacturing industry and a policymaker is considering whether to adopt a regulation to shift these resources elsewhere, perhaps as an environmental investment, she will face the same cost-to-transfer issue regardless of whether she initiates the transfer now or later.

The fallacy of the infinite postponement paradox lies in a misunderstanding of the nature of asymmetric discounting. By adopting a lower discount rate for a certain type of benefits, a decision maker is essentially

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72. *Id.* at 990.

73. *Id.* at 990–91.

74. *Id.* at 991–92.

75. *Id.* at 990. It appears that Professor Revesz limited the scope of his argument by stating that "[t]his assumption, [that costs and benefits will remain unchanged over time], is inconsistent with the structure of *many* environmental problems." *Id.* (emphasis added). It remains unclear why this assumption may not be applicable to other environmental problems that do have relatively stable costs and benefits in the long term.

76. *See supra* note 74 and accompanying text.

expressing her prediction, either descriptively or prescriptively, that these benefits will rise in value over time relative to other types of benefits; discounting them at the normal discount rate will not reflect this change in relative value and will improperly undervalue these benefits in the future.[77] It is therefore illogical to assume that the decision maker in Year t^* will use the relative value of Stream 2 benefits from Year 1 and make the same decision to postpone the adoption once again. This gradual change in the relative value of the benefits produced by the two streams does not contradict our basic assumption that these benefit streams remain constant over time. Each of the two streams will produce an annual benefit that remains unchanged when compared to its own historical values, yet the relative value of each stream will change by the very nature of asymmetric discounting.

To help illustrate this point, consider once again the example from above where Stream 1 produces $12 million per year and Stream 2 saves one life per year, with the value of a statistical life currently set at $6 million.[78] The reason we use a lower discount rate for the value of human lives is because a regular discount rate will grossly underestimate the value of a human life in the future, in either the descriptive sense or the prescriptive sense. In other words, the current rate of $6 million per statistical life is too low for future purposes. Therefore, asymmetric discounting necessarily predicts that the value of a human life, relative to financial assets, will gradually increase over time until it rises to $12 million in Year 20. After that point, although the benefits produced by Stream 1 and Stream 2 remain unchanged at $12 million and one human life, respectively, one human life will be worth more than $12 million, and we should switch to Stream 2. The infinite postponement argument fails when it ignores the prediction implied by the very nature of asymmetric discounting and mistakenly assumes that the relative values set in Year 1 will still apply in Year 20.

The discussion above reveals a functional equivalent of asymmetric discounting: we may apply a uniform discount rate, r, to all benefits but gradually raise the price tag of certain resources at some annual rate, g, to account for our prediction that these benefits will be undervalued relative to others if discounted at the regular rate. The result is the same: the annual growth rate in relative value, g, partially offsets the effect of the uniform discount rate r. The effective discount rate for these resources would then become r-g, which is lower than the regular rate r applicable to other resources and potentially zero if g equals r. This formulation better captures the underlying rationale of asymmetric discounting by embodying our prediction that certain resources will become more valuable in the future relative to others. Like the certainty-equivalent method, which makes separate adjustments for risk and time when discounting risky future cash flows,[79] this formulation also decouples discounting for pure time preference

77. *See supra* Part I.A-B.

78. *See supra* note 68 and accompanying text.

79. *See supra* note 36.

from adjusting for changes in relative value. With this alternative expression of the idea of asymmetric discounting, the infinite postponement paradox becomes even less perplexing. No longer will the increase in relative value have to be deduced from an exercise of logical reasoning—it is explicitly stated in the formulation of the problem.

III. The M-NPV Model and Nuisance Remedies: A Case Study

This Part applies the M-NPV model to nuisance cases arising out of incompatible land uses and concludes that a suspended injunction is the utility-maximizing resolution of such disputes. Section III.A briefly reviews existing literature on entitlement assignment and rules of protection in these nuisance cases. Section III.B examines one such case, *Boomer v. Atlantic Cement Co.*,[80] in which the court considered whether to award the plaintiffs a temporary injunction followed by permanent damages or vice versa. Section III.C applies the M-NPV model and argues that, in a case such as *Boomer*, the entitlement first should be awarded to the polluter for a number of years and then should be permanently awarded to the victims of pollution. Section III.D further argues that victims should be protected first by a liability rule and then, once the entitlement shifts, by a property rule.

A. *The Cathedral Revisited: Entitlement and Rules of Protection*

In a nuisance case between a polluter and neighboring residents, most courts use a two-step analysis. First, the court decides who has the entitlement: that is, whether the polluter is entitled to pollute or the residents are entitled to a pollution-free neighborhood. Then, the court makes a series of "difficult second order decisions"[81] in which the court decides whether to protect the entitlement established in the previous step with a property rule or a liability rule.[82] There are four possible outcomes in such a pollution case, as categorized by Professor Calabresi and Mr. Melamed and summarized by Professors Krier and Schwab. A court can (1) protect the residents with a property rule by issuing an injunction against the polluter, (2) protect the residents with a liability rule by finding a nuisance but limiting the remedy to damages, (3) protect the polluter with a property rule by finding that the pollution is not a nuisance and permitting the polluter to continue, or

80. 257 N.E.2d 870 (N.Y. 1970).

81. Guido Calabresi & A. Douglas Melamed, *Property Rules, Liability Rules, and Inalienability: One View of the Cathedral*, 85 Harv. L. Rev. 1089, 1092 (1972).

82. *Id.* A property rule applies when "someone who wishes to remove the entitlement from its holder must buy it from him in a voluntary transaction." *Id.* An entitlement is protected by a liability rule when "someone may destroy the initial entitlement if he is willing to pay an objectively determined value for it." *Id.*

(4) protect the polluter with a liability rule by ordering the neighbors to pay the polluter "damages" for discontinuing the polluting activity.[83]

The initial assignment of entitlement depends on the parties' valuation of the entitlement and the identification of the "cheapest cost avoider."[84] If the residents value their right to a pollution-free neighborhood more than the polluter values the right to pollute, then the residents should have the entitlement, and vice versa. From society's point of view, this is the "cost-minimizing or value-maximizing"[85] allocation.

Once the court initially allocates the entitlement, the choice between property rules (rules 1 and 3) and liability rules (rules 2 and 4) largely turns on the level of transaction costs anticipated in transferring an entitlement protected by a property rule. If transaction costs are insignificant, then the court should use a property rule to resolve the dispute. That is, even if the court makes an economically inefficient decision by awarding the entitlement to the party that values it the least, because subsequent voluntary negotiation can transfer the entitlement to the party that values it the most, an efficient outcome will result regardless of the initial allocation of the entitlement.[86] On the other hand, if the transaction costs are high—either due to the hold-out and free-rider problems[87] in multi-party negotiations or because of the strategic behavior induced by bilateral monopoly in a two-party suit[88]—the court should instead use a liability rule to ensure an efficient outcome.[89] The drawback of a liability rule, when compared to a property rule, is that the court must determine the efficient outcome. Due to the practical difficulties in gauging an individual's true valuation of an asset, this determination may involve significant assessment costs and "may result in over or under compensation."[90]

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83. James E. Krier & Stewart J. Schwab, *Property Rules and Liability Rules: The Cathedral in Another Light*, 70 N.Y.U. L. REV. 440, 443–44 (1995). *See also* Calabresi & Melamed, *supra* note 81, at 1119–20.

84. Krier & Schwab, *supra* note 83, at 448.

85. *Id.*

86. *Id.* at 450–51.

87. The hold-out problem refers to the phenomenon where one party to a transaction negotiates a purchase from multiple parties on the other side in order to complete the transaction so that each party on the other side has a de facto veto power and will attempt to extract an exorbitant price. *See* RICHARD A. POSNER, ECONOMIC ANALYSIS OF LAW 61 (6th ed. 2003). The free-rider problem occurs when multiple parties negotiate a purchase and each party has the incentive to contribute less than his fair share of the purchase price. *See id.*

88. *See* Ward Farnsworth, *Do Parties to Nuisance Cases Bargain After Judgment: A Glimpse Inside the Cathedral*, 66 U. CHI. L. REV. 373, 378 (1999). Bilateral monopoly refers to the high transaction costs that arise when "neither party has good alternatives to dealing with the other" in a two-party transaction. POSNER, *supra* note 87, at 60. The transaction costs may be high because if "there is a range of prices within which each party will prefer settlement to the more costly alternative of litigation," then "each party may be so determined to engross the greater part of the potential profits from the transaction that they never succeed in coming to terms." *Id.* at 60–61.

89. Krier & Schwab, *supra* note 83, at 450–51.

90. Calabresi & Melamed, *supra* note 81, at 1108.

B. *Time-Dividing Rules and Entitlement: The* Boomer *Case*

The choice between liability and property rules does not have to follow an all-or-nothing scheme. At least one court has considered the possibility of time dividing the protection of an entitlement between liability and property rules. In *Boomer v. Atlantic Cement Co.*,[91] a group of landowners sought an injunction against a nearby cement plant for emitting dust and conducting excessive blasting. Noting that "[t]he total damage to plaintiffs' properties is . . . relatively small in comparison with the value of defendant's operation and with the consequences of the injunction which plaintiffs seek,"[92] the court granted an injunction against the cement plant, to be lifted if and when it paid permanent damages to the residents.[93] This "disparity in economic consequences,"[94] a classic cause of bilateral monopoly and other strategic behavior that leads to high transaction costs, calls for a direct application of rule 2 as identified by Professor Calabresi and Mr. Melamed—protecting the residents with a liability rule by limiting their remedy to damages only.[95] Indeed, the trial court's decision to deny the injunction appears to have been based primarily on this ground.[96] Feeling constrained by the well-established doctrine that "where a nuisance has been found and where there has been any substantial damage shown by the party complaining an injunction will be granted,"[97] the Court of Appeals adopted a solution that was arguably a time-divided combination of property and liability rules. The court's holding initially protected the residents with a property rule by granting the injunction and subsequently protected the residents with a liability rule by allowing the polluter to pay permanent damages in order to remove the injunction.[98]

In addition to the time division between liability and property rules, the *Boomer* court also considered the possibility of time dividing the entitlement. The alternative contemplated by the court was "to grant the injunction but postpone its effect to a specified future date to give opportunity for technical advances to permit defendant to eliminate the nuisance,"[99] effectively

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91. 257 N.E.2d 870 (N.Y. 1970).

92. *Id.* at 872.

93. *Id.* at 875.

94. *Id.* at 872.

95. *See supra* note 83 and accompanying text.

96. *Boomer*, 257 N.E.2d at 872. This economic disparity in favor of the cement plant, however, also seems to imply that rule 3 as identified by Professor Calabresi and Mr. Melamed, a property rule, may be appropriate, at least from a pure economic-efficiency point of view, because if the court can ascertain that the cement plant values the entitlement more and that the residents are the cheapest cost avoiders, it can deny any remedies and permit the cement plant to continue to operate. *See supra* note 83 and accompanying text.

97. *Boomer*, 257 N.E.2d at 872.

98. *Id.* at 875 ("[T]he cases [should be] remitted to Supreme Court, Albany County to grant an injunction which shall be vacated upon payment by defendant of such amounts of permanent damage to the respective plaintiffs . . . .").

99. *Id.* at 873.

granting the entitlement first to the polluter until a future date after which the entitlement would shift to the residents. This approach appears attractive because it nominally adheres to the rule that the court should enjoin a nuisance "whenever the damage resulting from [the] nuisance is found not 'unsubstantial' "[100] and implicitly appeals to the intuition that the entitlement should be given to the party who values it more.[101] The court, however, dismissed this alternative as impracticable because "there would be no assurance that any significant technical improvement would occur" within any specified time period.[102]

C. *M-NPV Step 1: Who Gets the Entitlement, and at What Time?*

In this Section and the next, this Note applies the M-NPV model to the *Boomer* case and attempts to derive the utility-maximizing remedy. As will be clear from the analysis below, the remedy awarded by the *Boomer* court is the less efficient of the two alternatives it considered. A better remedy would have been to award temporary damages to the plaintiffs followed by a permanent injunction.

From an economic efficiency point of view, proper assignment of an entitlement depends on the parties' valuation of that entitlement. In turn, inquiring how much a party values an entitlement necessarily entails the question of what future benefits the entitlement will bring to that party and how to discount them. As with any other financial asset, the value of the entitlement to the cement plant in *Boomer* is determined by discounting to present value and summing up all future benefits, in this case the annual profits anticipated from its operation because without this entitlement the plant would be required to "close down . . . at once."[103] Therefore, the value of the permanent entitlement to produce pollution is equal to the present value of the future stream of the cement plant's profits. The trial court did not make any express determination as to the exact amount of such profits but noted that the defendant invested more than $40 million in the plant,[104] a fact mentioned again in the Court of Appeals opinion.[105] This figure is very likely intended to suggest the magnitude of the cement plant's annual profits when compared to the plaintiffs' damages. Even at a modest 7% to 8% annual rate of return, the plant likely had an annual profit of $3 million.

Likewise, the value of the entitlement to the residents is also determined by discounting to present value all future benefits derived from a pollution-free home. The *Boomer* court suggested that the value of this entitlement is

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100. *Id.* at 872.

101. *See supra* note 84 and accompanying text.

102. *Boomer*, 257 N.E.2d at 873.

103. *Id.*

104. Boomer v. Atl. Cement Co., 287 N.Y.S.2d 112, 113 (N.Y. Sup. Ct. 1967). Unless otherwise indicated, the term "*Boomer* court" refers to the New York Court of Appeals and the appellate opinion.

105. *Boomer*, 257 N.E.2d at 873 n.*.

equal to the "permanent depreciation of [the] value of affected property"[106] without the entitlement. At first glance, this suggestion does not involve any discounting because the depreciation in property value is simply the difference between the present price of the affected property and the present price of the same property if there were no nuisance. Upon closer look, however, the price of real property, like any other asset, is determined by discounting and aggregating all future benefits derived from the property. Depreciation in property value is in essence determined by discounting all future nuisance-induced loss of benefits, such as discomfort, loss of enjoyment, or loss of rental income, to present value. The *Boomer* court apparently agreed, as it described "permanent damages" as " 'present, past and future' " damages.[107] Therefore, the value of the entitlement to the residents is the present value of the stream of annual benefits, which is the difference between the amount of enjoyment residents derive from a pollution-free home and a home affected by the nuisance. The trial court in *Boomer* found this value to be $185,000,[108] less than one-tenth of the likely *annual* value of the entitlement to the cement plant.

Under a traditional NPV model, the entitlement analysis ends here. The polluter values the right to pollute much more than the residents value the right to enjoin pollution; accordingly, the polluter receives the entitlement because the residents are the cheapest cost avoiders. In contrast, the M-NPV model asks one further question in analyzing the valuation of the entitlement: what discount rates are used in calculating the present values of the entitlement? As demonstrated in Part II, if one discount rate is higher than the other, and if the annual benefit of the corresponding benefit stream is higher than that of the other benefit stream, the M-NPV model produces a different outcome than the NPV model.

Under the descriptive approach, the discount rate applicable to the cement plant should be higher than that applicable to the residents. First, the cement plant faces a higher degree of risk than the residents. The inherent volatility of the cement market as well as the speculative nature of the anticipated future profits both add to the risk premium component of the discount rate appropriate to the cement plant's future profits. The cement industry as a whole may become unprofitable for any number of reasons ranging from rising energy costs to competition from abroad, or this particular plant may fail to earn a profit in the future due to poor management. The residents, on the other hand, face a much lower risk. They most likely will have a positive gain from a nuisance-free home over a polluted home as long as the real property exists. Second, the polluter's entitlement itself is

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106. *Id.* at 874.

107. *Id.* (citing N. Ind. Pub. Serv. Co. v. Vesey, 200 N.E. 620, 634 (Ind. 1936)).

108. *Id.* at 873. This is likely too low an estimate. On remand, the defendant settled with all but one of the plaintiffs, and in the remaining case the trial court awarded $175,000 in damages. In the end, the defendant's liability, including the settlements, totaled $710,000. JESSE DUKEMINIER & JAMES E. KRIER, PROPERTY 764 (5th ed. 2002) (citing Daniel A. Farber, *Reassessing* Boomer: *Justice, Efficiency, and Nuisance Law*, *in* PROPERTY LAW AND LEGAL EDUCATION 7 (Peter Hay & Michael H. Hoeflich eds., 1988)).

more exposed to the risk of reduced future value than the resident's entitlement. Public sentiment against pollution and federal environmental regulations both operate as strong incentives for the development of new technologies to reduce pollution. As a result, there is a higher risk to the value of the polluter's entitlement to pollute. As pollution-control technology advances and provides cleaner production techniques, the right to pollute will become less valuable to the cement company. Third, under the "market distortion" theory,[109] individual residents typically discount future values at the consumer rate of time preference, which is lower than that of the private firms due to the "wedge" driven between them by the corporate income tax.

Under the prescriptive approach, residents also should have a lower discount rate than the cement plant. The depreciation in the residents' property value is merely a monetary expression of future nonmonetary damages such as the discomfort caused by dust and noise and the loss of enjoyment of a clean environment. Allowing the cement plant to pollute permanently will affect not only the current generation but generations to come. The discount rate for such nonmonetary damages should reflect the social preference for clean air as well as our moral and ethical obligations to future generations and, accordingly, be lower than the discount rate for financial assets.

Having determined that the cement plant values the entitlement more than the residents and that it also faces a higher discount rate, we observe that the *Boomer* case fits squarely with Scenario 3, as discussed in Part II. In this scenario, the net present value of adopting one activity is negative if it is adopted immediately but increases over time until reaching a positive maximum. Here, Stream 1 represents the cement plant's anticipated future stream of profits from continued operation and emission of pollution while Stream 2 represents the residents' anticipated additional enjoyment from a pollution-free home relative to a home plagued by dust, noise, and vibrations emitted by the cement plant. Stream 1 begins with a higher present value but is also discounted at a higher rate. Both streams have the potential of generating a perpetual income stream.

M-NPV analysis of the *Boomer* case indicates that the court should time divide the entitlement between the parties. Under Scenario 3, the best course of action to maximize social utility is to adopt Stream 1 for a limited period of time and then to adopt Stream 2 permanently. Here, the court should first give the entitlement to the cement plant for a limited period of time and then give the entitlement permanently to the residents. This result is essentially the same as the alternative solution considered by the *Boomer* court but dismissed as impracticable. This result allows lead time and provides an incentive for the cement plant to actively seek or develop technologies to abate pollution. It is also consistent with the intuition that an entitlement should be assigned to whoever values it more—first to the cement plant when it values the entitlement more and then to the residents when the situation is reversed in the future.

109. *See supra* note 42 and accompanying text.

A practical complication that may arise in implementing this solution is the question of how to determine the optimal time to reassign the entitlement to the residents. To calculate the time of reassignment accurately requires knowing the anticipated annual benefit of the cement plant, the value of the additional annual enjoyment the residents derive from a pollution-free home, and the annual discount rates applicable to each benefit stream. The discount rates themselves are difficult to ascertain empirically or theoretically, and, further complicating the matter, both benefit streams may realistically fluctuate from year to year. Additionally, both discount rates will depend on a variety of external factors such as the national economy, the volatility in each respective market, and future government intervention.

The application of the M-NPV model does not have to be a precise science to be an improvement over the NPV model. Even with limited information, a court can still make a reasonable effort at identifying the optimal time of reassignment. In *Boomer*, the traditional result of the entitlement analysis is to assign the entitlement permanently to the polluter. In other words, the time of reassignment is infinity, represented by the far-right end of the curve in Figure 8-3. Starting from infinity and moving left along the curve, the net present value increases as we assign the entitlement to the residents at earlier times until we reach the optimal time of reassignment after which the value declines. In this large interval between infinity and the optimal point, the court has great flexibility and can err on the safe side by using a high estimate of the optimal point of reassignment. Regardless of how high an estimate, the result will improve upon the traditional NPV approach so long as the estimate falls within the interval between the optimal point and infinity. While the eighteen months suggested by the dissent in *Boomer*[110] may fall short of the optimal point and thus seem inadequate, a significantly longer time, say, fifty to a hundred years, could be a rather conservative estimate.[111] An inaccurate estimate of the optimal point is preferable to permanently assigning the entitlement to the polluter. Furthermore, by allowing the judge to choose any date within this large interval, M-NPV analysis also enables the judge to consider equitable principles and policy issues that are impossible or difficult to consider under

110. *Boomer*, 257 N.E.2d at 877 ("I would enjoin the defendant cement company from continuing the discharge of dust particles upon its neighbors' properties unless, within 18 months, the cement company abated this nuisance.") (Jasen, J., dissenting).

111. These numbers are within the range of reasonableness given the facts of *Boomer*. For sake of simplicity, assume that the assets of the cement plant are worth $40 million and that the plant has an annual profit rate of 10% ($4 million annually) and a discount rate of 10%. Further assume that the residents' total damage, expressed in lump sum, is a one-time payment of $1 million, including court-awarded damages and settlements. If the residents face a discount rate of 5% for the lost enjoyment of their residences due to pollution, a lump sum award of $1 million is equivalent to a perpetual income stream of $50,000 per year. The present value of the residents' $50,000 annual income, discounted at 5%, will begin to surpass that of the plant's $4 million annual profits, discounted at 10%, after 83 years. If the residents' discount rate is 3% instead, the time for the present value of their benefits to overtake those of the cement plant is reduced to 67 years.

the rigid rule of permanent assignment of entitlement that apparently constrained the *Boomer* court.[112]

D. *M-NPV Step 2: Protecting the Time-Divided Entitlements*

Once the court has determined the initial location of the entitlement and t^*, the optimal time to reassign the entitlement to the other party, it must then decide whether to protect the entitlement with a property rule or a liability rule.[113]

Between the time of implementation and t^*, a court confronted with a case like *Boomer* should use a liability rule. Because the cement plant values the entitlement more than the residents during this time period, and the potentially high transaction costs between the parties may prevent them from bargaining, a court subscribing to the "virtual doctrine" that "[w]hen transaction costs are low, use property rules; when transaction costs are high, use liability rules,"[114] will order the cement plant to pay damages to the residents and allow it to continue to produce pollution until t^*. As Professors Krier and Schwab note, however, scholars have questioned the wisdom of this "virtual doctrine" given the assessment-cost problem.[115] The cost to "obtain[] and process[] information"[116] in damage calculations may be significant enough that the entitlement may be misplaced due to a miscalculation that is "sufficiently off the mark."[117] In a case like *Boomer*, however, we can be certain that the initial assignment of the entitlement is correct because "the large disparity in economic consequences of the nuisance and of the injunction"[118] makes it highly unlikely that any reasonable error in the calculation of damages would have led to a different allocation of the entitlement. Therefore, given the high transaction costs and low assessment costs, the court should prefer a liability rule.[119]

It is less clear which rule the court should favor to protect the residents for the time period after t^*. Neither of the two characteristics that call for a liability rule—low assessment costs and high transaction costs—is likely to exist in the future with much certainty. Assessment costs increase as we attempt to

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112. *See supra* note 97 and accompanying text.

113. Krier & Schwab, *supra* note 83, at 450.

114. *Id.* at 451.

115. *Id.* at 453.

116. *Id.*

117. *Id.* Professors Krier and Schwab summarize the assessment-cost criticism with the following example: Suppose that the polluter's avoidance cost is $100,000 and that residents are damaged by $120,000. Due to imperfect information, however, the judge estimated the damages to be only $90,000. Assuming high transaction costs, the judge will allow the pollution to continue, based on this misestimation of the residents' damages. This is not the efficient outcome. *Id.* at 453 n.46.

118. Boomer v. Atl. Cement Co., 257 N.E.2d 870, 873 (N.Y. 1970).

119. Krier & Schwab, *supra* note 83, at 455 ("If . . . transaction costs suggest that bargaining will probably break down, liability rules should be preferred . . . as a matter of course only in those instances where assessment costs are relatively manageable.").

calculate damages further into the future and discount them to their present values. Judges, like other people, make better predictions about the near future than the distant future. In estimating the value of the cement plant's entitlement, the *Boomer* court avoided the use of any profit projections of the cement plant, perhaps due to concerns that profit projections become more speculative and inaccurate as they extend further into the future.[120] Therefore, although it is apparent that, in the short term, the cement plant values the entitlement much more than the residents value the injunction, it is not clear how long this will continue to hold. To further complicate the matter, any small discrepancy in selecting the appropriate discount rate, itself a difficult task, will be amplified in the calculation of damages[121] and will in turn lead to the choice of a less-than-optimal time to reassign the entitlement. In the entitlement step, this error in choosing the time of reassignment is not too much of a concern because it is relatively easy to produce a time division that will leave the parties and society better off than in a traditional all-or-nothing scheme.[122] In the rule-selection step, however, the difficulty in choosing the appropriate discount rate increases the assessment costs as we look further into the future.

Transaction costs may decrease over time. While negotiating and reaching an agreement with each of the numerous opposing parties may be unduly difficult and costly for the cement plant within a short period, it may become possible if the cement plant is given ample time after the judgment. Furthermore, opportunistic behaviors early on, such as the free-rider problem, potential holdouts, and bilateral monopolies, may gradually give way to cooperative bargaining as parties realize that neither side is likely to gain and that it is in their individual best interest to cooperate.[123] In an all-or-nothing scheme, this realization may come too late, as valuable resources may be initially locked in by a party who values them less. In a time-division scheme, the parties are given more lead time to conduct postjudgment negotiation while the entitlement is given to the party who values it more in the short run. Therefore, due to the potentially higher assessment costs and lower transaction costs, the court could use a property rule to protect the residents after t^* and defer the assessment of damages to a future point, conceivably after any postjudgment negotiations.

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120. Courts have long been skeptical of any claim of lost profits based on projections or speculations. *See, e.g.*, Zenith Radio Corp. v. Hazeltine Research, Inc., 401 U.S. 321, 339 (1971) ("[I]t is hornbook law, in antitrust actions as in others, that . . . future damages that might arise from the conduct sued on are unrecoverable if the fact of their accrual is speculative or their amount and nature unprovable.").

121. *See supra* note 26 and accompanying text.

122. *See supra* Part III.C.

123. If we view each attempt to reach a bargain as a game, cooperation may be a sustainable outcome of this potentially infinite series of identical games. This is an example of the so-called folk theorem in game theory. *See* Eric Rasmusen, Games and Information 123–26 (2d ed. 1994). Furthermore, in our case, cooperation does not have to be sustainable. Only one cooperative play is sufficient, because the game ends thereafter.

If the court chooses to apply a property rule for the second time period, we have a result that is the opposite of *Boomer*. In *Boomer*, the court decided to protect the residents with a property rule followed by a liability rule. From our analysis above, the court should, at least in the cases where future assessment costs are high and transaction costs are low, apply a liability rule followed by a property rule.[124]

IV. The M-NPV Model Applied to the Cost-Benefit Analysis of Federal Regulations

Boomer is the quintessential illustration of the inadequacy of common law remedies in dealing with the problem of pollution.[125] "The courts' tendency to balance hardships and deny injunctions" in nuisance suits involving large economic disparities gives the polluter little incentive to reduce pollution.[126] Other significant barriers in the common law affect plaintiffs' chances of success in bringing a nuisance suit.[127] The plaintiff must prove that she is not hypersensitive to the nuisance and that she has suffered actual physical injury rather than aesthetic impairment or risk of injury, among other requirements.[128] The transaction costs involved in coordinating among the potential plaintiffs poses yet another barrier to private suits.[129]

Consistent with "The Great American Regulatory Tradition,"[130] the decades that followed *Boomer* saw a flurry of new federal regulations dealing with the pollution problem that cases such as *Boomer* failed to adequately address. In promulgating these environmental regulations, however, federal agencies inevitably faced the very same issue that troubled courts from the start: the potentially large economic disparities between risks and remedies.[131] The "common sense" that "at some point it would become absurd to

124. This result is consistent with the time-limited easement theory proposed by Professors Baxter and Altree some thirty years ago, about the same time *Boomer* was decided. *See* William F. Baxter & Lillian R. Altree, *Legal Aspects of Airport Noise*, 15 J.L. & ECON. 1 (1972). Under the time-limited easement theory, the polluter is required to pay periodic damages to residents, rather than a lump sum permanent damage. The rationale is that the polluter will then have the incentive to adopt pollution reduction technologies as they become economically more desirable than paying future periodic damages. *Id.* at 17–21. Thus, the solution the time-limited easement theory proposes consists of partial damages followed by a (voluntary) injunction, which coincides with M-NPV's suggestion in this case.

125. *See e.g.*, ROGER W. FINDLEY & DANIEL A. FARBER, ENVIRONMENTAL LAW IN A NUTSHELL 74–78 (6th ed. 2004).

126. *Id* at 76.

127. *Id. See also* FREDERICK R. ANDERSON, DANIEL R. MANDELKER & A. DAN TARLOCK, ENVIRONMENTAL PROTECTION: LAW & POLICY 64 (2d ed. 1990).

128. ANDERSON ET AL., *supra* note 127, at 64–65.

129. *Id.* at 65.

130. *Id.* (citing James E. Krier, *The Pollution Problem and Legal Institutions: A Conceptual Overview*, 18 UCLA L. REV. 429 (1971)).

131. DANIEL A. FARBER, ECO-PRAGMATISM 3–4 (1999).

pursue [minuscule environmental values] at all cost"[132] soon led to the development of cost-benefit analysis—a technique that the common law courts have long used implicitly when engaging in a balancing of hardships.

This Part adds two arguments to the controversy surrounding the application of asymmetric discount rates to the cost-benefit analysis of federal regulations. Section IV.A provides a brief account of the current state of the debate over cost-benefit analysis and its use of asymmetric discount rates, as well as the federal government's inconsistent positions in this debate. Section IV.B introduces the M-NPV model to the debate and argues that, contrary to common belief, asymmetric discounting does not lead to the immediate adoption of a regulation that would otherwise fail the traditional cost-benefit analysis. Instead, the application of asymmetric discounting may suggest that, from a pure utility-maximizing point of view, the regulation should be adopted at a later date, regardless of whether it produces a positive or negative present value after asymmetric discounting. Section IV.C uses the M-NPV model to provide a utilitarian argument for the gradual adoption of increasingly stringent environmental regulations over an extended period of time.

A. *The Debate over Cost-Benefit Analysis and Asymmetric Discounting*

Professor Sunstein divides the debate regarding cost-benefit analysis and its role in the federal government into two generations. The "first generation" debate concerns the desirability of cost-benefit analysis. Traditionally, environmentalists perceive cost-benefit analysis as antienvironment and oppose its use in federal environmental regulations, while regulated industries generally support it.[133] Indeed, some existing federal environmental regulations would not pass the cost-benefit analysis, and many more proposed regulations might fail.[134] Even so, because of the neutral appearance and intuitive appeal of cost-benefit analysis,[135] this generation of debate regarding cost-benefit analysis "appears to be terminating with a general victory for its proponents."[136]

According to Professor Sunstein, the "second generation" debate, concerning practical issues such as how to value life and health in implementing

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132. *Id.* at 3.

133. David M. Driesen, *Is Cost-Benefit Analysis Neutral?*, 77 U. COLO. L. REV. 335, 335 (2006).

134. In a 1996 study, 20 out of the 33 regulations examined failed to pass the cost-benefit analysis. *See* W. Kip Viscusi, *The Dangers of Unbounded Commitment to Regulate Risk*, *in* RISKS, COSTS, AND LIVES SAVED: GETTING BETTER RESULTS FROM REGULATION 154–55 (Robert W. Hahn ed., 1996). A more recent survey of 136 final and proposed regulations using government-supplied cost and benefit estimates showed that, of the 106 final regulations studied, 60 had negative net benefits; of the 30 proposed regulations, 17 had negative net benefits. ROBERT W. HAHN, REVIVING REGULATORY REFORM: A GLOBAL PERSPECTIVE 40–41, 88 n.30 (2000).

135. Driesen, *supra* note 133, at 337.

136. SUNSTEIN, *supra* note 6, at xi.

cost-benefit analysis, is currently underway.[137] Although his characterization of the current state of debate is not without critics,[138] Professor Sunstein appears to be at least partially correct. Instead of continuing to question the desirability of cost-benefit analysis, environmental scholars recently have turned to examining the discount rate used in cost-benefit analysis. They have argued that a lower discount rate—zero, in some cases—must be used in connection with the calculation of future nonmonetary environmental and health benefits.[139]

The logic behind the argument for a lower discount rate is clear. For a regulation to pass the NPV test, it must have a positive net present value.[140] If the recurring future benefits of an environmental regulation, such as a cleaner environment and longer and healthier human lives, are translated into a dollar amount lower than the monetary costs associated with the regulation, the only way to arrive at a positive net present value is to argue for a lower discount rate for such benefits such that the present value of the benefits may nevertheless outweigh the present value of the costs, which are discounted at a faster pace.

The argument in favor of a lower discount rate for the environmental benefits of federal regulations finds plenty of theoretical support. Under the descriptive approach, because regulations are government undertakings, the risk associated with the future benefits of any environmental regulation is most likely less than the risk associated with future costs.[141] Furthermore, the discount rate applicable to the benefits produced by government regulations (a weighted average of the lower consumption discount rate and the higher investment discount rate) is necessarily lower than the investment discount rate (the rate applicable to the costs of government regulations) which consists primarily of the compliance cost incurred by private industries. The prescriptive approach offers even stronger support for discounting environmental benefits at a lower rate. The nonmonetary nature of environmental benefits implies that neither the opportunity cost of capital nor pure time preference are applicable when it comes to discounting environmental benefits: foregoing one unit of clean air does not lead to two units of clean air sometime in the future, and one unit of clean air today and one unit of clean air twenty years from now seem equally important.[142] In addition, our ethical obligations to ensure a clean environment for future generations also mandate that environmental benefits should be discounted at a lower rate, possibly zero.[143]

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137. *Id.*

138. *See*, *e.g.*, Sinden, *supra* note 15, at 192 ("[B]ut I for one am still stuck on the normative question, wondering whether CBA is a good idea to begin with.").

139. *See, e.g.*, Heinzerling, *supra* note 15; Revesz, *supra* note 20.

140. *See supra* note 13 and accompanying text.

141. *See supra* notes 38–40 and accompanying text.

142. *See supra* note 50 and accompanying text.

143. *See supra* notes 52–55 and accompanying text.

Moreover, from a practical point of view, it may be considerably easier and more effective to convince policymakers that a lower discount rate is more appropriate than to convince them that a higher value should be put on human lives. First, there is far less consensus on the appropriate choice of discount rates than there is on the value of a statistical life. Because scholars generally agree that there are many factors that affect the appropriate choice of discount rate and that making such a choice is a difficult task, regulatory bodies of the government are often given substantial leeway in choosing their own discount rate so long as they can justify the choice.[144] The value of a statistical life, on the other hand, is consistently estimated at between $1.5 million and $6.1 million by the federal agencies.[145] Any substantial deviation from these estimates should include "an explanation of departures from the numbers thus indicated."[146] Second, it is more effective for environmentalists to argue for a decrease in discount rate than for an increase in the value of life. For example, a mere 50% decrease in the discount rate from 0.1% to 0.05% will result in a 100-fold increase in the present value of a human life 100 years from now, far greater than any reasonable increase in the valuation of a statistical human life per se.

The federal agencies' response to the theory of asymmetric discounting has largely been positive. The Environmental Protection Agency ("EPA"), for example, often chooses high discount rates (between 7% and 10%) for regulatory costs and low discount rates (around 3%) for benefits.[147] Likewise, the Department of Housing and Urban Development, noting the intergenerational and governmental nature of its regulations, adopts a 3% discount rate for certain long-term regulatory benefits but discounts all other costs and benefits at 7%.[148] The National Oceanic and Atmospheric Administration also applies a lower rate when discounting the benefits of its regulation but chooses to use a higher discount rate for the associated costs.[149]

The federal courts' reaction to the agencies' application of asymmetric discount rates, however, has been less than welcoming. When a defendant agency fails to perform asymmetric discounting in its cost-benefit analysis, courts have generally refused to adopt the plaintiff's position that the agency should not have discounted benefits at the same rate as costs and have largely deferred to the decision of the agency to discount benefits and costs

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144. Morrison, *supra* note 5, at 1356–57.

145. Sunstein, *supra* note 6, at 78–79.

146. *Id.* at 77.

147. Morrison, *supra* note 5, at 1361.

148. *See* Requirements for Notification, Evaluation and Reduction of Lead-Based Paint Hazards in Federally Owned Residential Property and Housing Receiving Federal Assistance, 64 Fed. Reg. 50,140, 50,186–87 (Sept. 15, 1999).

149. National Resource Damage Assessments, 61 Fed. Reg. 440, 456 (Jan. 5, 1996).

at identical rates.[150] On the rare occasion that a court had the opportunity to review a case where an agency, namely the EPA, did apply asymmetric discount rates, that court flatly rejected the EPA's differential treatment of costs and benefits of its regulation, even though the benefits of the regulation in question were primarily human lives saved, and opined that "[b]ecause the EPA must discount costs to perform its evaluations properly, the EPA also should discount benefits to preserve an apples-to-apples comparison."[151]

B. *The M-NPV Model Applied to Federal Environmental Regulations*

It is unclear whether the courts will renew their reluctance to accept asymmetric discounting the next time a federal regulation adopting this approach comes up for judicial review, especially in light of the scholarly work that has since emerged advocating the use of asymmetric discount rates in regulatory analysis. What appears inevitable, however, is that even if the courts reverse their position and approve asymmetric discounting, the agency that has promulgated the regulation in question must be prepared to justify the decision to adopt the regulation immediately rather than at some future time. While asymmetric discounting may result in a positive net present value for that regulation, it also implies that the question of "if" is converted into a question of "when."

As demonstrated in the three scenarios presented in Part II, introducing asymmetric discount rates in a cost-benefit analysis does not immediately save a regulation that would otherwise fail a cost-benefit analysis, contrary to the implicit belief of the many environmentalists who argue for a lower or zero discount rate for environmental benefits. Even if the net present value of the regulation is positive after applying the asymmetric discount rates, as in Scenario 2, M-NPV suggests that, from a pure utility-maximizing point of view, the optimal choice is to adopt the regulation at a future time, not immediately. The only way to argue for immediate adoption based on pure economic grounds is to prove both that the nonmonetary benefits are undervalued in the original calculation and that if the dollar value of such benefits is correctly adjusted upwards, the recurring benefits of the regulation, undiscounted, exceed its recurring costs, as is the case in Scenario 1. Even if environmentalists eventually overcome the courts' initial skepticism towards asymmetric discounting, those who advocate the discounting of environmental benefits at a lower rate to save stringent regulations on pure utility-maximizing grounds face the subsequent challenge of justifying the immediate adoption of a regulation on the same grounds, which may be exceedingly difficult to do.

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150. *See, e.g.*, Ohio v. U.S. Dep't of Interior, 880 F.2d 432, 465 (D.C. Cir. 1989) (holding that the Department of Interior did not act unreasonably in following the OMB guidelines and discounting future benefits).

151. Corrosion Proof Fittings v. EPA, 947 F.2d 1201, 1218 (5th Cir. 1991). The court's reasoning that the EPA must also discount nonmonetary benefits if it discounts regulatory costs has subsequently been criticized by legal scholars. *See* Lisa Heinzerling, *Regulatory Costs of Mythic Proportions*, 107 YALE L.J. 1981, 2053 (1998).

While the advocates of asymmetric discounting may have unintentionally set up a future hurdle in justifying the immediate adoption of more stringent environmental regulations, they have gained ground in another direction, perhaps also unintentionally. Regulations that produce a negative present value even though their environmental benefits are discounted at a lower rate—or not discounted at all—still will not pass the NPV test and still will not be treated as worthwhile from an economic point of view. Barring some other considerations that would recommend a "[divergence] from the conclusion recommended by CBA,"[152] such regulations will not be adopted at all. With asymmetric discounting, however, the M-NPV model provides the environmentalists a powerful argument that a policymaker should not pass over such regulations entirely but should instead give them favorable consideration for possible future adoption. Under asymmetric discounting, a regulation that produces a negative net present value if adopted immediately will necessarily yield a positive net present value if adopted at a future date, as shown in Scenario 3.

Therefore, the true consequence of applying an asymmetric discount rate in a cost-benefit analysis is the somewhat intermediate position between immediate adoption and total rejection of an environmental regulation. On one hand, asymmetric discounting suggests that regulations that produce a positive net present value should not be adopted immediately if the positive value is solely the result of discounting the environmental benefit at a lower rate than the monetary cost. On the other hand, asymmetric discounting suggests that regulators should not simply reject an environmental regulation with a negative net present value but should instead consider the possibility of adopting the regulation but deferring its enforcement, adoption, or activation to a later date.

C. *An Economic Justification for Progressively More Stringent Regulations*

In addition to identifying the double-sided consequence of asymmetric discounting, M-NPV analysis can also provide a strong economic justification for progressively more stringent environmental regulations. As shown in Part II, asymmetric discounting replaces the question of "if" the regulation should be adopted with the question of "when." But if the policymaker has a number of regulatory options of varying degrees of stringency and can only choose one to implement at a time, she must decide "when" to adopt "which" regulation.

The traditional NPV approach fails to adequately address this type of question. In fact, it is almost always biased towards less-stringent regulations because the requirement that benefits exceed costs "constitutes a one-way ratchet, systematically reducing the stringency of regulation in all cases where it has any influence at all."[153] As the regulation becomes more strin-

152. Sunstein, *supra* note 6, at xi.

153. Driesen, *supra* note 133, at 388.

gent, both its costs and benefits will increase, but its costs will increase at a faster pace than its benefits due to the law of diminishing marginal returns, and at some point the costs of the regulation will exceed its benefits.[154] As a result, "this . . . criterion [that benefits exceed costs] requires a reduction in stringency" and "never requires an increase in stringency."[155] Moreover, between two regulations that have identical net present values, the traditional NPV approach will almost certainly favor the one that achieves this net present value with lower costs and a better benefit-cost ratio, that is, the regulation that is less stringent.

Applying M-NPV analysis, it turns out that the utility-maximizing course of action is to adopt the regulations in the order of their stringency, from the least stringent to the most stringent, over an extended period of time, rather than to always favor the least stringent regulation. Two steps are involved in reaching this conclusion. First, given a less-stringent regulation, R_1, and a more-stringent regulation, R_2, we can determine the optimal times of adoption for each of these regulations independently. Since the increase in costs from R_1 to R_2 outpaces the increase in benefits, t_1^*, the optimal time of adoption for R_1, will be smaller than t_2^*, the optimal time of adoption for R_2. Thus, R_1, the less-stringent regulation, should be adopted earlier than R_2, as shown in Figure 9. Second, we observe that there is a point in time, t', when the marginal net present value of R_2, computed as the present value of R_2's marginal benefit minus the present value of R_2's marginal costs, begins to exceed that of R_1, as shown in Figure 10. This is because the marginal net present value of R_2 increases at a faster pace than that of R_1. In other words, from this point onward, R_2 is more desirable than R_1. Thus, t' is the optimal time to switch from R_1 to R_2 to ensure maximum utility.

154. *See id.* ("[T]he cost-benefit ratio will improve as the regulation becomes less stringent and get worse as it gets more stringent.").

155. *Id.*

FIGURE 9

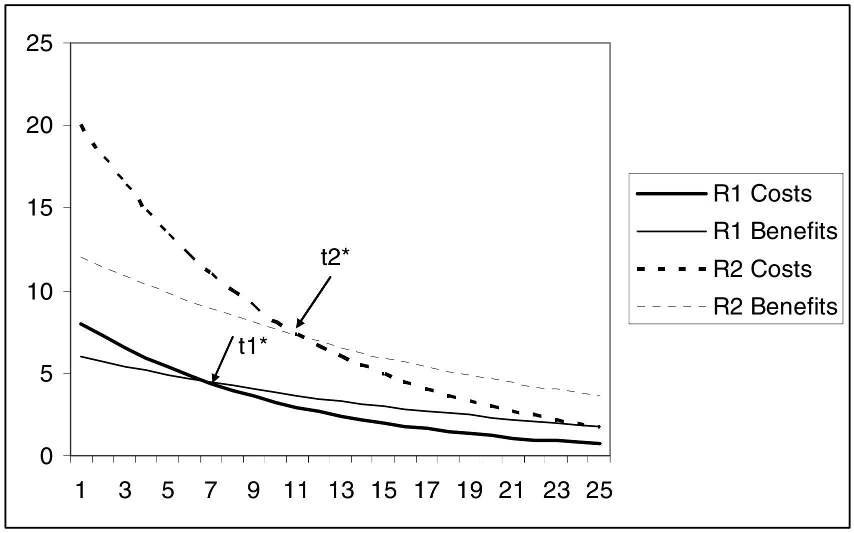
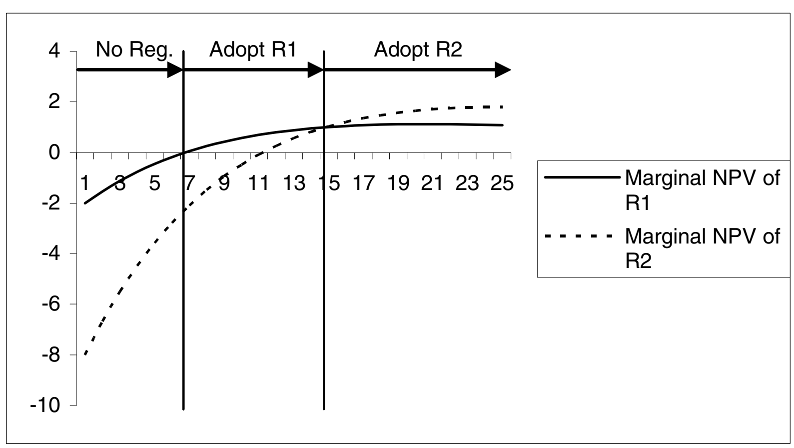


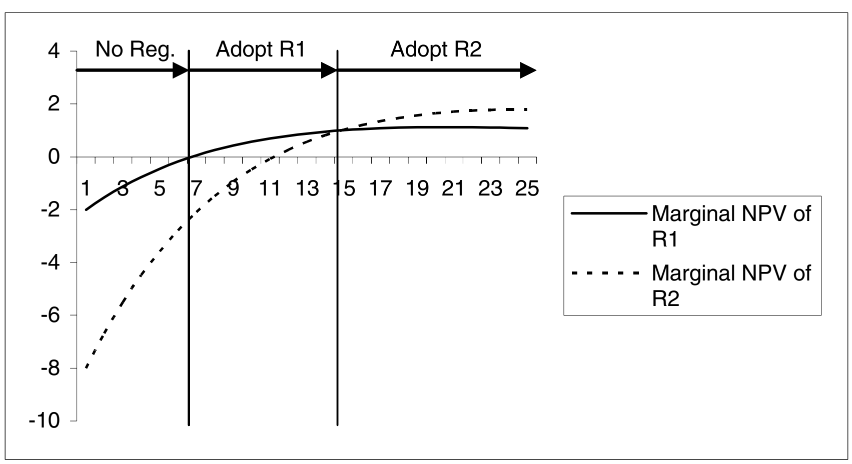
FIGURE 10



A simple example helps illustrate the point. Suppose that an agency is considering two alternative options, R_1 and R_2, to achieve a regulatory goal. R_1 is the less stringent of the two and saves one life at a cost of $8 million per year. R_2 is more stringent than R_1, and consequently saves two lives per year. Its cost, however, is $10 million per life saved, due to the law of diminishing marginal returns. Thus, R_2 costs $20 million per year. Further assume that the value of a statistical life is estimated to be $6 million and discounted at an annual rate of 5%. The financial cost associated with the environmental regulation, on the other hand, is discounted at 10%. Finally, assume that the benefits and costs associated with these regulations are perpetually recurring. Consequently, the benefit of R_1, discounted to present value, is \$120 million; its cost, discounted to present value, is \$80 million. Similarly, R_2 has a discounted benefit of \$240 million and a discounted cost of \$200 million. Which regulation should the agency adopt and at what time?

The traditional NPV and the M-NPV approaches produce drastically different results. Under the traditional NPV approach, both R_1 and R_2 have a net present value of \$40 million, but R_1 costs less than R_2 although both produce benefits with the same net present value. Because R_1's overall benefit-cost ratio is higher than that of R_2, the less-stringent R_1 will always be favored over R_2 and will be adopted immediately. M-NPV focuses on the marginal net present value of the regulations instead of their overall benefit-cost ratios. It suggests that R_1 should be adopted at some future point and that R_2 should be adopted at some point after R_1. The optimal time to adopt R_1 is when its marginal net present value becomes positive, approximately in the sixth year, as shown in Figure 11. The optimal time to adopt R_2 is when its marginal net present value becomes higher than that of R_1, approximately in the fourteenth year, as shown in Figure 11.

FIGURE 11



The M-NPV analysis can be further applied to more than two regulations to show that the regulations should be adopted in ascending order of their stringency over an extended period of time. Thus, not only is cost-benefit analysis not inherently biased towards less-stringent regulations, it is, in conjunction with the M-NPV model, actually a "one-way ratchet," systematically *increasing* the stringency of regulations over time.

Conclusion

The use of asymmetric discount rates in the economic analysis of law leads to the conclusion that resources should be time divided between competing activities. In the context of nuisance remedies, this implies that the courts should consider issuing a suspended injunction in cases where traditionally a permanent damage would have been awarded. When performing cost-benefit analysis for federal regulations, applying asymmetric discount rates will not lead to the immediate adoption of regulations that are not otherwise regarded as economically worthwhile or that are overly stringent. Instead, it implies that such regulations, regardless of whether they pass the NPV test after the lower discount rate is applied to the benefit side, should be adopted on a future date rather than immediately. Finally, asymmetric discounting implies that progressively more stringent regulations must be adopted over time.

Appendix

Given a constant and perpetual benefit streams S_1, let b_1 be the annual recurring benefit this stream produces once adopted, and r_1 be the continuous discount rate applicable to this type of future benefits, $0 < r_1 < 1$. The marginal present value of S_1 at time t is

$$u_1(t) = b_1 e^{-r_1 t},$$

and the present value of S_1 between any two points in time, t_a and t_b, is

$$v_1(t_a, t_b) = \int_{t_a}^{t_b} u(x)dx = \frac{b_1}{r_1}\left(e^{-r_1 t_a} - e^{-r_1 t_b}\right).$$

For a second constant and perpetual benefit stream S_2, let b_2 be the annual recurring benefit this stream produces once adopted, and r_2 be the continuous discount rate applicable to this type of future benefits, $0 \le r_2 < 1$. Thus, the marginal present value of S_2 at time t is

$$u_2(t) = b_2 e^{-r_2 t},$$

and the present value of S_2 between t_a and t_b is

$$v_2(t_a, t_b) = \frac{b_2}{r_2}\left(e^{-r_2 t_a} - e^{-r_2 t_b}\right).$$

We further stipulate that S_2 is discounted at a lower rate than S_1, that is,

$$0 \le r_2 < r_1 < 1,$$

and that S_1 and S_2 are mutually exclusive, that is, only one stream may be adopted at any time. Therefore the benefit of one stream becomes the cost of the other.

Proposition 1-1. There exist annual recurring benefits, b_1 and b_2, such that the net present value of S_2, defined as

$$NPV = v_2(0,\infty) - v_1(0,\infty),$$

is positive.

Proof.

$$v_1(0,\infty) = \frac{b_1}{r_1}\left(e^0 - e^{-\infty}\right) = \frac{b_1}{r_1};$$

$$v_2(0,\infty) = \frac{b_2}{r_2}\left(e^0 - e^{-\infty}\right) = \frac{b_2}{r_2};$$

$$NPV = \frac{b_2}{r_2} - \frac{b_1}{r_1} = \frac{b_2 r_1 - b_1 r_2}{r_1 r_2}.$$

Therefore, the net present value of S_2 is positive if

$$b_2 r_1 > b_1 r_2.$$

Proposition 1-2. There exist annual recurring benefits, b_1 and b_2, such that the net present value of S_2 is negative.

Proof. Omitted. The net present value of S_2 is negative if $b_2 r_1 < b_1 r_2$.

Proposition 2. If b_1>b_2, then there exists t^*>0 such that $u_1(t^*) = u_2(t^*)$.

Proof. Suppose $b_1 e^{-r_1 t^*} = b_2 e^{-r_2 t^*}$

Then $\ln b_1 - r_1 t^* = \ln b_2 - r_2 t^*$

and $t^* = \dfrac{\ln b_1 - \ln b_2}{r_1 - r_2}$.

Because $b_1 > b_2$ and $r_1 > r_2$, we have

$$t^* = \frac{\ln b_1 - \ln b_2}{r_1 - r_2} > 0.$$

Proposition 3. If we first adopt S_1 and switch to S_2 at time t, and call the time of switching that maximizes the net present value of this course of action t_{opt}, $t_{opt} \geq 0$, then for b_1>b_2, $t_{opt} = t^*$; for b_1<b_2, $t_{opt} = 0$.

Proof. The net present value produced by this course of action, $M(t)$, is the sum of the net present value of S_1 up to time t and the net present value of S_2 thereafter.

$$M(t) = NPV(0,t) + NPV(t,\infty) = v_1(0,t) - v_2(0,t) + v_2(t,\infty) - v_1(t,\infty).$$

$$M(t) = \frac{b_1}{r_1}\left(1 - e^{-r_1 t}\right) - \frac{b_2}{r_2}\left(1 - e^{-r_2 t}\right) + \frac{b_2}{r_2} e^{-r_2 t} - \frac{b_1}{r_1} e^{-r_1 t},$$

$$M(t) = \left(\frac{b_1}{r_1} - \frac{b_2}{r_2}\right) - 2\left(\frac{b_1}{r_1} e^{-r_1 t} - \frac{b_2}{r_2} e^{-r_2 t}\right),$$

$$\frac{dM(t)}{dt} = 2\left(b_1 e^{-r_1 t} - b_2 e^{-r_2 t}\right).$$

Setting $\frac{dM(t)}{dt} = 0$, we have

$$b_1 e^{-r_1 t} = b_2 e^{-r_2 t}.$$

From *Proposition 2*, we know this is satisfied if and only if

$$t = t^* = \frac{\ln b_1 - \ln b_2}{r_1 - r_2}.$$

Thus, t^* is the only critical point of this function. We also have:

$$\frac{d^2 M(t)}{dt^2} = -r_1 b_1 e^{-r_1 t} + r_2 b_2 e^{-r_2 t}$$

and

$$\frac{d^2 M(t^*)}{dt^2} = -r_1 b_1 e^{-r_1 t^*} + r_2 b_2 e^{-r_2 t^*}$$

At t^*, $b_1 e^{-r_1 t^*} = b_2 e^{-r_2 t^*} > 0$ and $0 \le r_2 < r_1 < 1$, we thus have

$$\frac{d^2 M(t^*)}{dt^2} < 0.$$

Therefore t^* is the maximum point of the function $M(t)$.

If $b_1 < b_2$, then $t^* = \frac{\ln b_1 - \ln b_2}{r_1 - r_2} < 0$, and therefore $t_{opt} = 0$. We also note that this situation is described by M-NPV Scenario 1. Thus, the only requirement for M-NPV Scenario 1 to hold is that $b_1 < b_2$ and $r_1 > r_2$.

On the other hand, if $b_1 > b_2$, then $t^* = \frac{\ln b_1 - \ln b_2}{r_1 - r_2} > 0$, and $t_{opt} = t^* = \frac{\ln b_1 - \ln b_2}{r_1 - r_2} > 0$.

In addition, we note that the net present value of switching at time 0 is simply the net present value of S_2, that is,

$$M(0) = NPV.$$

Therefore, if the net present value of S_2 is positive, that is, $b_2 r_1 > b_1 r_2$ (see *Proposition 1-2*), then *M(0)>0*, and together with the fact that $t_{opt} > 0$, this describes M-NPV Scenario 2. The condition for Scenario 2 to hold is therefore $b_1 > b_2$, $r_1 > r_2$, and $b_2 r_1 > b_1 r_2$.

We similarly derive the conditions for M-NPV Scenario 3 to hold, that is, $b_1 > b_2$, $r_1 > r_2$, and $b_2 r_1 < b_1 r_2$. (Steps omitted).