DISCOUNTING IN ENVIRONMENTAL POLICY EVALUATION

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Many of EPA's policies and programs impose costs and generate benefits over often long time horizons. As a result, cost-benefit and related analyses that are key components of EPA's regulatory development and assessment process necessarily must find ways to account for future effects in terms that help present day decision makers choose appropriate approaches for environmental protection. One common method for doing so is called discounting, a process whereby the values of future effects are adjusted (normally downward) to render them comparable to the values placed on current consumption, costs, and benefits.

In the past several decades EPA has conducted numerous cost-benefit and other regulatory analyses exploring a variety of environmental problems and potential policy solutions to them. Discounting practices, procedures, and specific rates adopted in these studies, however, have spanned a variety of approaches. Moreover, EPA and OMB guidance on discounting issues have been promulgated and revised several times during this same period, but still do not appear to agree on the correct approach or approaches suitable for EPA programs and analyses.

The purpose of this paper is to assist EPA in developing guidelines for discounting procedures and rates that (1) have broad applicability across programs and analyses, (2) are well-grounded in the theoretical and empirical literature on the subject, and (3) provide EPA decision makers with robust rationales for the particular rates and approaches thought to be most appropriate in a given set of circumstances.

The fact that several sources for guidance on discounting already exist suggests that this is not the first time EPA and others have sought to define the correct discounting framework for environmental public policy. But the use of different procedures and rates, and the disagreement among the guidance documents on the topic, also suggest that past attempts to identify correct approaches and discount rates have not met with success, or certainly have not produced consistency in application.

The ultimate goal of this paper, therefore, is not to survey the economic literature on discounting in order to deliver to EPA a final verdict on the correct discounting procedures and rates to use in evaluating environmental policies. Instead, it is to examine carefully what is known, knowable, and never to be known from an economic perspective about discounting in evaluating environmental and other public policies. The focus is on defining carefully the limits of what economic science can say about the matter, and where ethics and other policy considerations might be more reliable guides to policy makers. By itself, this analysis may help to settle at least some of the continuing disagreement about discounting policy in environmental regulatory analysis. Perhaps more important, however, is that this investigation may well reveal to policy makers the fundamental reasons for any remaining uncertainties about appropriate discounting procedures for environmental policies, and thus highlight where answers may only be obtained by supplementing the advice of economic science with considerations drawn from other disciplines and perspectives on public policy.

This paper is organized into three sections. The first section, which constitutes the majority of the paper, examines the broad topic of appropriate discounting approaches for analyzing environmental policies. The nature and importance of discounting in public policy evaluation are reviewed, as are existing EPA discounting practices. The section then provides a critical evaluation and summary of the approaches for discounting in the economic literature, emphasizing theoretical foundations, ethical underpinnings, and application in practice. The remaining two sections briefly explore two more specific questions that arise in EPA analyses. Section 2 examines whether effects of environmental regulations that are not expressed in terms of monetary values can or should be

discounted in cost-benefit and other regulatory studies. Section 3 concludes the paper by investigating what rates of discount EPA ought to use in its calculation of economic penalties for non-compliance with its regulations. A bibliography of selected literature on the subject of discounting in public policy evaluation is attached to the paper.

Finally, the target audience for this paper consists of economists and public policy analysts who possess at least some familiarity with discounting in public policy analysis. This technical level was chosen primarily because a short paper on the topic cannot be (1) a primer on the basics of discounting in public policy evaluation, (2) a comprehensive and exhaustive summary of the available literature on the subject, and (3) an assessment of what is known, knowable, and unknowable in this area, and of the dividing line between economic and philosophical guidance on the subject, all at once.

1. THE SOCIAL RATE OF DISCOUNT FOR ENVIRONMENTAL POLICY ANALYSIS

This section explores the various approaches for discounting in public policy evaluation developed in the extensive economic literature on the subject. The primary purposes here are to present the dominant themes in this literature as succinctly as possible, to carefully explore the conceptual and ethical underpinnings of the various candidate approaches, and to assess their applicability to the many different environmental policies EPA routinely evaluates in preparing regulatory impact assessments.

In terms of organization, a brief introduction to discounting in public policy evaluation is provided first. Section 1.1 thus focuses mainly on distinguishing discounting per se from other aspects of measuring and summarizing the costs, benefits, impacts, and other consequences of environmental regulations. It also seeks to identify the circumstances in which the process of discounting, and the rates used in doing so, do and do not have a large impact on the net social benefit summaries of a regulation's effects provided by analysts to policy makers.

The discussion then turns to a critical examination of two very different sets of economic literature on the subject of discounting in public policy evaluation. Section 1.2 targets what might be called the "conventional" economic literature, spanning over 30 years, concerning appropriate discount rates and procedures for evaluating the costs and benefits of public projects and policies. Section 1.3 explores the various approaches and considerations identified in the economic literature as relevant for discounting for "intergenerational" public policies.

Finally, the literature on discounting in public project evaluation is vast in scope and volume. Hence, the sources cited in this paper are those deemed to be central to the major themes reviewed. Excellent sources for summaries of the social discounting literature are the papers in Lind (1982a), Lind (1982b), IPPC (1996), and Pearce and Ulph (1994).

1.1 Social Discounting: Definition and Background

This section reviews a few basic concepts and considerations central to understanding the role and importance of discounting in public policy evaluation. First, discounting in public policy evaluation is normally referred to as "social discounting" or "discounting using the social rate of interest". The process itself - applying discounting to future flows of costs, benefits, and other

consequences of environmental and other policies - is mechanically the same as the discounting process in private individual's economic and financial calculations. What makes it "social" discounting is the fact that policy analysts and decision makers are applying discounting in the process of evaluating the social effects of a regulation or policy.

The costs of an environmental externality are typically not reflected in the costs or prices of market transactions and activities. Hence, from the "private" perspective of the entity engaged in an activity that generates an externality, the cost of its actions do not include the environmental harm caused. But the "social" perspective adopted by public policy analysts and decision makers does include these external costs. Social discounting thus identifies the particular perspective of the analyst in assessing all of the consequences of a policy rather than necessarily something different about the process of discounting itself.

Clearly, the private and social perspectives can yield very different conclusions concerning, for example, the cost of engaging in an activity that also generates environmental harms. Whether social discounting also departs significantly from private discounting, however, is less clear. Indeed, some approaches to social discounting suggest that the procedures and rates used ought to be the same as those used in at least some private discounting. Other perspectives, however, suggest that social discounting is a very different process than a single individual's discounting. In any event, at a minimum, the term social discounting at least refers to the broad society-as-a-whole point of view embodied in cost-benefit and similar analyses of public policies. Whether it also connotes a particular procedure and rate different from private discounting is a central question for this analysis.

Second, almost all discussions of social discounting focus on translating future values into present ones - which is the traditional process of time discounting using an interest rate. Discounting renders costs and benefits that occur in different time periods comparable by stating them all in present day terms. The resulting net present value is at least one measure of the social value of a policy decision makers might use in evaluating regulatory and other measures.

There are other procedures, however, for rendering costs and benefits that occur in more than one time period comparable. Benefit and cost streams might be annualized over the duration of the relevant policy, for example, so that the economic measure of whether the net benefit (benefits minus costs) is positive can be determined by the magnitudes of the annualized benefits and costs. Similarly, instead of discounting all future values back to the present, it is possible to accumulate them forward to some future time period. Here, the net benefit test is whether the accumulated future benefits exceed the costs.

Both of these alternatives to traditional discounting of future values to the present employ an interest rate to accomplish the relevant translation of values through or across time, so they are not really different methods of determining the benefits and costs of a policy. Instead, they are simply different ways to express costs and benefits that occur in multiple time periods on a consistent basis. Discounting places all costs and benefits in the present time period, annualization spreads them smoothly through time, and accumulation states them all in the future. But if each procedure uses the same discount (interest) rate, they are merely different ways to describe the same underlying phenomenon. Hence, the analysis, discussion, and conclusions presented in this paper apply to all methods of translating costs, benefits, and effects through time, even though the terminology is that of discounting.

Third, discounting is only one component of several that are necessary to produce comparable estimates of costs and benefits of policy actions that have effects in more than one time period.

Discounting concerns methods of translating values from one time period to another in order express the values of a policy's consequences in consistent terms. It is not, however, a method for actually determining the future values of future events, although these are often closely related tasks. For example, the future value of one of an environmental policy's effects may hinge critically on the assumed rate of growth of wealth over time. There may a connection between increasing wealth and the discount rate for expressing future values in present day terms. Nevertheless, the process of determining the values of a policy's consequences, and then translating them into to present terms are conceptually distinct. As such, it is generally appropriate to conduct each of these tasks separately, and not to attempt to "correct" for errors in one procedure by "adjusting" the other, such as using a present day valuation of a benefit that will occur in the future and then discounting at a lower rate to reflect an assumed rising valuation through time.

Fourth, the impact of discounting streams of costs and benefits in public policy evaluation is sometimes large, and sometimes not, depending on the circumstances. When all effects occur in one period, discounting may be unnecessary or superfluous: net benefits are positive or negative regardless of the discount rate used or the procedure for translating them through time. When costs and benefits of a policy are largely constant over the relevant time frame, then discounting again will not alter the net benefits conclusion based on a single year's consequences. Of course, these conclusions are limited to the process of determining whether a policy offers positive net social benefits. Higher discount rates will reduce the present value of any future cost or benefit. But if negative and positive effects occur simultaneously, and their relative values do not change over time, discounting will reduce the net present values of all future values, but will not change the conclusion concerning the sign of net benefits.

Discounting can produce dramatic impacts on the present value net benefit estimates of public policies - and change the conclusion regarding the sign of the net benefits - when there is a substantial difference in the timing of large positive and negative effects. For example, if the costs of a policy are borne today, they are not discounted at all. But if the policy's benefits will occur, say, 100 years from now, the present value of the benefits, and hence, the net present value of the policy, depends critically on the discount rate used.

Suppose the cost of some environmental policy borne entirely in the present is $1 billion, and that the 100 years in the future benefit is estimated to be worth $100 billion. Without discounting, benefits 100 times the costs appears to be an impressive return on a social investment. Discounting the $100 billion future benefits, however, can radically alter the economic assessment of the net present value benefits of the policy. $100 billion 100 years in the future discounted at 1% is $36.97 billion, at 2% is $13.8 billion, at 5% is $760 million., and at 10% is only $7.3 million. Hence, the choice of the discount rate largely determines whether this policy is considered, at least by some, to offer positive net present value benefits.

Finally, it is worth noting that EPA's discounting practices have varied over the past several decades and across programs, with discount rates ranging from 1% to 10%, depending on the policy involved and when the analysis was conducted. Some convergence recently on relatively lower rates in this range appears to have occurred, although a 7% rate (consistent with OMB's current guidance) is not uncommon.

1.2 Conventional Social Discounting

This section explores social discounting in conventional contexts, specifically those in which intergenerational issues are not important features. Most of the traditional discounting literature

focuses on these circumstances, which may well be characterized by decades-long time frames, but which nevertheless do not explicitly confront the extremely long time horizons and impacts on unborn generations that are central to the extensions of social discounting research into the climate change, nuclear waste disposal, and other such policy issues. The division of the problem into conventional and intergenerational social discounting helps to understand the substantially different contribution economic approaches can offer in each area.

This section begins with a brief discussion of the analytical foundations of conventional social discounting. It next outlines the major social discounting approaches suggested in the literature, and then concludes with a review of the concrete conclusions and advice offered by the traditional discounting literature.

1.2.1 Analytical Point of Departure of Conventional Social Discounting

In addition to the lengths of the time horizons considered, a key difference between conventional discounting approaches and those often central to intergenerational discounting concerns what might be referred to as their "ethical postures". As will be seen in Section 2, discounting in an intergenerational context is often (but not always) couched in terms of a social planner whose task is to maximize the utilities of present and future individuals according to the form and parameters of a social welfare function. The weights attached to different individuals' utilities are not derived from individual's preferences, but are instead considered to be "society's" preferences.

Conventional social discounting, however, is rooted firmly in the view that the government is acting on behalf of its citizens in undertaking public projects and promulgating regulations. Therefore, cost-benefit analyses of these actions should seek to estimate the costs and benefits experienced by all of the affected parties, and in so doing determine whether in aggregate, the gainers under a policy would be able to compensate the losers.

Two aspects of this foundation for conventional social discounting are worth highlighting. First, just as consumer sovereignty dictates that the government should incorporate the specific values that particular individuals place on outcomes that affect them in assessing its actions, the government should also discount future costs and benefits in the same way that the affected individuals do. This is necessary in order to determine how much each person would agree he or she is made better or worse off by a given policy.

Second, the conventional rule for deciding whether a policy has positive net benefits - whether the gainers could compensate the losers - does not require that this compensation actually occur, and under environmental regulations, it largely does not. One explanation for the lack of compensation is that deciding to regulate (or not) is both (1) an ethically acceptable reallocation or clarification of property rights to the environmental good affected by an externality, and (2) the establishment of the social optimal level of pollution and set of controls for the externality. Thus, if we decide to regulate, we implicitly also decide that the polluters have no right to unlimited use of the environment for disposal. Those who benefit from the regulation therefore owe no compensation because the polluters have not lost anything to which they were actually entitled. More broadly, the costs and benefits of individual environmental regulations are normally not that large and, taken as a whole, the beneficiaries of environmental regulations are largely the same people who bear the costs.

From a different perspective, finding practical mechanisms through which compensation can be extracted from the gainers and paid to the losers can be difficult, especially if many parties are involved. One might then argue that the distributional impacts of environmental regulations are acceptable if there is some reasonable expectation that governments and society can mitigate undesirable distributional changes outside the framework of those rules. Finally, in some instances forcing gainers to compensate losers runs counter to other public policy concerns. If those who gain from a policy change are poorer and those who loser are richer, for example, some might argue that forcing compensation in this case is not acceptable on other than efficiency grounds. Thus, there are many reasons why compensation is not a necessary condition for decision makers to determine that policy changes that offer net benefits, but impose gains and losses on different people, are still socially desirable. Of course, this does not preclude cases in which the lack of compensation causes policy makers not to promulgate a regulation that provides net social benefits, but imposes potentially large distributional impacts. There is, therefore, no blanket presumption that not requiring compensation for environmental regulations is always acceptable, but there are some valid reasons and explanations for this in practice.

The analytical foundation of the traditional social discounting literature thus rests on the traditional test of a "potential" Pareto improvement in social welfare - whether gainers could compensate the losers. Consumer sovereignty is a central fixture of this branch of economics. This implies that cost-benefit analyses of policies that produce effects in multiple time periods should evaluate all costs and benefits in the same way that the affected parties do - including time discounting. The traditional literature on social discounting therefore views situations to be analyzed using cost-benefit analysis as consisting of collections of individuals contemplating changes in their own consumption (broadly defined) over time.

Finally, none of this is intended to deny that the alternative perspective of a planner maximizing society's overall utility using the form and parameters of a specific social welfare function could apply to conventional, non-intergenerational circumstances. Indeed, there is nothing inherent in a short time horizon policy that dictates that only the Paretian perspective underlying the literature on conventional social discounting is appropriate, but this is the point of departure of the original social discounting literature.

It is worth considering the two perspectives separately because the implications for the two approaches for determining the social discount rate are quite different: the conventional literature's reliance on the Paretian tradition suggests that the social discount rate is to be found by examining the preferences of affected parties, while the discount rate under the social planner approach is not necessarily tied to the preferences of existing individuals.

1.2.2 Fundamental Procedures for Conventional Social Discounting

Given the reasonably precise and circumscribed objective of conventional social discounting, the volume of literature on the topic is surprisingly diverse and complex. Here, the major strands of that literature are briefly reviewed.

The traditional literature begins by pointing out that under a variety of restrictive assumptions - no taxes, no risk, perfect capital markets - the task of discounting effects experienced by individuals would be easy: simply use the observable market rate of interest that underlies the intertemporal consumption allocation decisions of those same individuals. The rate at which individuals are willing to exchange consumption over time is normally referred to as the "consumption rate of interest".

The simplifying assumptions (especially the absence of taxes on investment returns) imply that the consumption rate of interest equals the market interest rate, which also equals the marginal product of capital. In this case, individuals trade consumption through time at the market interest rate, which is equivalent to saying that they discount future consumption at the market rate of interest. In addition, the market rate of interest is also the rate of return on capital investments, so this is the rate at which consumption can be translated through time via private sector investments. In this simplified situation, it seems eminently reasonable to argue that the government ought to trade off any changes in present and future consumption caused by a policy change using the market rate of interest as well. Hence, in this case, the social rate of discount should be equal to the rate at which individuals themselves discount future consumption (the consumption rate of interest), which is also the market rate of interest at which society as a whole can trade consumption over time through private sector investments.

But most of the simplifying assumptions necessary for this answer - that the social rate of discount should be equal to the consumption rate of interest, which in turn is the market rate of interest - to suffice do not hold in practice. One assumption in particular - that the consumption rate of investment at which consumers discount future consumption equals the rate of return on private sector investment - seems highly implausible. Much of the traditional literature, therefore, focuses on the implications for social discounting of relaxing this crucial assumption. For purposes of analysis, in most cases it is assumed that taxes on private sector investment returns cause the "social" rate at which consumption can be traded through time (the social rate of return on, or opportunity cost of, private capital) to exceed the rate at which individuals can trade consumption over time (the consumption rate of interest).

Suppose the market rate of interest, net of inflation, is 5%, and that taxes on capital income amount to 40% of the net return. In this case, private investments will yield 5%, of which 2% is paid in taxes to the government, and the remaining 3% is received by individuals. Hence, from a social perspective, consumption can be traded from the present to the future at a rate of 5%. But individuals effectively trade consumption through time at a rate of 3% because they owe taxes on investment earnings. Hence, the consumption rate of interest is 3%, substantially less than the 5% social rate of return on private sector investments (also known as the social opportunity cost of private capital).

Over several decades, a very large body of economic literature analyzing the implications for social discounting of divergences between the consumption rate of interest and the social rate of return on private sector investment developed. The dominant approaches in this literature are briefly outlined here.

Shadow Price of Capital and Consumption Rate of Interest - The Traditional View

One approach that enjoys widespread support among economists recommends that social discounting in conventional contexts should use the consumption rate of interest to discount future costs and benefits that have been valued in terms of future consumption. Intuitively, this procedure makes sense because the government is assumed to be valuing future consequences of its policies just as the affected citizens would. If individuals discount future consumption (and the costs and benefits of a public policy) using the consumption rate of interest, then so should the government. So the social rate of discount should equal the consumption rate of interest.

But if the costs of financing a public project displace private investments, society loses the total pre-tax returns from those foregone investments. Private capital investments might be

displaced if, for example, public projects are financed with government debt and the supply of investment capital is relatively fixed. In this case, discounting costs and benefits using the consumption rate of interest (the post-tax rate of interest) does not seem to capture the fact that society loses the higher, social (pre-tax) rate of return on foregone investments. Indeed, proponents of this popular approach argue that when a public project does displace private sector investments, the correct method for measuring the social costs and benefits of such a project requires an adjustment of the estimated costs (and perhaps benefits as well) prior to discounting using the consumption rate of interest. This adjustment is referred to as the "shadow price of capital ".

The shadow (social) price (value) of private capital is intended to capture the fact that a unit of private capital produces a stream of social returns at a rate greater than that at which they are discounted by individuals. If the social rate of discount is the consumption rate of interest, then the social value of a $1 private sector investment will be greater than $1 - because the investment produces a rate of return for its owners equal to the post-tax consumption rate of interest, plus a stream of tax revenues (which is normally valued as consumption).

To illustrate this simply, suppose the consumption rate of interest is 3%, that the pre-tax rate of return on private investments is 5%, that the net-of-tax earnings from these investments are consumed in each period, and that the investment exists in perpetuity (amortization payments from the gross returns of the investment are devoted to preserving the value of the capital intact). A $1 private investment with these characteristics will produce a stream of private consumption of $.03 per year, and tax revenues of $.02 per year. Discounting the private post-tax stream of consumption at the 3% consumption rate of interest yields a present value of $1. Discounting the stream of tax revenues at the same rate yields a present value of about $.67. The social value for this $1 private investment is thus $1.67, nearly double the $1 private value individuals place on it.

Therefore, if financing a public project displaces private investments, this “shadow price of capital - consumption rate of interest” approach argues for adjusting the project’s costs upward by the shadow price of capital, and then discounting all costs and benefits using a social rate of discount equal to the consumption rate of interest. To apply this approach, the first step is to determine whether private investment flows will be altered by a policy. Typically, project costs are thought to displace private capital, at least in part, although project benefits could encourage additional private sector investments. Next, all of the altered private investment flows are multiplied by the shadow price of capital to convert them into consumption-equivalent units. All flows of consumption and consumption-equivalents are then discounted using the consumption rate of interest.

A simple example of this method is the following. Suppose the pre-tax rate of return from private investments is 5%, and the post-tax rate is 3%, with the difference attributable to taxation of capital income. Assume as well that increases in government debt displace private investments dollar-for-dollar. Finally, assume that the $1 current cost of a public project is financed 75% with government debt and 25% with current taxes, and that this project produces a benefit 40 years from now that is estimated to be worth $5 in the future.

Using the shadow price of capital - consumption rate of interest approach, first multiply 75% of the $1 current cost (which is the amount of displaced private investment) by the shadow price of capital (assume this is the 1.67 figure from above). This yields $1.2525, to which is added the $.25 amount by which the project’s costs displace current consumption. The total social cost is therefore $1.5025. This results in a net social present value of about $.03, which is the present value of the future $5 benefit discounted at the 3% consumption rate of interest ($1.5328) minus the $1.5025 social cost.

Thus, under the shadow price of capital - consumption rate of interest approach, costs are "higher" to reflect the social costs of displacing private investments, but discounting for time itself is accomplished using the consumption rate of interest - consistent with how individuals trade and value consumption over time.

Variants of this approach exist, such as its extension to regulatory interventions that require private sector investment. For example, the Kolb-Scheraga approach recommends annualizing capital expenditures using the pre-tax rate and then discounting all cost and benefits using the consumption rate of interest.

Shadow Price of Capital and Consumption Rate of Interest - The New View

Over the years, the shadow price of capital - consumption rate of interest approach has gained a considerable following. Recently, however, a key assumption in that analysis that is normally not made explicit has been questioned - the assumption that the economy is "closed" to foreign capital flows - and an alternative hypothesis concerning government crowding out of private investment has been put forward. According to this new view, earlier analyses implicitly assumed that capital flows into the nation were either non-existent or very insensitive to interest rates, which can thought of a "closed" economy assumption. Empirical evidence suggests, however, that international capital flows are quite large and very sensitive to interest rate changes. In this case, the supply of investment funds to the US equity and debt markets is likely to be highly elastic, which can be thought of as an "open" economy condition.

Under this new view, as a result, financing a public project through borrowing might not crowd out any private investment. If this is the case, then no adjustments using the shadow price of capital may be necessary at all. The implication of this new "open economy" view is that the cost of financing government programs is lower than previously thought. This conclusion has an intuitive basis: altering the supply of a factor of production from highly inelastic to highly elastic ought to make it cheaper to obtain more of the products or services that rely upon it.

This extension of the shadow price of capital-consumption rate of interest approach to the case of an economy "open" to substantial capital flows is relatively recent. And, as is true for most of the discounting literature, virtually all of the discussion focuses on public project financing, as opposed to environmental regulations, which largely mandate that private parties undertake certain actions or expenditures in pursuit of social objectives. Finally, while it is indeed intuitive to argue that private investments are not displaced by either additional government borrowing or mandatory private investments for environmental protection, it is often the gross gains and losses of the affected parties in the economy that are the focus of regulatory impact analyses. How the change in the assumption concerning the availability of investment funds to the economy translates into these gross gains and loses is critical for conducting accurate environmental policy assessments. For all of these reasons, it is worth clarifying - in terms of the gains and losses of traditional importance in regulatory impact analyses - the shadow price of capital adjustment issue for both public projects and environmental regulations that mandate capital investments, and in the context of both the "open" and "closed" economy assumptions regarding capital flows.

Public Projects and Mandated Private Investments in a "Closed" Economy

To focus closely and exclusively on the shadow price of capital adjustment issue, some simplifying assumptions are helpful. Assume that there is no risk and uncertainty, that all firms and the government borrow at the interest rate "i", that taxes on investment income are levied on all

sources of such income at a rate of "t", that the resulting post-tax interest rate, r (=i*(1-t)), is the rate individuals discount future consumption, and that the appropriate social rate of discount is this consumption rate of interest. Further, assume that the net-of-tax returns from all investments are consumed in each year (to assist in making this discussion as simple as possible). Assume finally that the supply of investment funds is perfectly inelastic with respect their price, the interest rate.

Public Projects

Consider first a public project that costs $1 and that is financed through taxes on labor and other factors of production (but not capital), and that offers future environmental benefits. Assuming that increased current taxation reduces current consumption exclusively, the cost of the project is this amount of reduced current consumption. This cost will be borne by current citizens. Future benefits, once valued in terms of future consumption, can be discounted to the present using a social rate of discount equal to the consumption rate of interest to estimate the net social present value of the project. For the remainder of this discussion, the benefits side of the calculations will be ignored to focus on the cost computations considerations of central importance here.

Now consider exactly the same project, but assume that it is financed only through government borrowing, which crowds out a equal amount of private sector investment. To calculate the costs of this project financing it is perhaps most instructive to analyze the impacts on the different entities affected.

Take first the private investors who lend $1 to the government instead of to private firms. They are indifferent because they receive the interest rate "i" from either source, and therefore continue to receive a stream of returns net of tax equal to $1*r.

Next consider the government, which can be thought of as representing the interests of citizens in future years. The foregone private investments would have generated a stream of tax revenues of $1*t*i each year which is lost. But the increased public debt is taxable, so the government regains this $1*t*i each year, which implies that the streams of gained and lost tax revenues offset each other. But, the government must service this new debt by raising future taxes each year by the amount $1*i (assuming, for simplicity, that the debt is a perpetuity).

As a result, the cost of financing this public project through government debt in a closed economy context is a stream of decreased consumption experienced by citizens in the amount of $1*i per year forever. The present value of this stream of foregone consumption computed using the consumption rate of interest, r, exceeds $1. This is the essence of the shadow price of capital adjustment rationale. "i" exceeds "r" in this example because of the tax "wedge" between the social (pre-tax) rate of return on investments and the (post-tax) consumption rate of interest. This is the equivalent of observing that a taxable investment yields a private return of "r" per year to the investor, and a "return" of t*i to the government in the form of tax revenues.

Mandated Private Environmental Investments

Assume now that the relevant investment is a private sector capital project that must be undertaken in order to comply with an environmental regulation. To estimate the social costs of this requirement under the closed economy assumption, two polar cases are useful to examine: no regulatory cost shifting to consumers (assume as well, for simplicity, that it is not possible to shift these costs to other factors of production), and full cost shifting to consumers through higher product prices.

In the case of no regulatory cost shifting to consumers, the owners of the entities required to make these investments either must obtain debt or equity funds, or reduce their other investment and lending activities, to comply. Wherever the required funds originate, two facts are clear. One is that other taxable investments of $1 will not be undertaken. The second is that, because the price of the products or services into which this environmental investment flows does not rise, the mandated investment will produce no "return" for the owners involved or for the government in the form of tax revenues.

The result is that the owners lose their stream of investment income, $1*r, and the government loses its stream of tax revenues of $1*t*i, because of the displaced private investment. But since r=i*(1-t), this adds up to a stream of costs per year of $1*i. The rationale for the shadow price of capital adjustment appears here once again.

Now assume that the cost of the mandated environmental investment is shifted to consumers through higher prices, which rise by enough to provide the full social pre-tax return of "i". In this case, the owners of the entities required to make these investments are indifferent (abstracting from short-run adjustment issues and related complications). Similarly, the government is indifferent - it still receives a stream of tax revenues on the $1 investment. Here, however, it is consumers of the regulated product or service who are not indifferent. In fact, the product price increase they face is precisely enough to provide the $1*i pre-tax social return on the regulatory investment. So, the shadow price of capital adjustment is relevant here as well.

Public Projects and Mandated Private Investments in an "Open" Economy

The central difference between the closed and open economy contexts concerns the conditions of supply of investment funds. In the closed economy case, the amount of these funds is fixed, so the total available for all projects, private, public, environmental or other purposes, is constant. Hence, the key to analyzing that case lies in tracing the implication of altering the composition of the investments undertaken with and without a new public project or a new environmental regulation mandating private investments.

In the open economy context, however, what is fixed is not the supply in investment funds, but the price at which they may be obtained. In this case, all investments worth undertaking without a new public project or a new environmental regulation requiring investments will still be worth it with those new policies - so that there will be no impact of such projects or regulations on capital availability and investments. This suggests that measuring the costs of these policies in this open economy context may be slightly different than in the closed economy case.

Public Projects

Purely taxed-financed public projects are not discussed here because the results for that case do not depend on the nature of supply of capital. For debt-financed public projects, however, the results under the closed and open economy assumptions are very different. In this open economy case, the government's increased $1 of borrowing does not change the level of US private sector investment. Hence, the government must service the debt at a cost of $1*i per year, but also gains from that $1*i*t of tax revenues from those taxable interest payments. The net cost is only $1*i*(1-t), which is the stream of net future consumption reduction citizens will experience as the cost of the new public project. But because i*(1-t)=r, this stream of reduced consumption is really $1*r. Discounted at the consumption rate of interest, "r", this implies that the present value cost is $1. Hence, the rationale for the shadow price of capital adjustment disappears in this case.

Mandated Private Environmental Investments

To analyze the implications of the open economy assumption for mandated private investments, the no- and full- cost pass-through polar cases continue to be illustrative. In the case of no regulatory cost pass-through, the results are very simple. The owners of the entities required to make the investments to comply with an environmental regulation will obtain the necessary funds from whatever sources are appropriate - from their own resources that would have been invested elsewhere, from new sources, and so forth - and devote them to the required investments. Because the price of the regulated services or products do not rise to compensate for these costs, no return to these owners or to the government in the form of tax revenues will result. But, because the supply of investment funds to the economy is perfectly elastic, no other worthwhile investments will be foregone.

The result in this case is that the owners of the entities required to make these investments will lose a stream of private investment returns of $1*r (their net of tax return on production investments) if the regulatory investment causes them to reduce investment elsewhere. Alternatively, the effected entities may increase their demands on the investment funds market and continue with their pre-regulation investment plans. Nevertheless, because "i" is constant, all investment projects that were profitable before the regulation is imposed will still be profitable, and these investments will be undertaken as if the regulation did not exist. Hence, the government loses no tax revenue as a result, and no shadow price of capital adjustment is appropriate here.

Finally, if the costs of the mandated private investments are fully passed-through to consumers, the owners of the affected entities are now indifferent. The government and the consumers of the relevant services or products, however, are not. First, the consumers of the regulated sector's output face cost increases equivalent to $1*i, which is the amount necessary to fully recoup the full pre-tax social return on the invested capital. But the government gains a stream of tax revenues associated with this mandated investment, amounting to a stream of $1*i*t per year. Again, all other investments are still undertaken because of the assumption regarding the supply of investment funds.

As a result, the net cost to society is the product or service cost increase to consumers, equal to $1*i per year, minus the increase government tax revenues - which represents future reduced taxation - of $1*i*t per year, for a net cost of only $1*i(1-t)=$1*r. The shadow price of capital adjustment appears not to be required here either. But note that the cost increase for the firm and its consumers is measured by the pre-tax amount pre year, $1*i, not the net social cost of $1*r per year. The former is the relevant measure for modeling private sector "economic impacts", and for assessing the gross gains and losses of a regulation, while the latter represents the social perspective.

Summary

The broad conclusions reached in this review of the shadow price of capital adjustment's rationale and necessity in the context of public projects and environmental regulations, and under the open and closed economy assumptions, are that the social costs of investments for environmental improvement do not depend on the entity undertaking the action, but instead depend on the assumption made concerning the supply of investment funds to the economy. Thus, the shadow price of capital adjustment is relevant for a "closed" economy for both a public project financed with government debt and for mandated private investments. It appears not to be relevant for either case if the supply of investment funds is perfectly elastic.

This analysis should also assist in illustrating the differences between net social cost analysis and private cost and impacts assessments. For example, in the open economy context, mandating private environmental investments whose costs are shifted to consumers of the relevant products and services imposes larger private costs than social costs. But perhaps equally interesting is that under the closed economy assumption, these same private costs also measure the social costs of the relevant intervention. The difference is in the assumption, or the reality, of whether other taxable investments are displaced in the process. Thus, the same private-perspective analysis for an industry investing to comply with a regulation yields two different conclusions for social costs depending on the underlying capital market conditions.

More generally, the location and magnitude of the private costs imposed by a regulation may bear no immediately obvious relationship to the net social costs: these privately-perceived components must be estimated and evaluated from a social perspective - using the appropriate assumptions to reflect capital market conditions - to arrive at net social cost measures. Careful consideration of this issue appears to be warranted in developing guidance materials for conducting regulatory impacts analyses in the future.

Key literature on the consumption rate of interest and the shadow price of capital approach include Lind (1982b), Lind (1990), Lind (1994), Lyon (1990), Lyon (1994), Kolb-Scheraga (1990), Scheraga (1990), and Pearce and Ulph (1994).

Weighted Average of Pre- and Post-Tax Rates of Return

Another approach for addressing the divergence between the higher social rate of return on private investments and lower consumption rate of interest recommends that the discount rate for public projects should equal a weighted average of the two, with the weights equal to the proportions of project financing that displace private investment and consumption respectively. Intuitively it is appealing to set an overall project discount according to the amount lost by displacing consumption (using the lower consumption rate of interest) and the amount lost by displacing investments (using the higher social rate of return on private capital).

For example, suppose the social rate of return from private investments is 5% and the consumption rate of interest is 3%, as above. Suppose further that a 75% of a public project's costs are financed using government debt, with the remaining 25% of the costs raised through taxation. Finally, assume that government debt crowds out private investment on a dollar-for-dollar basis and that increased taxes reduce individuals' current consumption also on a one-for-one basis. The weighted average approach then suggests that the social rate of discount should be 75% of 5% plus 25% of 3%, or 4.5%. If the proportions of the project's financing from each revenue source were reversed, however, the weighted average discount rate would instead be 25% of 5% plus 75% of 3%, or 3.5%.

This approach has enjoyed considerable popularity over the years, and is probably acceptable for similarly-timed cost and benefit flows. In the form stated above, however, it is technically incorrect, and can produce net present value results substantially different from the correct result ("correct" within the terms of the model and assumptions, and as measured using the shadow price of capital - consumption rate of interest approach). The problem with the simple weighted average approach is that it seeks to accomplish two tasks using the social discount rate - pure time discounting, and adjusting for the displacement of private investments that yield pre-tax social returns higher than the consumption rate of interest.

In general, the correct "synthesized" rate based on the social rate of return form private investments and the consumption rate of interest that accomplishes both objectives will depend on the timing of the cost and benefits flows, so that a simple weighted average based only on project cost components will not in general be correct. Hence, obtaining accurate results using this weighted average procedure requires computing the "correct" solution based on the distortions and other conditions that exist, and then deriving the implied discount rate to apply to monetized costs and benefits.

Consider how the weighted average discount rate approach performs for the simple numerical example discussed above. Assume that the social rate of return on private investments is 5%, that the consumption rate of interest is 3%, that increases in government debt displace private investments dollar-for-dollar, that the $1 current cost of a public project is financed 75% with government debt and 25% with current taxes, and that the project produces a benefit 40 years from now that is estimated to be worth $5 in the future. The weighted average social discount rate approach would suggest discounting the future benefit at a 4.5% rate (.75 times 5% plus .25 times 3%). This produces an estimated net social present value of -$.14, which is the present value of the future $5 benefit discounted using a 4.5% rate ($.86) minus the current year $1 cost. In this case, the weighted average social discount rate approach suggests that the project has a negative net social present value. But earlier, the shadow price of capital - consumption rate of interest approach was applied to exactly this scenario, concluding that the net social present value is positive.

The problem with the weighted average approach is that its method for accounting for the higher social cost of displaced private investments is to “overdiscount” the benefits. But the amount of “overdiscounting” necessary in this example to adjust for the actual social costs of the project’s costs depends on the time profile of the benefit stream - the further in the future the benefits occur, the less “overdiscounting” is needed. The source of the project’s financing is therefore insufficient to define a single rate of social discount that will produce correct net social present value results for any given policy. Accordingly, the shadow price of capital - consumption rate of interest method is widely considered to produce the correct social net present value answer within the confines of the model and assumptions underlying approach (particularly the view that the government ought to discount future consumption at the same rate as do affected individuals).

Lind (1982b) provides a clear exposition of the weighted average approach for estimating the social discount rate. A large literature on this topic spanning the 1960s through the early 1980s exists, and has been summarized well by Lind and others.

Opportunity Cost of Other Investments

Another strand of the traditional social discounting literature argues that the government should not invest (or compel investment through regulation) in any project that offers a rate of return less than the social rate of return on private investments. Stated another way, because the citizens collectively enjoy the benefits of all public and private investments, welfare will be higher overall if the government invests in projects with the highest rates of return.

Critics of this social investment rule argue that the government cannot realistically tax citizens and then invest in private sector projects. If not, the issue is not what "could" be done with the funds, but rather what "would" be done with them. Thus, if the government obtains funds for a project through taxation and this displaces only private consumption, then relative to consuming the resources today, welfare is increased as long as the project generates future benefits that exceed

those costs when discounted at the consumption rate of interest. Of course, it remains true that welfare would be further increased if the funds were devoted to an even more valuable project.

A closely related opportunity cost-based observation does not require taxes on private investments to generate complications through divergences of social and private investment returns. Instead, suppose that the government faces a menu of projects and is not able to undertake all projects that have positive net social benefits when computed using a social rate of discount equal to the consumption rate of interest, for whatever reason. In this event, the opportunity costs of funding one program are the benefits of other programs not funded. Proponents of this view typically conclude that the "hurdle" discount rate for a particular project should be equal to the rate of return offered by other projects foregone.

Regardless of the particular point of departure, the central point of the opportunity cost strand of the social discounting literature is valid. Social welfare will be improved if the government examines the net benefits of all courses of action before deciding to undertake any given project that has positive net benefits when calculated using a social rate of discount equal to the consumption rate of interest, and then selects the set with the highest net benefits. So stated, this advice is correct.

However, it does not follow that rates of return offered by other private or public projects define the level of the social discount rate. An alternative project might produce large benefits over the future, and thus offer a large "rate of return". But if individuals discount these future benefits using the consumption rate of interest, this project offers substantial net benefits, not guidance for intertemporal valuation. In general, the opportunity cost advice is not about the social discount rate *per se*, but about correctly and consistently examining the social values of all alternatives. As was the case for the shadow price of capital, a high rate of return alternative project will have a high social net present value, but that does not imply that its rate of return should become the social rate of discount to be used for pure time discounting for other projects.

Many authors cite high opportunity costs of public investments. Among these are Birdsall and Steer (1993), Schelling (1995), and Lyon (1994). On the technical issue of rates of return vs. net present values, see Lind (1990) and Cowen and Parfit (1992).

1.2.3 Concrete Advice on Discounting Procedures in Conventional Contexts

It is fair to say that the vast majority of the traditional discounting literature has focused on exploring the implications for public project evaluation of a few, probably very important, departures from the idealized no-other-distortions simplified economy for which unambiguous social discounting recommendations can be made. Yet, in the development of that literature, many matters have been addressed and are considered by many contributors to this literature to be somewhat settled, some of which are discussed above, and others not (largely because they are not directly social discounting issues).

In particular, for conventional social discounting:

- There is reasonable agreement that the social rate of discount ought to reflect the private rates of consumption discount of the citizens affected.

- If social and private returns from private investments are different, then adjustments should be introduced to reflect this when and if policies alter private investment flows.

- Uncertainty and risk should largely be addressed through appropriate valuation of costs and benefits, e.g., certain monetary equivalents, rather than through modifications of the discount rate.

- Changes in the values of environmental goods and other such factors should likewise by reflected in direct cost and benefit measurements, not through adjustments to the social discount rate.

- Irreversibility of consequences is an option value concept and requires separate treatment in cost-benefit analyses, but it does not provide a reason to adjust the discount rate.

- Opportunity costs of other public and private uses for funds should be considered in evaluating the desirability of undertaking a particular public investment or regulation. That is, deciding to pursue a public project depends on more than simply whether the project has positive net present value benefits when discounted using the consumption rate of interest.

Despite the considerable theoretical guidance these conclusions represent, none of these concrete suggestions pertain to the selection of a numerical social discount rate for use by analysts in practical policy evaluation settings. Indeed, the progress made in the social discounting literature for conventional situations relates mostly to resolution of certain theoretical implications of differences between social and private values of investments, and to valuation and other issues related to conducting cost-benefit analyses of intertemporal programs.

What guidance is offered on the choice of a rate for social discounting focuses on estimating the consumption rate of interest as the rate of return individuals face in translating consumption through time with reasonable certainty. For this, historical rates of return, post-tax and after inflation, on "safe" assets, such as US Treasury securities, are normally used, typically resulting in rates in the 1% to 3% range. Some work on expanding the portfolio to include other bonds, stocks, and even housing has been done, and this generally raises the range of rates slightly. It should be noted that these rates are *ex post* rates of return, not anticipated, and they are somewhat sensitive to the time periods selected and the classes of assets considered. A recent study of the social discount rate for the United Kingdom places the consumption rate of interest at 2% to 4%, with the balance of the evidence pointing toward the lower end of the range.

For the shadow price of capital, even less concrete guidance is offered. This parameter depends on the consumption rate of interest, the gross-of-tax rate of return on private investment, and the rate of consumption out of net investment returns. Depending on the magnitudes of these factors, shadow prices from close to 1 to 3, 20, 100, and infinity can result. Whether or not this adjustment is necessary appears to depend largely on whether the economy in question is assumed to be open or closed, and on the magnitude of the intervention or program considered relative to the flow of investment capital from abroad. Of course, for analyzing global regulations or public programs, there is no "outside" source of investment funds.

In providing concrete advice concerning rates to use in social discounting, the literature relies heavily on assumptions that allow one to assume that all individuals discount at the same rate

and that this rate of interest is observable in the market. Despite the use of these assumptions to produce an "answer" for policy makers, many economists are not convinced that these hold in practice. Casual observation of individuals in the US and across the world suggests that different people discount at different rates, sometimes radically different rates. Some save at near zero post-tax real rates, while others borrow at non-deductible real rates in excess of 10%, and purchases of energy-efficient appliances reflect even higher implied discount rates.

Perhaps worse, recent studies of individual's financial and other decision making suggest that even a single person may appear to value and discount value different actions, goods, and wealth components differently. This "mental accounts" or "self-control" literature suggests that individuals may well treat some aspects of the future quite differently from other consequences, and that the discount rate an individual might apply to a given future benefit or cost, as a result, may not be observable from market prices, rates, or phenomena. This may be especially the case if the future consequences in question are not tradable commodities.

Experimental evidence also indicates that discount rates appear to be lower the larger the magnitude of the underlying effect being valued, higher for gains than for losses, and tend to decline as the length of time to the event increases.

So where does this leave the practical policy maker who must evaluate future benefits and costs from a social perspective? Matters appear to have come full circle back to the original point of departure described at the outset. If policy analysts ought to be evaluating costs and benefits experienced by each individual and then discounting as each person would - to determine if the gainers could compensate the losers - the uncomfortable reality may be that the quest for one rate to represent the social perspective is analytically misguided, but perhaps necessary for expediency.

The options for conventional discounting situations at this point appear to be as follows:

- Continue with what is largely current practice and the most substantive advice offered in the literature: 1% - 3% - with or without the shadow price of capital adjustment (or the Kolb-Scheraga method).

- Disaggregate more and use different rates for particular subpopulations, derived by reference to observed rates, e.g., net savers, borrowers, etc., or perhaps attempt some more formal analysis of the mental accounts approach using different classes of costs and benefits of environmental policies, and the rates of discount different individuals might attach to them - with and without the shadow price of capital adjustment (or the Kolb-Scheraga method).

- Be agnostic, use a wide range of rates, display flows of costs and benefits, and so forth, but without necessarily arguing for one particular estimate - with and without the shadow price of capital adjustment (or the Kolb-Scheraga method).

Lind (1982b) is a comprehensive reference for empirical estimates of the consumption rate of interest. Pearce and Ulph (1994) provide the estimates of the consumption rate of interest for the United Kingdom. Lyon (1994) provides estimates of the shadow price of capital under a variety of assumptions. Shefrin and Thaler (1988) and Thaler (1985) are central sources for the mental

accounts idea, and Lowenstein and Thaler (1989) report numerous examples of various inconsistencies and other aspects of individual intertemporal choices.

1.3 Social Discounting and Long Time Horizons

This section focuses on social discounting in the context of intergenerational policies with very long time horizons. The discussion first examines how the point of departure for intergenerational discounting differs in some very fundamental ways from that of conventional social discounting. Next, various approaches for deciding whether and how to discount when evaluating intergenerational policies are then briefly reviewed. Finally, the section concludes with some observations concerning what operational advice might be obtained from this literature.

1.3.1 Analytical Point of Departure for Intergenerational Discounting

One obvious problem with long time horizon circumstances is that many of the people affected by a policy are not yet alive. Hence, while the preferences of each affected individual are knowable (if probably unknown in practice) for conventional social discounting problems, they are essentially unknowable for those involving future generations not yet born.

The need to "guess" at future generations' preferences alone, however, is not always a fatal problem in long time horizon social choice problems. We seem to have little trouble assuming that future people (presumably US people) will be pretty much the same as we are (or maybe different, but in ways that probably won't matter terribly) when policies impose relatively modest costs and benefits, or when the benefits begin immediately, or in the not too distant future. This is at least partially because the costs and benefit streams may be largely matched through time (so that the policy offers increased welfare in each year), or simply because the costs and benefits are just not very large.

The central social choice problem in long time horizon situations arises primarily when costs and benefits of an action or inaction are very large in the time periods in which they are felt, and are distributed asymmetrically over vast expanses of time (e.g., costs in the relatively near future and benefits in the much more distant future), such as global climate change mitigation policies. And the crucial problem is not ignorance of future generations' preferences. Rather, it is that future generations are not present to participate in making the relevant social choices. Instead, they will be made by only currently-existing generations.

As a result, perhaps the key evaluation factor that determines whether a policy provides positive net present value benefits over a long time horizon - discounting - can no longer be thought of as, essentially, the result of consulting the preferences of all affected parties concerning their valuation *today* of effects they will experience in different time periods. Without this epistemological (and ethical) anchor, the economic criterion for determining whether a policy is a potential Pareto improvement appears to become somewhat arbitrary. Discounting in an intergenerational context is fundamentally not the same thing as an individual discounting his or her own consumption stream.

Another significant issue in intergenerational discounting is distributional consequences. Costs and benefits may be quite large to those who bear or enjoy them, regardless of whether the present value of net benefits at some particular discount rate is positive or negative. Because of this, the slight-of-hand used in conventional environmental regulation to essentially ignore distributional effects doesn't work well. That is, some implicitly argue that regulations simply establish the

"correct" rights allocation, so gainers don't have to compensate losers. And if the stakes were really large, we might try to fashion some sort of compensation mechanisms through tax or other policies.

But there is a deeper, perhaps philosophical, problem with intergenerational compensation notions. In the conventional social discounting context, all of the parties affected are assumed to possess property rights for everything else, with only those related to the externality in question subject to change. Under these circumstances, compensation for a policy change restores some baseline (deserved) level of utility.

In the intergenerational context, it is not at all clear what rights current and future generations possess. People argue on both sides of this question. Some say that we individually and collectively ought to/do think that future generations will be richer than ourselves anyway; others argue for strict forms of sustainable development (bequeathing the same or better environmental assets) irrespective of other considerations. Thus, intergenerational compensation mechanisms (aside from their practical difficulties) are hard to define without clear notions of baseline rights. Evaluations of long time horizon policies with large stakes therefore may be more akin to deciding the equitable distribution of intergenerational consumption than they are like conventional cost-benefit analyses of public programs and regulations.

1.3.2 Perspectives on Intergenerational Social Discounting

The literature contains many different perspectives concerning social discounting in intergenerational contexts. The goal in this section is to briefly describe what appear to be the major approaches. The focus in all of these approaches is on the discount rate itself, so issues such as the shadow price of capital adjustments, while clearly still relevant, are not in the foreground.

Social Welfare Planner Approach

One popular recommendation is that social discounting procedures for intergenerational projects should be the same as those that economists have been used for many years in optimal growth analyses. The decision maker is understood to be maximizing social welfare defined over the utilities of all present and future generations using a well-defined social welfare function.

In optimal growth models, the social rate of discount generally equals a discount rate for pure time preference, plus an adjustment for declining marginal utility over time as consumption presumably increases, which equals the elasticity of marginal utility times the rate of increase of consumption over time. In a world without taxes and other distortions, the social rate of discount would also equal the market interest rate (which is equal to the social rate of return on private investments and the consumption rate of interest).

But because the world contains many distortions, the social rate of discount derived this way is not observable. Recent practical applications of this approach to very long time horizon analyses have therefore attempted to estimate the social discount rate by building it up from its components. Most assume that the rate of pure time discount is zero, adhering to the ethical precept that the decision maker ought not to inherently favor present generations' consumption over that of future generations. They then introduce hypothetical, but perhaps plausible, estimates of the elasticity of marginal utility and the rate of growth of consumption over time. The product of these two factors is the implied social discount rate. This computational procedure in essence derives an implied social rate of discount under the assumption that future generations will be richer than we are today, so

that the marginal utility of consumption is projected to fall over time. Rates developed using this technique generally range from .5% to 3%.

There is a substantial body of literature on the economics and ethics of intertemporal social welfare maximization and optimal growth. This literature can also be thought of as extending far and wide, from the economics and ethics of interpersonal and intergenerational wealth distribution, to the more specific environment-growth issues raised in the "sustainability" literature, and even to the appropriate form of the social welfare function, e.g., utilitarianism, or Rawls' maxi-min criterion. It should suffice for current purposes to note this, and to maintain that economics alone is not likely to provide definitive guidance for selecting the socially correct social welfare function or any of its parameters.

Indeed, some have raised very strong objections to the practical derivation of a social discount rate using a social welfare function formulation. It is argued that these rates are inconsistent with the rest of public policy making, particularly the general provisioning of future generations: savings rates "ought" to be far higher if these discount rates are the correct ones. If we don't appear to use this range of discount rates and the associated social welfare function in evaluating and acting on other intergenerational policies, why should we for any particular long time horizon environmental policy? Proponents, however, argue that policy making in other areas that is inconsistent with the implied social rate of discount does not affect the conclusion that policy analysis and action based on the "correct" social discount rate will still enhance overall welfare across all generations.

A battle between "is" and "ought" is clearly a matter for policy makers and philosophers, not economics. Nevertheless, economics can offer some advice concerning the implications and consequences of alternative choices, and can certainly offer advice on the appropriate and consistent use of its social welfare function policy evaluation tool.

For example, most of the formulations of social discounting from the social welfare function perspective assume that the beneficiaries of current and near future costs will be individuals who, in the distant future, will be richer than today. This provides for a positive discount rate because of declining marginal utility of consumption, even when the pure time rate of discount is zero.

Some have argued, however, this derivation of a positive social discount rate poses a potential consistency problem for public project evaluation. If future generations will be richer than today, even if a public project that imposes costs now and offers benefits in the distant future has positive net present value benefits, actually undertaking the project seems strange, for it is effectively a program that transfers wealth from poorer to richer individuals. Usually transfer programs seek to take from the rich and give to the poor. This perspective therefore examines intergenerational environmental policies in the broader context of socially appropriate intertemporal wealth distribution. Accordingly, actions to reduce pollution problems in the distant future are cast more in terms of the distribution of social wealth through time than they are environmental policies, and they appear to make little sense if they involve current sacrifices by individuals who are relatively poorer than those whom they seek to assist.

A related issue that arises under the social welfare function approach is that of compensation of the losers by the gainers. Discarding the Paretian framework that underlies conventional discounting framework and adopting an explicit social welfare function for the analysis inevitably places great emphasis on achieving and maintaining overall intergenerational equity. Hence, if we start from a position at which the relative wealth of present and future generations are acceptable and then suddenly discover that some of our current actions will impose large burdens on the future,

some sort of accumulation fund might be appropriate to provide compensation for those harms. There is considerable skepticism regarding the willingness of the current generation to provide these funds, and a significant concern that intervening generations may not continue the accumulation process.

Regarding climate change policies, a further observation is that a correct application of the social welfare approach would measure marginal utilities of the affected parties realistically. If those who bear the costs of climate change policies are individuals living in the richer nations in the present, and those who gain are future individuals who will reside mostly in what are now poorer nations and who will probably still be poorer even in the future than are those who bear the costs now, the implied social discount rate is negative. The marginal utility of consumption of the beneficiaries in the future will be higher than the marginal utility of those who bear the costs today. Because the discount rate in this welfare planner framework simply mirrors assumed changes in consumption and implied marginal utilities of different parties, the discount rate for effects on future poorer people will be negative to provide "just" comparisons to the utility of richer people living today. Of course, this simply reflects the difficulties that result from using a social welfare function approach for evaluating an intergenerational policy when the rest of our public policies (e.g., wealth distribution) are not consistent with that ethical formulation.

Finally, another related line of reasoning is that if the social welfare function contains future non-US individuals, presumably it should also include current non-US people. If so, perhaps their claims on any transfers from the developed nations have higher priority in social welfare terms than their distant descendants' because existing generations are likely to be far poorer than their future brethren will be.

Overall, in the literature, social welfare function formulations of intergenerational policies tend to be analyses in which the characteristics of optimal growth paths, or sustainable growth possibilities, and other such theoretical constructs are examined. Practical use of social welfare functions for social discounting have been focused on merely using the framework and its logical consequences for deriving an implied discount rate. The problem with relying on the social welfare function approach for this limited purpose is that the framework's consequences are hard to avoid for all other social choices, such as those enumerated above and many others that fundamentally involve wide-ranging distributional considerations. What is supposed to be merely a tool for generating an input for cost-benefit analyses of environmental policy interventions quickly fuels debates about the appropriate distribution of wealth across nations and time.

This has the more subtle effect of contributing to the general tendency in this literature to intertwine the analytically distinct acts of (1) valuing future consequences of a policy using a discount rate, and (2) choosing policies based on net present values. Logically, the latter procedure ought rightly to incorporate opportunity costs, but the former should not.

Key literature on this topic include Arrow et al. (1996), Lind (1994), Schelling (1995), Solow (1992), Manne (1994), Toth (1994), Sen (1982), Dasgupta (1982), and Pearce and Ulph (1994).

Approaches Based on Existing Individuals' Preferences

The major alternative to the social planner approach for intergenerational discounting is to rely on the preferences of current individuals for an appropriate discount rate. At its core, this perspective views the problem not as one of balancing the interests of all humans who will live now

and in the future, but instead as one of current individuals allocating today's scarce resources to competing ends, one of which happens to be the welfare of future generations.

Consumption Rate of Interest/Infinitely-Lived Individuals

Although not popular in theoretical terms, in practice it is common to adopt the approach of simply making no great distinction between intergenerational and conventional social discounting, and to use various rates without worrying about strong justifications. The consumption rate of interest is suggested by models of infinitely-lived individuals. This approach effectively ignores the fact that individuals actually do not live long enough to experience distant future consequences of a policy and to report the present values they place on those effects. As such, models of infinitely-lived individuals essentially ignore the fundamental problem posed in evaluations of policies that affect distant future unborn generations.

Intergenerational Discounting vs. Intertemporal Discounting

Some argue that the time dimension inherent in an individual's intertemporal allocation of his or her own consumption is largely absent from the individual's valuation of his or her descendant's welfare. The idea is that one's present valuation of consumption by future generations is generally less than one's own consumption, but that (1) this present valuation does not depend on when during the lifetime of a future generation this consumption occurs, and (2) the decline in present valuation of the consumption of successive future generations is gradual and approaches some constant positive value. Overall, this notion of social discounting represents a radical departure from the purely exponential time-based approaches that characterize most of the literature.

Along similar lines, some argue that large-scale catastrophic consequences in the future are viewed differently than marginal changes in welfare, and that it matters little whether these possibilities are 100 years or 1,000 years in the future. If so, applying exponential time discounting to such future consequences is inappropriate. The analytical basis for this point of view might be similar to the "mental accounts" notion described earlier whereby individuals place different phenomena into categories that are then handled separately for purposes of valuation and action. Of course, this leads to apparent inconsistency between time discounting for some actions and outcomes, and intergenerational or even no discounting for others, but perhaps no more than what is observed empirically.

Sources on this topic are Rothenberg (1993a), Cropper, Aydede, and Portney (1992), Shefrin and Thaler (1988), Thaler (1985), and Cowen and Parfit (1992).

Revealed/Stated Preferences for Altruism

According to this view, environmental policies that affect distant future generations are considered to be altruistic acts. As such, they should be valued by current generations in much the same way as are other acts of altruism. Hence, the discount rate in question is not that applied to an individual's consumption, but instead that applicable for an individual's valuation of the consumption or welfare of someone else.

At least some altruism is apparent from international aid programs, private charitable giving, and bequests within overlapping generations of families. But the evidence suggests that the importance of other people's welfare to an individual appears to grow weaker with temporal, cultural, geographic, and other measures of "distance".

Proponents of this perspective note that (1) if some environmental policies will benefit wealthier generations in the distant future, there is little evidence to suggest that current generations would agree to transfers from poorer to richer individuals, and (2) if the costs of those programs are to be borne primarily by currently richer nations, but will benefit primarily future generations in other nations, citizens of the former are not likely to assent to such transfers in light of the level of their current transfers to existing even poorer foreigners.

The desire some public policy analysts express for conducting a national referendum on the overall issue of climate change policy might resolve some of these questions, at least for the US.

Evidence on the implied discount rates survey respondents appear to reflect in trading off present and future lives also is relevant under this approach. One such survey suggests that these rates are positive on average, and substantially so, although they do appear to decline with the length of the time horizon involved.

Schelling (1995), Birdsall and Steer (1993) are good references for these arguments. The survey is reported in Cropper, Aydede, and Portney (1992).

Opportunity Cost of Other Programs

A variety of perspectives in the intergenerational discounting literature converge on the broad notion that devoting resources to long time horizon environmental projects such as climate change - largely because low discount rates appear to make these attractive in present value terms - neglects numerous other social investment opportunities with higher values. Advocates of this point of view point to numerous alternative social investments that would generate far larger benefits now and in the future, such as basic infrastructure, education, medical assistance, and other projects in developing nations.

Depending on the context, this point of view is often expressed in two different ways: (1) many other investments would be more beneficial to society, and so long-time-horizon environmental programs, such as climate change, face very high opportunity costs, or (2) the rates of return offered by alternative investments are high, and these rates ought to be used as the social rate of discount. As noted earlier in the context of conventional social discounting, the first way of stating this opportunity cost argument is the correct one; the second is somewhat problematic.

To recapitulate, if the actual rate at which future benefits are valued is lower than rates of return offered by some set of alternative government or private investment programs, then the cost of foregoing those projects is quite high because the returns from those alternatives are valued in present terms using a discount rate lower than the rate of return they provide. But this does not imply that future benefits of some other project ought to be discounted at an alternative project's higher rate of return.

Many authors cite high opportunity costs of public investments. Among these are Birdsall and Steer (1993), Nordhaus (1993), Schelling (1995), Lyon (1994).

Paretian Compensation Tests

One final approach for social discounting in an intergenerational context returns to the theoretical motivation and ethical underpinnings of conventional social discounting. The basic

thrust of this position is that the social discounting question in an intergenerational context can be productively thought of as simply whether the distribution of wealth among many different generations could be adjusted in order to compensate the losers under some environmental policy and still leave the gainers better off.

Using this approach, a variety of assumptions would be required to forecast the distant future value of the consequences of an environmental problem or policy. But once this future valuation is settled on, the questions of whether gainers could compensate losers hinges on the rate of interest at which society (the US presumably, or perhaps the entire world) can transfer wealth across hundreds of years. Some argue that in the US context, a good candidate for this rate is the federal government's borrowing rate.

It is worth noting that this approach implicitly abandons the goal of somehow measuring the present "social" value of some distant future event or consequence. The conventional approach to social discounting values goods and anything else of interest using the preferences of individuals. But, as discussed above, no one alive now will experience distant future consequences of many public policies, so no one can be said now to have preference regarding the present value of experiencing these future effects.

Nevertheless, it is conceptually coherent to ask how much current compensation would have to be "locked away" for distant future generations to compensate them for the future environmental harms they endure due to current actions or omissions on environmental and other problems, or how much present generations should reduce their contributions for future generations if in fact the obligations are deemed to be reversed. Of course, applying this approach in intergenerational contexts requires many more assumptions and confronts numerous uncertainties, and the practical problems of whether adjustments to intergenerational wealth distribution are actually possible remain largely unresolved. But from a purely analytical perspective, the approach has at least some merit.

1.3.3 Guidance on Intergenerational Discounting

There is little consensus at the theoretical level in the intergenerational social discounting literature. At the core of the debate lies what appears to be matters of ethics and policy making. In particular, the fundamental choice of what moral perspective should guide intergenerational social discounting - a social planner who weighs all present and future generations equally vs. the preferences of the current generations regarding future generations - cannot be made on economic grounds alone.

Despite the clash of views and the lack of a clear consensus on theoretical grounds, a couple of central themes do emerge from this literature.

- Intergenerational discounting is qualitatively different from an individual's discounting of his or her own consumption. How society ought to make choices that affect the welfare of many generations, especially those not yet born, appears to be fundamentally an ethical question.

- In very long time horizons, environmental externalities that involve potentially large future consequences and current costs inevitably are viewed from the perspective of intergenerational equity. This contrasts sharply with the conventional view under which who should be allocated the right related

to an externality - or those harmed by pollution - is a secondary consideration. Thus, the economic debate concerning the desirability of embarking on expensive long-term policies to reduce substantial environmental impacts in the distant future centers largely on who should sacrifice for whom, rather than whether the policy action itself is a potential Pareto improvement. Despite the power of the social discount rate in determining the net present value of long-range environmental policies such as climate change, the intergenerational equity posture of the social choice involved (presumably without compensation) dominates.

- Some contributions to the literature suggesting actual time rates of discount for use in intergenerational project evaluation are within the range of the conventional advice for the consumption rate of discount - e.g., 0.5% - 3% for the social welfare formulations. The use of rates even at the lower end of this range for discounting large consequences in the distant future still might produce unsatisfactory results in the eyes of many who fundamentally disagree with the resulting ethical implications.

- The literature offers several ways to continue to discount the future without rendering far future large consequences minuscule in today's terms, such as intergenerational discounting of future human welfare, or the "mental accounts" point of view applied to distant future environmental effects, but these methods are very different from conventional time discounting and are largely hypotheses at present. Yet they might offer an avenue for entertaining low or no discounting for certain types of phenomena, perhaps large-scale profound consequences of climate change, which might be placed in a different conceptual "box" than other effects and policies, and so be discounted differently. Similarly, the suggestions that discount rates might decline over very long time horizons might be pursued.

- Discounting and the resulting net present values of intergenerational environmental policies cannot be the only determinants of whether such projects should be undertaken. Many contributors to the literature point to a host of other public policy opportunities with substantial net benefits that ought to be considered. These may not be, strictly speaking, advice on the social discount rate *per se*, but are quite relevant for making collective decisions regarding the allocation of scarce resources.

- Some of the literature argues that intergenerational policies, such as climate change, should not be viewed as "all or nothing" choices - where the discount rate then plays an overwhelmingly crucial role. Instead, they advocate hedging policies, act-and-learn strategies, and other incremental approaches.

In the end, the discounting literature appears to offer very little, if any, concrete and undisputed guidance on specific procedures and rates to apply in evaluating policies that span many generations. But the practical effect of this lack of consensus for environmental policy choices is probably not as profound as it at first appears.

First, as noted earlier, the major problems with discounting in long time-horizon contexts occur in probably a few cases out of a vastly larger set: where costs and benefits are inherently high and are substantially divorced in time. But the environmental regulations and policies that fit this

description are uncommon because most environmental programs are relatively short in duration and reversible (time frames determined largely by capital investments). And even many longer term policies result in costs and benefits that occur simultaneously through time, so that the discount rate is not such a controlling factor in determining their desirability.

Second, for the large-stakes, long time horizons circumstances in which applying conventional discounting procedures and rates is problematic: predicting and valuing future effects, forecasting possible technological change and wealth growth, and a accounting for host of other issues. These factors are all important determinants of the net social valuation of a policy and are just as difficult as discounting to accomplish with any precision. In these cases, one can argue that no discounting, or both no discounting and discounting, is preferable not necessarily on the grounds that diminution of value through time does not apply, but because discounting may hide important features of the problem and tradeoffs from decision makers, and confer an undeserved sense of analytical and empirical rigor, which the results do not in fact possess.

Third, there probably are many instances in which discounting is still acceptable in long time-horizon projects. Examples include cases in which benefits and costs occur at the same time (either lumpy or continuous streams through time), projects and policies that involve "small" costs and benefits, and cases in which, while there may be some asymmetry in the net benefits through time, the impacts - positive and negative - tend to occur in all time periods through the future - so that there is no obvious "break point" between the present, the near future, and the very far future. This casts the problem in a broader ethical context than the usual "now" versus the "distant future", so that the present, the near future, the more distant future, and the far future are all of concern. Indeed,, where the time horizon spans two to three generations, conventional discounting may be justified under an "overlapping generations" criterion: because these generations will consist of the current generation's children and grandchildren, and we assume these generations have a strong bond, we may be comfortable in assuming that the preferences of the current generation are representative of the preferences of future individuals.

Another class of cases in which conventional discounting principles seem to be unobjectionable even in long time-horizon situations is when one is considering alternative policies that alter the time distribution of benefits and costs experienced in the distant future. If future generations will resemble ourselves, then they presumably would prefer to bear costs later and enjoy benefits sooner. If so, these tradeoffs ought to be made for them in the same way that we would evaluate them for ourselves using conventional discounting. Here the focus is not on the “present” versus the "distant future", but about how those in the distant future would want us to decide about alternative policies that affect them exclusively.

Finally, policy makers probably would want to discount distant future events if not doing so would tend to result in what we would think of as absurd implications. For example, not discounting might indicate that undertaking projects that provide current, near future, and even more distant future benefits is undesirable because we can imagine allocating the resources to projects that result in even more benefits in the very distant future. Just as discounting at high rates is thought by some to unduly favor the present, not discounting at all can result in a tyranny of the very distant future over the present. This is especially pronounced if capital investments are productive, so that not spending now to benefit the present and the near future means that the funds can be invested to accumulate an ever-growing pool of resources to provide benefits to the ever more distant future. Without discounting far future benefits, it is possible to conclude that never spending the funds is the most desirable outcome.

2. DISCOUNTING AND NON-MONETIZED EFFECTS

For some few environmental policies or regulations under consideration, the environmental benefits - in terms of human health effects and valued environmental endpoints over time - will have been estimated in physical terms and monetized into a stream of dollar-denominated benefits. In many analyses, however, at least a portion of the environmental benefits will not have been monetized. The question then arises: "How should we deal with benefits that have not been monetized, in the context of cost-benefit analysis and discounting?"

One possible response is to treat such benefits as though they had been monetized, and to discount benefits that occur in the future. Arguments are sometimes made, however, that environmental benefits that have not been monetized cannot - or should not - be discounted and summarized together with costs in a cost-effectiveness or cost-benefit summary. These arguments tend to follow two basic lines of reasoning. One is that because discounting is essentially a financial process designed to evaluate investment decisions, it is only relevant to dollar-denominated streams, and so benefits that are in physical rather than dollar terms *cannot* be discounted. By discounting some types of benefits, such as avoided damages to human lives or natural resources, we are treating these tangible risk-related benefits as monetary outcomes, when they are not in fact financial consequences.

The second strand is that we *should not* discount benefits that have not been monetized. Proponents of this view generally argue that it is ethically unacceptable to discount physical units. If, for example, one discounts cancer cases that occur in the future, one is implicitly saying that a future cancer case is not really a cancer case, but rather is only 80%, 20%, or some other fraction of a cancer case, whereas a current cancer case is a “full” cancer case. The principle is that discounting effects that occur in the future somehow cheapens their value or reduces their importance and, therefore, is unfair to future individuals or generations whose lives or natural resources are at stake. This argument is often applied not only to human health and environmental effects that are simply enumerated, but also to those that are monetized.

Evaluating these arguments requires first a clear understanding of the various reasons why benefits might not have been monetized in any given analyses. In some cases, benefits are not monetized because the environmental and health impacts may be unknown, i.e., only changes in emissions, production, exposure, or another imperfect proxy for benefits, damages, or harms, is available. Sometimes there may be an estimated time stream of human health and environmental impacts, but the needed valuation tools and information on how to monetize the benefits are not - or are only partially - available. Finally, in still other cases, physical effects have been estimated and could be monetized, but this last step - converting measured physical effects into dollar values of benefits - has simply not been taken.

In cases where we have good information on the time streams of physical effects, and these effects employ metrics of human health and ecosystem damage that correspond to endpoints normally monetized, then the decision of whether or not to discount and at what rate, depends only on the principles governing the efficiency and equity of alternative discounting procedures (as presented in preceding sections of this paper), *whether or not these benefits have been converted into dollar values*. Thus, in cases where the conventional approach would likely be used to compare streams of dollar-denominated benefits and costs, the approach is equally applicable to the situation where benefits are estimated using well-defined and consistent metrics, perhaps lives saved or illness avoided.

As in the case of conventional discounting, choosing not to discount non-monetized benefits can in these cases have undesirable consequences. First, to the extent that the act of discounting and the choice of discount rate embody a rational investment criterion, failing to discount non-monetized benefits may produce results that appear to be irrational, or intrinsically unappealing. Suppose, for example, there is a policy that is estimated to save five lives in the year it is implemented. This policy can either be implemented today (option A) or 20 years from now (option B), and the costs in current dollars are the same in either case. If the discounted costs are compared with undiscounted benefits, cost-effectiveness calculations will clearly indicate option B. Thus, the opportunity cost arguments are as relevant to non-monetized benefits as they are to monetized benefits; failing to discount benefits can in some cases produce a situation where society has little motive to generate environmental benefits in the present since, by investing and waiting, greater environmental benefits can be enjoyed in the future.

Surveys that examine preferences for public policy also suggest that individuals express preferences related to non-monetized benefits that reflect a positive discount rate. For example, contingent valuation studies (Cropper, Aydede, and Portney, 1992; Carson, Horowitz, and Machina, 1987; Horowitz and Carson, 1990) that look at individuals' preferences for saving lives in the present and in the future suggest that individuals prefer projects that save lives in the near term over equivalent-cost projects that save lives in the future. This is not to say that the discount rate used to value future benefits should necessarily be guided by personal preferences about the future, but that individuals appear to have a preference for (at the least) saving lives in the near term over the long term, a preference that is implicitly analogous to discounting.

Thus far, this discussion has assumed that the analyst has access to good information about the benefits streams associated with a given policy and has simply chosen not to discount the streams for one reason or another. For situations where the benefit streams are all but monetized, the discounting decision is fully analogous to a decision about whether or not to discount monetized streams of benefits.

The reality, however, is that many other situations may occur in which benefits are not in dollar terms for reasons that pose more significant problems for discounting. There are classes of situations where available measures of benefits might be very poor proxies of ultimate damages, making it difficult to discount.

The first arises when the analysis stops *far* short of physical effects that are good proxies for damages. This situation can arise when the relationship between harms and emissions - or another relevant physical measure - is poorly understood. In the case of the greenhouse effect, for example, the ultimate impact of a ton of greenhouse gas emitted in a given year depends on the subsequent change in the time path of temperature and sea level and other variables and on the physical effects and economic impacts accompanying these changes. Changes in temperature depend, in turn, on the magnitude of emissions of all greenhouse gases over time and their radiative forcing. Further, the impacts of climate change may depend not only on the absolute levels of changes, but on the rate at which they occur. Because linking quantified physical harms to a unit of emissions is a difficult task, discounting greenhouse gas emissions will be a premature and problematic step in determining the cost-effectiveness of two alternative emission reduction strategies.

The second circumstance occurs when, even though analysts have measures that go beyond emissions or production, such measures of physical effects do not approximate closely the types of valued endpoints that are, ideally, the outcome of a benefits analysis. For example, although we have some measures of species diversity, ecosystem health, or forest productivity, we do not have metrics

that bear a clear functional relationship to current and future recreation, production, non-use, or other values identified by economists and ecologists.

In both these examples, the problem is that analysts have an incomplete understanding of the relationship between emissions - or production or other physical unit that is potentially subject to control - and the actual harms to human health or the environment that result. Thus, the problem is not that the procedure of discounting is flawed, *per se*, because the efficiency and equity properties of discounting are unchanged by the fact that damages are not monetized. Rather the problem arises because discounting masks important information. Because we are far from connecting emissions, production, or measures of physical effects to economic damages, our preferences over when emissions occur in time is governed by both the impact of emissions on harms and our time preference. In contrast, discounting can only account for the latter.

A related problem may occur when benefits are left unmonetized because of our incomplete ability to value effects. Although many goods and services are difficult to value, time in particular can pose challenges. For example, there may be reasons to believe that the relative valuation of some physical measure or endpoint may change over time, as society's preference structure and wealth changes. We may believe that human lives or ecosystems may be become relatively more or less valuable over time, and that our current values are a poor proxy for future values, particularly in the distant future. In this context as well, discounting masks important information.

Moreover, the case of greenhouse gases can be used to typify another problem. In reality, some environmental problems may be associated with a variety of physical effects and damage streams. Because benefits are expressed in more than one metric, the luxury of cost-benefit analysis - summarizing options in a single measure - is not available unless the benefits are monetized and thus made comparable. In the case of global warming, potential impacts range across human health, agriculture, forestry, coastal areas, unmanaged ecosystems, recreation, and other sectors. Not only do available valuation techniques limit our ability to convert diverse impacts into a single measure in any year, but doing so masks the variation in individual valuations of these impacts. Discounting these streams further conceals differences in how individuals perceive the relative values of different types of impacts over time. While, as argued above, individual preference is not always the guiding principle in decision making, some have argued that a referenda approach to decision making that explicitly seeks public opinion for certain types of environmental problems may, at the least, provide one more point in the data arsenal of decision making (Kopp and Portney, 1996).

In cases where discounting non-monetized benefits seems to be an inappropriate approach there are several alternatives:

- presenting streams of benefits, however measured, which policy-makers can compare against costs;
- calculating cost-effectiveness measures, i.e., comparing present value costs against cumulative benefits or annualized cost against average annual benefits;
- cumulating costs forward with interest to a future year, particularly if benefits occur only in one year.

Finally, although this discussion has focused exclusively on non-monetized benefits, many cost categories are often not monetized as well. The time costs consumers experience as a result of some regulations, the financial costs of business delays that result from others,

and the quality and performance impairments entailed by yet other regulations often are not monetized in regulatory impact analyses. Discounting policy regarding these non-monetized effects should largely track discounting practices for monetized costs unless there are compelling reasons for not doing so similar to those described here for non-monetized benefits.

3. DISCOUNTING/INTEREST RATES IN ECONOMIC PENALTY CALCULATIONS

This paper has focused almost entirely on discounting procedures in the context of EPA's analyses of the costs, benefits, and other consequences of regulatory and non-regulatory approaches for addressing environmental problems. But one other area in which discounting and related interest rate calculations arise is in penalty calculations for noncompliance with regulations. This section briefly examines whether any of the discussion, analysis, and conclusions reached in this paper significantly affect current penalty calculation methods.

One element of EPA's noncompliance penalty computation focuses on estimating the economic benefits enjoyed by parties who fail to comply with EPA's environmental regulations. The basic idea is to ensure that, at a minimum, these penalties at least remove the financial gains noncompliance confers on violators.

EPA has developed a computer model to calculate the economic benefits of noncompliance (see "BEN: A Model to Calculate the Economic Benefits of Noncompliance", Office of Enforcement, USEPA, December 1993). This model assists analysts in determining what investments and other costs were avoided by failing to comply with a regulation, when these costs should have been incurred, and how these costs can be summarized and translated to the present for purposes of determining appropriate penalties for noncompliance that may have occurred several or many years ago.

Clearly, a time discount-related concept is relevant for this model - accumulation of avoided costs to the present - because the funds that were not expended in complying with an environmental regulation in the past would either have been devoted to some other productive and profitable activity, or would have permitted the relevant entity to reduce its demand for external equity or debt. Hence, the benefit of past noncompliance in today's terms should reflect not only the original amounts of money, but also investment return gains or avoided financing costs. Accumulating past avoided costs with interest accomplishes this goal.

Discounting is also involved in noncompliance penalty calculations and negotiations when future investments in environmental controls are pledged as part of a settlement. Here, these future investments are discounted to the present to reflect the fact that costs expended in the future are cheaper than costs incurred today.

The BEN model accumulates and discounts flows of costs using private rates of interest that reflect the cost of either borrowing incremental funds or of obtaining them through new equity. The use of a private rate of return measure in this context is appropriate because the goal is to remove the financial gains conferred on noncomplying entities. It is therefore the investments gains or financing costs these parties experienced that should guide such penalty calculations, not social notions of discounting and valuation.

Hence, if the goal is to estimate economic costs and benefits from the private perspective, the use of industry-specific cost-of-capital estimates, or other more firm-specific figures, for the financial

gains experienced by those entities is correct. The same can be said of the application of this analysis and technique to governments, which are also treated appropriately in the BEN model.

This does not imply that examining the consequences of noncompliance with EPA regulations from a social perspective would not yield important insights relevant for a broader evaluation of appropriate penalties. But because the BEN modeling framework explicitly focuses on the private perspective of the parties who have failed to comply with a regulation, the analysis of social discounting in the majority of this paper is largely not germane.

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