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Appropriate Discounting for Benefit-Cost Analysis

David F. Burgess and Richard O. Zerbe

Abstract

In order to be sensible about what discount rate to use one must be clear about its purpose. We suggest that its purpose is to help select those projects that will contribute more net benefits than some other discount rate. This approach, which is after all the foundation for benefit-cost analysis, helps to reconcile different suggested procedures for determining the discount rate. We suggest that the social opportunity cost of capital (SOC) is superior to other suggested approaches in its generality and its ease of use. We use the SOC to determine a range of real rates that vary between 6% and 8%. We suggest that approaches based on determination of preferences, which result in hyperbolic discounting, are less appropriate and less useful.

KEYWORDS: discount rate

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Introduction

Perhaps no methodological question within benefit-cost analysis (BCA) has been so widely discussed as the discounting of future benefits and costs. The body of literature regarding this subject is vast. However, it is also unresolved. Little consensus can be found on issues such as what should be discounted, or on the choice of a discount rate. Sources of discrepancy include: (1) the effects of risk; (2) displacement of private capital; (3) rate of time preference; (4) whether rates should be hyperbolic with respect to the time period in which effects are felt (an issue related to the use of time preferences); (5) ethical issues such as whether the changing wealth of future generations should allow for rates that reflect preferences for income (a marginal utility of money that is different from those at the time the project is initiated) (Weitzman 2001; Moore et al. 2004; Dasgupta 2008) and (6) whether or not certain goods such as lives and health are special and should not be discounted. Part of the problem lies in the fact that proponents of different approaches to discounting are frequently unclear about what they are maximizing, or what function the discount rate is supposed to perform. In this paper we take the position that the basic principles that underlie benefit-cost analysis should be carried forward with respect to discount rates. The case for discounting arises from the concepts of time preference, uncertainty, and the opportunity cost of capital, all of which coalesce to underlie the simple premise that a dollar in hand today is held to be worth more than receiving that same dollar at any future point (US OMB 1992; 2003).

This paper assumes that the purpose of discounting is to select that rate which will lead to selection of the best projects in terms of maximizing net present values. We assume that projects should be chosen that meet the potential Pareto test.[1] This will occur when the present value of benefits compensates for the capital foregone and the consumption displaced. We find that the social opportunity cost approach to the discount rate is the most likely to meet this objective, and a major purpose of this paper is to develop a rate, or a range of rates, that can serve as a standard for best practice in the context of the U.S. economy.

Main Approaches

There are three main approaches to determining discounting rates: (1) the social opportunity cost of capital (SOC) approach, which proposes that the discount rate reflects the social (economic) opportunity cost of capital, a weighted average of

[1] Elsewhere Zerbe and Davis (2010) argues for replacing the potential Pareto test with a Pareto relevance test, but for our purposes here this makes no difference

the pre-tax and after tax rates of return, and, in an open economy, the marginal cost of foreign funding, where the weights reflect the proportions of funding that are obtained from displaced investment, postponed consumption, and incremental funding from abroad when the government borrows to finance the project (Sandmo and Dreze 1971; Harberger 1972; 1985; Sjaastad and Wisecarver 1977; Burgess 2010a; 2011); (2) the social time preference (STP) approach (Marglin 1963; Feldstein 1972; Bradford 1975; Lind 1982), which discounts benefits and costs at the after-tax rate of return (or a politically determined social rate of time preference) but converts all investment displaced in financing (or induced by the project) into its consumption equivalent by multiplying by the shadow price of capital; (3) the marginal cost of funds criterion (MCF) (Liu 2003; Liu et al. 2004) which discounts within-generation benefits at the after tax rate, between-generation benefits at the pre-tax rate, and costs (including indirect revenue effects) at the pre-tax rate, but multiplies all costs and indirect revenue effects by a parameter reflecting the marginal cost of funds.[2] The MCF approach emphasizes the need for project evaluation to take into account the marginal social cost of raising the revenue necessary to cover any budgetary deficit that arises on account of the project.

Apparent differences between the SOC and MCF criteria arise from different interpretations of a project's indirect revenue effect. For the MCF criterion, the indirect revenue effect is the uncompensated effect of the project on tax revenue (holding income fixed) whereas for the SOC criterion it is the compensated effect (holding utility fixed). Apparent differences between the SOC and STP criteria arise from different assumptions about the private sector's knowledge of the project's benefits and costs. Burgess (2011) shows that these approaches can be reconciled. He does not indicate discount rate estimates for the SOC and this is our primary purpose here.

All approaches recognize that the displacement of private capital must be taken into account, but they differ in terms of whether it should be incorporated into the discount rate or reflected by a shadow price. Liu (2003) and Liu et al.'s (2004) MCF criterion depends upon an exogenous rate of return to capital, but Burgess (2011) shows that the MCF approach can be extended to situations where the rate of return to capital is endogenous. In this more general setting the MCF criterion requires that (within-generation) benefits be discounted at the after tax

[2] A fourth approach to discounting comes from the literature on optimal growth. Gramlich (1981), for example, proposes that under certain conditions the growth rate of the economy be used to determine a government discount rate. The idea is to accumulate that quantity of capital that maximizes steady state consumption per effective worker. Thus capital formation is justified whenever the rate of return net of depreciation exceeds the growth rate. However, it does not follow that any project whose internal rate of return exceeds the growth rate is worthwhile because there is no assurance that undertaking the project will divert resources solely from consumption rather than from other projects.

rate of return (consumption rate of interest) but costs and indirect revenue effects must be discounted at the weighted average rate that is appropriate for the SOC criterion. Costs and indirect revenue effects must be multiplied by the MCF parameter that measures the marginal cost of raising a dollar of revenue using the particular tax instrument that is relevant. In this more general setting the fundamental equivalence between the MCF and SOC criteria continues to hold. The key insight is that the MCF criterion is evaluating the impact of a project on private surplus (present value of consumption discounted at the consumption rate of interest) by converting the budgetary cost of the project (present value of project expenditures minus indirect revenue effects discounted at the SOC rate) into its consumption equivalent cost using the MCF parameter, whereas the SOC criterion is measuring the impact of the project on government revenue holding private surplus fixed at its pre-project level. While the standard SOC criterion assumes that the marginal tax instrument is a lump sum tax, the SOC criterion can be adapted to situations when a distortionary tax is used instead. The weighted average discount rate is appropriate for the SOC criterion whether or not the marginal tax instrument is a lump sum tax.

The SOC approach is justified by the straightforward principles of applied welfare economics—demand price measures marginal benefit, competitive supply price measures marginal cost, and adding up (i.e. dollars of benefits and costs are valued independently of to whom they accrue) (Harberger 1971). The basic exercise is the extraction of resources from the economy, which displaces investment and stimulates saving and in an open economy attracts additional foreign funding. The discount rate should be consistent with choosing a project that is more productive over another that is less productive. The rate then must cover the productivity that is forgone as a consequence of displaced investment and the net-of-tax supply price of the newly induced savings and the marginal cost of incremental foreign funding. Any lower rate than the weighted average represented by the SOC will fail this test. Though one can find a number of ways to motivate lower rates, one cannot escape the penalty of ignoring the correspondingly higher social productivity of investment funds. Any higher rate will forego desirable projects.

The STP approach plays a prominent role in the academic literature on the social discount rate. Because our ultimate position is in support of the SOC approach, we will focus on comparing how the STP and SOC criteria perform in simple situations.

In the case of two period projects, where costs are incurred in period 1 and benefits accrue in period 2, the SOC and STP criteria give equivalent results if benefits are just like income. Thus, for a project with costs C1 and benefits B2 it is a matter of indifference whether one converts costs and benefits into "consumption equivalents" and discounts at the STP rate, or discounts

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unconverted benefits and costs at the SOC rate. Assuming that the capital market is the marginal source of funds for all projects and (for simplicity) that the pre-tax rate of return p is exogenous, the SOC rate will equal the pre-tax rate of return and the STP rate will equal the after tax rate of return r.[3] The wedge between the two rates is explained by the capital income tax so $r = p(1-\tau)$. If the private sector consumes the annuity value of wealth the consumption equivalent of a dollar of investment displaced will be equal to the ratio of the pre-tax rate of return to the after tax rate. In other words, the shadow price of a dollar of private investment displaced is p/r.

A project that costs $C1$ and provides benefits of $B2$ is worthwhile according to the SOC criterion if $-C1 + B2/(1+p) > 0$. Using the STP criterion, the project's cost is converted into its consumption equivalent by multiplying by the shadow price of investment (because the costs displace private investment dollar for dollar), and the benefit $B2$ is separated into an income component, B2-$C1$, which is available for consumption, and a "replacement of capital" component $C1$, which is reinvested. The project is worthwhile according to the STP criterion if $-C1\ (p/r) + [B2-C1+C1\ (p/r)]/(1+r) > 0$. But this is equivalent to the SOC criterion.[4]

If the benefits are fully consumed the project has no effect on private sector behavior, so ultimately it must be financed by raising taxes to balance the government's budget. If lump sum taxes are used, the project's cost has a consumption equivalent of $C1\ [p(1+r)/r(1+p)]$ and the project is worthwhile according to the STP criterion if $-C1\ [p(1+r)/r(1+p)] + B1/(1+r) > 0$.[5] However, in this case the SOC criterion requires that an "indirect revenue effect" be included along with the conventional benefit and cost estimates, but the appropriate discount rate is still the SOC rate. The benchmark for the SOC criterion is a project whose benefits are "just like income." In other words, providing the project and increasing lump sum taxes by an amount equal to the private sector's willingness to pay for the project leaves capital income tax revenue unchanged. Any project whose benefits are not equivalent to income will have an indirect revenue effect. For a project whose benefit $B2$ is fully consumed, the indirect revenue effect is the effect on capital income tax revenue of a lump

[3] The STP rate is interpreted by some as a "politically determined" rate that may lie below the after tax rate of return, but we set aside this issue in this section.

[4] Sjaastad and Wisecarver (1977) were the first to make this point. The SOC criterion and STP criterion yield different results for projects with long gestation lags, but the STP criterion fails to take into account the interim costs of financing such projects. See Burgess (2010).

[5] A lump sum tax increase of one dollar will reduce the present value of consumption by one dollar, but increase the present value of government revenue by just $r(1+p)/p(1+r)$ dollars. This is because the private sector discounts consumption at rate r but government revenue is discounted at rate p. If the government needs to raise $C1$ dollars to finance the project, the cost in terms of current consumption is $C1$ multiplied by $p(1+r)/r(1+p)$.

sum tax increase of *B2* in period 2. Assuming that the private sector consumes the annuity value of wealth, capital income tax revenue will increase in period 2 by $\tau prB2/(1+r)^2$, and decrease in periods 3 and thereafter by $\tau pB2/(1+r)^2$. The present value of the project's indirect revenue effect (discounted at the SOC rate) is therefore $\tau B2(p.r-1)/(1+r)^2(1+p)$. Including the indirect revenue effect along with the conventional benefit and cost estimates, the SOC criterion becomes $-C1+B2/(1+p) + \tau B2(p.r-1)/(1+r)^2(1+p)>0$. It is easy to verify that the SOC criterion with the indirect revenue effect taken into account is equivalent to the STP criterion specified above.

Bradford (1975) argued that for projects whose costs displace investment in the same proportion as the benefits induce investment, the appropriate discount rate is the STP rate with no need to shadow price benefits or costs. However, his result depends upon two critical assumptions: first, that the private sector behaves myopically so its saving is not governed by optimizing behavior but rather by a simple rule of thumb whereby a constant proportion of (disposable) income is saved independent of the rate of return; and second, that investments in the private sector are not feasible options for the government, because otherwise scarce resources should be invested in such projects rather than in any project that can pass muster only at the STP rate. Even if private sector investments are off limits for the government, whenever there is public debt outstanding debt reduction is always an option and the rate of return on debt reduction is the SOC rate.

Estimating the SOC rate for the United States

The SOC rate is a weighted average rate that takes into account both the displacement of capital and foregone consumption, and in an open economy the use of foreign funds. The general expression for the SOC rate in a multi-sector economy with different effective rates of tax on capital in each sector, and with different rates of personal income tax on different groups of savers, is:

$$SDR = \sum \beta_i r_i + \sum \theta_j p_j + \alpha f \tag{1}$$

Where:

$$\sum \beta_i + \sum \theta_j + \alpha = 1 \tag{2}$$

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Given that:

β_i = proportion of funds from increased savings of group i

r_i = marginal rate of time preference, typically after-tax real rate of return, as perceived by group i

θ_j = proportion of funds from displaced investment in sector j

p_j = marginal rate of capital productivity in sector j in home country

α = proportion of funds from incremental foreign funding

f = marginal cost of incremental foreign funding

While the SOC is conceptually straightforward, it is empirically challenging to arrive at a reliable estimate; not only must rates of return on alternative sources of funds be estimated, so must the proportions of funding drawn from each source.

A reasonable estimate of the opportunity cost of displaced investment is the pre-tax rate of return on capital in place.[6] National Accounts data can be used to estimate annual rates of return on reproducible capital (consisting of residential and non-residential structures, machinery and equipment, and inventories) as the ratio of the total income accruing to capital divided by the stock of capital. Rates of return estimated this way tend to exhibit low volatility, unlike financial rates of return, primarily because capital is measured at replacement cost rather than market prices (see Jenkins and Kuo 2010). A major advantage of using national accounts data is that the estimated rate of return encompasses all sectors of the economy and all forms of reproducible capital and is thus likely to provide the best estimate of the rate of return that the economy as a whole will forego when private investment is displaced.[7]

There are several challenges involved in estimating such a rate of return however. They include: how to separate the return to capital from the return to labor in unincorporated businesses; how to reliably separate payments to

[6] Under competitive conditions and constant returns to scale the rate of return to capital in place will equal the marginal productivity of an increment to capital.

[7] Some have argued that the rate of return on real return bonds (TIPS) would provide a market-based measure of the risk free rate of return, which could then be grossed up by adding the various taxes that apply to capital. If TIPS yield 3% and capital income is taxed at 35%, the implied pre-tax rate of return on "risk-free" capital would be in the order of 4.6%. Quite apart from whether this provides a reasonable estimate of the risk-free economic opportunity cost of private investment displaced, it would not be appropriate for the government to use a risk free rate as the discount rate unless all project specific risk could be eliminated by pooling and spreading. Bond rates of course are a part of rates that make up our opportunity cost of capital.

unimproved land from the return to capital; how to determine appropriate rates of economic depreciation for the various capital types; and how to determine what proportion of the measured return to capital (GNP minus labor compensation) reflects monopoly profits that should not be fully attributable to capital. In this paper we will have to rely on a less than fully comprehensive estimate of the rate of return to capital. Poterba (1999) estimated an average pre-tax rate of return in the U.S. non-financial corporate sector of 8.5% over the period 1959-1996. His estimates are based upon an improved methodology for determining the replacement cost of corporate capital. We will use this estimate as our baseline measure of the opportunity cost of displaced investment.

The consumer rate of interest is usually calculated as a group's after-tax rate of return, but for some groups (e.g. negative savers) it may be better approximated by the real interest rate on credit cards and other debt. Since the aggregate household sector is a net saver, a reasonable estimate of the marginal cost of foregone consumption is the pre-tax rate of return to capital net of all taxes on income from capital. Applying the corporate, property and personal tax rates to Poterba's 8.5% estimate of the pre-tax rate of return gives an after tax rate of return of approximately 3.5%. We will use this as our baseline estimate of the opportunity cost of postponed consumption.

Under certain conditions the average cost of foreign funding can be approximated as the rate of return that foreign investors earn on the capital invested in the country net of all taxes paid to the host government. If the supply price of foreign funding is upward sloping, the average cost will understate the marginal cost. If the withholding tax corrects the divergence between average and marginal cost, the marginal cost of foreign funding will be the rate of return to capital net of corporate and property taxes but gross of withholding taxes. Assuming a pre-tax rate of return of 8.5% and a combined corporate and property tax rate of 35%, the implied marginal cost of foreign funding is approximately 5.5%.

According to the SOC approach the marginal source of funding for all projects is the capital market, thus keeping the issue of tax reform separate from project evaluation. If a particular tax is being proposed to finance a particular project, the revenue from the tax could be used to pay down the debt instead of funding the project, so an alternative use of funds for any project is to pay down the debt.[8] Comparing the benefits from a proposed project to the benefits of debt reduction using the same funds (a comparison which is equivalent to the SOC criterion) ensures a level playing field for all projects, and avoids situations where a project is judged to be worthwhile solely on the merits of the efficiency of the tax intended to fund the project (Burgess 2011). Thus, the capital market should

[8] With the assumed benefit of debt reduction being a tax cut in the following period. For a more detailed discussion, see Burgess 2011.

appropriately be evaluated as the marginal source of funding for all projects, even if a project is funded by a tax.

The weights that enter the SOC formula reflect the proportions of an incremental dollar of funding that is obtained from each source when funding is drawn from a well functioning, but distorted capital market. Harberger (1969) and Sandmo-Dreze (1971) show that these weights can be expressed in terms of the rate of return elasticities of supply and demand for each source and the proportions of existing funding drawn from each source. Estimates of the elasticity of demand for investment spending on fixed capital with respect to the cost of capital typically range from -1.0 to -0.7 (Department of Finance Canada 2008; Gilchrest et al. 2007), while estimates of the compensated elasticity of supply of indigenous saving with respect to the after tax rate of return are in the range from 0.1 to 0.2[9]

The elasticity of supply of foreign funding with respect to the rate of return is more problematic. Some would argue that this elasticity is close to infinite given the high degree of capital market integration, but it is crucial to recognize that what is relevant is the responsiveness of the net supply of real capital from abroad with respect to the real rate of return offered to attract this capital. If incremental funding for a project drives up the rate of interest it will crowd out some foreign direct investment as well as attract additional foreign portfolio investment. The net supply of real capital from abroad is the sum of these two competing effects. Burgess (2010b) shows that the SOC formula can be re-written in a way that does not depend (directly) upon an estimate of the elasticity of supply of external funding but instead upon an estimate of the "saving retention coefficient." Given an exogenous shock to indigenous saving, the saving retention coefficient is a ratio of the proportion of the indigenous savings increase that is invested within the country to the proportion of the savings increase that is invested abroad. Beginning with the widely cited paper by Feldstein and Horioka (1980), saving retention coefficients have been estimated by numerous researchers. The saving retention coefficient for OECD countries has been estimated to be in the range of 0.5 to 0.7 by Helliwell (1998). Since the U.S. is the largest OECD country, and larger countries have more market power, they will tend to have larger saving retention coefficients. At the same time, national saving and investment rates have become increasingly

[9] The compensated elasticity of supply of saving with respect to the after tax rate of return is the product of the elasticity of inter-temporal substitution and the proportion of wealth that is consumed. The elasticity of inter-temporal substitution must be non-negative but Hall (1988) could not reject the hypothesis that it was zero. Attanasio and Weber (2010) review the literature and report estimates from reputable studies of 0.67 and higher. They perform simulations with an elasticity of inter-temporal substitution in the range from 0.25 to 0.5. The implied range of values for the compensated elasticity of supply of saving is less than this.

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decoupled in recent years due to globalization. In light of these considerations a reasonable estimate of the saving retention coefficient for the U.S. is 0.6, with an upper bound of 0.67 and a lower bound of 0.5.

Burgess (2010b) shows that the SOC rate can be written as the following function of the relevant rates of return (opportunity cost of displaced private investment p, opportunity cost of postponed consumption r, and marginal cost of incremental foreign funding r*) the (compensated) elasticity of supply of indigenous saving e, the elasticity of demand for investment n, the proportion of investment that is financed by indigenous saving S/I, and the saving retention coefficient SRC:

$$SOC = \{p - (e/n)(S/I)r + ((1/SRC) - 1)f\}/D \tag{3}$$

Where:

$$D = -(e/n)(S/I) + 1/SRC \tag{4}$$

Using the estimates for the rates of return *p*, *r* and *f* identified above, the elasticity values $e = 0.2$ and $n = -1.0$, an assumed ratio of indigenous saving to investment S/I equal to 0.9 (which implies that 10% of private investment is financed from abroad), and a saving retention coefficient SRC equal to 0.6, the implied estimate of the SOC rate is 7.0% (which matches one of the two base-case rates recommended by the OMB for regulatory analysis, the other being 3%, see US OMB 1992; 2003). The implied proportions of an incremental dollar of funding that is obtained from displaced investment, postponed consumption, and incremental foreign funding are 0.54, 0.10, and 0.36 respectively.

It is possible that the benchmark estimates of the rates of return are biased upward or downward.[10] The weights indicate the extent to which the SOC rate will change in response to a change of one percentage point in the respective rate of return. For example, if the opportunity cost of displaced investment is underestimated by one percentage point the SOC rate will be underestimated by 0.54 percentage points, whereas if the opportunity cost of postponed consumption is underestimated by one percentage point the SOC rate will be underestimated by 0.1 percentage points.[11]

[10] For example Harberger (2010) makes the case that the pre-tax rate of return on investment is at least 10%. On the other hand, it could be argued that Poterba's estimate of 8.5% is biased upward because it pertains to the corporate sector only and ignores residential capital, which is more lightly taxed.

[11] McGrattan and Prescott (2003) estimate that the real after tax rate of return on U.S. reproducible capital averaged approximately 4% over the period 1880-2002.

The table below (Table 1) shows the sensitivity of the SOC rate to alternative values of the saving retention coefficient and alternative values of the elasticity parameters e and n. If plausible ranges for e are 0.1 to 0.2 and plausible ranges for n are -0.7 to -1.0 it is conceivable that the ratio could be as low as .1 and as high as .28. It is also possible that the saving retention coefficient could be as high as .67 or as low as .5. The results indicate that the implied SOC rate is in the range from 6.6% to 7.3%. Finally, the ratio of S/I could be as low as .8 but the implied SOC rate is only mildly affected by this change. It seems reasonable to conclude that an appropriate range of values for the SOC rate for the U.S. economy is a lower bound 6% and an upper bound of 8%.

Some have argued that the SOC rate obtained from national accounts data will be biased upward because it contains a risk premium that represents necessary compensation for bearing risk (Boardman et al. 2010). A dollar of foregone investment constitutes a well-diversified portfolio of assets in all sectors of the economy. This rate of return will be well approximated by the average rate of return on this broad mix of capital over a sufficiently long time period to encompass business cycle swings, and it may contain a premium to compensate risk-averse investors for bearing any non-diversifiable risk. If so, the "risk free" SOC rate will be somewhat lower. However, unless the project adds less risk to the aggregate portfolio than what is foregone on the private investment displaced the appropriate discount rate should include the risk premium that is embedded in the SOC rate.[12]

Table 1: SOC Rate for the United States

SRC	**e = 0.1, n = -1.0**	**e = 0.2, n = -1.0**	**e = 0.2, n = -0.7**
0.5	6.9%	6.7%	6.6%
0.6	7.1%	7.0%	6.7%
0.67	7.3%	7.1%	6.9%

A frequent point of criticism regarding rates that arise from the SOC and related approaches is that they will materially reduce effects felt very far in the future. However, there is nothing inherently wrong with this. Nor will this mean that really large effects that occur in the future will necessarily be ignored. Suppose that unless corrective mitigation is taken now the worlds GDP will suddenly fall to zero in 100 years. The current world GDP is about $62 trillion. This will grow to $1192 trillion (constant dollars) in 100 years at a 3% annual real

[12] The analyst ideally should adjust for risk where the risk level is apt to be quite different from the average as is, for example, done for the Capital Asset Pricing Model. Unfortunately there are few in any relevant betas calculated for public projects.

rate. Assume that with the mitigation, GDP will continue to grow forever at 3%. The present value of the lost future GDP at year 100 will be $30 quadrillion, assuming infinite life for the world. When this is discounted at 7%, its present value today is $34 trillion. This is not a trivial sum to consider to place on the side of mitigating the future harm.

Time Preference and Ethical Rates

Time Preference Rates

There is recent interest in time preference and ethical discount rates. Time preference refers to a demonstrated behavioral economic preference for immediate or near-term benefits over future accruement, which skews economic decision-making towards near term benefits. There is evidence that time preference rates do not correspond with the SOC rates. Evidence about the divergence of rates also suggests that the use of individuals' rates make choices practically difficult. Frederick et al. (2002) suggest that people have different discount rates for different activities and contexts. Thus rates individuals might feel to be most appropriate for application to government social policy analyses might differ significantly from the rates they use in their own investment or consumption decisions. In addition, surveys of rates of time preference are so varied that no single rate seems possible (Frederick et al.). More importantly there is no compelling rationale or motivation for using such rates even if available, since their use would result in a loss of efficiency and no clear gain in equity.

Recent work by Weitzman (1998; 2001) uses the opinions of economists about rates to form a set of discount factors:

$$1/(1/r)^t \tag{5}$$

Weitzman (2001) argues that it would be sensible to assume that each expert has an equal chance of knowing the "correct" social discount rate and thus we should compute the present value of a public project using each individual expert's discount rate, and then compute an average of these present values. One can then back out the implied social discount rate.[13] Weitzman fits a gamma distribution to

[13] Weitzman (2001) notes: "What is the expected value today of an extra expected dollar at time *t*? It should be the expected present discounted value of a dollar at time *t*, weighted by the 'probability of correctness' or the 'probability of actuality' of the rate at which it is being discounted" (264). Weitzman infers that the probability that an individual expert is "correct" is given by the distribution of responses to a survey he conducted of 2,160 Ph.D.-level economists.

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the distribution of rates implied by the discount factors as suggested by the sample of economists. These rates are necessarily hyperbolic due to the divergence of rates. However, the gamma distribution over-weights the lower rates in his sample, significantly overestimating the frequency density of those with rates between 0% and 2% (see Weitzman 2001, Figure 1); this leads to rates that are too low, especially for longer time periods. When Weitzman's data is used to calculate actual discount factors and a rate extracted that represents the average rate the result is rates for every time period higher than calculated by Weitzman (Long et al. 2011).

There are several other objections to using Weitzman's results. First, economists as a general class are unlikely to be experts on the discount rate. Weitzman assumes an equal probability of each economist being correct (a uniform distribution); however, there is no reason to assume this sample of experts consists of the most knowledgeable people, or that their opinions should have equal weight. Further, in using a sample of discount factors (the present value calculation for different people) one will necessarily find social rates to be hyperbolic and find very low rates for projects in the far future as the rates will asymptotically approach the lowest rate in the sample.[14] Third, the spread of rates is disconcertingly wide. Even when Weitzman restricts his sample to only fifty eminent economists, their opinions as to an appropriate discount rate for global warming mitigation policies (with all benefits and costs converted into consumption equivalent real dollars for each year) still range from 0% to 15%. Even greater spreads have been found by Frederick et al. (2002). Finally, there is little underlying rationale rooted in economic theory for using these rates.

Ethical Rates

The manner in which BCA addresses intertemporal comparison is highly significant to project outcomes, as well as highly controversial philosophically. Some argue for a zero discount rate (i.e. no discounting of future benefits and costs) on philosophical and/or economic grounds (Parfit 1992; 1994; Pearce and

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From the survey responses, Weitzman finds that the distribution of the preferred discount rates roughly corresponds to a gamma distribution with a mean of 3.96% and standard deviation of 2.94%. Assuming a gamma distribution, Weitzman derives an implied effective discount rate of $m/(1+ts^2/m)$, where m is the mean, s^2 is the variance, and t is the number of years in the future when the benefit is to be received (or costs paid).

[14] The US OMB (1992) recommends against time varying discount rates on the grounds that it results in time inconsistency and that it is not ethically attractive. However, time inconsistency and hyperbolic rates for individuals appear to arise from uncertainty and risk (Farmer and Geanakoplos 2009). Once risk is accounted for, no time inconsistency exists and individual rates are constant, i.e. exponential.

Turner 1989; Plater et al. 1998; Schultze et al. 1981) (see Goodin 1982 for an even-handed discussion of the limitations of discounting in policy analysis). Though it is commonly accepted that *money* should be discounted, both due to time preference and the investment value of money, the discounting of life and health (as is done in many social policy BCAs) is disputed (Sunstein 2007). Philosophers and legal scholars often question such discounting on ethical or legal grounds (e.g. Cowen and Parfit 1992; Revesz 1999; Shapiro and Glicksman 2003, Ackerman and Heinzerling 2002; 2004). This concern is addressed by the Principle of Intergenerational Neutrality (Sunstein 2007), which holds that members of any particular generation should not be favored over members of any other. This principle is in fact a core tenet of benefit-cost analysis (Zerbe et al. 2010), and does not repudiate discounting life and health values.

A significant amount of disagreement about rates arises from those who wish to impose special conditions on particular projects. The most common candidates are health and life. The arguments center around considerations that lives or pain or other human health-related goods have equal value regardless of when they are incurred. This in a sense is true of virtually all goods. The capital penalty for avoiding the more productive investment is not avoided by this consideration and there is no sound reason to adjust discount rates for heath and lives. The standard SOC criterion assumes that benefits are “just like income.” If the benefits are not just like income there will be indirect revenue effects to include along with the “willingness-to-pay” (WTP) estimates of benefits, and they will be positive or negative depending upon the project. The appropriate discount rate remains the SOC rate. One might appropriately consider rates below the SOC rate for projects whose benefits are likely to induce private investment to an unusual extent, and conversely consider rates higher than the SOC for projects whose benefits are purely consumptive. However, these sorts of effects will be expensive to determine in many cases and could result in a ménage of various rates.

Conclusion

The SOC approach suggests discount rates in the range of 6%-8% given the current state of knowledge and data. The SOC approach is consistent with the main alternative approaches to determining discount rates but it is easier to implement because (unlike the shadow price algorithm) it requires no shadow pricing of investment and (unlike the MCF criterion) it applies a single discount rate to all benefits and costs. Rates that are time varying are not consistent with the SOC unless the parameters that determine the SOC change. Adjusting rates for future benefits to account for a decline in the marginal utility of income is also inconsistent with the SOC. If the current generation wishes to subsidize or penalize future generations these sentiments can be expressed directly through the values given to future costs or benefits. The use of very low rates, such as found by Weitzman's experts and independently assumed by Stern (2007), seems to be a way to account for the risk of extreme damage rather than a desirable adjustment to rates. This sort of adjustment should take place through determining the values of benefits and costs and not through the adjustment of discount rates. That is, where the current generation has moral values that apply to future generations these should be counted in terms of WTP at present and not incorporated into the discount rate. To use a lower discount rate than the SOC rate for long-term projects is to either transfer wealth from the present generation to the future at greater cost to the present generation than necessary, or to leave future generations worse off than they would be without the project. Sunstein (2007) takes the correct stance when he recommends treating all generations the same.

The method by which to treat this problem is to count present intergenerational equity concerns in terms of the current populations' WTP for such a moral value instead of into the discount rate. An example is presented in Zerbe (2004). This provides an effective means to address equity concerns without having to adjust the discount rate used in the analysis.

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