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More appropriate discounting: the rate of social time preference and the value of the social discount rate

Abstract: Recently, a number of authors, including Burgess and Zerbe, have recommended the use of a real social discount rate (SDR) in the range of 6–8% in benefit-cost analysis (BCA) of public projects. They derive this rate based on the social opportunity cost of capital (SOC) method. In contrast, this article argues that the correct method is to discount future impacts based on the rate of social time preference (STP). Flows in or out of private investment should be multiplied by the shadow price of capital (SPC). Using this method and employing recent United States data, we obtain an estimate of the rate of STP of 3.5% and an SPC of 2.2. We also re-estimate the SDR using the SOC method and conclude that, even if analysts continue to use this method, they should use a considerably lower rate of about 5%.

Keywords: benefit-cost analysis; social discount rate; social opportunity cost of capital; social time preference.

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1 Introduction

The choice of the real social discount rate (SDR) is one of the most important decisions in benefit-cost analysis (BCA). It is especially critical for projects that have high net costs in early years and high net benefits in later years. Recent publications (Burgess and Zerbe, 2011; Zerbe et al., 2010, 2011) argue that the SDR should be based on the social opportunity cost of capital (SOC) method and conclude that the value of the real SDR for the United States (US) should be about 7% with a range of 6–8%. Zerbe et al. (2010, 2011) is an important document because it aspires to provide “principles and standards” for the conduct of BCA. However, the section concerning the SDR is controversial. Indeed, Cole (2010), originally a member of the Scientific Committee reviewing these principles and standards notes that "not one of those three [commissioned white papers] supports the high discount rates recommended in Professor Zerbe's report." Perhaps partly as a result of such criticisms, this section of the report has been revised. However, the current version (Zerbe et al., 2011, p. 84) still concludes "we recommend discounting using the SOC approach (and thus using the 6–8% SDR rate…)."[1]

While Burgess and Zerbe (2011), Harberger (1972), Jenkins (1973), Zerbe et al. (2010, 2011) and some others continue to advocate the SOC method, many, if not most, economists argue that the appropriate way to discount the impacts of a public-sector project is to discount consumption or "consumption equivalents" using an SDR based on the rate of social time preference (STP). This approach goes back many years; key contributors include Eckstein (1958), Marglin (1963), Feldstein (1972), Bradford (1975) and Lind (1982).[2] Furthermore, over the last decade a number of governments have switched from using a SOC-based recommended value of the SDR to an STP-based value. In each country, this has resulted in a reduction in their recommended discount rates. For example, the UK lowered its recommended rate from 6% to 3.5% for most government projects in 2003, Germany lowered its recommended rate from 4% to 3% in 2004 (European Commission, 2008) and France lowered its recommended rate from 8% to 4% in 2005.

Surprisingly, in contrast to most other developed countries, there is neither a single overarching US federal recommended approach nor a single specified value for the SDR. (For a review of US federal discounting practices, see Boardman, Greenberg, Vining and Weimer, 2011, pp. 263–265.) Without a consistent and appropriate SDR approach, and without a consistent and appropriate value of the SDR, there is potential for a misallocation of resources across federally-funded projects.

In this article, we explain the STP approach and present new estimates of all significant parameters. Using the STP method and these new estimates, we derive a value of the SDR for the US of about 3.5%. Our discussion also facilitates sensitivity analysis of the key parameters.

A secondary purpose of this article is to show that, even if one uses the SOC method, the 7% rate proposed by Burgess and Zerbe (2011) is too high. Based on what we regard as better estimates of the returns used in the SOC method, we arrive at an estimate of the SDR of approximately 5%. One might ask why we make the effort to recalculate the SDR using the SOC method given that we do not think it

1 Zerbe et al. (2011, p. 84), accessed 29 August, 2012.
2 For a recent review and discussion in a BCA context see Boardman, Moore and Vining (2010).

is the best approach. Our rationale is purely pragmatic. Our estimate of approximately 5% for the SOC method is considerably lower than Burgess and Zerbe's 7% estimate and, obviously, quite a bit closer to our STP-based recommended rate of 3.5%. Given that most government-based and academic BCA practitioners (quite reasonably) use one of the recommended rates, closeness matters, just as in horseshoes (e.g., Belfield, Nores, Barnett and Schweinhart, 2006; Rothstein and Rouse, 2011).

The outline of this article is as follows. Section 2 explains and justifies the STP method. Section 3 estimates parameters for the STP method based on comprehensive US data (mostly based on the 1947–2011 period) and derives our recommended value of the SDR. Section 4 explains and critiques the SOC method, and presents new and more appropriate estimates of the key SOC parameters based on US financial market data. Section 5 briefly discusses how to discount very long-term, inter-generational projects. Section 6 concludes the article.

2 The STP method

The STP method is based on the idea that the fundamental goal in welfare economics is to maximize the utility (or "happiness") of society (or of a representative individual), where utility depends on per capita consumption in present and future time periods. Consumption includes all goods and services, both private and public. Thus, it includes non-market goods, such as a hike in a national park, as well as market goods, such as a restaurant meal. Future consumption can be increased at the expense of current consumption, either through savings that lead to investment in human or physical capital, or in the generation of new ideas.

Given that society's well-being is a function of consumption, the SDR should reflect the weights that society puts on present and future consumption flows. In order to derive these weights, starting with Ramsey (1928), numerous economists (for example, Marglin, 1963; Mirrlees and Stern, 1972; Cline, 1992; Arrow, 1995; and Stern, 2007) have postulated that policy makers should act as though they are maximizing a social welfare function that equals the present (discounted) value of current and future utilities from consumption:

$$\int_0^\infty e^{-\rho t} U(c_t)\,dt \tag{1}$$

Here, $U(c_t)$ is the utility that society (or a representative individual) derives from public and private per-capita consumption during period t, $e^{-\rho t}$ is the discount factor (or weight) that applies to the *incremental utility* from more consumption in period t, e is the exponential function and ρ is the rate at which future utility is

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discounted. ρ reflects impatience. It is the rate of decrease in the utility of incremental consumption just because it is in the future, sometimes called the pure rate of time preference. It is normally assumed to be constant over time.

To determine the discount *rate* that society should apply to *incremental consumption*, we first compute the discount *factor* that society should apply to incremental consumption, given the objective is to maximize equation (1). Let W denote the integrand in equation (1), then the derivative of W with respect to consumption in period t can be interpreted as the social present value of more consumption in period t. It is the discount factor that society should apply to incremental consumption in period t.[3] The social discount *rate* equals the proportionate rate of decrease in this discount factor over time, which can be shown to equal:[4]

$$r = \rho + g\varepsilon \tag{2}$$

where, g is the percentage change in per capita consumption and ε is the absolute value of the elasticity of the marginal utility of consumption with respect to consumption.

In principle, ρ, g or ε could vary over time periods. However, we will assume that they are constant and, therefore, r is constant, at least within a generation. We refer to r as the *rate* of STP. It is the rate at which consumption should be discounted in order for society to maximize the present value of utility from its current and future per capita consumption flows. If investment continued until the real return to investment were equal to this rate, society would achieve the optimal growth rate of consumption. For this reason, this method of deriving the SDR is sometimes referred to as the "optimal growth rate model".

3 The discount factor that society should apply to consumption in period t is given by $\frac{dW}{dc_t} = U'(c_t)e^{-\rho t}$. It equals the product of $U'(c_t)$, the derivative of $U(c_t)$ with respect to c_t, which is the marginal utility of consumption, and the discount factor for utility of consumption, $e^{-\rho t}$.

4 Given that $\frac{d\left(\frac{dW}{dc}\right)}{dt} = U''\frac{dc}{dt}e^{-\rho t} + U'e^{-\rho t}(-\rho) < 0$, then the rate of change of the absolute value of the discount factor, which equals $-\frac{d\left(\frac{dW}{dc}\right)}{dt}$ divided by $\frac{dW}{dc}$, is $\rho + g\varepsilon$, where, $g = \frac{dc/dt}{c}$, is the rate of change in per capita consumption, and $\varepsilon = -\frac{dU'}{dc}\frac{c}{U'}$, which is the absolute value of the elasticity of the marginal utility of consumption with respect to consumption. We drop the time subscript on c for simplicity.

The second term in equation (2) incorporates the idea that society prefers more equality in per capita consumption over time than would otherwise occur (i.e., consumption smoothing), given that consumption will be higher in the future due to economic growth. It is the product of two parameters: g, the future growth rate of per capita consumption, and ε, the percentage reduction in the marginal utility of per capita consumption as per capita consumption increases by 1% (i.e., the absolute value of the elasticity of the marginal utility of per capita consumption). If the growth rate in consumption is higher, or if society has more preference for reducing inequality over time, then the rate of STP will be higher.

The parameter ε is a measure of society's preference for reducing inequality in per capita consumption over time. Its value could be anywhere between zero and infinity. In principle, it could vary with the level of consumption, but it is usually treated as constant. If ρ were zero (no preference for present over future happiness) and ε were zero, then society would value each unit of consumption received in the future as equal to the value of a unit of consumption in the present, thus reflecting a complete lack of concern for temporal inequality in consumption. In contrast, as ε approaches infinity, society would completely discount each unit of consumption received in the (richer) future, reflecting an overwhelming desire to equalize per capita consumption over time. When ε equals one, the marginal utility of society's per capita consumption in each time period is equal to the inverse of its per capita consumption.[5]

Some public projects displace some private investments that would yield higher returns than r and, therefore, would result in higher increases in future consumption. In order to ensure that society is better off through a public sector investment, increases or decreases in private-sector investment should be converted into consumption equivalents by multiplying them by the shadow price of capital (SPC) prior to discounting.

In order to calculate the SPC, suppose that a private sector investment of \$1 yields a return on investment, which is net of depreciation, of ROI. Further suppose that f is the fraction of this return that is reinvested, while the fraction $1–f$ is consumed. In the next period, \$(1+fROI) is invested which yields a return of ROI(1+fROI). Again suppose that fraction f of this return is reinvested and $1–f$ is consumed. If this process is repeated it yields a consumption stream of: $(1–f)$

5 If $U(c)$=ln(c), then U'=1/c and ε=1. In this case, the marginal utility of consumption equals the inverse of per capita consumption. Therefore, a 10% reduction in the per capita consumption of the current generation (for example, from \$50,000 to \$45,000) is equivalent to a 10% reduction in the per capita consumption of a richer future generation (for example, from \$100,000 to \$90,000).

ROI, (1–f)ROI(1+f)ROI, (1–f)ROI[(1+f)ROI]^2,…. The SPC is the present value of this consumption stream discounted at the SDR and is denoted s:[6]

$$s=\frac{(1-f)ROI}{r-f\,ROI} \tag{3}$$

Admittedly, this is a simple model because individuals do not always save a constant fraction of their returns. However, it does not require strong assumptions about the ability of private agents to foresee the impacts of government policy and to adjust their savings and consumption accordingly. Furthermore, as we argue later, shadow pricing is rarely necessary in practice.

3 Estimating the STP and the SPC

3.1 The value of the rate of STP

The values of ρ, g and ε can be derived in a number of ways. Consider first ρ, the pure rate of time preference. For intra-generational project evaluation, there is little disagreement that ρ should be positive for two major reasons. One is that people are impatient and, even if they thought they would live forever, they would rather consume sooner than later. A second is that they will not live forever and, therefore, would rather consumer sooner than later because they may not be here later.[7] For inter-generational projects, there has been considerable debate about the value of ρ since Ramsey (1928, p. 543). He argues that it is "ethically indefensible" to use a positive value, as this devalues future generations' utility relative to that of the present generation. However, Arrow (1995) shows that if ρ were equal to zero – weighting all generations' welfare equally – extremely high rates of savings would be required in every time period. For example, using our best estimate for ε of 1.35 (discussed below), setting ρ equal to zero in a simple model of economic growth would imply a savings-to-income ratio of nearly 75%. It seems unreasonable for the current, lower-consuming individuals to save such high amounts. Furthermore, one does not observe anything close to these rates of

6 We would like to thank an anonymous referee for pointing out an error in this formula in a draft of this article.

7 Such considerations have led Kula (1984) and the European Commission (2008) to suggest that ρ can be inferred from the population's annual death rate, which is an estimate of a representative individual's instantaneous probability of death. While this might make sense for individuals who discount the future since they may not be around to enjoy it, it is not compelling from a societal perspective.

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saving. Arrow, therefore, suggests ρ should be around 1%. Given the above logic and the absence of plausible alternatives, we use a value of 1% for ρ.

The future growth rate of per capita consumption, g, can be derived by extrapolating past growth rates. Many researchers currently propose 2% as an approximate estimate for the future growth rate in per capita consumption in the US (Prescott, 2002; Evans and Sezer, 2004; Moore, Boardman, Vining, Weimer and Greenberg, 2004; Nordhaus, 2007; Weitzman, 2007) although other authors propose lower rates for the US and for other countries. Our predicted growth rate is derived from Shiller's (2005) data on US real per capita consumption. This data series is updated on his website to 2009.[8] While the annual growth rate averaged approximately 2.2% over 1947–2009, it has been trending down.[9] For the most recent decade for which data are available (1999–2009), it averaged only 1.63% per annum. Recent growth rates have been even lower. There are several explanations for this lower growth rate, including the combination of government and consumer debt (Reinhart and Rogoff, 2009; Checherita and Rother, 2010). Pessimistically, Gordon (2012) presents several reasons why the US growth rate might fall further in the future. While we think (and hope) that the long-term future growth rate will exceed 1.63% due to technological progress, we do not expect it to revert to the post-war average of 2.2%, and use 1.9% (the average of 2.2% and 1.6%) as our estimate of future growth in consumption per capita.

One way to obtain a value for ε, the absolute value of the elasticity of the marginal utility of consumption, is to base it on observations of individual behavior. Doing so, Arrow et al. (1996) argue that ε is between 1 and 2 for individuals. Evans and Sezer (2004) use an alternative approach based on society's revealed preference for reducing inequality. They infer ε from the progressivity built into the federal income tax schedule and calculate values for ε of 1.43 for the US using OECD tax data.[10] Evans (2005) uses US data on federal tax rates and calculates ε as 1.15 for low-income earners, 1.45 for high-income earners and uses 1.35 overall. We adopt this approach and use new OECD (2010) tax data for the US that combines federal and local taxes for the wage income of a single, full-time employee, including social security contributions. We calculate ε annually for 2000–2010 at 0.67, 1.00 and 1.67 of the average production wage. Averaging over these three wage levels and these 11 years, we estimate that ε equals 1.38. For the average pro-

8 Data source: http://www.econ.yale.edu/~shiller/data/chapt26.xls (accessed June 30, 2011).

9 We computed this average in two ways. One method regresses the natural logarithm of real per capita consumption on time and the other computes the average annual growth rate based on the per capita consumption in 1947 and 2009.

10 Evans and Sezer (2004) assume an iso-elastic utility function and that tax rates are set such that each tax payer sacrifices an equal absolute amount of utility. Based on this model, they infer that $e=\ln(1–t)/\ln(1–T/Y)$, where t=marginal tax rate and T/Y=average tax rate.

duction wage during this period, ε averaged 1.30, although it has been trending up and the most recent estimate is 1.34. We use 1.35 as our estimate.

Using g=1.9%, ε=1.35, and ρ=1% implies that r equals 3.565%, which we round to 3.5%. Sensitivity analysis with ε ranging between 1 and 2 and with g varying between 1.6% and 2.2% suggests r ranges between 2.6% and 5.4%. Thus, we recommend using a value of 3.5% for the SDR with sensitivity analysis at 2.6% and 5.4%.

3.2 The value of the SPC

Estimation of the SPC requires an estimate of the value for the SDR, r, an estimate of the ROI, and of the proportion of this return that is reinvested, f. We discuss these parameters in turn and then derive the SPC.

A profit-maximizing firm will not make an investment unless the expected net present value is positive. This decision normally requires the expected after-tax nominal ROI to be greater than or equal to the nominal weighted average cost of capital (WACC).[11] Thus, the nominal WACC provides a means of estimating the nominal marginal ROI. To estimate the nominal WACC, one needs estimates of the nominal cost of equity, the nominal cost of corporate debt, the marginal corporate tax rate, and the proportion of debt and equity to assets. The real ROI can then be computed from the nominal WACC using estimates of inflation and the corporate tax rate.[12]

Using Shiller's (2005) data, we calculate that the geometric average of the nominal annual return on equity was 10.38% for the post-war period.[13] We calculate that the geometric average nominal annual return on long-term (20–30 year) AAA corporate bonds during this period was 6.43% per annum.[14] We obtained the proportions of equity to assets and debt to assets from the Wharton Research Data Services (WRDS) database. We sampled all active US corporations (n=4459) with book values of assets greater than \$100 million that reported their results in US

11 That is, $(1-t)\geq WACC$, where the weighted average cost of capital is computed as: $WACC=w_e k^e+w_d(1-t)k^d$, where, k^e is the cost of equity, k^d is the cost of debt, w_e is the proportion of equity, w_d is the proportion of debt, and t is the corporate tax rate.

12 That is, $real\,ROI=\left(\frac{nominal\,WACC}{1-t}-i\right)/(1+i)$, where i is the actual rate of inflation.

13 This estimate measures total returns to the S&P 500, that is, dividends plus capital appreciation from 31 Dec 1947 to 31 Dec 2010. The returns are lower in more recent time periods. For example, the average return is 9.11% for 1987–2011, and only 1.17% for the most recent decade.

14 Federal Reserve Bank of St. Louis Economic Research (FRED) using Moody's "Seasoned Aaa" corporate bonds (AAA) for 1948–2011, available at http://research.stlouisfed.org/fred2/data/AAA.txt (accessed July 26, 2011).

dollars for the 2010 fiscal year. We compute the debt to assets ratio by dividing the book value of total long-run liabilities for all corporations by total long-run liabilities plus the book value of owners' equity. This ratio equals 56%. Using Chen and Mintz's (2011) effective marginal US corporate tax rate of 34.6% yields a nominal WACC equal to 6.92% and marginal nominal ROI of 10.58%. Finally, converting this return to a real rate using the geometric average of the actual inflation rate of 3.55% during this period[15] yields a real marginal ROI equal to 6.79%.[16]

The gross investment rate provides a rough estimate of *f*, the fraction of the return that is reinvested. Using data from the Federal Reserve Bank of St. Louis Economic Research database (FRED), we calculate that the average ratio of real gross private domestic investment to real GDP for 1947–2011 is 12.8%.[17]

We can now determine the SPC for the US using equation (3). The computed value of the SDR, *r*, equals 3.565%; the pre-tax marginal return on investment, *ROI*, equals 6.79%; and the reinvestment rate, *f*, equals 12.8%, which yields a measure of the SPC, *s*, equal to 2.2. This implies that one dollar of private sector investment would produce a stream of consumption benefits with a present value (PV) equal to $2.2. For sensitivity analysis, if the SDR equals 2.6%, then the SPC equals 3.42, and if the SDR equals 5.4%, then the SPC equals 1.31.

4 The SOC method

Many BCA analysts appear to acknowledge that in principle the STP method is preferable to the SOC method. However, some may still favor the SOC method because it does not require the shadow pricing of investment (e.g., Burgess and Zerbe, 2011). Here we briefly describe the SOC method and then we compare and contrast it with the STP method.

15 Federal Reserve Bank of St. Louis Economic Research (FRED) using Consumer Price Index for All Urban Consumers: All Items for 1947–2011, available at: http://research.stlouisfed.org/fred2/data/CPIAUCSL.txt (accessed July 27, 2011).

16 This estimate is consistent with previous estimates of the pre-tax ROI in the US, which range between 5% and 8% (Cline, 1992; Nordhaus, 1999; Portney and Weyant, 1999). Nonetheless, we should point out that our estimate is sensitive to the tax rate and the debt to assets ratio. Damodaran computes the actual average US corporate tax rate (by dividing taxes paid for 5891 firms by the taxable income as reported to shareholders) as 15.48% (See "Cost of Capital by Sector" on http://pages.stern.nyu.edu/~adamodar/, accessed 28 August 2012). Using this lower tax rate, results in a much lower ROI of 5.27%. The estimated ROI increases as the debt to assets ratio decreases and vice versa.

17 See FRED: www.research.stlouisfed.org/fred2/categories/106 (for GDP) and www.research.stlouisfed.org/fred2/categories/112 (for investment), accessed July 28, 2011.

The SOC method assumes that the marginal source of funds for any government project is from borrowing in the capital market. When government adds to the demand for loanable funds, it increases the interest rate, which will displace private sector investment and personal consumption and, in an open economy, will increase foreign lending. Thus, the SOC method computes the SDR as a weighted average of the opportunity costs of these funds: the real, marginal before-tax return on displaced private-sector investment (ROI); the real, after-tax return to saving (CRI); and the real marginal cost of incremental foreign borrowing (FB):

$$SDR=\alpha ROI+\beta CRI+\gamma FB \tag{4}$$

where, α, β and γ denote the proportion of funds from displaced private sector investment, from forgone consumption, and from foreign borrowing, respectively.

We argued above that the STP method is the conceptually correct approach for discounting government projects. The SDR should reflect the rate at which society should trade-off consumption in one period versus another. As we explained above, the STP method correctly accounts for displaced private investment by shadow pricing. Instead, the SOC method tries to account for displaced private sector investment by adjusting the discount rate, with a high weight placed on the ROI. Since both methods appear to take into account displaced investment, one might suppose that they would result in the same government investment decisions. But this is not the case except under very restrictive assumptions (Spackman, 2004).

As discussed above, a central assumption of the SOC method is that each and every government project should be evaluated as if it were funded by borrowing. If this were the case then government debt would quickly become unsustainable with either observed or plausible growth rates. While the government debt as a share of GDP has increased at times, especially during wars, it has (thus far) returned to a manageable level. In fact, the government share of GDP has stayed fairly consistently between 20 around 25%, except for periods of war.[18] Although government debt has been increasing recently, both major political parties seem to agree that something has to be done about the level of government debt as a percentage of GDP. Government borrowing (as a percentage of GDP) cannot increase indefinitely. A more realistic assumption is that increased government spending is funded by increased taxes. While some projects at the margin might

18 Based on Federal Reserve Bank of St. Louis Economic Research (FRED) Real Government Consumption Expenditures and Gross Investment, available at http://research.stlouisfed.org/fred2/categories/107 and Real GDP, available at www.research.stlouisfed.org/fred2/categories/106 (accessed August 23, 2012).

be financed by debt, all projects are *ultimately* funded by taxes. Furthermore, taxes primarily reduce current consumption rather than private investment for the simple reason that consumption is much larger than investment (typically five times as large) and, therefore, taxes on investment cannot yield as much as taxes on consumption.

A further implication of the assumption that government projects are funded mainly by taxes is that, if one uses the STP method, there is little need to shadow price private-sector investment. Under these circumstances discounting becomes easy: analysts should simply discount using the rate of STP. In fact, one would also not have to shadow price if all costs and benefits are government expenditures and revenues. The same shadow price would apply to all quantities being discounted, which would only affect the magnitude and not the sign of the net present value.

To recap, the STP method argues that the SDR should reflect society's preferences for future versus present consumption. Using this method one might decide to pursue a particular government project because it yielded a higher return than the rate of STP. But, advocates of the SOC method might argue that if there were a private sector project that would yield an even higher rate of return then it would be a potential Pareto improvement to do that project instead. However, as Bradford (1975) points out, this is not the relevant comparison because, for practical purposes, government does not have the option of investing in the private sector. In practice, government has the choice between investing in a government project and funding it by taxes or not doing the project and not raising taxes. Implicitly, the SOC method assumes that the government can do the project and issue debt to finance it or it can choose not to do the project and not to raise debt. Thus, they might conclude that the government project is not worth doing because it crowds out higher-yielding private investments. However, as we discussed above, government projects are ultimately tax funded. In response, SOC advocates might argue that if the project were tax funded, then the government has a choice of either doing the project or using the taxes to pay down the debt. In our view, governments make decisions about the debt level first and subsequently decide whether or not to do various projects that are financed through taxes.

Another important issue concerns the use of market rates of return. In a world with perfectly rational agents and perfect markets, rates of return on investments, borrowing rates, lending rates and the SDR would all be equal. Even though markets are not perfect, market rates are still a potential source for the SDR. Indeed the SOC method computes the ROI, CRI and FB using market rates of return. This is particularly problematic for the CRI, which measures after-tax returns to savers, because there is abundant evidence that individuals do not make rational borrowing and lending choices over time (Frederick, Loewenstein and O'Donoghue, 2002). The myriad number of market returns on borrowing and savings, which reflect often inconsistent individual borrowing and lending behaviors, do not provide a satisfactory estimate of a single CRI.

Despite our criticisms of the SOC method, some analysts may continue to use it. In our view, Burgess and Zerbe (2011) overestimate the SOC. As discussed above, our best estimate for the ROI is 6.79%. Using the average real, expected after-tax return to 10 year US Treasury bonds from 1953 to 2011 as a measure of the real, after-tax return to savers, we estimate the CRI as 1.19%.[19] Finally, we measure the real marginal cost of foreign borrowing, FB, by the real, expected pre-tax return on 10 year Treasury bonds, which averaged 2.59% from 1953 to 2011. Using Burgess and Zerbe's weights, this yields an estimate for the SOC of 4.72%, or approximately 5%.

5 Intergenerational projects

Recently, there has been considerable attention on the discounting of projects with long-term impacts, such as climate change (Stern, 2007; symposium in the *University of Chicago Law Review Winter* 2007). Weitzman (2001), Cropper (2012) and Gollier, Koundouri and Pantelidis (2008) discuss the reasons why analysts might want to use time-declining discount rates. Many scholars and practitioners, including HM Treasury (2003) and the European Commission (2008), now accept Weitzman's (2001) argument that uncertainty about the future values of the parameters underlying the SDR implies a time-declining schedule of SDRs with only the lowest possible rates applying in the very long term.

In contrast to the growing acceptance of the use of time-declining rates for very long-term discounting, the earlier version of the "principles and standards" asserts: "[h]yperbolic [i.e., time-declining] rates are inconsistent with the SOC recommended rate, and thus are not recommended" (Zerbe et al., 2010, p. 76).

19 Federal Reserve Bank of St. Louis Economic Research (FRED) using 10 year constant maturity US Treasury Bond rates for 1953–2011, available at http://research.stlouisfed.org/fred2/data/GS10.txt (accessed July 26, 2011). The nominal, pre-tax average monthly yields on bonds are converted to real, after-tax rates by adjusting for taxes and inflation. Shoven and Topper (1992) calculate that the personal tax rate on savings is 30%, which we use in our calculations. To measure the rate of inflation that consumer/savers expected, we use the implicit forecasts of 1-year ahead expected inflation from the Federal Reserve Bank of Philadelphia Livingston survey, http://www.philadelphiafed.org/research-and-data/real-time-center/livingston-survey/, accessed July 24, 2011. For details on our procedure, see Moore et al. (2004, pp. 800–801).

It recommends a constant, non-zero discount rate, apparently on the basis that the use of time-declining discount rates would result in time inconsistent social choices: choices that might be changed simply because of the passage of time. However, time-declining rates result from uncertainty about the future rather than from inconsistent preferences (Hepburn and Koundouri, 2007). If choice reversals occur, it will be because of resolution of this uncertainty. Zerbe et al. (2011) appear less dogmatic on this question, but do not explicitly recommend any procedure. In our view uncertainty about the future does justify the use of time declining rates.[20]

6 Conclusion

Burgess and Zerbe (2011) and Zerbe et al. (2010, 2011) argue that the correct approach is to discount future impacts using the SOC method and suggest a value of the SOC of about 7%. In contrast, this article argues that the correct approach is to discount future impacts based on the STP method and suggests a discount rate of about 3.5%. Flows in or out of private investment should be shadow-priced at about 2.2.

There are two fundamental differences between the two methods. The first difference concerns the source of funding of the government project. The STP method presumes that taxes are the ultimate source of funding for any project. In contrast, the SOC method treats all government projects as debt-financed. We think that the former assumption is more realistic because governments tend to make decisions about the overall debt level before they consider whether or not to do specific projects. The second difference between the two approaches concerns the relevant alternative to the government project. The STP method compares the effect on an explicit measure of social welfare of a tax-financed government project with the counterfactual of no project (with no increase in taxes). In contrast, the SOC method implicitly assumes that the government raises a certain amount of taxes and then either uses these funds to pay for the project or to reduce the government debt. It does not seem sensible to evaluate government projects under the assumption that the counterfactual to the tax-financed project is to raise an equivalent amount of taxes, pay down the government debt by this amount, and therefore to crowd in an equivalent amount of private investment.

20 For a schedule of US-derived declining rates, which are based on Newell and Pizer (2003), see Moore et al. (2004).

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References

Arrow, K. J. (1995). *Intergenerational equity and the rate of discount in long-term social investment*. Paper presented at the IEA World Congress. Available at: http:www-econ.stanford.edu/faculty/workp/swp97005.pdf. Accessed on 11 February 2008.

Arrow, K. J., Cline, W. R., Maler, K. -G., Munasinghe, M., Squitieri, R., & Stiglitz, J. E. (1996). Intertemporal equity, discounting and economic efficiency. In: J. P. Bruce, et al. (Eds.), *Climate change 1995* (pp. 128–144). Cambridge, UK: Cambridge University Press.

Belfield, C. R., Nores, M., Barnett, S., & Schweinhart, L. (2006). The high/scope perry preschool program: cost-benefit analysis using data from the age-40 followup. *The Journal of Human Resources 41*(1), 162–190.

Boardman, A. E., Moore, M. A., & Vining, A. R. (2010). The social discount rate for Canada based on future growth in consumption. *Canadian Public Policy 36*(3), 323–341.

Boardman, A. E., Greenberg, D. H., Vining, A. R., & Weimer, D. L. (2011). *Cost-benefit analysis: concepts and practice* (4th ed). Upper Saddle River, N.J.: Prentice Hall.

Bradford, D. F. (1975). Constraints on government investment opportunities and the choice of discount rate. *American Economic Review 65*(5), 887–899.

Burgess, D. F., & Zerbe, R. O. (2011). Appropriate discounting for benefit-cost analysis. *Journal of Benefit-Cost Analysis 2*(2), Article 2.

Checherita, C., & Rother, P. (2010). *The impact of high and growing government debt on economic growth: an empirical investigation for the euro area*. European Central Bank Working Paper No. 1237.

Chen, D., & Mintz, J. (2011). *New estimates of effective corporate tax rates on business investment*. Cato Institute Tax & Budget Bullletin # 64. Feb.

Cline, W. R. (1992). *The economics of global warming*. Washington, DC: Institute for International Economics.

Cole, D. (2010). Blog on 'Law, Economics and Cycling.' Dec 25, Available at: http://cyclingprof.blogspot.ca/2010/12/revised-report-on-principles-standards.html.

Cropper, M. L. (2012). *How should benefits and costs be discounted in an intergenerational context?* Resources for the Future Discussion Paper 12-42.

Eckstein, O. (1958). *Water resource development: the economics of project evaluation*. Cambridge, Mass: Harvard University Press.

European Commission. (2008). *Guide to cost-benefit analysis of investment projects*. Available at: http://ec.europa.eu/regional_policy/sources/docgener/guides/cost/guide2008_en.pdf. Accessed on 25 October 2011.

Evans, D. J. (2005). The elasticity of marginal utility of consumption: estimates for 20 OECD countries. *Fiscal Studies 26*(2), 197–224.

Evans, D. J., & Sezer, H. (2004). Social discount rates for six major countries. *Applied Economic Letters 11*(9), 557–560.

Feldstein, M. (1972). The inadequacy of weighted discount rates. In: R. Layard (Ed.), *Cost-benefit analysis* (pp. 311–332). Harmondsworth, UK: Penguin.

Frederick, S., Loewenstein G., & O'Donoghue, T. (2002). Time discounting and time preference: a critical review. *Journal of Economic Literature 40*(2), 351–400.
Gollier, C., Koundouri, P., & Pantelidis, T. (2008). Declining discount rates: economic justifications and implications for long-run policy. *Economic Policy 23*, 759–795.
Gordon, R. J. (2012). *Is U.S. economic growth over? faltering innovation confronts the six headwinds*. NBER Working Paper 18315.
Harberger, A. C. (1972). On measuring the social opportunity cost of public funds. In: *Project evaluation: selected papers*. Chicago: University of Chicago Press.
HM Treasury. (2003). *The Green Book: appraisal and evaluation in central government*. London: TSO. Available at: www.hm-treasury.gov.uk/d/green_book_complete.pdf.
Hepburn, C. J., & Koundouri, P. (2007). Recent advances in discounting: implications for forest economics. *Journal of Forest Economics 13*(2–3), 169–189.
Jenkins, G. P. (1973). The measurement of rates of return and taxation for private capital in Canada. In: W.A. Niskanen et al. (Eds.), *Benefit cost and policy analysis* (pp. 211–245). Chicago: Aldine.
Kula, E. (1984). Derivation of social time preference rates for the United States and Canada. *Quarterly Journal of Economics 99*(4), 873–882.
Lind, R. C. (Ed.). (1982). *Discounting for time and risk in energy policy*. Baltimore and Washington, DC: Johns Hopkins University Press and Resources for the Future.
Marglin, S. A. (1963). The opportunity costs of public investment. *Quarterly Journal of Economics 77*(2), 274–289.
Mirrlees, J. A., & Stern, N. H. (1972). Fairly good plans. *Journal of Economic Theory 4*(2), 268–288.
Moore, M. A., Boardman, A. E., Vining, A.R., Weimer, D. W., & Greenberg, D. H. (2004). Just give me a number!: practical values for the social discount rate. *Journal of Policy Analysis and Management 23*(4), 789–812.
Newell, R. G., & Pizer, W. A. (2003). Discounting the distant future: how much do uncertain rates increase valuations? *Journal of Environmental Economics and Management 46*(1), 52–71.
Nordhaus, W. D. (1999). Discounting and public policies that affect the distant future. In: P. R. Portney & J. P. Weyant (Eds.), *Discounting and intergenerational equity* (pp. 145–162). Washington, DC: Resources for the Future.
Nordhaus, W. D. (2007). A review of the Stern review on the economics of climate change. *Journal of Economic Literature 45*(3), 682–702.
OECD. (2010). OECD StatExtracts: Taxing Wages at www.stats.oecd.org/Index.aspx (accessed on July 21, 2011).
Portney, P. R., & Weyant, J. P. (Eds.). (1999). *Discounting and intergenerational equity.* Washington, DC: Resources for the Future.
Prescott, E. (2002). Prosperity and depressions. *American Economic Review 92*(2), 1–15.
Ramsey, F. P. (1928). A mathematical theory of saving. *Economic Journal 38*(151), 543–559.
Reinhart, C. M., & Rogoff, K. S. (2009). *This time is different: eight centuries of financial folly.* Princeton, NJ: Princeton University Press.
Rothstein, J., & Rouse, C. E. (2011). Constrained after college: student loans and early-career occupational choices. *Journal of Public Economics 95*(1–2), 149–163.
Shiller, R. (2005). *Irrational exuberance* (2nd ed). Princeton: Princeton University Press. Data source: Available at: http://www.econ.yale.edu/~shiller/data/chapt26.xls (accessed on June 30, 2011).

Shoven, J.B., & Topper, M. (1992). The cost of capital in Canada, the United States and Japan. In: J.B. Shoven & J. Whalley (Eds.), *Canada-U.S. tax comparisons* (pp. 217–235). Chicago, IL: University of Chicago Press.

Spackman, M. (2004). Time discounting and of the cost of capital in government. *Fiscal Studies 25*(4), 467–518.

Stern, N. (2007). *The economics of climate change: the Stern review.* New York: Cambridge University Press.

Weitzman, M. L. (2001). Gamma discounting. *American Economic Review 91*(1), 260–271.

Weitzman, M. L. (2007). A review of the Stern review on the economics of climate change. *Journal of Economic Literature 45*(3), 703–724.

Zerbe, Jr., R. O., Davis, T. B., Garland, N., & Scott, T. (2010). *Toward principles and standards in the use of benefit-cost analysis*. Benefit-Cost Analysis Centre, University of Washington, 10 November. Accessed on 28 December 2010.

Zerbe, Jr., R. O., Davis, T. B., Garland, N., & Scott, T. (2011). *Toward principles and standards in the use of benefit-cost analysis*. Benefit-Cost Analysis Centre, University of Washington (Available at: http://evans.washington.edu/files/Final-Principles-and%20Standards-Report--6_23_2011.pdf), Accessed on 29 August 2012.