The Discount Rate for Public Sector Conservation Projects in South Africa

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Abstract: South Africa, in an attempt to reduce unemployment and alleviate poverty, has implemented a number of public sector conservation projects: the largest one being the Working for Water Programme (WfWP). Sound economic decision-making regarding the economic feasibility of these public sector conservation projects require that they be subjected to economic assessment in the form of cost-benefit analysis. One aspect of cost-benefit analysis, which is often neglected, is the choice of the social discount rate. This paper addresses the issue of what the social discount rate for public sector conservation projects should be and provides an example of how to derive a social discount rate for a public sector conservation project, namely the WfWP.

1. Introduction

A number of public sector conservation projects are being conducted in South Africa at the moment; the biggest one being the Working for Water Programme (WfWP).[1] Sound economic decision-making regarding the economic feasibility of these projects requires that they be subjected to economic assessment in the form of cost-benefit analysis. One aspect of cost-benefit analysis, which is often neglected, is the choice of the social discount rate. Invariably the derivation of a social discount rate produces a positive value. A relatively high social discount rate normally favours projects with a low initial capital cost and high current costs, whereas the reverse holds true for a relatively low social discount rate.

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The outcomes of a cost-benefit analysis are significantly influenced by the choice of the social discount rate applied in the decision-making criteria (i.e. the net present value, internal rate of return and the benefit cost ratio). This paper addresses the issue of what the social discount rate for public sector conservation projects should be and provides an example of how to derive a social discount rate for a public sector conservation project, namely the WfWP.

2. A Short Theoretical Overview of Cost-benefit Analysis Methodology

2.1 A Definition of Cost-benefit Analysis

Cost-benefit analysis (CBA) is a method of comparing the social costs and benefits of alternative projects or investments (Turner *et al*., 1993). Costs and benefits are measured and then weighed up against each other in order to generate criteria for decision-making. The original theoretical basis for CBA, as a technique of economic evaluation for public investment, was laid in the 1930s when the US Corps of Engineers devised a methodology to justify dam projects to the Congress. Since the 1930s CBA has become a popular tool for evaluating public sector projects in developed countries. In developing countries, where official assistance is often sought from the World Bank, the United Nations, or other international agencies, CBA is increasingly being employed. CBA is now also widely applied to private sector projects.

2.2 Decision-making Criteria

Typically one or more of three decision-making criteria are used: the net present value (NPV), the internal rate of return (IRR) and the discounted benefit cost ratio (discounted BCR).

The NPV is defined as the discounted sum of all net benefits (i.e. the difference between the benefits and the costs) over the economic life of the project (Zerbe and Dively, 1994). More formally,

$$NPV = \sum_{t=0}^{n} \frac{B_t - C_t}{(1+i)^t} \tag{1}$$

where NPV is the net present value; B_t is the benefit after t years; C_t is the cost after t years; n is the number of years over which the project runs; and $(1+i)^t$ is the factor by which the difference between B_t and C_t is discounted. The discount rate is i.

The criterion for acceptance of a project is that the NPV must be positive. Where a choice has to be made between mutually exclusive projects, the project with the highest NPV will be chosen (Harberger and Jenkins, 1994).

The IRR is defined as the discount rate at which the present values of costs and benefits are equal (Hanley and Spash, 1993). It is, therefore, the value of the discount rate, i, in the following equation:

$$NPV = \sum_{t=0}^{n} \frac{B_t - C_t}{(1+i)^t} = 0 \tag{2}$$

The criterion for acceptance of a project is that the IRR must exceed the social discount rate. Given two independent projects and a budget constraint, the one with the higher IRR should be accepted before the one with the lower IRR.

The discounted BCR is defined as the ratio of the present value of the benefits relative to the present value of the costs (Kirkpatrick and Weiss, 1996). More formally,

$$BCR = \frac{\sum_{t=0}^{n} \frac{B_t}{(1+i)^t}}{\sum_{t=0}^{n} \frac{C_t}{(1+i)^t}} \tag{3}$$

The criterion for acceptance of a project is that the discounted BCR must exceed one. For choices among mutually exclusive projects the acceptance rule would be to select the project with the highest discounted BCR.

2.3 The Social Discount Rate

In all three of the CBA decision-making criteria described above the discount rate plays a crucial role. It serves dual purposes. First, it is an indication of the social opportunity cost of capital rate (SOCC rate) and secondly; it is an indication of societies' time preference in consumption rate (STPR). In this section the dual function of the discount rate is examined.

The role played by the discount rate in relating consumption in different periods may be described in a simple two-period model. There are two aspects in this model: the intertemporal consumption possibilities and the intertemporal consumption preferences. The consumption possibilities are described first. Consumption in periods $(t+1)$ and t respectively are given by $C_{(t+1)}$ and C_t, where $C_{(t+1)}$ is a function of C_t.

A negative relationship exists between consumption in these two periods. The less that is consumed in period t, and hence saved and invested, the greater the consumption that can take place in period $(t + 1)$,

$$C'_{(t+1)} = \frac{dC_{(t+a)}}{dC_t} = -(1 + r); r > 0 \tag{4}$$

where r is the extra proportion of consumption yielded in year $(t + 1)$ over that saved (not consumed) and invested in year t.

From Equation 4 it can be deduced that the consumption choices open to people are defined as follows:

$$C_{(t+1)} = C_0 - (1 + r)C_t \tag{5}$$

Equation 5 describes the person's intertemporal budget constraint. The value of r is determined in capital markets by the forces of demand and supply and is termed the social opportunity cost of capital (SOCC). However, capital markets are segmented and do not perfectly reflect the opportunity cost to society of investable funds.

In the preceding analysis the preferences of society with respect to consumption between two periods t and $t + 1$ were ignored. The intertemporal consumption preferences of the individual are analysed with reference to that person's utility function. If:[2]

$$\frac{dU}{dC} > 0 \tag{6}$$

and

$$\frac{d^2U}{dC^2} < 0 \tag{7}$$

and

$$\frac{dU}{dC} \bullet \frac{C}{U} = 1 - b \tag{8}$$

the person's utility function is of the following form:

$$U = \mathrm{a}C^{1-\mathrm{b}} \tag{9}$$

where a and b are constant and $1 - \mathrm{b}$ is the consumption elasticity of utility. As Equation 9 will hold for both time periods:

$$U'(C_t) = (1 - \mathrm{b})\mathrm{a}C_{\mathrm{t}}^{-\mathrm{b}} \tag{10}$$

$$U'(C_{t+1}) = (1 - \mathrm{b})\mathrm{a}C_{\mathrm{t+1}}{}^{-\mathrm{b}} \tag{11}$$

If $C_t < C_{t+1}$ then

$$U'(C_{t+1}) < U'(C_t) \tag{12}$$

which implies when the person is maximizing utility, the absolute value of the slope of the indifference curve (MRS) exceeds unity.

$$MRS = \left|\frac{U'(C_t)}{U'(C_{t+1})}\right| = (1 + s); s > 0 \tag{13}$$

where MRS is the marginal rate of substitution of current consumption for future consumption and s is the rate a person would trade future consumption for (more) current consumption, that is, society's time preference in consumption rate (Hosking, 1983, p. 44). The optimum choice is defined where utility is maximized (Equation 9) subject to the budget constraint defined by Equation 5. Using Lagrangian optimization methods it may be deduced that the person would always choose to save and borrow investable funds where:

$$r = s \tag{14}$$

If the capital market is competitive, savings and borrowing behaviour should ensure that this equivalence is indeed brought about. If $s > r$, some individuals in the society would be motivated to save less and borrow more because they would prefer current consumption to future consumption. As a result r would be bid upwards in the capital market until it was brought into equivalence with s, and vice versa for $r > s$. However, where there are capital market imperfections and multiple interest rates, this equivalence will not necessarily be brought about (Feldstein, 1964, p. 361) and s will not necessarily equal r.

The main imperfections are institutional barriers preventing the equilibrating process. These barriers include taxation on dividends (Baumol, 1968), differences in risk and the existence of externalities. For these reasons r should not simply be assumed equivalent to s. A composite rate is required based upon both r and s components. The components of r (SOCC rate) and s (STPR) are discussed below (see Sections 2.3.1 and 2.3.2).

2.3.1 The Social Time Preference Rate (STPR)

The conventional formula for the social time preference rate (STPR) is as follows:

$$STPR = \mu g + a \tag{15}$$

where μ is the elasticity of marginal utility of income; g is the per capita rate of growth of income; and a is pure time preference (Ramsey, 1928).

The elasticity of marginal utility of income, μ, is the rate at which extra utility arising from income declines as income increases. With respect to the value of this elasticity, Cowell and Gardiner (2000) suggest 'a reasonable range seems to be from 0.5 (corresponding to the indirect evidence on risk aversion from models of lifetime consumption) to 4.0 (corresponding to direct experimental evidence)'. The value of μ adopted by the UK government, for use in the derivation of its official discount rate, is one (HM Treasury, 2002).

Pure time preference, a, reflects individuals' preference for current consumption over future consumption, with an unchanging level of consumption per capita over time. According to Ramsey (1928) giving any less weight to the utility of future generations is 'ethically indefensible and arises merely from the weakness of the imagination' and hence it was argued that the pure time preference rate has a value equal to zero.

More recently, Arrow (1995) argued that 'the strong ethical requirement that all generations be treated alike, itself reasonable, contradicts a very strong intuition that it is not morally acceptable to demand excessively high saving rates of any generation, or even of every generation'. Arrow (1995), thus, suggested that the pure time preference rate should be approximately equal to 1 per cent.

Future per capita output growth rates, g, for a specific country should, ideally, be based on past growth rates. Projecting long-run values of g becomes subject to speculative forecasting for which the information requirements are great but the margins of error are virtually unknown.

2.3.2 The Social Opportunity Cost of Capital (SOCC)

The social opportunity cost of capital (SOCC) is 'the rate of return on the best investment of similar risk that is displaced as a result of a particular project being undertaken' (Turner *et al.*, 1993). A popular choice of the SOCC for public sector projects is the government-borrowing rate because of its long-term, risk-free nature and the fact that it defines the financial cost of government expenditure. The use of the government-borrowing rate for this purpose does, however, amount to a declaration of considerable confidence in the competitiveness of capital markets.

2.4 The Correctness of Discounting: Positive Discounting versus Zero Discounting

Much of the literature concerning the determination of the discount rate focuses attention on the estimation of the 'correct' rate (see, for example, Marglin, 1963; Baumol, 1968; Arrow and Lind, 1970; Little and Mirrlees, 1974; Lind *et al.*, 1982; and Portney and Weyant, 1999) rather than on the correctness of discounting.

With regard to the correctness of discounting, Krutilla and Fisher (1975) argue that neoclassical environmental economists attempted to rationalize discounting in three ways. First, environmental costs should be included in project analysis. The fact that almost all environmental transformations are irreversible and that there is value attached to retaining future options raises the argument for adding extra value on environmental factors. Since environmental impacts mostly extend indefinitely into the future, low discount rates will give them the greatest influence on the benefit-cost ratio. Therefore, environmentalists concerned with the negative consequences of development should favour low rates over high ones.

Second, Smith (1972) argued that technological advances favour the availability of new resources over time and production of material goods more than they favour provision of environmental goods and services. Resource and commodity prices will thus decline over time relative to environmental goods and services. In other words, progress makes future generations better off except with regard to environmental goods and services. Smith's (1972) argument does, however, appear to overlook the dependency between the production of goods and environmental good availability.

Third, it is acknowledged (Costanza, 1991) that the present generation must value future generations, since people frequently leave estates to their children and make donations to environmental causes.

These arguments presented provide a rationale for positive discounting and tend to favour low discount rates instead of high ones. However, since a positive discount rate means that effectively less weight is given to resource use or welfare beyond a generation, discounting appears to discriminate against the future. This discrimination can be highlighted in the following ways:

- where the environmental damage is done far into the future, discounting will generate a present value of damage that is substantially smaller;
- the higher the discount rate the faster exhaustible natural resources are likely to be extracted, leaving less for future generations.

As a result of this discrimination, due to positive discounting, it has been argued (Turner *et al.*, 1993) that a zero per cent discount rate should be applied. O'Neill (1993), focusing on the Ramsey formula for the STPR, refutes the use of positive discounting based on three philosophical objections. First, O'Neill (1993) objects to the notion of pure time preference due to the fact that it establishes confusion between discounting by a person within his or her lifetime and discounting across different generations. Moreover, it is argued that pure time preference is irrational (O'Neill, 1993).

Secondly, O'Neill (1993) argues that future generations will be worse off and hence he objects to consumption discounting. It is, however, very unlikely that future generations will be worse off since it is very unlikely that they would have to deal with both a paucity of technological progress and a natural capital constraint.

Thirdly, O'Neill (1993) argues that uncertainty pertaining to the future should not form part of the discount rate. Although compelling, these objections do not warrant the rejection of a positive discount rate.

Broome (1993) followed a different line of reasoning in an attempt to justify a discount rate of zero. The basic premise of Broome's (1993) argument is that one should differentiate between well-being and commodities when discounting; real commodities can be discounted, but not well-being. It is, however, uncertain whether this argument provides sufficient justification for the use of a zero discount rate.

The abovementioned critiques of positive discounting, however, fail to address the consequences of using a discount rate of zero. A study by Olsen and Bailey (1981) suggests that the use of zero discount rates (or even relatively low ones) implies the impoverishment of the current generation, due to the fact that the lower the discount rate, the more future consumption matters, which in turn suggests larger and larger sacrifices of current well-being. A protocol of current sacrifice is, however, discarded on the basis of the Rawls criterion[3] (Rawls, 1972), because the sacrifice is incurred by the poorest generation.

2.5 The Solution: A Declining Social Time Preference Rate?

Recent studies (see, for example, Weitzman, 2001) have questioned the traditional view of applying the same positive discount rate over the short and long term. According to these studies discount rates change with time and, in general, they fall as the time horizon rises (see, for example, Newell and Pizer, 2001; Gollier, 2002; and Li and Lofgren, 2000).

Weitzman (2001) conducted a study on the appropriate discount rates for climate change mitigation. During the study Weitzman (2001) administered a survey in which the following question was asked to more than 2000 PhD graduates: 'Taking all relevant considerations into account, what real interest rate do you think should be used to discount over time the (expected) benefits and (expected) costs of projects being proposed to mitigate the possible effects of global climate change'. It was found that the mean discount rate was 4 per cent, with a standard deviation of 3 per cent. The results produced by the study approximately followed a gamma distribution. The latter was taken as an image of the uncertainty about the future conditions of the world, which resulted in the calculation of the appropriate discount factor, and hence the implicit discount rate.

The discount rates derived by Weitzman (2001), by fitting survey data to a gamma distribution, declined from approximately 4 per cent per annum for the immediate future (i.e. 1–5 years) down to approximately zero per cent per annum for the far-distant future (i.e. more than 300 years).

2.6 Selected Social Discount Rate Measures Used by Others

The World Bank normally employs the social opportunity cost of capital as a theoretical basis for their choice of the discount rate (Conningarth Economists, 2002). Typically it applies a rate of 10 per cent per annum.

Not unlike the World Bank, government institutions in the United States, like the United States Fish and Wildlife Services and water-related federal agencies, normally use a discount rate, based on the social opportunity cost of capital, equivalent to the long-term Treasury bond rate (CEAS, 1989). This is a nominal rate but is applied as a real rate (CEAS, 1989). The US Forest Services typically have used lower (compared to other government institutions) discount rates, for example, 4 per cent (Loomis, 1993). Their rates are derived from the rate of returns on capital and corporate bonds (Loomis, 1993).

Several empirical estimates of the discount rate, based on the underlying theory of the social time preference rate, have been calculated. According to Kirkpatrick and Weiss (1996) 'such estimates are normally in the one percent to five percent range, since per capita consumption growth will rarely exceed three percent annually and the conventional estimates of the elasticity of the marginal utility of consumption are typically between 1.0 and 1.5'. Walshe and Daffern (1990) argue that the STPR is slightly in excess of the growth rate of the economy. The STPR is equal to the growth rate of the economy in question if it is assumed that the elasticity of marginal utility of consumption is equal to one and pure time preference is rejected based on the notion that it is ethically indefensible to discount the future simply because this generation is impatient. STPRs of 3.5 per cent, 3 per cent and 8 per cent were estimated for use in the United Kingdom (HM Treasury, 2002), Germany and France (Evans and Sezer, 2002), respectively.

In South Africa the most widely used discount rate is 8 per cent (Conningarth Economists, 2002). The STPR is estimated at between 2.5 and 5 per cent, if one only considers the long-term growth rate in accordance with the approach of estimating the STPR proposed by Walshe and Daffern (1990). The STPR is significantly lower than the widely applied 8 per cent mentioned above.

The SOCC rate is, however, more in line with a discount rate of 8 per cent. The real rate of interest on government bonds (1990–2000) is 4.5 per cent. If it is assumed that investors are interested in a return on investment of 5 percent above the real rate of interest on risk-free government bonds, then this implies a return on capital in real terms of about 9 per cent on risk attached investments (Conningarth Economists, 2002).

3. An Example of Deriving a Composite Social Discount Rate for a Public Sector Project, Namely the Working for Water Programme (WfWP)

As mentioned in Section 2.3 above, the SOCC rate (r) should not simply be assumed equivalent to the STPR (s). Therefore, it is not appropriate to use a single rate as the discount rate, for example, the government-borrowing rate on long-term, risk-free government bonds. A composite rate is required based upon both the SOCC rate and STPR components.

In order to determine the components of the social discount rate (i) of the WfWP, average sources of funding for public sector projects were investigated during the period 1996 to 2000. There were three main sources of funds for public sector projects from 1996 to 2000: taxes, government borrowing and foreign aid. Tax funding requires consumption and savings to be sacrificed by households and companies. The cost of the consumption sacrificed is measured by the interest rates consumers are prepared to pay to borrow (X_1). The saving sacrificed is measured by foregone dividend yield and capital growth on their savings (X_2). Government borrowing also has a cost, that is, the rate of interest paid on government bonds (X_3). Foreign aid does not carry any opportunity cost from the South African perspective unless the money would have been allocated elsewhere in the country (hence X_4 equals zero).

The social discount rate, i, was estimated using the equation below:

$$i=(1-f)t[(1-s)(x_1-p)+(s)(x_2-p)]+(1-f)(1-t)(x_3-p)+f(x_4-p) \quad (16)$$

where t is the proportion of government expenditure funded through tax and duty collection; $1 - t$ is the proportion of government expenditure funded through borrowing; s is the proportion of disposable income saved; $1 - s$ is the proportion of disposable income consumed; x_1 is the average of the predominant overdraft rate on current accounts and the term lending base rate (hire – purchase credit rate); x_2 is the average of the dividend yield (per cent) and the capital growth of all listed shares on the JSE; x_3 is the average of the government loan stock yield (10 years and over) and the Eskom bond rate; x_4 is the interest rate cost of foreign funding; f is the proportion of foreign funding of total; and p is the inflation rate (CPI).

The data used to calculate the discount rate i (Equation 16) are shown in Tables 1, 2 and 3. Table 1 shows the cost of government borrowing, the cost of household consumption borrowing, the return on savings and the annual inflation rate for the period 1996 to 2000. Table 2 shows the calculation of weights, t and $1 - t$, and Table 3 shows the calculation of weights, s and $1 - s$.

Employing formula (16) and the information provided in Tables 1, 2 and 3, the discount rate for a public sector project, namely the WfWP, was estimated at 10.1 per cent per annum.

4. Conclusion

The choice of a social discount rate for use in a cost-benefit analysis is a critical one. Various schools of thought exist regarding the basis for the choice of the social discount rate. For instance, there are those who argue that it should equal the social opportunity cost of capital (SOCC), there are those who advocate a social time preference rate (STPR), there are those who advocate the use of one long-term rate (i.e. the traditional view) and there are those who advocate different rates for different periods (i.e. a declining social time preference rate). Due to imperfections in the market place the former two suggested rates will rarely be equivalent, and due to changing market circumstances, the rates will change over time. Ideally allowance should be made explicitly for differences.

This study makes allowance for differences in rates by source. The deduction is that the social discount rate for public sector conservation projects in South Africa, including the Working for Water Programme, between 1996 and 2000, was 10.1 per cent per annum. This discount rate is slightly higher than the discount rate most often applied in South Africa, namely 8 per cent, and much higher than the social time preference rate of between 2.5 and 5 per cent. It is, however, very close to the social opportunity cost of capital in South Africa, namely 9.5 per cent.

Table 1: Cost of government borrowing, cost of household consumption borrowing, the return on savings and the annual inflation rate (1996–2000)

Cost of government borrowing				Cost of household consumption borrowing			Return on savings			Average annual inflation rate as measured by consumer price index %
Year	Government stock – yields on loan stock traded on the bond exchange (10 years and over), % (*a*)	Eskom Bond Yield, % (*b*)	Average yield, % $\frac{(a)+(b)}{2}$ x_3	Predominant overdraft rate on current accounts, % (*c*)	Long-term lending base rate (Hire – purchase credit), % (*d*)	Average rate, % $\frac{(c+d)}{2}$ x_1	Dividend* yield % (*e*)	Capital Growth % (*f*)	Average % $\frac{(e)+(f)}{2}$ x_2	p
1996	16.19	16.16	16.18	22.5	19.8	21.15	2.25	21	11.63	7.4
1997	14.14	14.19	14.17	22	19.25	20.63	2.45	3.3	2.88	8.6
1998	16.36	16.78	16.57	22.64	22.36	22.5	2.71	−5.6	−1.45	6.9
1999	13.96	14.45	14.21	18.10	18.69	18.4	2.62	5.9	4.3	5.2
2000	12.88	13.23	13.06	14.83	14.5	14.67	2.45	15.2	8.83	5.3

Notes: * All classes of shares.
Sources: SARB *Quarterly Bulletin* (December 1998, September 1999, September 2001); Stats SA (2000).

Table 2: The calculation of weights — (*t*) and (1 − *t*)

Year	Government borrowing requirement R millions (*a*)	Government revenue R millions (*b*)	Total R millions (*c*) = (*a*) + (*b*)	Borrowing proportion $\frac{(a)}{(c)}$ (1 − *t*)	Tax revenue proportion $\frac{(b)}{(c)}$ (*t*)
1996	29,001	127,109	156,110	0.19	0.81
1997	31,501	145,999	177,500	0.18	0.82
1998	25,764	163,921	189,684	0.14	0.86
1999	20,862	183,166	204,028	0.10	0.90
2000	19,025	197,380	216,405	0.09	0.91

Source: SARB *Quarterly Bulletin* (September 2001).

Table 3: The calculation of discount rate weights — (*s*) and (1 − *s*)

Year	Final consumption expenditure R million (*a*)	Gross savings R million (*b*)	Total R million (*c*) = (*a*) + (*b*)	Final consumption expenditure proportion $\frac{(a)}{(c)}$ (1 − *s*)	Gross savings proportion $\frac{(b)}{(c)}$ (*s*)
1996	505,419	97,732	603,149	0.84	0.16
1997	566,671	99,074	665,744	0.85	0.15
1998	612,480	105,015	717,495	0.85	0.15
1999	657,568	116,498	774,066	0.85	0.15
2000	716,458	132,541	848,999	0.84	0.16

Source: SARB *Quarterly Bulletin* (September 2001).

What is clear from this enquiry is that there are divergent views on the appropriate social discount rate that should be applied in the economic assessment of public sector conservation projects, but regardless of how it is derived, it is likely to produce a positive value.

Notes

1. The WfWP entails the removal of high water-consuming alien vegetation and restoring of low water-consuming indigenous vegetation.
2. Reasons for assumption 6 include the higher probability of death argument according to which present consumption is preferred to future consumption because a person may not be alive in the future to benefit from his or her restraint (Turner *et al.*, 1993, p. 105) and a propensity among people to take short-run perspectives.
3. According to the Rawls criterion the aim should be to maximize the well-being of the poorest group in society.

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