About the Paper
Juzhong Zhuang, Zhihong Liang, Tun Lin, and Franklin De Guzman survey theories and practices in the choice of the social discount rate for cost-benefit analysis of public projects. The issue of choosing an appropriate discount rate for intergenerational projects is also highlighted in light of recent debates on the economics of climate change.

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Theory and Practice in the Choice of Social Discount Rate for Cost-Benefit Analysis: A Survey

Juzhong Zhuang, Zhihong Liang,
Tun Lin, and Franklin De Guzman

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May 2007

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FOREWORD

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ABSTRACT

The choice of an appropriate social discount rate for cost–benefit analysis of public projects has long been a contentious issue and subject to intense debate among economists. This debate has gained new impetus from the recent discussions on the economics of climate change. The purpose of this paper is to survey theories and practices in the choice of the social discount rate. More specifically, the paper examines economic arguments for discounting future benefits and costs and analytical approaches to the choice of the social discount rate, including how a social discount rate can be estimated empirically under each approach; and policy practices followed by countries around the world in the choice of the social discount rate. This paper is intended as a reference material on project economic analysis for ADB staff, consultants, and concerned government officials in developing member countries.

I. INTRODUCTION

The choice of an appropriate social discount rate[1] for cost–benefit analysis of public investment projects has long been a contentious issue and subject to intense debate in the economics literature. The recently released *The Economics of Climate Change: The Stern Review* has added new impetus to this debate (Stern 2006). The Review issued a stunning warning that failing to invest 1 percent of world gross domestic product (GDP) now to reduce global warming could risk a future reduction of up to 20% in global GDP. Critics have argued that these results, dramatically different from earlier studies using the same basic data and analytical structure, depend crucially on a very low social discount rate—1.4%—used in economic modeling. If a higher discount rate more in line with its usual range had been applied, the estimated cost of not acting now would be reduced by an order of magnitude (Nordhaus 2006 and Dasgupta 2006).

A social discount rate reflects a society's relative valuation on today's well-being versus well-being in the future. Choosing an appropriate social discount rate is crucial for cost–benefit analysis, and has important implications for resource allocations. Setting the social discount rate too high could preclude many socially desirable public projects from being undertaken, while setting it too low risks making a lot of economically inefficient investments. Further, a relatively high social discount rate, by attaching less weight to benefit and cost streams that occur in the distant future, favors projects with benefits occurring at earlier dates; while a relatively low social discount rate favors projects with benefits occurring at later dates. Choice of the social discount rate affects not only the *ex ante* decision of whether a specific public sector project deserves the funding, but also the *ex post* evaluation of its performance.

Economic efficiency requires that the social discount rate measure the marginal social opportunity cost of funds allocated to public investment. In a perfectly competitive world without market distortions, the market interest rate is the appropriate social discount rate. In the real world where markets are distorted, the market interest rate will no longer reflect marginal social opportunity cost of public funds. Economists have proposed several alternative approaches to the choice of the social discount rate in the presence of market distortions, but there has been no consensus on which is the most appropriate. The differences among these approaches reflect largely differing views on how public investment affects domestic consumption, private investment, and the cost of international borrowing. In cases of very long-term projects with impacts lasting for more than one generation or even hundreds of years, such as those addressing climate changes and other environment problems, many have argued that the choice of the social discount rate should not only consider economic efficiency, but also intergenerational equity.

There are significant variations in public discount rate policies practised by countries around the world, with developing countries in general applying higher social discount rates (8–15%) than developed countries (3–7%). These variations reflect the different analytical approaches followed by various countries in choosing the social discount rate. But more fundamentally, it can be argued

[1] The social discount rate is sometimes also referred to as the cut-off economic internal rate of return (EIRR).

that the divergence reflects differences in the perceived social opportunity cost of public funds across countries and in the extent to which the issue of intergenerational equity is taken into consideration in setting the social discount rate.

The purpose of this paper is to provide a survey of the vast literature on the social discount rate that the decades of debate have generated, covering theory, estimation methods, and policy practices.[2] More specifically, the rest of the paper attempts to ask and answer the following questions:

(i) What are the economic arguments for discounting future benefits and costs and analytical approaches to the choice of the social discount rate?

(ii) How can a social discount rate be estimated empirically under each approach?

(iii) What are the policy practices followed by countries around the world and by multilateral development banks (MDBs) in the choice of the social discount rate?

The choice of social discount rate is also an important issue for MDBs, including the Asian Development Bank (ADB), and has significant relevance for their operations. In both *ex ante* project economic analysis and *ex post* project performance evaluation, most MDBs estimate and evaluate benefits and costs of development projects using a uniform cut-off discount rate, also called economic internal rate of return (EIRR), of 10–12 percent. This paper is intended not only to provide a reference material on project economic analysis for ADB staff, consultants, and concerned government officials of ADB's developing member countries (DMCs), but also to stimulate discussions among MDBs on whether the current practice of applying a uniform social discount rate of 10–12% to all development projects in all countries is still appropriate in a changing world.

II. THEORETICAL FOUNDATIONS FOR THE CHOICE OF A SOCIAL DISCOUNT RATE

A. Approaches to Discounting Future Benefits and Costs: Unsettled Debate

A public investment project typically incurs costs and generates benefits at different points of time. A common practice in cost–benefit analysis, called discounting, is to express all costs and benefits in terms of their present value by assigning smaller weights to those that occur further away in the future than to those occurring more recently. Discounting, a critical step in determining whether or not a public project is socially desirable, makes costs and benefits with different time paths comparable.[3]

There are two arguments why costs and benefits with different time profiles may not be comparable if not properly discounted. The first is that consumers (or savers) prefer to receive the same amount of goods and services sooner rather than later. There are two standard textbook explanations for this time preference (Dasgupta and Pearce 1972). The first is that individuals expect their level of consumption to increase in the future, hence, marginal utility of consumption will diminish. With this expectation, individuals would have to be paid more than one unit in the future to compensate for sacrificing (saving) one unit of consumption now. The second explanation, which

[2] There have been a number of surveys and reviews of this subject in the literature (Stiglitz 1994, Spackman 2004, Evans 2005). Most of these focus either on theory, empirical estimation, or policy practices; not many look at all the three aspects at the same time.

[3] Discounting is also required in investment decision making in the private sector where the present value of financial benefits of a project is compared with that of financial costs.

has been a subject of great controversy (see Box 1), is that individuals have a positive pure time preference, that is, even if levels of future consumption are not expected to change, they would still discount the future. Two reasons are often quoted in explaining the pure time preference. One is that consumers are generally "impatient" or "myopic." The other is the risk of not being alive in the future. According to these lines of reasoning, the rate to discount future benefits and costs should be the marginal social rate of time preference (SRTP), that is, the rate at which society is willing to postpone a marginal unit of current consumption in exchange for more future consumption.[4]

The second argument for discounting future costs and benefits takes the perspective of a producer (or an investor). According to this, capital is productive and resources acquired for a particular project can be invested elsewhere, generate returns, and so have an opportunity cost. Therefore, to persuade an investor to invest in a project, the expected return from the investment should be at least as high as the opportunity cost of funding, which is the expected return from the next best investment alternative. Following this logic, the rate the investor should use in discounting benefits and costs of a project is the marginal rate of return on investment in the private sector. In the absence of market distortions, this is equivalent to the marginal social rate of return on private investment, also termed marginal social opportunity cost of capital (SOC).

In a perfectly competitive economy without distortions, prices of inputs and outputs would reflect their economic or social values. The supply and demand prices of investible funds are given by SRTP and SOC, respectively. The capital market clears at an interest rate that equates the supply of and demand for investible funds. Both SRTP and SOC are equal to the market interest rate. The market interest rate reflects marginal social opportunity cost of investible funds, which is then the appropriate social discount rate to achieve an efficient allocation of resources in the economy.

In reality, the market is often distorted due to various imperfections. A typical example of imperfection is the taxes imposed on corporate incomes and individuals' interest earnings. Other examples are risks, information asymmetry, and externalities. These imperfections create a wedge between SRTP and SOC (with the former generally lower than the latter), and make both deviate from the market interest rate. Under such circumstances, the market interest rate will not reflect the marginal social opportunity cost of public funds, and the latter will vary depending on whether it is measured in terms of SRTP or SOC. What rate then should be used to discount future benefits and costs in cost–benefit analysis? The debate on this has been ongoing for many decades. Four alternative approaches have been put forward: (i) SRTP, (ii) SOC, (iii) weighted average approach, and (iv) shadow price of capital (SPC) approach. However, there has been no consensus on which is the most appropriate (Boardman et al. 2001). In essence, these different approaches reflect differing views on how public projects affect domestic consumption, private investment, and cost of international borrowing.

Earlier discussions on public sector discounting coincided with the rise of cost–benefit analysis in the 1960s and 1970s. In the 1990s, the choice of the social discount rate was brought up again in the context of finding a rate to discount the long-term environmental benefits and costs, such as those related to addressing climate changes and global warming. Here, the problem of choosing an appropriate discount rate is further complicated by the consideration of intergenerational equity. In the following subsections, we review in some detail how the social discount rate can be estimated under each of the four approaches, and the latest debate on how to choose a discount rate for very long-lived environmental projects.

[4] Here we disregard the issues involved in aggregating individual preferences into the social preference. See Dasgupta and Pearce (1972) for discussions on these issues.

B. Social Rate of Time Preference

The social rate of time preference is the rate at which a society is willing to postpone a unit of current consumption in exchange for more future consumption. The use of SRTP as the social discount rate, supported by Sen (1961), Marglin (1963a and b), Diamond (1968), and Kay (1972), is based on the argument that public projects displace current consumption, and streams of costs and benefits to be discounted are essentially streams of consumption goods either postponed or gained. Two alternative methods have been suggested for empirical estimation of SRTP. One is to approximate it by the after-tax rate of return on government bonds or other low-risk marketable securities. Although this is straightforward, a major concern is that individuals may not express all their preferences concerning the future in the marketplace and, even if they do, their preferences expressed as individuals may not be the same as their preferences expressed when they see themselves as part of a society. Society as a whole would have a lower rate of discount in its collective attitude than the observed market rates, which could reflect individuals' myopia (Dasgupta and Pearce 1972).

The other method is to use a formula named after the renowned British economist Frank P. Ramsey. According to Ramsey's formula derived from a growth model, SRTP is the sum of two terms: the first is a utility discount rate reflecting the pure time preference and the second is the product of two parameters—the elasticity of the marginal utility of consumption[5] and the annual rate of growth of per capita real consumption (Ramsey 1928). The second term of the formula reflects the fact that, when consumption is expected to grow in the future, people will be less willing to save in the current period to obtain more in the future, because of diminishing marginal utility of consumption. Using the Ramsey formula to empirically estimate SRTP requires information on the utility discount rate (ρ), elasticity of marginal utility of consumption (θ), and annual rate of per capita real consumption growth (g). The choice of g is relatively straightforward while the choice of ρ and θ is more difficult, as it involves normative value judgments, and has been a subject of intense debate, as discussed in Box 1.

The utility discount rate, ρ, is conceptually considered as consisting of two components, one related to individuals' impatience or myopia and the other related to the risk of death or human race extinction.[6] Many empirical studies set the first component to zero often on the ethical ground (see, for example, Kula 1984, 1987, and 2004; Cline 1992; Stern 2006). It has also been argued that considering myopia in estimating SRTP implies introducing irrationality into the decision-making process, which is inconsistent with the principle of cost–benefit analysis, i.e., to bring rationality into investment decisions (Kula 1984). The difficulty in empirically estimating this first component of pure time preference could also be a reason why many studies have ignored it. On the other hand, setting this to zero does lead to some paradoxical results (see Box 1). Among empirical studies that consider this to be positive, the suggested range is 0–0.5% (OXERA 2002). Scott (1977 and 1989) argues that the long-run savings behavior in the United Kingdom (UK) is consistent with a value of 0.3–0.5% for this component of ρ. Table 1 provides a survey of some of the empirical studies on the utility discount rate including both of its two components. The suggested range is 1–3 percent.

[5] The elasticity of marginal utility of consumption is the percentage change in individuals' marginal utility corresponding to each percentage change in consumption.

[6] In the literature, some authors relate the pure time preference only to the first component while most relate it to both. In this paper, we follow the convention used by most authors: pure time preference reflects both individuals' impatience and risk of not being alive in the future.

For the component of the utility discount rate related to the risk of not being alive in the future, the controversy is not on whether it should be considered; rather, it is on how to measure this risk. Some attempt to estimate individuals' survival probability and risk of death using death rate statistics (Kula 1984, 1987, 2004). Others argue that individuals' risk of death is not relevant to the derivation of the social time preference; what is relevant is the changing life chance for whole generations (Pearce and Ulph 1999).

Box 1
The Debate on Pure Time Preference

Many argue that the positive pure time preference, which implies valuing utility of future generations less than the present generation, is ethically indefensible (Ramsey 1928, Pigou 1932, Harrod 1948, Solow 1974). Others, while admitting that ethically all generations should be treated alike, point out that a zero rate of pure time preference implies a savings rate excessively higher than what we normally observe and contradicts real world savings behavior, leading also to other paradoxical results (Arrow 1995). There are also those who argue that the risk of death, or mortality, is a rational enough reason for positive pure time preference (Eckstein 1961). This argument, although more amenable to empirical investigation and less prone to fundamental disputes about value judgments, is also subject to disagreement about what precise risks are being discussed (Pearce and Ulph 1999). Dasgupta and Pearce (1972) highlight the problem of considering risk-of-death time preference in calculating the social discount rate, because the social time preference relates to society, and not to an aggregate of individuals; although individuals are mortal and society is not. Among more recent empirical studies, some authors look at the increasing risk of death, or changing survival probability, for an individual as one gets older (Kula 1985, 1987, 2004; Evans and Sezer 2004). Pearce and Ulph (1999) highlight problems of this approach, and argue that when dealing with very long-lived projects, the appropriate risks are not so much the increasing probability of death of a single individual, but what is happening to the life chances of whole generations. Newbery (1992) attempts to measure this risk by estimating the perceived risk of the end of mankind in 100 years. The *Green Book* of the UK HM Treasury refers to this as a catastrophe risk, that is, the likelihood that there will be some events so devastating that all returns from policies, programs, or projects are eliminated, or at least radically and unpredictably altered (HM Treasury 2003). The Stern Review defines this as the risk of extinction of the human race and argues that such risks could arise from possible shocks such as a meteorite, a nuclear war, or a devastating outbreak of some diseases.

Empirical estimates of the elasticity of marginal utility of consumption (θ) also vary from one study to another. Three different approaches have been used: direct survey methods; indirect behavioral evidence; and revealed social values (see a recent review by Evans 2005). The survey methods focus on measuring risk and inequality aversion[7] from responses to specially designed survey questions. The indirect behavioral evidence is based on observed consumption behaviors from empirically estimated consumer demand models. The third approach in estimating θ involves inference from government behavior revealed through spending and tax policies. A survey of empirical estimates of θ based on the three approaches indicates that its values mostly fall within the range from 1 to 2%, except for a few outliers (Table 2). The differences suggest that the results

[7] Risk aversion measures the reluctance of an individual to accept a bargain with an uncertain payoff rather than another bargain with a more certain but possibly lower expected payoff. Inequality aversion measures an individual's tolerance to income inequality. Risk aversion is closely related to inequality aversion, and both are closely related to the elasticity of marginal utility of consumption.

are sensitive to model specification, level of aggregation in the data, choice of estimators, sample size, and the length of sample periods.

Table 1
Empirical Estimates of the Utility Discount Rate

Source	Empirical Estimates	Theoretical Basis
Scott (1977)	1.5%	Component reflecting myopia is 0.5%, and that reflecting the changing life chance due to the risk of total destruction of a society is 1.0%
Kula (1985)	2.2%	Reflecting average annual survival probability in the UK during 1900–1975
Kula (1987)	1.2%	Reflecting average annual probability of death in the UK in 1975
Scott (1989)	1.3%	Component reflecting myopia is 0.3%, and that reflecting the changing life chance due to the risk of total destruction of a society is 1.0%
Newbery (1992)	1.0%	Perceived risk of the end of mankind in 100 years
Dynamic Integrated Model of Climate and the Economy (DICE) model (Nordhaus 1993)	3% per year	Utility discount rate reflecting pure social time preference, determined by calibrating the DICE model to match actual data
Pearce and Ulph (1995)	1.1%	Reflecting the average annual probability of death in the UK in 1991
Arrow (1995)	1%	Utility discount rate reflecting pure social time preference, and matching the observed savings behavior
OXERA (2002)	Myopia = 0-0.5% Risk of death = 1.1% with a projected change in the near future to 1.0%	Based on previous studies and projected and recent average annual death rates in the UK
Evans and Sezer (2004)	1.0–1.5%	1% for EU countries and 1.5% for non-EU countries, reflecting catastrophe risks
Kula (2004)	1.3%	Reflecting the average annual death rate in India during 1965–1995
Evans (2006)	1%	Based on the approximate average annual death rate in 2002–2004 in 15 countries of the European Union
Stern Review (2006)	0.1%	Probability of human race extinction per year

Sources: Compiled by authors.

Table 2
Empirical Estimates of the Elasticity of Marginal Utility of Consumption

Source	Empirical Estimates	Dates
A. Survey Method		
Barsky et al. (1995)	Approximately 4.0	Reflecting risk aversion of the US middle-aged who were surveyed
Amiel et al. (1999)	0.2–0.8	Reflecting inequality aversion of US students who were surveyed
B. Indirect Behavioral Evidence		
Constant elasticity demand models		
Kula (1984)	1.56	Canada: 1954–1976 data
Kula (1984)	1.89	US: 1954–1976 data
Evans and Sezer (2002)	1.64	UK: 1967–1997 data
Evans (2004a)	1.6	UK: 1965–2001 data
Kula (2004)	1.64	India: 1965–1995 data
Evans et al. (2005)	1.6	UK: 1963–2002 data
Percoco (2006)	1.28	Italy: 1980–2004 data
Almost ideal demand system		
Blundell (1988)	1.97	UK: 1970–1984 data
Evans (2004b)	1.33	France: 1970–2001 data
Lifetime consumption model		
Blundell et al. (1994)	1.2–1.4	UK: 1970–1986 data
Quadratic almost ideal demand system		UK: 1970–1984 data
Blundell et al. (1993)	1.06	Aggregate model
	1.06–1.37	Micro models
Banks et al. (1997)	1.07	UK: 1970-1986 data
C. Revealed Social Values		
Cowell and Gardiner (1999)	1.28-1.41	UK: 1999–2000 data
Evans and Sezer (2004)	1.5	UK: 2001–2002 data
Evans (2005)	1.25-1.45	Five major OECD countries (France, Germany, Japan, UK, US): 2002–2003 data

Sources: Evans (2005); compiled by authors.

With estimates of ρ, θ, *and g*, SRTP can be calculated using the Ramsey formula. Box 2 provides an illustration.

Box 2
Estimating SRTP Using the Ramsey Formula

Consider the following Ramsey growth model where the representative agent maximizes its life-time welfare subject to intertemporal constraints (Ramsey 1928):

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

$$\text{subject to } \dot{k}_t = f(k_t) - c_t \tag{2}$$

where *U(.)* represents a time-invariant utility function with properties of *U′(.)>0* (the marginal utility of consumption is positive) and *U″(.)<0* (the marginal utility of consumption diminishes); ρ is a utility discount rate reflecting pure time preference; c_t is consumption at time *t*; *f*(.) represents a production function; and $\dot{k}_t$ is net investment at time *t*.

Maximization requires

$$U'(c_t)\, f'(k_t) + U''(c_t)\, \dot{c}_t - \rho\, U'(c_t) = 0 \tag{3}$$

where $\dot{c}_t$ is change in consumption at time *t*. Equation (3) can be simplified to

$$r = f'(k_t) = \rho + \theta\, g \tag{4}$$

where *r* is the rate of return to savings; $\theta = -\frac{U''}{U} c$ is the elasticity of marginal utility of consumption representing preference and is also known as the coefficient of relative risk aversion; and $g = \dot{c}_t / c_t$ is the growth rate of per capita consumption. Equation (4) is the familiar Ramsey formula, which states that households choose consumption so as to equate the rate of return to savings to the rate of pure time preference plus the rate of decrease of the marginal utility of consumption due to growing per capita consumption.

Following Evans and Sezer (2004), the rate of pure time preference ρ is assumed to be 1.5%, elasticity of marginal utility of consumption θ is assumed to be 1.3, and the average growth rate of per capita real consumption *g* is the average annual growth rate of per capita real GDP from 1970 to 2004 (Penn World Tables 6.1). The Ramsey formula yields the following estimates of SRTP for four selected Asian countries (see box table).

Box Table
Empirical Estimates of SRTP for Selected Asian Countries

	ρ (%)	*g* (%)	θ	SRTP (%)
Indonesia	1.5	3.55	1.3	6.1
Malaysia	1.5	4.88	1.3	7.8
Singapore	1.5	4.48	1.3	7.3
Japan	1.5	2.34	1.3	4.5

A major criticism on using SRTP as the social discount rate is that it is purely a measure of the social opportunity cost in terms of foregone consumption and ignores the fact that public projects could displace or crowd out private sector investment if they cause the market interest rate to rise (Baumol 1968 and Harberger 1972). If additional public investment is made at the cost of displacing private investment, its marginal social opportunity cost should also reflect what the displaced private investment would otherwise bring to the society, which can be measured by the marginal social rate of return on private sector investment (SOC).[8] Since SRTP is generally lower than SOC because of the wedge created by market distortions such as taxes, this raises the possibility that too many low-return investments in the public sector would be undertaken when SRTP is used as the social discount rate.

C. Marginal Social Opportunity Cost of Capital

The proposal for using the marginal social opportunity cost of capital (SOC) as the social discount rate, advocated by Mishan (1967), Baumol (1968), and Diamond and Mirrlees (1971a and b), among others, is based on the argument that resources in any economy are scarce; that government and private sector compete for the same pool of funds; that public investment displaces private investment dollar by dollar; and those devoted to public sector projects could be invested in the private sector. Therefore, public investment should yield at least the same return as private investment. If not, total social welfare can be increased by reallocating resources to the private sector, which yields higher returns.

It has been suggested that SOC could be approximated by the marginal pretax rate of return on riskless private investments. A good proxy for this is the real pretax rate on top-rated corporate bonds (Moore et al. 2004). Box 3 provides an illustration of estimating the marginal rate of return based on Moody's AAA bonds. Some have argued that SOC, as estimated in Box 3 should be adjusted downward for a number of reasons (Lind 1982, Boardman et al. 2001). First, in theory, the marginal pretax rate of return, rather than the average rate, should be used in estimating SOC. The marginal rate of return will be lower than the average rate as rational businessmen will make their best deal first. Second, the rate of return on private investment includes premiums to compensate investors for risks that are generally higher than those for public sector investment. Third, returns on private investment as social opportunity cost of capital may also be contaminated by market distortions such as externalities and monopolistic pricing.

Box 3
Estimating SOC from Yields on Corporate Bonds

Based on the method used by Boardman et al. (2001), the average annual yield on Moody's AAA long-term corporate bonds was estimated at 6.81% from January 1947 to December 2005 in the United States (US). Applying the 2004 corporate tax rate of 40% (KPMG 2004), the nominal pre-tax return on bonds was calculated at [0.0681 / (1- 0.38)] = 11.35 percent. A proxy for the expected rate of inflation is the average annual inflation rate, which was 3.78% between 1947 and 2005 in the United States. Therefore, the real pretax rate of return on top-rated corporate bonds in the US is [(0.1135 – 0.0378) / (1+0.0378)] = 7.29%, which approximates SOC.

[8] This can be approximated by the pretax rate of return on private investment. See discussions in the next subsection.

Dasgupta, Marglin, and Sen (1972), on the other hand, note that the argument for using SOC as the social discount rate is only justified in the context of a two-period model where the total amount of capital available for investment is fixed independently of project choice in the public sector. In this case, the public investment displaces (or crowds out) private investment dollar for dollar, and the marginal rate of return on private investment (inclusive of taxes) provides an adequate measure of SOC. But when either assumption (two-period model or fixed amount of capital) is dropped, the argument would not hold anymore. If capital needed for financing public projects is partially satisfied by consumers postponing their current consumption, the return required by consumers usually is less than the marginal rate of return on private investment; hence, the social discount rate should be lower than SOC.

D. Weighted Average Approach

Previous discussions suggest that using SRTP to discount future costs and benefits is problematic since it does not take into account impacts of public projects on funds available for private investment. Using SOC as the social discount rate, on the other hand, assumes that public investment only displaces private investment and not private consumption, which is also not always true in reality. The weighted average approach, associated with contributions by, among others, Harberger (1972), Sandmo and Drèze (1971), and Burgess (1988), attempts to reconcile the SRTP approach with that of SOC.

Proponents of the weighted average approach recognize that sources of funds available to public projects may come from displacing private investment, inducing consumers to postpone current consumption, and, in the case of an open economy, borrowing from international capital markets. The social opportunity costs of funds from these various sources are different because of market distortions such as taxes. Thus, the social discount rate should be the weighted average of SOC, SRTP, and the cost of foreign borrowing, with weights reflecting proportions of funds obtained from their respective sources. Harberger (1972) argues that SOC may differ from one productive sector to another and SRTP could also vary among different groups of savers (reflecting, for instance, different tax brackets); therefore, SOC and SRTP themselves should be the weighted average of those of various productive sectors or saver groups. Burgess (1988) suggests that the weights depend also on the degree of complementarity or substitutability between public and private investment, but points out that the positive externalities of public investment due to its complementarity can be considered as part of benefit streams and, in that case, no adjustments to the weights are necessary.

For a closed economy, if the supply of funds is perfectly inelastic, a public sector project will displace only private investment, so the weight for SRTP will be zero and the social discount rate will be equal to SOC. If, on the other hand, the demand for funds is perfectly inelastic, a public project will only displace current consumption, the weight for SOC will be zero, and the social discount rate will be equal to SRTP. In general, it is believed that both the supply and demand of investible funds respond to changes in the market interest rate, so the social discount rate will lie somewhere between the two extremes. Harberger (1972), however, argues that the accumulated econometric evidence on investment functions clearly shows that many categories of investment are quite sensitive to changes in the interest rate, while evidence that savings are responsive to interest rate changes is only scanty. Hence, there is a reasonable presumption that the relevant weighted average will be reasonably close, if not precisely equal, to SOC.

For an open economy where capital is mobile across countries, it is expected that the domestic interest rate will be related in some way to the interest rate at which the country can borrow in the world capital market (Sandmo and Drèze 1971, Edwards 1986, Lind 1990). In the extreme case of a small open economy with perfect capital mobility, risk neutrality, pegged exchange rate (with zero expected devaluation), and an infinitely elastic supply of foreign capital, public projects will displace neither domestic consumption nor private investment. The weights for SOC and SRTP will, therefore, both be zero and the social discount rate will be equal to the international borrowing rate. However, Edwards (1986) argues that even a small economy with perfect capital mobility will face an upward-sloping supply curve of foreign capital. One justification is that a higher level of foreign indebtedness could be related to a higher probability of default as perceived by lenders, and to a higher cost at which this particular country can borrow from the international capital market. In this case, a public project that is (partially) financed with additional foreign debt will result in a higher rate charged on foreign loans, and perhaps, higher domestic interest rates as well since the two are linked. Therefore, a public project will be financed partially by an increase in foreign debt, and partially by an increase in private savings and a reduction in private investment. Then, in the presence of country risk premiums, the social discount rate will be a weighted average of SOC, SRTP, and the international borrowing rate inclusive of risk premiums.[9] In another extreme, if a country faces credit rationing from abroad, the new demand for public funds will be met fully by additional domestic private savings and displaced private investment. Then, the social discount rate will be a weighted average of only SOC and SRTP.

A key challenge in the empirical estimation of the social discount rate using the weighted average approach is to determine the weights attached to SRTP, SOC, and the international borrowing rate, as well as weights for SRTPs of various saver groups and for SOCs of various productive sectors. Harberger (1972) provides a formula for calculating the social discount rate using the weighted average approach in the case of a closed economy, where the weights are estimated from interest derivatives (the responses of private investment and savings to changes in market interest rates), which can also be expressed in terms of elasticities. Sandmo and Drèze (1971) expands the formula to an open economy context by incorporating the international borrowing rate, with weights being estimated from the interest derivatives of the domestic and foreign supplies of funds. Based on Harberger and Jenkins (2002), Box 4 provides an example using the weighted average approach to estimate the social discount rate, assuming varying SRTP among saver groups, varying SOC among productive sectors, taxation on interest earnings (including withholding tax for foreign savers) and on investment returns, and an upward-sloping supply curve of foreign capital.

A major criticism on the weighted average approach is that, while it recognizes that costs of public investment can displace private investment, it assumes that benefits will be consumed immediately and ignores the fact that they could also be reinvested in the private sector, generate future consumption, and bring more social value than if they were consumed immediately. Recognizing higher social cost of displaced private investment than displaced consumption, while ignoring the higher social value of project benefits that are reinvested than immediately consumed, leads to overdiscounting of project benefits. This overdiscounting will be higher the farther in the future

[9] Edwards (1986) argued that whether this higher interest rate should be considered as a higher cost of borrowing will depend on the relationship between the probability of default as perceived by the lenders and by borrowers. If the perceived probability of default is the same for lenders and borrowers, the higher interest rate charged to the developing country will not represent a higher economic cost of foreign funds. But in general, the perceived probability of default is different between lenders and borrowers (the former is mostly greater than the latter); the risk premium does constitute economic cost for a borrowing country.

the benefits occur. Therefore, compared to SRTP, the weighted average approach could be biased against long-term projects (Zerbe and Dively 1994).

Box 4
Estimating the Social Discount Rate Using the Weighted Average Approach

According to the weighted average approach, also known as Harberger approach, the social discount rate can be expressed as

$$\delta = \alpha SOC + (1 - \alpha - \beta) i_f + \beta SRTP \quad (1)$$

where δ denotes the social discount rate, i_f is the government's real long-term foreign borrowing rate, α is the proportion of funds for public investment obtained at the expense of private investment, β is the proportion of funds obtained at the expense of current consumption, and $(1 - \alpha - \beta)$ is the proportion of funds from foreign borrowing. SRTP and SOC are measured, respectively, by the rate of real return on savings exclusive of (i_i) and investments inclusive of (r_j). Expressing the weights attached to different funding sources in terms of elasticities of demand and supply of funds with respect to changes in interest rates, equation (1) becomes:

$$\delta = \frac{\sum_i \varepsilon_i \left(S_i / S_t\right) i_i + \varepsilon_f \left(S_f / S_t\right) i_f - \sum_j \varepsilon_j \left(I_j / I_t\right) r_j}{\sum_i \varepsilon_i \left(S_i / S_t\right) + \varepsilon_f \left(S_f / S_t\right) - \sum_j \varepsilon_j \left(I_j / I_t\right)} \quad (2)$$

where $\varepsilon_i, \varepsilon_f, \varepsilon_j$ are respectively elasticities of savings, supply of foreign capital, and private investment with respect to the interest rate. *S_i/S_t and S_f/S_t are the shares to the total savings by various groups of domestic savers and foreign savers.* I_j/I_t is the investment share of various business sectors.

Using Equation (2) and 1988–1989 data for Papua New Guinea, Harberger and Jenkins (2002) present an example of calculating the social discount rate, which they call economic opportunity cost of capital. The example assumes that there are four savers groups: households, business, government, and foreign. For each saver group, the real rate of return on savings was calculated from the nominal market interest rate by taking out the respective taxes and inflation. In estimating the real marginal cost of foreign borrowing, further adjustment was made by taking into consideration the effects of new borrowing on the country's foreign borrowing rate. In the case of investors or demanders of funds, they were classified into the following sectors: housing, agriculture, manufacturing, government, and mining. The nominal pre-tax rate of return on investment for each sector was again calculated from the normal market interest rate by adding respective tax rates.

These rates, together with the estimated saving shares and elasticities of various saver and investor groups, yield an estimated economic cost of capital, or the social discount rate, of 11.76 percent. Detailed calculations are in the Appendix.

Source: Harberger and Jenkins (2002).

E. Shadow Price of Capital Approach

The shadow price of capital (SPC) approach, associated with contributions by Feldstein (1972), Bradford (1975), and Lind (1982) among others, also attempts to reconcile the SRTP approach with that of SOC and, at the same time, addresses the limitation of the weighted average approach. The

SPC approach recognizes that while costs of a public project can displace private investment, its benefits can also be reinvested in the private sector. In terms of generated future consumption streams, these benefits are worth more to society than if they are consumed immediately. Thus, the total cost of a public project is the sum of the current consumption that is directly displaced and those future consumption streams that are foregone due to the displacement of private investment. Similarly, the total benefit of a public project is the sum of those immediately consumed and those future consumption streams generated from reinvestment.

The SPC approach involves four steps. The first is estimating SPC, which is the present value of streams of future consumption foregone arising from displacing one unit of private investment or the present value of future consumption streams generated from reinvesting one unit of project benefits in the private sector. The second step involves, for each time period, converting all the costs and benefits that either displace or generate private investment into consumption equivalents by multiplying them by SPC. The third step is adding these costs and benefits to the other portions of costs (in the form of directly displaced consumption) and of benefits (in the form of immediate consumption), respectively. Finally, discount the total cost and benefit streams at SRTP to calculate the net present value (NPV) (see Box 5).

Zerbe and Dively (1994) discussed a number of situations where costs and benefits need not be adjusted by SPC:

(i) For a closed economy, if the fraction of benefits that return to private capital is equal to the fraction of costs that displace private investment, adjusting the costs and benefits by SPC does not change the sign of the NPV of a project. In this case, a project is socially desirable if the NPV is positive when applying SRTP as a discount rate to the ordinary costs and benefits. This is likely the case for many environmental projects where benefits are costs avoided whose financing is similar to initial costs.

(ii) For an open economy, if the supply of capital is highly or perfectly elastic, the displaced and generated private investment will be small and be similar in size, or both, will be zero, and it is then sufficient to discount benefits and costs by the international borrowing rate without adjusting them by SPC.

(iii) For least-cost analysis (also referred to as cost-effectiveness analysis), the goal is to compare the costs of alternative methods of producing the same output. As long as the financing of the various alternatives is similar, adjustment by SPC is not warranted.

When project costs and benefits need to be adjusted by SPC, empirical estimation of SPC is warranted, which requires information on the following parameters: SOC, SRTP, depreciation rate, and marginal propensity to save. Lyon (1990) provides two alternative formulas to calculate SPC. One applies when the savings rate is expressed in terms of the gross return, and the other applies when the savings rate is expressed in terms of the return net of depreciation. Box 5 provides these formulas. The application of the SPC approach requires further information on proportions of displaced consumption and private investment due to project costs, and proportions of generated consumption and reinvestment due to project benefits.

The SPC approach, although theoretically attractive (see Feldstein 1972, Bradford 1975, Lind 1982) is difficult to implement. The value of SPC is very sensitive to the values of SRTP and SOC, to how depreciation and reinvestment are assumed, and to the length of life of a project. Lyon (1990) shows that the value of SPC could vary from about one to infinity, depending on different

assumptions on the values of the various parameters. Harberger and Jenkins (2002) argue that if the SPC approach is employed, a different shadow price of capital has to be estimated for every project according to the length of life of the project. This could be very confusing for policymakers in the government decision-making process, many of whom are noneconomists.

Box 5
The Shadow Price of Capital Approach

Consider a project with a lifespan of n years, benefit streams, B_t, and cost streams, C_t. The net present value of the project will be

$$\text{NPV} = \sum_{t=0}^{n} \frac{B_t^* - C_t^*}{(1+i)^t} = \sum_{t=0}^{n} \frac{B_t\left[\phi_b V + (1-\phi_b)\right] - C_t\left[\phi_c V + (1-\phi_c)\right]}{(1+i)^t} \quad (1)$$

where B_t^* is the consumption equivalents of benefits at time t; C_t^* is the consumption equivalents of costs at time t; ϕ_b is the fraction of benefits that return to the private sector for investment; ϕ_c is the fraction of costs that displace private investment; i is SRTP; and V is SPC. Lyon (1990) provides two alternative formulas to calculate V:

$$V = \frac{r - sr}{i + d - sr} \quad (2)$$

where r is the gross rate of return on private investment prior to depreciation, d is the depreciation rate, and s is the rate of savings from the gross return; and

$$V = \frac{\lambda - \sigma\lambda}{i - \sigma\lambda} \quad (3)$$

where λ is the rate of return from private investment net of depreciation, and σ is the rate of saving from the net return.

Source: Zerbe and Dively (1994).

F. Discounting Intergenerational Projects

From the mid-1990s, with the growing concerns over climate changes, global warming, and other environmental problems, there has been a renewed interest on whether and how discounting should be applied to long-term projects, the effects of which spread over more than one generation (more than 30–40 years) or even hundreds of years, and whose present values are extremely sensitive to the choice of the discount rate. In evaluating intragenerational projects, it could be argued that the main issue is to achieve efficient allocation of scarce resources, thus the discount rate should reflect the economic opportunity cost of capital. When evaluating intergenerational projects, identifying an appropriate discount rate involves an additional challenge of considering intergenerational equity.

What is common to the four approaches described above is that the discount rate, whatever it is, is time-invariant, implying that discounting would be exponential. With a constant discount rate, benefits and costs that occur in the distant future will become very small in terms of their

present value. Thus, it seems not worth investing even a little to avoid potential catastrophic consequences of some environment problems if they will occur only far into the future. Since beneficiaries of projects dealing with such type of problems will be future generations, attaching very small weights to future benefits implied by exponential discounting does pose a question of whether it is "ethically indefensible." Put simply: why should the well-being derived from the same level of consumption of any future generation be given less weight than for the current generation on the grounds of individuals being impatient? Many believe that this is not ethical, and the pure rate of time preference should be zero. Others argue that weighting generations equally leads to paradoxical and even nonsensical results (see Box 1). Apart from the ethical issue, exponential discounting implies that the importance of a cataclysmic event happening four centuries from now is much less significant relative to that of a cataclysmic event occurring, say, three centuries from now. Weitzman (1998) argues that "almost no one really feels this way about the distant future."

Some have proposed a solution to the problem, which involves using a declining discount rate, namely, "hyperbolic discounting" (Weitzman 1994, 1998, 2001; Henderson and Langford 1998; Cropper and Laibson 1998). Hyperbolic discounting hypothesizes that the discount function with regard to time is shaped like a hyperbola, thus allowing the discount rate to decline with time according to some predetermined trajectory and raising the weight attached to the welfare of future generations. According to Weitzman (1998), "near future" and "far future" should be viewed differently because of different levels of uncertainties involved. Compared to the near future, the far distant future has much greater uncertainties about economic growth, rate of capital accumulation, state of the environment, pace of technological progress, rate of pure time preference, etc. As a result, there is a wide range of possible discount rates for the far future, and a "certainty equivalent discount rate" should be calculated as a weighted average of these possible discount rates. He shows that the "certainty equivalent discount rate" equals the lowest possible discount rate.[10] This way he explains why different discount rates should be used for near future projects and far distant future ones. Over the past decades, there has also been increasing evidence from experiments conducted by economists and psychologists, which suggests that people do use a declining discount rate in making intertemporal choices (Weitzman 2001).

A conceptual problem with time-declining discounting is that it leads to time-inconsistent planning: a person who applies a hyperbolic discount rate will not carry out the consumption plans made today and reverse the decisions in the future even though no new information emerges (Cropper and Laibson 1998). Due to this type of problem, some have suggested that intergenerational equity should be treated directly rather than through adjusting the discount rate (Lesser and Zerbe 1995, Schelling 1995). More specifically, some argue that in the context of global warming mitigation, one should not simply lower the discount rate used to evaluate costs and benefits of projects; in cases where there may be significant irreversibility and potential questions of intergenerational equity, one should not rely on the project discount rate alone. Instead, a full analysis of all these concerns and options should be carried out separately and explicitly for informed choice and decision-making (Lind 1997, Nordhaus 1999, Kopp and Portney 1999, and Toman 1999). Henderson and Bateman (1995) suggest that discount rate sensitivity analysis may include hyperbolic discount rate results

[10] This is best illustrated through an example (Spackman 2004). Suppose in the long term that the discount rate is believed to be either 2% or 4%, with equal likelihood. The project benefits are worth $1 million in 500 years. The present value of the $1 million in 500 years would be $50 using 2% discount rate, and almost $0 using 4% discount rate. Since two discount rates have an equal likelihood to occur, the expected present value of the project is about $25, the average of $50 and $0. This gives an "effective discount rate" of 2.1%, close to the lower end of two possibilities.

along with classical constant discount rate results for intergenerational projects. There is also a suggestion that the dilemma in the choice of the social discount rate for intergenerational projects could be resolved by realizing that the problem is one of concern over missing values to ignoring ethical values. This deficiency could be overcome by incorporating moral values directly into the cost–benefit analysis and, inter alia, recognizing all values for which there is a willingness to pay (Zerbe 2005).

Despite the debates, there appears a general agreement that the SRTP should be used in discounting intergenerational projects. The Stern Review applies an SRTP of 1.4% to discount damages of global warming, estimated using the Ramsey formula. It is the sum of two numbers: 0.1%, which is the rate of pure time preference reflecting solely the assumed risk of human race extinction,[11] and 1.3%, which is the product of a unity elasticity of marginal utility of consumption and an expected annual growth rate of per capita real consumption reflecting the diminishing marginal utility of consumption. Nordhaus (2006), in his critique of the Stern Review, argues that the near-zero rate of pure time preference combined with the unity elasticity of the marginal utility of consumption is inconsistent with key economic variables observable in the real world such as the real interest rate and saving rate. To match the observed values of these variables, either a higher rate of pure time preference or higher elasticity of marginal utility of consumption has to be assumed, implying a much higher social discount. Using the Dynamic Integrated Model of Climate and the Economy (DICE), he shows that if the rate of pure time preference is raised from 0.1% (as assumed by the Stern Review) to 3% at the beginning, then declining slowly to about 1% in 300 years (matching key economic variables observable in the real world), the optimal base year (2005) carbon price would decrease from $159 to $17–20 per ton.[12] He concluded that the radical revision of the economics of climate change proposed by the Stern Review depends decisively on the assumption of a near-zero rate of social time preference.

III. THE SOCIAL DISCOUNT RATE IN PRACTICE AROUND THE WORLD

Since there is no consensus as to which approach is the most appropriate for the choice of a social discount rate, it is not surprising that there are significant variations in public discount rate policies in different countries around the world. This section provides a survey of the social discount rate policies in practice used by countries around the world and by multilateral development banks.

A. Countries around the World

A survey of social discount rate policies of individual countries around the world show significant variations. Even within a country, different government agencies may have their own policy. Table 4 summarizes the discount approaches and rates adopted in selected countries.

[11] The Stern Review therefore disregards the "impatience" related argument for discounting.

[12] Developed by William D. Nordhaus, the DICE model is one of the economic models widely used to estimate costs and benefits of different paths for slowing climate change and for analyzing the impact of control strategies over time (Nordhaus 1994). The optimal carbon price, or carbon tax, sometimes also called the "social cost of carbon", is the calculated price of carbon emissions that will balance the incremental costs of reducing carbon emissions with the incremental benefits of reducing climate damages.

Table 4
Social Discount Rates in Selected Countries

Country/ agency	Discount rate	Theoretical basis
Australia	1991: 8%; current: SOC rate annually reviewed	SOC approach
Canada	10%	SOC approach
People's Republic of China	8% for short and medium term projects; lower than 8% rate for long-term projects	Weighted average approach
France	Real discount rate set since 1960; set at 8% in 1985 and 4% in 2005	1985: To keep a balance between public and private sector investment 2005: SRTP approach
Germany	1999: 4% 2004: 3%	Based on federal refinancing rate, which over the late 1990s was 6% nominal; average GDP deflator (2%) was subtracted giving 4% real
India	12%	SOC approach
Italy	5%	SRTP approach
New Zealand (Treasury)	10% as a standard rate whenever there is no other agreed sector discount rate	SOC approach
Norway	1978: 7% 1998: 3.5%	Government borrowing rate in real terms
Pakistan	12%	SOC approach
Philippines	15%	SOC approach
Spain	6% for transport; 4% for water	SRTP approach
United Kingdom	1967: 8% 1969: 10% 1978: 5% 1989: 6% 2003: 3.5% Different rates lower than 3.5% for long-term projects over 30 years	SOC approach until early 1980s; thereafter SRTP approach

continued.

Table 4. continued.

US (Office of Management and Budget)	Before 1992: 10%; after 1992: 7%	Mainly SOC approach with the rate being derived from pretax return to private sector investment Other approaches (SPC, Treasury borrowing rates) are also mentioned
US (Congressional Budget Office and General Accounting Office)	Rate of marketable Treasury debt with maturity comparable to project span	SRTP approach
US (Environmental Protection Agency)	Intragenerational discounting: 2–3% subject to sensitivity analysis in the range of 2–3% and at 7%, as well as presentation of undiscounted cost and benefit streams Intergenerational discounting: presentation of undiscounted cost and benefit streams subject to sensitivity analysis in the range of 0.5–3% and at 7%	SRTP approach

Sources: Compiled by ADB staff.

In North America, Canada uses a rate of 10% based on the SOC approach, while in the US, the situation is more complicated. The US Office of Management and Budget (OMB) uses a discount rate that approximates the marginal pretax rate of return on private investment, thus following the SOC approach. In the 1970s and 1980s, it was specified at 10 percent. In 1992, OMB revised the discount rate to 7% (OMB 2003). The OMB also takes the view that the SPC discounting is "the analytically preferred means of capturing the effects of government projects on resource allocation in the private sector." In its Circular A-94, OMB indicates that the Treasury borrowing rates should be used as the discount rate in cost-effectiveness analysis, lease-purchase analysis, internal government investments, and asset sale analysis.

The US Congressional Budget Office and the General Accounting Office (1991) favor the use of discount rates based on government bond rates (Lyon 1990, Hartman 1990). They use the interest rate for marketable Treasury debt with maturity comparable to the program being evaluated as a base case discount rate for cost benefit analysis, thus favoring the SRTP approach.

The US Environmental Protection Agency supports using the SRTP approach in evaluating environmental projects (EPA 2000). It recommends that for intragenerational discounting, a rate of 2–3% be used, which is reckoned to be the market interest rate after tax. The EPA further recommends undertaking sensitivity analysis of alternative discount rates in the range of 2–3% as well as at 7% (prescribed by OMB), as this may provide useful information to decisionmakers. In addition, all analyses are required to present undiscounted benefit and cost streams. For intergenerational

projects or policies with intergenerational effects, the EPA prescribes that economic analyses should generally include a "no discounting" scenario by displaying undiscounted cost and benefit streams over time. The economic analysis should also present a sensitivity analysis of alternative discount rates, including discounting at 2–3% and 7% as in the intragenerational case, as well as scenarios using rates in the range of 0.5–3% as prescribed by optimal growth models. The discussion of the sensitivity analysis is required to include appropriate caveats regarding the state of the literature with respect to discounting for very long time horizons.

In Europe, there is now a near convergence among official social discount rates (Evans 2006). Germany uses 3%, based on values of real long-term government bond rate. Norway has been using a 3.5% discount rate after 1998—also based on real government borrowing rate. France's Commissariat General du Plan in 2005 lowered its project discount rate to 4% based on the SRTP approach. Italy uses the SRTP approach to derive a 5% discount rate, while Spain adopts 4–6% for different sectors.

The UK government indicates in the *Green Book, Appraisal and Evaluation in Central Government* (HM Treasury 2003) that an SRTP of 3.5% should be used to discount future benefits and costs of public projects with a lifespan below 30 years. This figure is calculated on the basis of the estimates of the following three parameters: (i) the rate of pure time preference at 1.5%; (ii) the elasticity of the marginal utility of consumption at around 1; and (iii) the output growth per capita over the period 1950–1998 in the UK at 2.1 percent. For projects with very long-term impacts (over 30 years), the discount rate will depend on the length of their lifespan: 3.0% for projects with a lifespan of 31–75 years; 2.5% with 76–125 years; 2.0% with 126–200 years; 1.5% with 201–300 years; and 1.0% with 301 years and beyond.

In Asia, the social discount rates adopted are generally higher. The Philippines and Pakistan use 15% and 12%, respectively, both based on the SOC approach. India currently uses 12 percent. In the PRC, according to National Development and Reform Commission and Ministry of Construction (2006), the economic cost of capital is a weighted average of social time preference and returns on capital. The former is estimated to be around 4.5–6% and the latter around 9–11 percent. The suggested social discount rate is 8% for short- and medium-term projects. The document also recommends that a lower than 8% discount rate be adopted for projects with a long time horizon. In Australia, the mandated discount rate was 8% before 1991 and, since then, there has been no prescribed benchmark social discount rate on the basis that the appropriate discount rate may vary from one year to another, and should be under continuous review. The New Zealand Treasury has a long-standing discount rate of 10%, which was reaffirmed in its *2005 Cost Benefit Analysis* primer (Rose 2006).

B. MDBs and other Supra-National Agencies

The World Bank's *Handbook on Economic Analysis of Investment Operations* provides guidance on how to calculate the social discount rate (Belli et al. 1998). The handbook states that the discount rate used should reflect not only the likely returns of funds in their best relevant alternative use (i.e., the opportunity cost of capital or "investment rate of interest"), but also the marginal rate at which savers are willing to save in the country (i.e., the rate at which the value of consumption falls over time, or "consumption rate of interest"). Therefore, the World Bank prescribes the weighted

average approach. The World Bank traditionally has not calculated a discount rate but has used 10–12% as a notional figure for cost–benefit analysis. The handbook further advises that task managers may use a different discount rate as long as departures from the 10–12% rate have been justified in the Country Assistance Strategy.

ADB's policy on the social discount rate, specified in its *Guidelines for the Economic Analysis of Projects* (ADB 1997), follows the World Bank approach. Although the *Guidelines* state that "economic rates of return differ considerably between sectors and countries", and "from time to time, an appropriate discount rate for economic analysis should be calculated for each country to compare with the existing practice", in practice, a single minimum rate of 10–12% has been used to calculate the net present value of a project, or to compare with the internal rate of return, for economic analysis for all countries and all projects all the time. ADB would expect to

(i) accept all independent projects and subprojects with an EIRR of at least 12%;

(ii) accept independent projects and subprojects with an EIRR between 10 and 12% for which additional unvalued benefits can be demonstrated, and where they are expected to exceed unvalued costs;

(iii) reject independent projects and subprojects with an EIRR between 10 and 12% for which no additional unvalued benefits can be demonstrated, or where unvalued costs are expected to be significant; and

(iv) reject independent projects and subprojects with an EIRR below 10 percent.

Other MDBs have chosen a social discount rate more or less in the range similar to those of the World Bank and ADB. In the case of the Inter-American Development Bank, a 12% discount rate is being used as a measure of the economic opportunity cost of capital while the European Bank for Reconstruction and Development uses 10 percent. The African Development Bank, based on a review of various project appraisal reports, also uses a project discount rate ranging from 10 to 12 percent.

Among supranational governmental agencies, the European Commission advocates a benchmark discount rate of 5% in real terms for cost–benefit analysis in the case of member countries of the European Union. This is a compromise figure based on market interest rate, cost of capital, and time preference considerations. However, the European Commission encourages member states to provide their own benchmark for the project discount rate, which must then be applied consistently to all projects (see Evans 2006 and European Commission 2006).

In sum, there are significant variations in the social discount rate policy around the world. Most MDBs apply a rate of 10–12%, following the weighted average approach. Among individual countries, most developed countries follow the SRTP approach and apply much lower discount rates, mostly in the range of 3–7%, with many revising the rates downward in recent years. On the other hand, the three Asian developing countries surveyed (India, Pakistan, and Philippines) follow the SOC approach, and apply a much higher rate, in the range of 12–15%, and the PRC uses 8 percent. As shown in Table 4, these differences in the social discount rate policies in practice are due to different analytical approaches followed. The various approaches reflect differing views on how public investment affects domestic consumption, private investment, and cost of international borrowing. At a deeper level, however, the divergence reflects the differences in the perceived marginal social opportunity cost of public funds, and in the extent to which the issue of intergenerational equity

is taken into consideration in setting the social discount rate. Public funds, in general, have a higher marginal social opportunity cost in developing countries than in developed countries for a number of reasons, such as more scarcity of capital, poorer financial intermediation, greater market distortions, and greater impediments in accessing international capital markets. Intergenerational equity is a newer issue in the public domain of developing countries than that of developed countries. Therefore, it is not surprising to see that developing countries generally use a higher social discount rate than developed countries.

IV. CONCLUDING REMARKS

The choice of the social discount rate plays a critical role in cost–benefit analysis and project evaluation, and has been a subject of intense debate for the last several decades. In a perfectly competitive world without market distortions, the market interest rate is the appropriate social discount rate. In the real world where markets are distorted, there are four alternative approaches in the choice of the social discount rate: SRTP, SOC, weighted average of SRTP and SOC, and SPC. Economists have not reached a consensus as to which is the most appropriate.

The difference among the four approaches reflects largely the different views on how public projects affect the domestic economy: whether public investment displaces current consumption, or private investment, or both, and whether benefits of projects are consumed immediately, or reinvested to generate more future consumption (see Table 5 for a summary). In cases of very long-term projects, an additional consideration is intergenerational equity, where the debate has centered on whether or not one should assume a positive pure time preference on the grounds that individuals are "impatient", and whether a declining discount rate should be used to avoid problems associated with exponential discounting as implied by a constant discount rate. The recent controversy over the Stern Review focuses largely on what discount rate should be used in cost–benefit analysis of policies to control global warming, which impacts on future generations.

There are significant variations in public discount rate policies in practice around the world, with developed countries applying lower rates (3–7%) than the developing countries surveyed (8–15%). These variations largely reflect different theoretical approaches to the choice of the discount rate followed by various countries. At a deeper level, however, the divergence also reflects differences in the perceived marginal social opportunity cost of public funds that the social discount rate tries to measure in order to ensure efficient allocation of resources, and differences in the extent to which the issue of intergenerational equity is considered.

What conclusion can we draw from this survey? First, there is no one-size-fits-all solution to the choice of the social discount rate. Countries differ in economic structure, capital scarcity, stage of financial development, efficiency of financial intermediation, impediments faced in accessing the international capital market, and social time preference. All these factors together determine a country's social opportunity cost of capital, and should be taken into consideration in the choice of the social discount rate. Second, there is need for each country to regularly review the appropriateness of its social discount rate policy in light of changing domestic economic circumstances and international capital market conditions, and to adjust the social discount rate as necessary. Third, there is a strong case for considering the equity issue in discounting benefits and costs of intergenerational projects (e.g., those designed to address climate changes and other environmental problems) in addition to the economic efficiency issue, as opposed to intragenerational projects where efficiency should be the primary concern. Finally, for MDBs that provide development assistance to developing

countries through capital investment, there could be a case for reviewing their decades-old practice of applying a uniform discount rate of 10–12% to all projects to see whether this practice is still appropriate in a changing world.

Table 5
Alternative Approaches to the Choice of the Social Discount Rate

Approach	Implied Assumption	Who Uses It	Method of Empirical Estimation	Major Criticism
Social Rate of Time Preference (SRTP)	Time-invariant Public projects only displace current consumption	Mostly developed countries	Apply "Ramsey formula" with the following parameters: (i) utility discount rate, (ii) elasticity of marginal utility of consumption, and (iii) growth rate of real per capita consumption Approximated by after-tax rate of return on government bonds	Ignores the fact that public investment could displace private investment Choice of utility discount rate involves normative value judgment, and estimation of the elasticity of marginal utility of consumption is sensitive to data and methodology
	Time-declining Public projects only displace current consumption, and discount rate declines over time as uncertainty increases. There is need to consider intergenerational equity.	Mostly academic and policy researchers	Typically estimated through experiments	Leads to time-inconsistent planning
Social Opportunity Cost of Capital (SOC)	Public projects only displace current private investment	Mostly developing countries	Approximated by pretax rate of return on riskless private investments, such as top-rated corporate bonds	Ignores the fact that public investment also displaces current consumption

continued.

TABLE 5. CONTINUED.

Approach	Implied Assumption	Who Uses It	Method of Empirical Estimation	Major Criticism
Weighted Average	Closed economy or open economy with foreign capital rationing Public projects displace current consumption and private investment	Mostly MDBs	Weighted average of SRTP and SOC	Ignores the possibility that project benefits could be reinvested Determining the weights attached to SRTP, SOC, and international borrowing rate could be difficult
	Open economy with upward sloping supply curve of foreign capital Public projects funded by displaced current domestic consumption, displaced domestic private investment, and foreign borrowings		Weighted average of SRTP, SOC, and foreign borrowing rate	
	Open economy with perfectly elastic supply of foreign capital Displacement of domestic consumption and investments would be small or negligible; the weighted average approach uses a discount rate equal to foreign borrowing rate		International borrowing rate	
Shadow Price of Capital	Appropriate when public investments displace current consumption and investment and generate not only future consumption, but also future investment		Converts all costs and benefits into consumption equivalents using the SPC. Discount total cost and benefit flows with SRTP to calculate NPV When the effects of displacement and generation of investments are the same, the SPC approach is equivalent to using SRTP as the discount rate	Although considered as theoretically the most attractive approach, practical application could be difficult

APPENDIX
ESTIMATING THE SOCIAL DISCOUNT RATE USING THE WEIGHTED AVERAGE APPROACH[13]

According to the weighted average approach, also known as Harberger approach, the social discount rate can be expressed as

$$\delta = \alpha SOC + (1 - \alpha - \beta) i_f + \beta SRTP \quad (1)$$

where δ denotes the social discount rate, i_f is the government's real long-term foreign borrowing rate, α is the proportion of funds for public investment obtained at the expense of private investment, β is the proportion of funds obtained at the expense of current consumption, and $(1 - \alpha - \beta)$ is the proportion of funds from foreign borrowing. SRTP and SOC are measured, respectively, by the rate of real return on savings exclusive of (i_i) and investments inclusive of (r_j). Expressing the weights attached to different funding sources in terms of elasticities of demand and supply of funds with respect to changes in interest rates, equation (1) becomes:

$$\delta = \frac{\sum_i \varepsilon_i (S_i/S_t) i_i + \varepsilon_f (S_f/S_t) i_f - \sum_j \varepsilon_j (I_j/I_t) r_j}{\sum_i \varepsilon_i (S_i/S_t) + \varepsilon_f (S_f/S_t) - \sum_j \varepsilon_j (I_j/I_t)} \quad (2)$$

where ε_i, ε_f, ε_j are respectively elasticities of savings, supply of foreign capital, and private investment with respect to the interest rate. S_i/S_t and S_f/S_t are the shares to the total savings by various groups of domestic savers and foreign savers. I_j/I_t is the investment share of various business sectors.

Using Equation (2) and 1988–1989 data for Papua New Guinea, Harberger and Jenkins (2002) present an example of calculating the social discount rate, which they call economic opportunity cost of capital. The example assumes that there are four savers groups: households, business, government, and foreign. The assumptions and results of calculations are given in Appendix Table 1 below:

Appendix Table 1
Savers

Assumptions	Households	Business	Government	Foreign
Share (S_i/S_t)	33.70%	44.90%	7.80%	13.60%
Elasticity (ε_s, ε_f)	0.5	0.5	0	2
Nominal market interest rate (i_m)	14.50%	14.50%	14.50%	
Nominal cost of foreign borrowing (i_f)				18.00%
Tax rate (t_i, t_w)	9.30%	30.00%	0%	17.00%
Rate of inflation (g)	5.00%	5.00%	5.00%	5.00%
Real return on savings(i_i)	7.76%	4.90%	9.05%	
Real marginal cost of foreign borrowing				12.31%

[13] This Appendix draws from Harberger and Jenkins (2002).

The real return on savings for each domestic saver group is calculated by removing the respective tax rates from the nominal market interest rate and then removing inflation:

$$\text{Real return on savings } (i_i) = [i_m * (1 - t_i) - g] / (1 + g).$$

For the foreign savers group, the same procedure is applied as for domestic savers, but with a further adjustment to reflect the effect of additional foreign borrowing on the country's overall borrowing costs. The adjustment involves the elasticity of supply of foreign funds (ε_f) as well as the rate of change in the foreign borrowing cost as the country becomes more indebted—which is assumed to be 0.6 by Harberger and Jenkins.

$$\text{Real marginal cost of foreign borrowing } (i_f) = \{[i_f * (1 - t_w) - g] / (1 + g)\} * [1 + 0.6 * (1 / \varepsilon_f)]$$

The example further assumes that there are five groups of investors or demanders of funds: housing, agriculture, manufacturing, government, and mining. See Appendix Table 2 for the assumptions and calculations.

APPENDIX TABLE 2
INVESTORS OR DEMANDERS OF FUNDS

	HOUSING	AGRICULTURE	MANUFACTURING	GOVERNMENT[1]	MINING
Share (I_j/I_t)	14.40%	17.70%	65.80%	0%	2.10%
Elasticity (ε_j)	–1	–1	–1	0	–1
Nominal Market Interest Rate (i_m)	14.50%	14.50%	14.50%	0%	14.50%
Tax rate (t_i)	15.00%	0.00%	30.00%	0%	35.00%
Rate of inflation	5.00%	5.00%	5.00%	0%	5.00%
Real return on investment (r_j)	11.43%	9.05%	14.95%	0%	16.48%

[1]No data was available on the government's share of investment in Papua New Guinea.

The real return on investment is calculated by adjusting the nominal pretax rate of return on investment for each sector (i.e., the nominal market interest rate) with tax rates and then taking out inflation, using the following formula:

$$\text{Real return on investment } (r_j) = [i_m * (1 - t_j) - g] / (1 + g)$$

Following equation (2), the social discount rate, which is the economic cost of capital, for Papua New Guinea is estimated at:

$$\delta = \frac{\sum_i \varepsilon_i (S_i/S_t) i_i + \varepsilon_f (S_f/S_t) i_f - \sum_j \varepsilon_j (I_j/I_t) r_j}{\sum_i \varepsilon_i (S_i/S_t) + \varepsilon_f (S_f/S_t) - \sum_j \varepsilon_j (I_j/I_t)} = 11.76\%$$

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