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The Choice of Discount Rate Applicable to Government Resource Use

Theory and Limitations

James P. Quirk, Katsuaki L. Terasawa

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This report presents a review of theories of the social discount rate, identifying the sources of divergent views and limitations of the theories in actual application. The question of the optimal discount rate to use in evaluating government projects has been debated in the economic literature since the late 1950s. The authors suggest that the discount rate be used as a filter rather than a device to achieve the desired level of government spending. Adopting this approach implies the choice of a discount rate that is in principle computable from existing data, with government budget limits acting as an effective constraint on government investment spending. Risk, flexibility, and data manipulability are considered. The approach is based purely on efficiency grounds and thus does not require information on the social rate of time preference. It does not address important equity issues, which the authors believe can be better resolved outside the framework of cost-benefit analysis. Keywords: to front

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The Choice of Discount Rate Applicable to Government Resource Use

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James P. Quirk, Katsuaki L. Terasawa

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Director, Program Analysis and Evaluation

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PREFACE

This report reviews theories of the social discount rate, identifying the sources of divergent views and the limitations of these theories when actual applications are concerned.

In 1972, the Office of Management and Budget directed most federal agencies to apply a 10 percent real rate of discount when calculating the present value of the costs and benefits of federal projects (OMB Circular A-94). Since that time, much progress has been made in the theoretical foundations of cost-benefit analysis, and some earlier misconceptions have been clarified. Some confusion still exists, however, as to how best to apply in practical terms this improved understanding of the conceptual issues.

The recommendations of this study are based principally on an efficiency argument, although the authors recognize the importance of equity issues in government resource usage. This emphasis on efficiency does not suggest in any way that one may ignore the intra/intergenerational distribution issues. Instead, the authors argue that these issues require more explicit consideration in a policy debate rather than being hidden in a particular choice of discount rate. Moreover, different policy instruments may be much more effective than discount rate adjustment in dealing with the equity issues. The study emphasizes the aspect of discount rate as a filter to choose "correct" government projects, rather than as an instrument to select the level of government spending. In this context, the approach suggested in the study does not apply to regulatory actions that involve private sector compliance costs but are not constrained to any significant extent by the government agency's budget.

This project was conducted in the International Economic Policy Program of RAND's National Defense Research Institute, an OSD-sponsored Federally Funded Research and Development Center. The study was sponsored by the Director, Program Analysis and Evaluation, Office of the Secretary of Defense.

EXECUTIVE SUMMARY

PURPOSE

This study reviews the existing theories of the social discount rate, and identifies the sources of divergent views and the limitations of these theories in actual application. Procedures that would help improve the possible revision of OMB Circular A-94 are recommended.

CONCLUSIONS

- If the government discount rate is used to determine the level of government investment spending that will maximize intergenerational social welfare, the approach taken by the "second-best" theorists is indisputable. However, it is a formidable task to implement such an approach because of problems associated with identifying the value of the social rate of time preference.
  - — Use of the consumer rate of interest as the social rate of time preference can be justified only in very special circumstances; the ethical issues involved in choice of a social rate of time preference are not easily resolved.
  - — There seems to be a consensus that there can be a multiplicity of social discount rates depending on the nature of the finances, risks, and the degree of spillover effects of a given project.
  - — The "opportunity cost" school approach can be derived as a special case of a more general "second-best approach."
  - — The "shadow price approach," as generalized by Bradford and refined by Lind, is formally equivalent to the second-best approach. Although it uses a uniform discount rate (social rate of time preference), the approach adjusts the special features of individual cases by the choice of multipliers to compute consumption-equivalent costs and benefits.
- On the other hand, if the discount rate is used to *filter government projects, rather than to determine the level of government investment expenditure needed to reach some societal optimum,* then the existing theories do *not* adequately address the problem. This is the case of a "third-best" situation, and the discount rate needed is what we call the government opportunity cost rate (g). The government opportunity cost rate equals the social discount

rate (d) if available government funding is equal to the optimum. However, if government funding differs from the second-best optimum, the government opportunity cost rate differs from d, and equals the highest rate of return that can be earned from the portfolio of unfunded government projects. The third-best approach does not apply to regulatory actions which involve private sector compliance costs but are not constrained to any significant extent by the government agency's budget.

- The third-best approach is based purely on efficiency grounds, and hence does not require information regarding the social rate of time preference. Neither, however, does it address equity issues. We believe these issues can better be addressed outside the framework of cost-benefit analysis.
- Issues of data bias, and potential manipulation of estimates due to the third-best approach are important problems so far as implementation is concerned, and they must be more carefully examined before we embark on this path. In particular, it is a matter of first priority to reform the process of generating cost-benefit estimates so that reliable unbiased estimates will be available to decisionmakers.
- Given reliable, unbiased cost-benefit estimates, a data base *should be established, giving a merit ranking* of proposed government projects (ranking by cost-benefit ratios) to provide information on tradeoffs and on differential funding standards among different government agencies. This data base is needed to implement a third-best approach to project decisionmaking, but the data are of value even if some other approach is adopted.

BACKGROUND

In 1972, the Office of Management and Budget (OMB) directed most federal agencies to apply a 10 percent real rate of discount when calculating the present value of the costs and benefits of federal projects (OMB Circular A-94). Since this directive, there has been much progress in understanding the theoretical foundations of cost-benefit analysis and the implications of discounting. Some earlier misconceptions have been clarified, and modifications of the use of cost-benefit analysis have been suggested. One argument suggests that perhaps different rates are appropriate for each project and policy, and the appropriate social discount rate (d) may even lie outside of the band between the pre-tax rate of return on private capital (r), and the consumption rate of interest (i), or the social rate of time preference (μ).

Although the conceptual issues underlying the choice of the appropriate social discount rate(s) might be better understood now than before, the problems facing policy analysts today are possibly more complex than in the past. There still exists confusion as how best to apply the improved understanding of the conceptual issues to practical usage.

FINDINGS

Government Discount Rate in a First-Best World

In a perfectly competitive economy operating without any distortions and without any distributional (equity) problems, the correct choice of a government rate of discount (g) should be the rate of discount used by consumers and firms: the market rate of interest, i.e., $g = i = r$.

Distributional Issues

At least two distinct distributional problems arise in the evaluation of government projects: the intragenerational problem, namely, the problem that arises when individuals in the existing population are allocated costs and/or benefits from a project in an asymmetric fashion; and the intergenerational problem, one that arises when individuals in different generations are allocated costs and/or benefits from a project in an asymmetric fashion. These problems arise in the evaluation of a government project, even in the simple setting of a perfectly competitive economy operating without distortions.

Although at the first-best optimal, g must be equal to the market rate of interest [i.e., $g = i(\mu) = r(\mu)$], the equality of two observable rates, i and r [i.e., $i(\mu^*) = r(\mu^*)$], does not necessarily imply that we are at the first-best optimum. In fact, the imputed social rate of time preference, (μ^*), based on observed market rates, may be quite different from the desired level of the social rate of time preference (μ).

Determination of the desired social rate of time preference (μ), or the desired intra/intergenerational income distribution, is fundamentally derived from ethical value judgments, and there is very little economists can say on these issues *qua* economists. Consequently, the judgments made in classical welfare economics all involve comparisons in which there is unanimous agreement among all consumers, that is, they involve the Pareto dominance criterion.

However, it is too much to expect that each project, considered in and of itself, can be justified on Pareto dominance grounds. What is relevant are the distributional effects of the entire *portfolio* of projects.

Problems of intragenerational equity may be handled through distributional neutrality of the *portfolio* of government projects.

Problems of intergenerational equity may be handled through appropriate monetary and fiscal policies, and investment set-asides.

This approach leads to a Pareto optimal allocation of resources, with the *portfolio* of government projects producing, on average, Pareto superior allocations of resources.

In our discussion of efficiency issues, we will assume that the issues associated with intragenerational and intergenerational income distributions are resolved outside of the cost-benefit framework.

Government Discount Rate in a Second-Best World

There is very little (if anything) in the way of consensus among economists concerning the appropriate discount rate to use on government projects. Differences exist, even concerning the appropriate theoretical approach.

There are two major schools of thought. We begin by looking at the approach taken by economists such as Arrow, Kurz, Diamond, Usher, Stiglitz, Pestieau, Bradford, and Lind in viewing the basic problem as one of "second-best welfare economics." The views of the "opportunity cost" school (Baumol, Harberger, Hirshleifer, Ramsey) will also be noted.

The "second-best" approach involves choosing a time path of government investment spending, to maximize the discounted present value of social welfare in an economy where the private sector operates as a competitive system, but with the corporate income tax creating a wedge between the consumer rate of interest and the pre-tax corporate rate of return. The discount rate used to calculate the present value of *social welfare* is the "social rate of time preference (μ)." All the ethical problems relating to the intergenerational case are assumed to be resolved and incorporated into this magnitude (μ).

At a steady-state second-best optimum, the rate of return earned by the marginal government investment project is identified as the *social discount rate* (d). The social discount rate is then a function of the social rate of time preference (μ), the tax structure (T), and monetary policy restrictions (MP), among other things, i.e., $d = f(\mu, T, MP) = h[i(\mu, T, MP), r(\mu, T, MP)]$.

If the social rate of time preference (μ) can be identified, then we can solve for the *social discount rate* (d) in terms of observable interest rates i and r at the second-best optimum. If not, while the approach adopted by the second-best theorists is formally the correct way to go, it leaves the problem of specifying a social discount rate (d) unsolved until one can determine the "correct" value of the social rate of time preference (μ).

In the "opportunity cost" approach, the sources of the resources employed in the project are identified—that is, the fraction of the resources drawn from consumers and the fraction drawn from the corporate sector. The rate of discount in this approach is then the weighted average of the two private rates, with the weights the fractions of the resources drawn from the two sectors.

The opportunity cost approach and the second-best approach provide similar calculations for the government discount rate (g) if the economy is at its optimum, if the social rate of time preference (μ) is equal to the consumer rate of interest (i), and if there is no additional private investment induced by the government spending. Otherwise, the two approaches provide different solutions to the problem of choosing a government rate of discount.

The assumption that the economy is at an optimum with the social rate of time preference equal to the consumer rate of interest (i.e., $i = \mu$) is not a trivial qualification.

If government investment spending differs from the (second-best) optimum level, then we are in a third-best situation.

Government Discount Rate in a Third-Best World

In the second-best literature, government spending is the control variable and is chosen to maximize social welfare, given the distortions in the society due to the corporate income tax and other factors. The government rate of discount is simply a by-product of the maximization process, representing the rate of return (d) on the marginal dollar of government spending at a steady-state optimum. Because government investment spending is chosen in an optimum manner, a project is funded at a second-best optimum if and only if the discounted present value of net benefits associated with the project is positive, using d as the discount rate.

The role of government in the second-best literature is a highly idealized one. In reality, the level of government investment spending is the result of a complicated political process in which economic efficiency is only one of many factors at work. The government rate of discount plays a different role from that which the literature assigns to the social discount rate. In the legislation and executive orders dealing with cost-benefit studies of government projects, the rule that the cost-benefit ratio must be greater than one is only a necessary condition for a project to be funded, not a sufficient condition. Thus, the cost-benefit test acts only as a filter. This leads to a role for the government rate of discount (g) different from that envisioned for the social rate of discount (d). By choosing d, government expenditures create a second-best optimum level. When g is chosen, given the level of government expenditures, the optimum portfolio of projects is funded.

To accomplish that goal, the appropriate value of the government rate of discount (g) should be the opportunity cost rate of return. This is the highest rate of return available from the portfolio of unfunded government projects. Given this choice of g, projects become funded if and only if the discounted present value of net benefits from a project is positive, using g as the discount rate. Government investment spending then exhausts the amount of funds made available by the Congress. If actual government spending exceeds the level for the second-best optimal, the proper rate of government discount is less than the discount rate d associated with the second-best problem, and if government spending is less than the second-best optimum level, $g > d$.

There still remains the problem of how to identify whether government investment spending is less or greater than the second-best optimal. This is not an easy task since, in some ways, it involves specifying the social rate of time preference. However, the following procedure would partly finesse this problem:

- For any given suggested social discount rate (d), and for any suggested level of government funding, compare d with the opportunity cost rate of return (g) associated with that level of funding. If $g > d$, spending is less than optimal; if $d > g$, spending is more than optimal.
- Data should be kept current on the time paths of net benefits of projects in the portfolio of unfunded government projects, so that this can be used as a measure of the opportunity cost of any proposed government project.

Flexibility of the Government Discount Rate and Bias in Cost-Benefit Estimates

If the third-best approach is adopted, some flexibility should be incorporated into portfolio choices. The amount of flexibility that should be built into the procedure for choosing projects depends on the variability and bias of cost and benefit estimates.

To the extent that cost-benefit estimates are uncertain, and that many of the costs and benefits occur in the future (and hence not much accountability can be enforced), manipulation of these estimates is a problem for government project decisionmaking, whatever approach is followed in choosing a government discount rate.

Under the present system, where the discount rate is prespecified and known beforehand, there is an incentive to produce cost-benefit estimates that lead to a positive discounted present value at this discount rate. But, because the present system acts only as a filter, there is an independent review of projects by Congress. Under either the second-best or third-best approach, the discounted present value (DPV) test is a necessary *and* sufficient condition for funding. This creates incentives to stack the ranking of projects (in DPV terms) in favor of those desired by the administration. Consequently, implementation of either appproach requires modification to present methods of calculating cost-benefit time paths to eliminate such biases, as well as the introduction of flexibility of choice because of the uncertain nature of cost and benefit estimates even when no bias is present.

To minimize the potentially distortive effects of bias in cost-benefit estimates, it is suggested that:

- *Consideration* be given to strengthening the role of independent agencies in evaluating cost-benefit estimates prepared for government projects.
- *Flexibility be introduced* into the project choice process.
- Studies be made of the use of incentives for truthful and accurate reporting of costs and budgets.

Risk

- Except for extraordinary cases, government projects should be evaluated in terms of the expected value of net benefits.
- Under the third-best approach, the internal rate of return of the marginal government project should be evaluated as if it were risk-free.

Exceptions to these rules are those projects with net benefits strongly correlated with national income. In the exceptional cases, a premium should be added to net benefits if the net benefits of a project have a strong negative correlation with national income, and a penalty applied if they have a strong positive correlation with national income.

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CONTENTS

GLOSSARY

CONSUMER'S MARGINAL RATE OF SUBSTITUTION BETWEEN DATED GOODS (MRS/C), **OR "CONSUMER RATE OF (CONSUMPTION) TIME PREFERENCE":**

Let $U = U(C_1, \ldots, C_t, C_{t+1}, \ldots)$ be the consumer's utility function, where C_t denotes his consumption in period t. Then (MRS/C) between C_t and C_{t+1} is given by $(\delta U/\delta C_t)/(\delta U/\delta C_{t+1})$.

CONSUMER RATE OF INTEREST (i):

Consumer rate of interest is the rate of interest that a consumer faces; it is the opportunity cost of consumption today, in terms of forgone consumption tomorrow. At a consumer equilibrium, we have $(1 + i) = $ (MRS/C).

PRODUCER'S MARGINAL RATE OF TRANSFORMATION BETWEEN DATED GOODS (MRT):

Let $0 = \varphi(C_1, \ldots, C_t, C_{t+1}, \ldots)$ be the producer's production possibility function. Then (MRT) between C_t and C_{t+1} is given by $(\delta\varphi/\delta C_t)(\delta\varphi/\delta C_{t+1})$.

PRODUCER RATE OF INTEREST (r):

Producer rate of interest is the rate of interest that a producer faces; it is an opportunity cost of investment today. At a producer equilibrium, we have $(1 + r) = $ (MRT).

SOCIAL MARGINAL RATE OF SUBSTITUTION BETWEEN DATED GOODS (MRS/S), **OR "SOCIAL RATE OF (CONSUMPTION) TIME PREFERENCE":**

Let $W = W(C_1, \ldots, C_t, C_{t+1}, \ldots)$ be the social welfare function. Then (MRS/S) between C_t and C_{t+1} is given by $(\delta W/\delta C_t)/(\delta W/\delta C_{t+1})$.

SOCIAL RATE OF (UTILITY, or PURE) TIME PREFERENCE (μ):

Let the social welfare function be of the following special form:

$$W = \Sigma\, U(C_t)(1 + \mu)^{-t} \ .$$

Then μ is called the social rate of (utility, or pure) time preference. At a steady-state, competitive equilibrium (MRS/S) equals μ.

SOCIAL DISCOUNT RATE (d):

Social discount rate (d) is the rate of return earned by the marginal government investment project at a steady-state second-best optimum, where government investment expenditures are at an optimum level.

GOVERNMENT DISCOUNT RATE (g):

Government discount rate (g) is the discount rate that should be used in evaluating government projects.

GOVERNMENT OPPORTUNITY COST RATE (GOR):

Government opportunity cost rate (GOR) is the opportunity cost of government investment spending representing the rate of return that can be earned from the best alternative investment from among unfunded government projects. When it is used as a discount rate, then investment outlays required to fund projects with discounted net benefits positive equal the total amount available for government investment spending.

I. INTRODUCTION

PURPOSE

This study reviews the theories of the social discount rate, and identifies the sources of divergent views and the limitations of these theories when actual applications are concerned. The study recommends procedures that would help improve the possible revision of OMB Circular A-94.

BACKGROUND

In 1972, the Office of Management and Budget (OMB) directed most federal agencies to apply a 10 percent real rate of discount when calculating the present value of the costs and benefits of federal projects (OMB Circular A-94). Prior to this directive, there had been no uniformity in discounting procedures, or in discount rates used by federal agencies. Some agencies used the Treasury cost of borrowing as the appropriate discount rate, whereas others applied a rate based on the return on investment in the private sector of the economy. Still others employed different criteria to determine their agencies' discount rate and borrowing cost. The move in 1972 toward a uniform discount rate perhaps reflected the prevailing view of economists at the time. Although they could not agree on the correct rate, economists generally did concur with the principle that whatever the correct rate, this rate should be uniformly used for cost-benefit analysis of public projects. In 1977, the Ele[illegible]c Power Research Institute and Resources for the Future held a joint conference on "Discounting for Energy Policy." The conference proceedings contributed to an improved understanding of the theoretical foundations of cost-benefit analysis and of the implications of discounting. The proceedings also clarified some earlier misconceptions, and suggested modifications of both the techniques and the interpretation of cost-benefit analysis. One argument suggests that different rates may be appropriate for different projects and policies, and that the appropriate social discount rate (d) may even lie outside of the band between the pre-tax rate of return on private capital (r) and the consumption rate of interest (i), or the social rate of time preference (μ).

Although the conceptual issues underlying the choice of the appropriate social discount rate(s) might be better understood now than in the 1970s, the problems facing policy analysts today are possibly more complex than in the past.

SCOPE

Section II contains a short survey of the social discount rate literature. Widely divergent views on discounting as an aspect of cost-benefit analysis and cost-effectiveness analysis are evident in the economic literature. These differences often result from different assumptions about capital theory, fiscal economics, and the structure of the economy. But also, as Sen properly notes, they are due to ambiguities in the concept of equivalence of dated commodities and the measurement of "costs-benefits" (particularly the unit of measurement).

Section III deals briefly with issues of intergenerational equity. It argues that discounting utilities over different generations is essentially an exercise in ethical value judgments, and economics has not resolved this problem. Different ethical criteria are introduced and their implications for discount rates explored. A brief account of the Sen-Marglin-Lind "isolation paradox" is provided.

Section IV provides a summary evaluation of theories of social discount rates including both the "opportunity cost" approach and the "second-best" approach. It also briefly discusses pertinent welfare economics involved in cost-benefit analysis.

Section V considers the situation in which the discount rate is used as a filter rather than a device to achieve the desired level of government spending. It is argued that the use of the discount rate as a filter may be more realistic than the approach of the existing literature. Adopting this approach implies the choice of a discount rate that is in principle computable from existing data with government budget limits acting as an effective constraint on government investment spending. Issues of risk, flexibility, and data manipulability are discussed in this section. Section VI summarizes conclusions derived from the study.

II. THE SOCIAL RATE OF DISCOUNT— A LITERATURE REVIEW

The issue of the optimal discount rate to use in evaluating government projects is one that has been debated in the economics literature since the late 1950s, when it arose in connection with cost-benefit studies of water projects (Eckstein, 1958; Hirshleifer, DeHaven, and Milliman, 1960). But as the literature developed, its connection with earlier studies of the optimal rate of saving for a society became more apparent, so the roots of the problem stretch back at least as far as the pioneering work of Ramsey in 1928. Ramsey turned his attention to the problem of intergenerational equity and argued that the appropriate rate to discount the satisfactions of future generations is zero: "One point should perhaps be emphasized more particularly; it is assumed that we do not discount later enjoyments in comparison with earlier ones, a practice which is ethically indefensible and arises merely from the weakness of the imagination. . . ." Ramsey handled the mathematical problems that arise from a zero discount rate by postulating the existence of a bliss point of consumption for society, or negative marginal product of capital for a sufficiently large stock of capital. Neither of these assumptions has played a major role in the literature that has developed since Ramsey's paper appeared, but the issue he raised as to the ethical justification for discounting the utilities of future generations remains central to the discussion of choice of a social discount rate.

In the early 1960s, papers by Sen (1961) and Marglin (1963a, 1963b) revived the Ramsey argument that "the rate of interest determined in an atomistic competitive market need (not) have any normative significance in the planning of collective investment." (Marglin, 1963b, p. 111.) Meanwhile, a voluminous literature developed during the 1960s dealing with one-, two-, and n-sector growth models, including the optimal growth model of Cass (1965), in the Ramsey tradition. Arrow (1966) specifically formulated the problem of choice of the social rate of discount as one of determining the optimal growth path for an economy, an approach that has been followed in most of the formal literature since that time.

However, it was a paper by Baumol (1968) that seems to have provided the spark for the debate that developed during the 1970s over the social rate of discount. Baumol views the choice of the social rate of discount as one to be made on opportunity cost grounds. The social rate of discount measures "the opportunity cost of postponement of receipt of any benefit yielded by a public investment" (p. 788). A central theme of his paper is the problems that develop in choosing an appropriate social rate of discount because of the corporate income tax. The corporate income tax produces a "wedge" between the consumer rate of interest (marginal rate of time preference) and the before-tax rate of return on corporate investment, because after-tax returns from corporate investments must equal the returns earned on savings by consumers and investments in the non-corporate sector. Baumol finds that this leads to a paradox, because the consumer rate of interest is the discount rate that should be used for optimal allocation of resources, but the corporate rate of return before taxes is the opportunity cost of government projects. Baumol argues that the method of financing government projects is irrelevant to choice of a social discount rate; that instead, all that matters is the rate of return that resources diverted to the government could earn if they were in private hands, and he argues that this rate of return is in fact the before-tax corporate rate of return.

With respect to the Ramsey-Sen-Marglin argument as to discounting future generations, Baumol argues two positions: first, with Tullock (1964), he feels that future generations will be richer than the present one, so there is a weak argument on equity grounds for a social discount rate less than the market rate. Second, if there is insufficient saving for future generations, this is not grounds for using a different discount rate in evaluating government projects as compared to private projects—instead, fiscal and monetary policy should be used to lower the market rate of interest. In this second position he agrees with Hirshleifer (1966).

Baumol also comments on the appropriate treatment of risk in the social discount rate. His position is similar to that of Vickrey (1964) and Samuelson (1964), and also reflects arguments of Hirshleifer (1964). He agrees with Samuelson and Vickrey that the government might do a better job of pooling risks than the private market, and that payoffs from (independent) government projects should be evaluated at expected net benefits. However, if the resources used by the government displace investment projects that are discounted for risk in the private market (because of imperfect pooling), then they have to be discounted for risk by the government to correctly reflect the opportunity cost of the resources.

As it turned out, almost every position taken by Baumol was at least somewhat controversial, and Baumol himself changed his views on several critical points (Baumol, 1969, 1970). The "paradox" that Baumol saw as a result of the corporate income tax reflected the fact that the problem of choice of a social discount rate is a "second-best" problem rather than a "first-best" problem, that is, a problem of optimizing subject to certain "built-in" distortions in the economy. This was pointed out explicitly by Usher (1970), who resolved the Baumol paradox by deriving the social discount rate associated with an optimal level of government investment in a second-best world, showing that the social discount rate lies between the consumer rate of interest and the pre-tax rate of return on corporate investment. Usher also pointed out that an essential ingredient in the social discount rate problem is a distinction of kind between public and private investment, resulting from politically imposed restrictions on the types of investment in which the government can engage. (See also Marglin, 1963a, who had also pointed out that the problem of choice of a social discount rate is a second-best problem.) The restrictions on the scope of government investment had been implicit in the Arrow (1966) model, where the aggregate output of the economy is a function of private and public capital, each treated as distinct inputs.[1] As Usher noted, in the absence of such restrictions, one would conclude that government should invest in all projects offering a rate of return greater than the consumer rate of interest, projects that corporations find unprofitable solely because of the corporate income tax.

D. Ramsey (1970) used an opportunity cost approach to resolve the Baumol paradox, and concluded that the social rate of discount should be a weighted average of the consumer rate of interest and the pre-tax rate of return on corporate investment, the weights depending on the fraction of resources drawn from consumption and from investment.

Both D. Ramsey and Usher used two-period models to derive their results. By doing so, they had implicitly finessed one of the more delicate issues concerning evaluation of the costs and benefits associated with government projects, namely, the problem of dealing with reinvestment of the proceeds of a project, and the reinvestment of the reinvestment, ad infinitum. Both the benefits and the costs of government projects must take these secondary effects into account. The measure of benefits must include the additions to consumption over time that result from private investment, which in turn results from reinvestment of the proceeds of the government project. Similarly, the opportunity cost (in terms of forgone future consumption) of any resources transferred from the corporate sector to the government project must include the effects of reinvestment of the "throw off" from an original

[1]In all of the second-best literature dealing with the social discount rate, it is assumed that a social welfare function of the time-separable form exists, with a well-defined (and, usually, constant) social rate of time preference. We follow the same approach in our discussion of the discount rate problem.

private investment. This is the "shadow price of capital" problem, first recognized by Marglin (1963a) and made explicit in the optimization models of Arrow (1966) and Arrow and Kurz (1970). Diamond (1968) presents an abstract formulation of the shadow price problem, one that makes clear that the two-period model (all investment today is consumed tomorrow) is a highly special case of the general model.

The idea behind the shadow price of capital problem is summarized by Lind (1982, p. 41):

> If one accepts the argument that the appropriate way to look at public investment decisions is to trace the impacts on consumption over time and then to discount at the social rate of time preference (and there is growing acceptance of this position), then the appropriate procedure is to compute the shadow price of capital and to multiply the costs of public investment that represent a displacement of private capital by this shadow price to obtain the true opportunity cost in terms of consumption.

Lind (1982, p. 39) defines the shadow price of capital as "the present value of the stream of consumption benefits associated with $1 of private investment discounted at the social rate of time preference." The social rate of time preference is that rate used to discount future utilities of consumption in the social welfare function. In some of the literature it is simply identified with the consumer rate of interest, thereby completely abstracting from the intergenerational equity issues.[2]

One critical variable that underlies any calculation of the shadow price of capital is the marginal propensity to save (MPS) in the society, as projected into future years. Differences among authors as to the "correct" social rate of discount often reduce to differences among them as to assumptions, implicit or explicit, concerning the MPS, and how it varies with respect to different aspects of the flow of income from investment, or between private and government investment. In particular, Sjaastad and Wisecarver (1977) argue that a major source of disagreement in the literature relates to the (implicit) assumptions made by various authors as to the treatment of depreciation—that is, whether there is preservation of capital (100 percent reinvestment), as in Dreze and Sandmo (1971) and Dreze (1974), or consumption of depreciation (O percent reinvestment) as in Marglin (1963b). Bradford (1975) presents the simplest and most straightforward explanation of the shadow price of capital problem, a version which is summarized in

[2]Within a generation, of course, the consumer rate of interest correctly reflects the consumption time preferences of the given generation, although there still remains the usual intragenerational equity problem with respect to the distribution of wealth that helps to determine the equilibrium values of r and i.

Lind (1982). Depending on how the shadow price of capital is factored into the analysis, it can be regarded simply as an element of costs and benefits, in which case one can use the social rate of time preference to discount costs and benefits, as in Lind's treatment. Alternatively, the shadow price of capital can be incorporated into the discount rate directly, in which case there is generally a different discount rate for each project, as in the treatment by Stiglitz (1982).

Baumol's argument, that the corporate income tax represents a major force distorting the allocation of resources between consumption and saving, and a major factor in determining the social rate of discount, was reiterated by Feldstein (1977). The latter identifies the corporate income tax as the main culprit in his argument that the United States saves too little. On the other hand, Stiglitz (1973) points out that so long as corporations finance their investments through issuance of bonds, then the corporate income tax is in effect a lump sum tax, with no distorting effects so far as the social rate of discount is concerned. Thus, the distorting effects of the corporate income tax relate to the fraction of corporate investment financed out of equity capital.

On another point, the position taken by Baumol has been rejected in recent literature. This relates to the irrelevance for the social rate of discount of the method of financing government investments through taxes or issuance of debt. A literature has grown up concerned with analyzing and measuring the "excess burden" of the tax system, that is, the efficiency losses imposed on the economic system by tax increases as consumers and businesses act to avoid such taxes. Browning (1976), Ballard, Shoven, and Whalley (1983), and Stuart (1984) produce estimates of the excess burden of the tax system that range from 9 to 16 percent (Browning), 13 to 24 percent (Stuart), and 17 to 56 percent (Ballard, Shoven, and Whalley). Excess burdens differ according to the item taxed. Excess burden rates are higher when the elasticity of supply of the item taxed is higher. The consequence is that if a project is financed through increases in existing tax rates, the appropriate measure of social costs is not simply the loss in current consumption, representing the amount collected from consumers plus the shadow price of capital multiplied by the amount collected from corporations. Instead, this amount must be added to the cost associated with efficiency losses, which, according to the cited papers, might range up to 50 percent of the amount financed. On the other hand, when the throw off from the project increases government revenues, benefits should be increased if these are used to reduce future tax rates.

Lind (1982) points out that typical government projects are financed through issuance of debt rather than through an increase in taxes, with changes in tax rates being reserved for economic stabilization purposes. Hence, in identifying the sources of the resources diverted from the private sector to the government for use in a project, the macroeconomic policies pursued by the government are of importance. Debt financing will affect interest rates, inflation, and employment levels, with the effects being determined in part by monetary and fiscal policies. Thus, estimates of the appropriate social rate of discount will generally depend on forecasts of the macroeconomic policies of the government, a somewhat speculative undertaking.

One possible approach to modeling the role of government fiscal policy is to assume that taxes as well as investments are optimally chosen by the government, thus relaxing somewhat the "built-in" distortions of the typical second-best model. This is the approach taken by Pestieau (1974) and Stiglitz (1982). Pestieau shows that the optimal structure of taxes in an overlapping generations model is of the Ramsey variety, with the appropriate social rate of discount being the social rate of time preference, which he takes as equal to the consumer rate of interest. Stiglitz looks into the effects of various methods of raising funds on the social discount rates to apply to different projects, in a two-period setting.

Lind (1982) is the best source of information concerning the current state of the debate on the social rate of discount. His summary paper identifies the major issues of the debate and how they are interrelated. He even undertakes the heroic task of estimating a range of values for the social rate of discount, which he takes to be centered at 4.6 percent (in real terms). Arrow (1982) provides a particularly straightforward statement of the second-best approach, generalizing the results from his earlier papers, and clarifying the central role of the social rate of time preference. Stiglitz (1982) emphasizes the fact that diverse sources of distortions lead to different versions of "the social rate of discount." Stockfisch (1982) discusses the problems of estimating the rate of return in private markets, taking an "opportunity cost" point of view, and Wilson (1982) deals with the subtleties of risk assessment and the social discount rate. Sen (1982) and Dasgupta (1982) discuss intergenerational issues.

We next turn to the question of how risk should be treated in choosing a discount rate for government projects. Hirshleifer (1964, 1966) argues that differences in rates of return on private projects reflect differences in riskiness. If resources are drawn from a particular project, riskiness of the project should be reflected in the discount rate employed by government. As Sandmo (1972) has noted, Hirshleifer's world is one in which for every public investment project, there is a private project which has returns highly correlated with it. Sandmo agrees with Hirshleifer that in such a world, the existence of an efficient stock market (efficient pooling facilities) implies that government projects should be discounted for risk just as private projects are. This is in contrast to the Vickrey (1964) and Samuelson (1964) positions that the government has better opportunities for pooling than private markets provide, so that this should be reflected in a lower risk premium (in the limit with independent projects, no risk premium) on government projects.

Most of the literature on the effect of risk on the social rate of discount is concerned with pooling and the relative advantages of private and government pooling. A completely different approach to risk appears in Arrow and Lind (1970), who point out the possibilities of "risk spreading" by government, in contrast to "risk pooling." The idea here is that government has a capacity in certain circumstances to invest in a risky project, spreading the costs and benefits in a more or less uniform fashion over a large population of individuals, each of whom is risk averse. Given the appropriate conditions, Arrow and Lind show that spreading risk in this fashion results in a situation where, for each individual, the marginal cost of the added risk (the "risk allowance") goes to zero as population size goes to infinity, and the aggregate risk (marginal cost per person times number of persons) goes to zero as well. Hence, by spreading the risk of the project over the population, a government acting in the interests of its population evaluates such a project in terms of its expected net benefits, using a risk-free rate of discount. The critical assumptions under which risk spreading enables the government to treat a project as risk free are: independence of project net benefits from the level of national income, and the ability of the government to spread costs and benefits over the population.

Given the conditions for risk spreading, Arrow and Lind argue that if a government project has a lower expected return than a private project, it still might make sense to substitute the government project for the private one, because of government risk spreading. Hirshleifer's position is that in such a situation, the government should subsidize the private project because the "social" risk is the same whether the project is undertaken by private individuals or the government, but Arrow and Lind argue that the subsidies would not alter the cost of risk bearing, which only goes down due to risk spreading.

Finally, Arrow and Lind note that if some large benefits or costs accrue directly to individuals, instead of the government capturing such benefits and costs to spread them over the population, then risk spreading no longer works. Therefore such costs and benefits should be discounted at the risk inclusive rate of discount.

Fisher (1973) pointed out that the Arrow and Lind argument does not hold in the case of public goods, where the amount of net benefits is the same, whatever the size of the population. Consequently, the risk associated with benefits does not go to zero as population increases in size nor does the aggregate risk go to zero. Since public goods presumably represent a major part of the economic activities of government, this suggests that the scope of the Arrow and Lind proposition might be quite limited. Foldes and Rees (1977) reiterate the Fisher argument, and add that risk spreading also does not apply to investments in social infrastructure and basic industries, both of which have returns highly correlated with the level of national income. James (1975) notes that when projects have correlated net benefit streams, the use of the Arrow-Lind approach could conceivably lead to a situation in which each one of a portfolio of separate projects is accepted on cost-benefit grounds as a risk-free project, while the portfolio of projects might be rejected because of the correlation of the portfolio as a whole with national income.

Finally, one of the clearest statements of the risk controversy appears in Pauly (1970), although his paper was written before the notion of risk spreading appeared. Pauly argues that private markets can provide as good (or nearly as good) pooling as the government, thus pooling is not an argument for a government discount rate lower than the private rate. However, the government has the ability to print money, which necessarily makes government securities less risky to the individuals purchasing them than private securities are. This leads to a lower rate of interest on government than on private securities. On the other hand, government projects, like private projects, are subject to the same "public" risks that private projects are (war, depressions, droughts), and these risks impose costs on taxpayers so that the true social cost exceeds the market cost of government funds. The conclusion is that the true social cost of government borrowing is then simply the private rate on pooled projects.

III. ISSUES OF INTERGENERATIONAL EQUITY

When government investment activity affects the consumption pattern of future as well as present generations, then issues of how to compare these different generations' utilities arise. Such a comparison clearly resides in the realm of ethical value judgments, and the discipline of economics has very little to say as to the "correct" weighting of intergenerational utilities. This can be readily seen from the studies examining the implications of different ethical criteria on social discount rates.[1]

Schulze and Brookshire (1982) consider investment in nuclear power by the current generation. Suppose an investment in nuclear power adds utility to the present generation, but decreases utility of future generations through the creation of nuclear wastes. If the ethical criterion used for this simple example is the Pareto criterion (investment should be undertaken only if some generations would be better off while no generation would be worse off because of this investment), then nuclear investment of this nature should never be undertaken. Consequently, the relevant discount rate for this project would be (-1). However, if compensation from the current generation to future generations is possible, then the appropriate discount rate in evaluating this project would be the opportunity cost rate of return for the project.[2] Similar results for this example would be obtained if the criterion is a utilitarian ethical system that postulates "the greatest good for the greatest number," as expressed by Jeremy Bentham in 1789.

Although it might not be relevant in a modern democratic society, if one adopts the Nietzschean criterion of a total elitist view, then the "right" thing to do is to maximize the well-being of the best-off generation. According to this criterion, if the maximum utility of the current generation exceeds the maximum utility of future generations, then the appropriate discount rate in the example should be infinite. On the other hand, if the maximum utility of future generations exceeds that of the current generation, then the discount rate should be chosen to best serve the best-off future generation. This does not necessarily imply starving the current generation.

[1]These studies include Schulze and Brookshire (1982), d'Arge, Schulze, and Brookshire (1980), Schulze, Brookshire, and Sandler (1981), and Kneese et al., 1984.

[2]Because of the inability of future generations to compensate the current generation, a project that will shift consumption from the current generation to future generations (such as basic research or large water projects) may never be undertaken under the Pareto criterion, assuming no bequest motive.

In contrast to the Nietzschean criterion, the Rawlsian criterion seeks a totally egalitarian outcome. It states that the well-being of a society is measured by the well-being of the worst-off generation. Therefore, for example, if the current generation's utility cannot be brought up to the future utility level, then the discount rate should be set at infinity. If, on the other hand, the current generation's utility level exceeds the future utility level, then the discount rate in this example should be (-1).

Unfortunately, as can be seen, these ethical systems have different implications on the choice of a social discount rate, and these choices may even vary, depending on the nature of the project. Although each formulation may be preferred by some economists, it must be understood that this is purely a value judgment. Because of this, the hope of (society) finding a universally acceptable social rate of time preference and (resulting) social rate of discount may be quite limited. Similar and possibly even greater difficulties challenge the search for the social rate of time preference,[3] than those which confronted Arrow (1963) in his effort to find a social welfare function. Nonetheless, many economists have examined the implications of intergenerational welfare functions involving a given (though usually unspecified) value of the social rate of time preference.[4] Although one may not agree with their choice of the functional form or the value for the time preference, these studies have clarified the relationship between the social rate of time preference and the resulting market rate of interest, the consumer rate of interest, and the rate to be used in the government projects.

For example, Frank Ramsey (1928) believed that there is no legitimate reason to discount the utilities of future generations. Along with Bentham in 1789, he believed the utility of each generation should be weighed equally. However, the use of a zero discount rate creates a basic difficulty in determining the optimal saving-investment policy, since the appropriate integral may not converge. Although Ramsey finessed the problem by converting the utility maximization framework into a minimization of the utility difference between bliss and actual consumption, the zero rate of time preference can still pose serious difficulties.[5] As Koopmans (1960) pointed out, this implies that the

[3]Sen (1982) embarks on this challenging task, but practical application of his work is so far limited.

[4]In all of the second-best literature dealing with the social discount rate, it is assumed that a social welfare function of the time-separable form exists, with a well-defined (and, usually, constant) social rate of time preference. We follow the same approach in our discussion of the discount rate problem.

[5]Another way to cope with this problem is the so-called overtaking criterion, which was first proposed by von Weizsäcker in 1965, and later by others in the field of growth theory. See Gale (1967). Alternative objective functions such as the Cesaro mean or

criterion cannot be sensitive to consumption in any period, and that following any feasible time path for any finite period of time is consistent with optimality. This means roughly that the interests of any one generation can be sacrificed for any other. Hence Koopmans argues that impatience is virtually a necessity.

In more recent years, Arrow (1966), Arrow and Kurz (1970), Pestieau (1974), and Stiglitz (1982) have formulated the social welfare function as a discounted sum of intergenerational utilities, where the discount rate for the social welfare function is the "(pure) social rate of time preference." From this formulation, they derived the discount rate for marginal government projects in a "second-best" optimum, as a function of the given social rate of time preference. (Throughout Sec. III we call this rate associated with the second-best optimum the social discount rate d.) The difficulty, as noted before, is that economics does not provide any way to determine the value of the social rate of time preference. This is true even if there are no distortions in the society. In particular, we cannot infer that the social rate of time preference is equal to the market rate of interest, even when the consumer rate of interest equals the corporate rate of return.

To overcome this impasse, some economists suggest use of the consumer rate of interest as the social rate of time preference. In the Arrow case of an economy with one immortal individual, this is an immediate consequence of the model. In the Barro-Ricardo model in which each individual has a concern for his or her heirs, it is also as if the individual lived forever. However, this does not necessarily lead to the conclusion that the consumer rate of interest should be the social rate of time preference, given individuals with differing wealth positions and different degrees of impatience.

Another way to break this conundrum is to assume that the observed state of the world is distributionally optimal. Then, by assumption, we need not concern ourselves with the social rate of time preference or intergenerational equity issues. We will simply compute the social discount rate from the observed market rates of interest. Such a process may be guided by the analytical work that relates the social discount rate to various observed rates of interest. But in the absence of such special conditions, identification of the social rate of time preference with the consumer rate of interest remains a highly restrictive assumption.

the Abel limit are also considered by some. Given $P(t)$ is the payoff in period t, the Cesaro mean is

$$\lim_{T\to\infty} [1/T] \sum_{t=0}^{T} P(t), \text{ and Abel limit is } \lim_{\delta\to 1} (1-\delta) \sum_{t=0}^{\infty} \delta^{t-1} P(t) \ .$$

Before leaving the intergenerational equity issue, we will address one of the more heated debates concerning whether or not the social rate of discount should be lower than the private rate. Sen (1961) and Marglin (1963b) raised the issue of intergenerational externalities. They argued that it might be the case that each consumer prefers more saving by all consumers to less, but still such saving may not take place in a competitive market due to an "externality of consumption." This phenomenon, the so-called isolation paradox, was illustrated for the case of identical individuals. Sen (1961, 1967) shows that a prisoner's dilemma equilibrium can arise in which it is necessary to impose government controls over saving to achieve intergenerational optimality. Lind (1964) has discussed difficulties with this phenomenon, but it remains a possible source of inefficiency in the allocation of resources over time.

In summary, one can say both a great deal and very little from the intergenerational equity point of view as to what rate of discount should be used in government cost-benefit analysis. If one should agree further that all ethical intergenerational equity issues can be summarized in the value of the social rate of time preference, and if such a value could be identified, then one could compute the proper discount rate as a function of the social rate of time preference at the second-best optimum. Or, in a shadow price of capital approach, the social rate of time preference may be used directly to discount the total (final) consumption stream of the project. However, it is unrealistic to assume that one could identify the social rate of time preference that would satisfy all major ethical considerations. Even if we agree to restrict our attention to the preferences of the current generation, and agree to have the current generation made up of identical individuals, the observed consumer rate of interest may still not equal the social rate of time preference. Theoretically, if we assume that the observed state of the world is optimal, then we can identify the correct formula for the social discount rate and compute it, based on observed data. Although such an approach provides the empirically oriented analysts ample "hard numbers" and opportunities to run regressions, the premises of the approach can hardly be justified.[6]

[6]Among the many problems left unresolved both in the literature and in the present paper is that of consistent planning. As Burness (1973) has pointed out, the time separable social welfare function (with constant social voted time preference) formally satisfies time consistency. However, there is no way that the present generation can commit future generations to a predetermined investment time path, so that the time consistency problem can arise even with the "standard" social welfare function. This becomes a source of intergenerational inefficiency, to add to that involved in the isolation paradox.

IV. THE CHOICE OF A GOVERNMENT DISCOUNT RATE: THE BASICS

The problem of choosing a discount rate to use in evaluating government projects arises as follows:

Consider a government project that promises to pay benefits B_t in periods $t = 1, \ldots, T$, and incur costs C_t in periods $t = 1, \ldots, T$. How does one go about comparing costs and benefits that occur in different periods, and what rule should be used in determining whether the project is a worthwhile undertaking? The standard approach in economics is to introduce a discount rate g, the government discount rate, and to use this discount rate in determining the present value of the benefits (PVB) and costs (PVC) of the project.[1] The present value of benefits is given by

$$PVB = \sum_{t=1}^{T} B_t(1 + g)^{-t}$$

while the present value of costs is

$$PVC = \sum_{t=1}^{T} C_t(1 + g)^{-t}$$

A government project is then regarded as worth undertaking if, and only if, PVB is greater than PVC—that is, the present value of *net* benefits from the project is positive.

Why are future costs and benefits discounted in calculating the present value of net benefits? The economist's answer is basically an application of the notion of opportunity cost. The idea is this: any government project will require the use of resources such as labor, machinery, buildings, and land, resources that would otherwise be employed elsewhere, either on other government projects or in the private sector to produce consumer goods or investment goods. To justify the use of these resources by the government on efficiency grounds, it must be shown that the stream of net benefits generated by a government project is at least as valuable to individuals in the society as the stream of net benefits that would have occurred had the

[1]For notational simplicity, it is assumed here that the government discount rate is constant over time. In fact, to be discussed later, the discount rate might vary from period to period.

resources been put to their best alternative use, either in government or in the private sector. To put it another way, any worthwhile government project must promise to earn a rate of return (in the form of net benefits) at least as large as that which would be earned by the resources if employed at their highest rate of return use elsewhere in the economy. If not, consumers in the society would be better off if the government project were canceled.

Thus, under steady-state conditions, there are two equivalent ways of formulating the decision rule associated with a proposed government project: the project should be undertaken if discounted net benefits are positive, using the government rate of discount g as the discount rate; or, the project should be undertaken if the rate of return earned by resources invested in the project exceeds the government discount rate g. (When the economy is not at a steady state, however, it might be desirable to depart from the steady-state rule for a few periods.)

One issue should be disposed of before we proceed any further. It might be asked whether the use of an aggregated measure such as discounted net benefits leads to a loss of information relevant for decisionmaking, compared with the original vector of benefits and costs, dated by period. The answer is that so long as costs and benefits are correctly measured (in terms of consumers' plus producers' surpluses associated with the net consumption time stream, generated by the project), and so long as the correct government rate of discount is used in the calculation, a positive value for discounted net benefits is equivalent to the assertion that the society's social welfare (measured in terms of aggregated benefits and costs) has increased. Needless to say, there are some interesting problems involved in correctly calculating benefits and costs, and in identifying the correct value of the government rate of discount, but there is no aggregation problem per se involved in the discounting process. There are, however, well-known problems in using aggregated consumer surplus as a measure of benefits.

This will be our approach in what follows: We will first look at the idealized world of a perfectly competitive economy operating under certainty, and with no distortions due to externalities, market power, market failure, or government regulations, rules, or policies. There are certain problems concerning the calculation of net benefits and the identification of the correct government rate of discount, even in this highly simplified environment. We will discuss these problems and suggest ways in which they might be resolved, so that those problems can be ignored in our attempt to deal with a more complicated environment. This is essentially the approach that is adopted in the literature, building up from the simplest case to more realistic models.

THE GOVERNMENT DISCOUNT RATE IN A PERFECTLY COMPETITIVE ECONOMY

We begin by considering the role of individuals as consumers and savers in a perfectly competitive economy. We take it as given that consumers have well-defined preferences with respect to consumption over time, and make rational decisions as to their consumption levels. The benefits and costs that come to them in future periods must be made comparable with benefits and costs that occur today, to reflect their rates of time preference. Individual consumers differ in the degree of their time preference, and hence in their valuation of future versus present consumption.

But all individuals as consumers adjust their spending and saving patterns to the level and structure of interest rates that prevail. Suppose, for simplicity, that there is just one interest rate facing all consumers, and that consumers can borrow or lend as much as they wish at this interest rate. This is the case of a "perfect lending market." Then each consumer will adjust his pattern of spending and saving so that the marginal utility of a dollar's worth of consumption tomorrow, discounted at the market rate of interest, is equated to the marginal utility of a dollar's worth of consumption today.

If the interest rate is 10 percent, then each consumer in the society will adjust his spending and saving so that he is willing to trade $1 worth of consumption today for $1.10 worth of consumption next year. Since this applies to every consumer, we can use the market rate of interest as a measure of the rate at which, at the margin, consumers discount the benefits of future consumption. The fact that we are dealing at the margin means that we have identified the rate of discount appropriate in the decisionmaking that concerns shifting resources from producing consumer goods today into producing consumer goods in the future. We will refer to this as the "consumer rate of interest (i)."

From the consumer's viewpoint, a dollar should be transferred out of the production of current consumer goods and into the production of future consumer goods if the discounted present value of the stream of future output is greater than one dollar, using the consumer rate of interest as the discount rate.

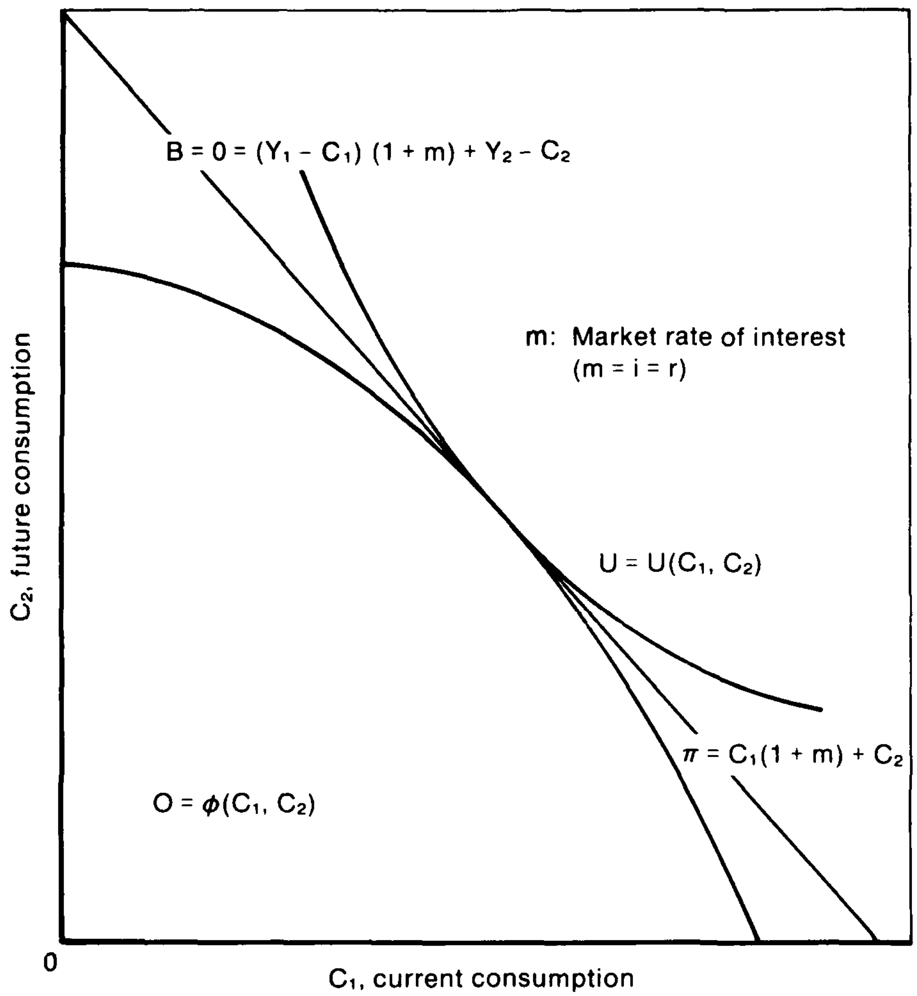
This is just one side of the picture concerning the interest rate. Interest rates are set in the market for loanable funds, with savers on one side of the market and investors on the other side. Consumer time preference acts as a force in this market operating on the supply side, with savings responding to the rate of interest in terms of income and substitution effects, and negatively responsive to the degree of consumer time preference (absence of income effects). On the demand side, investment spending reflects the prospective yield of newly produced capital goods such as buildings, inventories, machinery, and the like. In a perfectly competitive world in which there are no taxes, firms are operated to maximize the discounted present value of the income time stream associated with their portfolio of assets, using the rate of interest firms face as the discount rate. We will refer to this as the "producer rate of interest (r)," which equals the consumer rate of interest (i) in the absence of taxes. Investment demand by business is negatively related to the interest rate, with fewer projects passing the profitability test at high interest rates, and positively related to the prospective yield of investment goods. Since all firms face the same borrowing rate, then, at the margin, investment projects in all firms in the economy yield the same rate of return, equal to the market rate of interest. That is, firms will invest up to the point where the last dollar invested promises a rate of return equal to the market rate of interest. Hence, the market rate of interest provides us with a measure of the rate of return that is earned, at the margin, by investments in the private sector of the economy.

Given that there is just one interest rate in the economy ($i = r$), the interaction between consumer-savers and business-investors in the market for loanable funds generates an equilibrium market rate of interest that on the one hand measures the rate at which consumers discount the benefits of future consumption at the margin, and on the other measures the rate of return that is earned on investments in the private sector of the economy at the margin.

The figure depicts a competitive equilibrium in a one-consumer two-period world. As will be discussed later, the two-period model masks some important issues concerning the reinvestment of the proceeds of earlier investments; and of course some of the most interesting problems of welfare economics are bypassed in a one-consumer world.

Suppose, in addition, that the government invests in every project available to it that has the present value of net benefits positive, using g as the discount rate. Then, *it is natural to identify g*, the government discount rate, with the market rate of interest as determined in the capital market. And, in fact, *if we were dealing with a world in which there were no distributional (equity) problems, there would be a consensus among economists that the government rate of discount should be the same as the rate of discount used by consumers and firms, that is, the market rate of interest.*[2]

[2]This abstracts from the problems of government expenditures associated with public goods, incomplete markets, and externalities, all of which "imperfections" can lead to competitive equilibria that are not optimal. Moreover, the fact that government is a



Market equilibrium in a first-best world

There are at least two distinct distributional problems that arise in the evaluation of government projects: the intragenerational problem, namely, the problem that arises when individuals in the existing population are allocated costs and benefits from a project in an asymmetric fashion; and the intergenerational problem, the problem that arises when individuals in different generations (the present and future generations) are allocated costs and benefits from a project in an asymmetric fashion. These problems arise for the evaluation of a government project even in the simple setting of a perfectly competitive economy operating without distortions, and need to be dealt with before going on to other complications.

PARETO SUPERIORITY AND PARETO OPTIMALITY

Welfare economics starts from the fundamental premise that in evaluating a project, the critical question is how the project affects consumers in the society; and what counts in the evaluation of the project is the preferences of consumers with respect to it. In other words, economists do not impose value judgments of their own concerning the desirability of a project. Instead they take as given the preferences of consumers with respect to the costs and benefits associated with a project, and use these to decide whether or not the project is desirable. Moreover, welfare economics has no criteria by which it can assign "weights" to different individuals in the society, nor does it have the capability to make "interpersonal comparisons of utility" by which the losses of one individual can be judged to be "more than offset" by the gains of some other individual. The consequence is that classical welfare economics arrives at unambiguous conclusions concerning equity issues only when there is unanimous agreement among all consumers.

In particular, given two projects, A and B, A would be ranked as "more desirable" than B by welfare economists if every consumer regards the outcome achieved under A as at least as preferred as the outcome under B, and some consumer(s) strictly prefer A to B. When this holds, we say that A Pareto dominates B, or A is Pareto superior to B. We can then define what is meant by an "efficient allocation of resources," or a "Pareto optimal allocation of resources," using the notion of Pareto dominance. An allocation of resources is said to be Pareto optimal if it is feasible (if it is attainable within the limits of society's resources), and there does not exist another feasible allocation

non-atomic component of the market means that government investment decisions have nontrivial impacts on market interest rates, which therefore are regarded as dependent on the government's discount rate.

that Pareto dominates it. Only Pareto optimal allocations are "efficient," that is, they do not "waste resources." Why? Suppose that an allocation of resources is not Pareto optimal. Then there exists a feasible way of reallocating the resources such that everyone is as well off as before and some people are better off; if such a dominating outcome is not achieved, then certainly society is wasting resources. One major aim of welfare economics is to identify efficient policies, that is, policies that will achieve Pareto optimal allocations. And when any such Pareto optimal allocation is also Pareto superior to the status quo, an unambiguous judgment can be made that this is a desirable allocation of resources.

This still leaves the unanswered question of how economists make policy recommendations in cases in which the Pareto superiority condition does not hold. The "practical" alternative adopted in applied welfare economics has been to use aggregated measures of net benefits such as consumers' (plus producers') surpluses or, at an even more aggregated level, the change in real national income. The argument here is that, so long as the present value of consumers' and producers' surpluses exceeds the present value of cost of the project, there are net benefits from the project in the aggregate, and hence the project should be accepted. But this ignores the fact that typically some consumers are better off and some are worse off under the project than under the status quo, thus leading to equity issues.

One possible way to finesse the equity problem is to look at the entire portfolio of government projects, rather than at each project considered separately. It is too much to expect that each project, considered in and of itself, can be justified on Pareto dominance grounds, or that each has "neutral" distributional properties. What is relevant is the distributional effects of the entire portfolio of projects that the government implements. If each project satisfies the efficiency test (present value of consumers' plus producers' surpluses exceeds the present value of costs), and the entire portfolio of projects has neutral distributional effects, then over a sufficiently large set of projects, something like Pareto dominance emerges. That is, so long as the government only invests in projects that satisfy the criterion that discounted net benefits are positive, and so long as the portfolio of projects of the government is such that in the aggregate net benefits are distributed in a neutral manner, with no group or individual being discriminated against or favored on average, then on average, the effect of government activities is to move the economy to Pareto superior allocations.

It is critical that distributional neutrality in this sense be present, because if not, it is illegitimate to argue that a policy of accepting projects when discounted net benefits are positive can be justified on economic grounds. Welfare economics does not provide a justification for any particular efficient allocation of resources, but only for allocations in which every consumer is made better off. This certainly raises the questions as to whether distributional neutrality is, in fact, satisfied under current project decisionmaking procedures used by the Congress and the Executive Branch, and how one might go about testing this. In what follows, we will simply assume that distributional neutrality characterizes the government cost-benefit decisionmaking structure, and move on to the question of choice of a discount rate in an environment in which distributional problems (at least among the present generation) are taken as solved by that structure.

There remains the intergenerational problem. Suppose that, in our perfectly competitive economy, the government discount rate is chosen equal to the market rate of interest. The market rate of interest reflects the impatience of the current generation and its "bequest motives," insofar as these do not involve isolation externalities. Is there any way in which we can justify the resulting intergenerational allocation of resources as being "equitable" or "fair?" If the answer is "no," should not the discount rate used on government projects be adjusted (downward if future generations are regarded as being given too small an endowment from the present generation, or upward if the endowment is regarded as too large) to correct for the inequities? One conclusion that can be drawn from a literature review is that there is *no presumption that use of the market rate of interest as the government discount rate results in an equitable resolution of the intergenerational problem.* That does not mean, however, that the way to resolve this difficult ethical problem is by adopting a rate of discount for government projects that differs from the market rate of interest.

The reason for this is as follows: The choice of a government rate of discount that is, say, less than the market rate of interest has two effects. On the one hand, assuming that the government follows the rule of investing in all projects with positive discounted net benefits using the government rate of discount leads to the implementation of more government projects with net benefits for future generations; in this sense it helps to correct for the perceived intergenerational inequity. But under the same assumptions, the choice of a government rate of discount less than the market rate of interest also results in a shifting of current resources out of the private sector and into the public sector, as public investment is encouraged at the expense of private investment. As Marglin, Hirshleifer, and Baumol, among others, have pointed out, the *intergenerational problem is not simply a problem of government investment policy, but also of private investment policy.* If there is agreement that the market rate of interest results in too low a level of investment to benefit future generations, then the appropriate policy response is to implement monetary and fiscal policies that lower the market rate of interest, not a policy of encouraging government investment relative to private investment through a government discount rate less than the market rate.[3]

The discussion that follows deals with choice of a rate of discount for government projects. We will ignore both the intragenerational problem and the intergenerational problem. The former must be addressed through distributional neutrality of the portfolio of government projects.

On the other hand, the intergenerational problem is one that is appropriately addressed using monetary and fiscal policy to alter the market rate of interest. To the extent that there is an incomplete set of markets to handle the special prisoner dilemma problem raised by the isolation paradox, there might exist a justification for consumption taxes and further subsidies of private and public investment beyond the levels that would be achieved with a lower interest rate. There appear to be some very difficult problems associated with determining the quantitative significance of these externalities.

Finally, the same distributional problems that arise in the intragenerational case are present as well in the intergenerational case. If the portfolio of government projects, on average, imposes net costs on future generations, then investment set-asides should be established to compensate those future generations. These investments should be funded in an amount such that, when compounded at the opportunity cost rate of return, they offset future costs.

The upshot of all this is that in a perfectly competitive economy operating under certainty, with no distortions, and with the government investing in every project that has positive net benefits when discounted at the government rate of discount, the correct choice of a government rate of discount is the market rate of interest. Problems of intragenerational equity are handled through distributional neutrality of the portfolio of government projects, and problems of intergenerational equity through appropriate investment set-asides and monetary and fiscal policies, and perhaps direct subsidies. Any proposed government project will be accepted, if discounted net benefits under the project are positive, using the market rate of interest as the government rate of discount in a first-best world. This approach leads to a Pareto optimal allocation of resources, with the portfolio of

[3]In a rational expectations world in which monetary and fiscal policy are ineffective in influencing the interest rate, government subsidies of private investment might be required to attain an optimum level of investment.

government projects producing, on average, Pareto superior allocations of resources, i.e., on average, all present and future individuals in the economy gain positive net benefits from the portfolio of government projects.

THE GOVERNMENT RATE OF DISCOUNT IN A SECOND-BEST WORLD

So much for the perfectly competitive economy operating under certainty and without distortions. When we turn to our functioning economic system, we find an environment in which distortions exist in the form of externalities, market power, market failure, and government rules and regulations that sacrifice efficiency for equity or other considerations. There are important problems present, relating to risk and uncertainty. We are dealing with the cloudy area of "second-best" welfare economics in which the constraints on the system and the choices available to policy makers are often not clearly delineated.[4] There is very little (if anything) in the way of consensus among economists as to the appropriate discount rate to use on government projects. There are even differences among economists as to the appropriate theoretical approach to follow in determining the defining characteristics of the "correct" government discount rate.

In what follows, we begin by looking at the "main stream" approach of economists such as Arrow, Kurz, Diamond, Stiglitz, Bradford, Lind, and Usher in viewing the basic problem as one of second-best welfare economics. The views of the "opportunity cost" school (Baumol, Harberger, Hirshleifer, and Ramsey) will also be noted. We then summarize our position, which might be described somewhat facetiously as "third-best" welfare economics, and discuss our differences with the second-best and opportunity cost approaches. Once again following the approach of the existing literature, we will look at a single distortion (the corporate income tax) in a world of certainty, deferring considerations of risk until later. In the literature, the main focus of attention has been on the distorting effects of the corporate income tax, and we will highlight the same distortion.

Baumol was among the first to point out that the existence of a corporate income tax means that resources for a government project drawn from the corporate sector earn, on the margin, more than

[4] Note that in the "second-best" case, the constraints imposed on the system are such that a first-best optimum cannot be achieved, and that policies that are inefficient in an unconstrained world can lead to results Pareto superior to those achieved by any policies that would be efficient in the absence of constraints.

comparable resources drawn from consumers. The corporate income tax creates a wedge between the consumer rate of interest and the pre-tax rate of return earned on investments by corporate firms.

Lind provides a simple example of the problem. Suppose that the corporate income tax is 50 percent and the personal income tax is 25 percent, that corporations are wholly financed by equity, and that all corporate profits are paid out to consumers. Suppose, in addition, that consumers require a rate of return of 6 percent after taxes in order to make investments or loans. Then, on the margin, investments in the corporate sector must earn 16 percent pre-tax. A 16 percent pre-tax rate of return for corporate investment means an 8 percent rate of return after taxes. After personal income taxes are factored in, the 8 percent rate of return pre-tax to equity holders is reduced to 6 percent.

Thus, under the above conditions, if a government project draws resources away from private investment in a world where all private investment is by corporations, the project must earn a rate of return of 16 percent if it is to meet the opportunity cost criterion. If it draws the resources away from consumption, it need earn only the 6 percent rate of return (after-tax) that represents the consumption rate of interest. As a consequence, the simple identification of the government rate of discount with the market rate of interest in the perfectly competitive economy no longer holds, and the relationship between the government rate of discount and market rates of return becomes somewhat speculative.

For completeness we might note that the 16 percent-6 percent example is overdrawn. Because interest is tax deductible, a corporation financing all of its investments through the issuance of bonds requires only an 8 percent (before 25 percent personal tax) yield to return 6 percent after taxes to consumers. Moreover, when corporations reinvest earnings after taxes rather than pay them out to stockholders, the personal tax of a stockholder is converted from one on ordinary income to one on capital gains, which reduces the effective corporate income tax rate (this changes under the final implementation of the 1986 tax reform bill). But while these devices have the effect of mitigating the effects of the corporate tax rate, it is still true that, on average, the marginal corporate investment must earn a rate of return in excess of the consumer rate of interest.

The second-best literature formulates the problem as that of choosing a time path of government investment spending to maximize the discounted present value of social welfare, in an economy where the private sector operates as a competitive system, but with the corporate income tax creating a wedge between the consumer rate of interest and the pre-tax corporate rate of return. The discount rate used to calculate the present value of social welfare is the "social rate of time preference." All the ethical problems relating to the intergenerational case are assumed to be resolved and incorporated into this magnitude, which also is supposed to reflect the time preferences of the current population. For some authors, the social rate of time preference is simply identified with the rate of time preference of the current population, but in general this is to be regarded as a somewhat heroic assumption. In any case, no attempts are made in the literature to assign a numerical value to the social rate of time preference (with the sole exception of Lind, 1982).

A distinction is drawn between those capital goods in which the government invests (presumably these are "public goods") and the capital goods representing investment vehicles for the private sector. This can be viewed as a second "distortion" in the economy, since the government is restricted in the areas in which it is allowed to channel its investment funds.

At a steady-state second-best optimum, government investment expenditures are at an optimum level subject to these constraints. Given this optimum level, the rate of return earned by the marginal government investment project is identified as the "social rate of discount" for the economy, and this is of course the appropriate rate at which government projects should be discounted. The social rate of discount equals the opportunity cost of the marginal government project, which in turn is a function of the social rate of time preference, the corporate tax rate, and the corporate pre-tax rate of return.[5] Since the social rate of time preference is not an observed magnitude, this still leaves the specification of the social rate of discount somewhat vague.

If we assume that the social rate of time preference for the economy equals the consumer rate of interest, then we have a more or less simple resolution of the problem of choice of a government discount rate: at a second-best steady-state optimum, the government rate of discount g equals the social rate of discount d, which equals the opportunity cost of government investment, which in turn is a function of the consumer interest rate i and the corporate pre-tax rate of return r. In principle, we could solve the opportunity cost function to derive the social rate of discount from the consumer rate of interest and the corporate pre-tax rate of return, and Arrow has in fact done this for the case of an economy operating with a Cobb-Douglas production function.

[5]If, as in Stiglitz's work, additional distortions are introduced into the picture, these will also be arguments of the opportunity cost function. Moreover, Stiglitz shows that this leads in turn to a myriad of social rates of discount, approaching the case where there is a different social rate of discount applied to every project.

While the approach adopted by the second-best theorists is formally the correct way to go, it leaves the problem of specifying a social rate of discount unsolved until one can determine the "correct" value of the social rate of time preference. The assumption that the consumer rate of interest equals the social rate of time preference is a strong one indeed, since, in effect, it implicitly assumes that the knotty ethical problems associated with the intergenerational issue have already been resolved through appropriate fiscal and monetary actions.

The "opportunity cost" approach offers what appears to be a much more straightforward view of the problem. In the opportunity cost approach, the sources of the resources employed in any government project are identified—that is, the fraction of the resources drawn from consumers and the fraction drawn from the corporate sector. The appropriate social rate of discount to use on a project is simply the weighted average of the two private pre-tax rates, with the weights being the fractions of the resources drawn from the two sectors. This implies in general that (as with Stiglitz) there will be a different discount rate for every project, depending on the sources of the resources used in the project.

There are members of the opportunity cost school, however, who argue that the correct social discount rate is the corporate pre-tax rate of return. One version of the argument goes as follows. The correct opportunity cost for a government project is the best alternative use of the resources. The best alternative use of the resources employed on any government project is in corporate investment, hence, this is the rate of return that government projects should earn, regardless of where the resources are drawn from. The problem with this argument is that if the resources for a project were to come partly from consumers and partly from the corporate sector, when released they in fact earn less than the corporate rate of return. Moreover, if the argument is carried to its logical conclusion, the government should tax consumers to subsidize corporate investments, and continue to do so as long as the consumer rate of interest is less than the corporate rate of return. It is true that this will in fact move the economy toward a first-best Pareto optimum allocation of resources; however, a much simpler way to accomplish this is simply to abolish the corporate income tax. Presumably there are certain political and/or social goals that are furthered by the existence of the corporate income tax; in any case, arguments based on the assumption that the social rate of discount can be used to bypass the corporate income tax are not consistent with the basic second-best framework.

Another use of the opportunity cost argument provides the justification for an alternative "end run" around the corporate income tax.

The argument is that the social rate of discount should be the consumer rate of interest, because any government investment that earns more than the consumer rate of interest provides a net benefit to consumers. If government can invest in private capital goods then a social discount rate equal to the consumer rate of interest would lead to government investing in all those projects earning rates of return between the consumer rate of interest and the corporate rate of return, projects that corporations find unprofitable because of the corporate income tax. Once again, a first-best Pareto optimum would be achieved, with the investment distortions of the corporate income tax being eliminated through the expansion of government investment. This solution requires that the existing limitations on avenues of government investment be eliminated, an approach that is much less realistic or appealing than abolishing the corporate income tax.

One other opportunity cost argument for use of the corporate pre-tax rate of return as the social discount rate should be mentioned. Harberger argues that one reason why the appropriate social rate of discount should be the corporate pre-tax rate of return on investment is that government projects obtain their funding through government borrowing, which displaces private investment funds through an increase in the rate of interest. Hence, even though the weighted average approach to calculating the social rate of discount is formally correct, in practice it turns out that all of the weight falls on the corporate investment sector. As Lind points out, this view has considerable merit, since the tax laws are adjusted only infrequently and typically not in response to the revenue needs engendered by spending on specific government projects, but rather for objectives such as increasing employment or lowering inflation. However, the argument is formally correct *only* if consumption is insensitive to increases in interest rates and the economy remains fully employed with *stable prices*. As Lind argues, in the face of an increase in government spending, maintaining full employment requires monetary actions that in effect finance government spending through inflation, reducing both real investment and real consumption expenditures.

The opportunity cost approach and the second-best approach provide similar calculations of the social rate of discount if government investment spending is at its optimum level, and if the social rate of time preference is identically equal to the consumer rate of interest. In both approaches, the social rate of discount at the optimum is a linear function of the consumer pre-tax rate of interest and the corporate pre-tax rate of return. But the weights assigned these two rates generally differ between the two approaches. Clearly the *only* correct way to choose the level of government investment and hence the social rate of discount is the second-best approach, so that unless the opportunity cost approach is adjusted to incorporate the correct weighting factors, it leads to an incorrect specification of the social rate of *discount*.[6]

The assumption that the economy is at an optimum with the social rate of time preference equal to the consumer rate of interest is certainly not a trivial qualification, but when it is met, in principle the social rate of discount can be calculated from observed values of the consumer rate of interest and the corporate pre-tax rate of return.

When the economy is not at a second-best optimum position, the opportunity cost approach to the social rate of discount suffers from a further defect. The problem is that if government investment spending is below the optimal level, then the observed opportunity cost of government investment (a convex combination of the consumer rate of interest and the corporate rate of return) understates the true social rate of discount, assuming that the social rate of time preference is identically equal to the consumer rate of interest. The reason for this is that an expansion of government investment spending to its (second-best) optimum level will force both the consumer rate of interest and the corporate rate of return up. At the optimum, when the social rate of discount equals the opportunity cost of government investment spending, the opportunity cost will be higher, given fixed marginal propensity to save (MPS) and shadow price of capital. When the social rate of time preference differs from the consumer rate of interest, the opportunity cost approach generally leads to misallocation of resources.

A simple two-period version of Bradford's model can be used to identify the links between the second-best approach and the "opportunity cost" approach, and to clarify the role played by the shadow price of capital in the second-best appr ach.

Let: μ = social rate of time preference
r = pre-tax corporate rate of return
v = shadow price of capital $\equiv$ the discounted present value of changes in consumption due to a \$1 investment in private capital (using μ as the discount rate)
z = rate of return on a government project

[6]Another way to put this is that the opportunity cost approach of the existing literature identifies the wrong set of alternative uses of the resources. The "third-best" approach described in the next section is also an opportunity cost approach but with a completely different view of the set of alternatives relevant to choices.

a = decrease in private investment because of a \$1 increase in government spending

α = increase in private investment due to a \$1 increase in output in the economy.[7]

Consider now an increase of \$1 in government investment at time t, with investors supplying a percent and consumers supplying $1 - a$ percent.

	Period	
Change	t	$t + 1$
In consumption	$-(1 - a)$	$(1 + z)(1 - \alpha)$
In investment	$-a$	$(1 + z)\alpha$

Then the change in the discounted present value of consumption due to the \$1 increase in government spending is given by

$$\Delta PV = -[(1 - a) + av] + [(1 + z)/(1 + \mu)][(1 - \alpha) + \alpha v] \ .^{8}$$

(Changes in investment are multiplied by the shadow price of capital to obtain the consumption equivalent of the change in investment.)

The government investment should be undertaken if $\Delta PV \geq 0$ or, equivalently,

$$(1 + z) \geq (1 + \mu)\{[1 + a(v - 1)]/[1 + \alpha (v - 1)]\} \ .$$

This is the second-best criterion. Note that changes in private investment are multiplied by the shadow price of capital v to convert these into consumption-equivalent terms. The second-best optimum rule then is to invest in the government project if, and only if, $\Delta PV(\mu) \geq 0$, or, equivalently,

$$(1 + z) \geq (1 + \mu)\{[1 + a(v - 1)]/[1 + \alpha(v - 1)]\} \ .$$

Some special cases are of interest:

[7] $1 - \gamma$ is the increase in consumption due to a \$1 increase in output, and $1 - a$ is the decrease in consumption because of a \$1 increase in government spending. If there is distributional neutrality, then, on the margin, all consumers will be equally affected (in terms of the marginal rate of substitution between consumption today and tomorrow) by changes in government spending.

[8] Note that the social rate of time preference is used as the rate to discount future consumption.

- If $a = \alpha$, so that the MPS equals the percentage of resources drawn from private investment in funding government investment, then the second-best rule becomes: invest if, and only if, $z \geq \mu$, that is if, and only if, the rate of return on government investment is at least as large as the social rate of time preference.
- If $a = 1$ and $\alpha = 0$, so that all resources for government investment are drawn from private investment, and all of the proceeds of government investment are consumed directly, then the second-best rule reduces to $(1 + z) \geq (1 + \mu)v$.

Note that in a two-period setting, $v = (1 + r)/(1 + \mu)$, since \$1 of private investment at t yields \$$(1 + r)$ of consumption at $t + 1$, which is discounted at μ. Hence in the case $a = 1, \alpha = 0$, the second-best rule reduces to the Harberger version of the opportunity cost rule: invest if, and only if, $z \geq r$.

- When $\alpha = 0$ but $0 < a < 1$, and when $\mu = i$, the consumer rate of interest, then the second-best rule becomes the D. Ramsey version of the opportunity cost rule: invest if, and only if,

  $$(1 + z) \geq (1 + i)\,[1 + a\,\{(1 + r)/(1 + i) - 1\}]$$

  which reduces to: invest if, and only if, $z \geq ar + (1 - a)i$.
- When $a = 0, \alpha = 1$, then the funding of government projects can be justified even when $z < \mu$, since the second-best rule becomes: invest if, and only if, $(1 + z) \geq (1 + \mu)/v$, where generally, $v > 1$, so that the social rate of discount (the rate of return on the marginal government project) can be less than μ.

This represents a very brief summary of the second-best and opportunity cost positions with respect to the social rate of discount. The economics literature almost without exception implicitly identifies the social rate of discount with the government rate of discount. However, as we wish to show below, there are good reasons for drawing a clear distinction between these two concepts.

V. THE CHOICE OF A GOVERNMENT DISCOUNT RATE: EXTENSION

THE GOVERNMENT DISCOUNT RATE IN A THIRD-BEST WORLD

In the second-best literature, government spending is the control variable and is chosen to maximize social welfare, given the distortions in the economy due to the corporate income tax. The social rate of discount *d* is obtained for simply as a by-product of the maximization process, representing the rate of return on the marginal dollar of government spending at a steady-state optimum. A project is funded at a second-best optimum if and only if the net benefits of the project are positive, using the social rate of discount as the discount rate.

The role of government in the second-best literature is highly idealized. In reality, the level of government investment spending is the result of a complicated political process in which economic efficiency is only one of many factors. In contrast to the second-best view, the third-best approach treats the level of government investment spending as exogenously fixed, on the basis of political or fiscal policy considerations, independently of the characteristics of projects making up the portfolio of prospective candidates for government investment spending. In legislative bills and executive orders dealing with cost-benefit studies of government projects, the rule that the cost-benefit ratio must be greater than one is only a necessary condition for a project to be funded, but not a sufficient condition. Thus, in reality, the cost-benefit test acts only as a filter. The consequence is that at any point in time, there is in existence an inventory of proposed government projects, all of which have passed the minimum cost-benefit test, but have not yet been funded. This creates potential inefficiencies, since the political process can lead to the funding of relatively low-return projects (which have passed the cost-benefit test) rather than relatively high-return projects.

This leads into a role for the government rate of discount *g* different from that envisaged for the social rate of discount *d*. Discount *d* is chosen so that government expenditures are at a second-best optimum level. Discount *g* is chosen so that, given the level of government expenditures, the optimum portfolio of projects is funded.

The third-best approach thus provides an answer to the problem of choosing a rate of discount to apply to government projects to maximize social welfare, given that the level of the government investment spending is some predetermined fixed amount. The role of the discount rate is solely to identify the "correct" projects to fund, not to determine the "correct" amount to spend on investment projects.

What the third-best approach argues concerning the choice of a discount rate to accomplish this objective is the following:

Assuming fungibility,[1] independence of the time streams of net benefits associated with projects, and divisibility and scaling of projects, the appropriate approach is to calculate the opportunity cost rate of return associated with the portfolio of potential government projects (based on the level of funding of government investment spending), and to use this as a discount rate. Projects should be funded if and only if the discounted present value of net benefits associated with a project are positive, using the opportunity cost rate of return as the government discount rate.

In turn, at a steady-state optimum, the opportunity cost rate of return is the maximum rate of return that can be earned from investing an additional dollar in the portfolio of unfunded projects, subject to the constraint that the aggregate investment expenditure associated with the portfolio of funded projects is equal to the amount of investment funds available under the predetermined budget. Note that among the unfunded projects might be the "market" project, if the government is permitted to use some of its available funds to invest in opportunities in the private sector.

Our main interest is in the case of a steady-state optimum. However, to illustrate the difference between the opportunity cost rate of return approach and other approaches, we will use the following simple, non-steady-state example. Suppose that the government has set aside \$1 for investment, to be allocated over a two-period horizon. At time 0, the portfolio is:

Project	Payoff $t = 0$	Payoff $t = 1$	Payoff $t = 2$
A	–\$1	\$3	0
B	–\$1	0	\$9
C	–\$1	\$2	0
D	0	–\$1	\$2

[1]By fungibility we mean that returns can be reallocated over time at some determinable rate of return.

Note that the internal rate of return on project A is 200 percent, as is the internal rate of return on project B. Projects C and D can be thought of as "market" projects; on the market, a rate of return of 100 percent is always available. What does the opportunity cost rate of return approach imply about the investment decision? Using the opportunity cost rate of return approach, project B is funded. With project B funded, the portfolio of unfunded projects consists of A, C, and D. The opportunity cost rate of return in this case turns out to be a vector (200, 100). That is, the opportunity cost rate of discount in the second period is the market rate (100 percent) because it is the only rate of return available on invested capital at $t = 1$. The first period opportunity cost rate of discount is 200 percent, achieved by investing in project A. Using the opportunity cost rate of return vector as the discount rate vector, the discounted present value (DPV) of net benefits under project B is +\$.50, the DPV of net benefits of project A or D is 0, and the DPV of net benefits of project C is −\$.33. Thus, using the vector (200, 100) as the government discount rate vector implies that funding projects if and only if their DPV of net benefits is positive exhausts the investment funds available. Moreover, the vector gives us the maximum rate of return in each period from investments available from the portfolio of unfunded projects.

To show that the opportunity cost rate of return is the appropriate approach to the problem of choosing a portfolio, we use a simple dominance argument. Suppose that project A were chosen instead of B, offering \$3 at $t = 1$ and \$0 at $t = 2$, rather than the \$9 at time 2 under project B. Why is B a preferred choice relative to A? The reason is that since the market alternative is available at $t = 1$, the time stream available under project B can be changed from (−1, 0, 9) to (−1, 4.5, 0), because the market alternative is available to convert a $t = 2$ benefit of 9 into a benefit of 4.5 at $t = 1$ (providing a 100 percent rate of return to market participants). Hence, by investing in B, we can generate a time stream of net benefits that dominates the time stream under A. The same argument applies for B relative to C or D, hence B is certainly the preferred alternative.

This holds in general for the case of allocating a fixed initial sum of money over a T-period horizon. Let M denote the amount of money available for investment at time $t = 0$. Suppose that at each point in time, the same portfolio of projects is available. Each project in the portfolio offers a certain stream of net benefits for T periods into the future, following an investment of \$1 in the current period. Because we are truncating the horizon, only payoffs up to and including $t = T$ are relevant to the decisionmaker. Let S denote the index set of projects, where $S = (1, \ldots, N)$. Let m^{it} denote the time stream associated with project i, involving an investment of \$1 at time t, so that m^{it} can be written as

$$m^{it} = (-1, m_{t+1}^{it}, \ldots, m_T^{it}) \ .$$

Let S_F denote the index set of funded projects using the opportunity cost rate of return rule, whereas S_U denotes the set of unfunded projects.

At $t = T - 1$, the best available opportunity is that unfunded project that offers the highest net benefit at time T for a \$1 investment at time $T - 1$. Hence, if r_T^* denotes the opportunity cost rate of discount for the Tth period (from $T - 1$ to T), then r_T^* satisfies

$$r_T^* = \max_{i \epsilon S_U} m_T^{iT-1} - 1,$$

where m_T^{iT-1} is the net benefit at time T of a \$1 investment in project i at time $T - 1$. Equivalently, r_T^* is the internal rate of return on the maximal project available at time $T - 1$:

$$-1 + (\max_{i \epsilon S_U} m_T^{iT-1})/(1 + r_T^*) = 0 \ .$$

At time $T - 2$, the best available unfunded project is that project that produces the maximum discounted present value of net benefits at $T - 1$, using r_T^* to discount benefits received at T back to $T - 1$. Thus r_{T-1}^*, the opportunity cost rate of return for the $T - 1$st period, is given by

$$r_{T-1}^* = \max_{i \epsilon S_U} \{m_{T-1}^{iT-2} + (m_T^{iT-2})/(1 + r_T^*)\} - 1 \ .$$

Again, equivalently, the vector (r_{T-1}^*, r_T^*) satisfies

$$-1 + \max_{i \epsilon S_U} \{(m_{T-1}^{iT-2})/(1 + r_{T-1}^*) + (m_T^{iT-2})/(1 + r_{T-1}^*)(1 + r_T^*)\} = 0 \ .$$

In general, let r^* denote the opportunity cost rate of return vector, with $r^* = (r_1^*, \ldots, r_T^*)$. Then r^* satisfies the property that at any point in time t, the vector $(r_{t+1}^*, \ldots, r_T^*)$ is such that

$$\max_{i \epsilon S_U} DPV^i \ (r_{t+1}^*, \ldots, r_T^*) = 0 \ .$$

Given the opportunity cost rate of return vector derived as above, the following proposition is immediate.

Proposition 1

Assume that the government operates with a T-period horizon. Let M denote the amount of money available for government investment at time $t = 0$ under a one-shot investment plan, and let r^* denote the opportunity cost rate of return vector calculated as above and associated with the portfolio of projects S_F chosen under the opportunity rate of return rule. Then this portfolio maximizes social welfare.

Proposition 1 should be viewed as a simple extension of the classical Fisherian argument regarding the separability of investment decisions on the part of a consumer from the consumer's time preferences with respect to consumption in the case of a perfect lending market. Regardless of a consumer's time preferences, the optimal investment rule for the consumer is to invest only in assets for which the discounted present value of income equals or exceeds the cost of the asset, using the consumer rate of interest as the discount rate. (Note that in the case of a perfect lending market, the consumer rate of interest is the opportunity cost rate of return for the consumer.) If the consumer faces some binding constraint on his savings such that he cannot achieve a first-best savings-investment optimum, then according to Proposition 1, he should use the opportunity cost rate of return associated with his constrained savings level, rather than the market rate of interest, as the discount rate in evaluating alternative assets.

A natural extension of Proposition 1 is to the case in which there is an active budget constraint on investment expenditures in each period. Given a T-period horizon, let M_t denote the maximum allowable level of expenditures at time t. Again, suppose that there are N possible projects, each involving an expenditure of \$1 in the first period of funding, with the same portfolio of projects available at each point in time t.

Let $m^{it} = (-1, m^{it}_{t+1}, \ldots, m^{it}_T)$ denote the time stream of net benefits from investing \$1 in project i at time t.

Let $m^{it}_s = b^{it}_s - c^{it}_s$ for $s = t, t+1, \ldots, T$, where b denotes benefits and c denotes committed expenditures ($b^{it}_t = 0$, $c^{it}_t = -1$).

Let S^t_I denote the set of projects initiated at time t, and let S^t_U denote the set of projects available but not initiated at time t. The budget constraint at t is then given by

$$M_t \geq \sum_{s=1}^{t} \sum_{i \epsilon S^s_I} c^{is}_t \quad t = 1, \ldots, T-1 \; .$$

At time $T - 1$, M_{T-1} is the available funding, and

$$\sum_{s=1}^{T-2} \sum_{i \epsilon S^s_I} c^{is}_{T-1}$$

is the already committed expenditure level at $T - 1$ based on early investment decisions. S_F^{T-1} consists of those projects with highest values of m_T^{iT-1} such that the total expenditure on such projects exhausts the budget at $T - 1$, i.e., S_F^{T-1} is chosen so that

$$\sum_{i \epsilon S_F} c_{T-1}^{iT-1} = M_{T-1} - \sum_{s=1}^{T-2} \sum_{i \epsilon S_F^s} c_{T-1}^{is}$$

The opportunity cost rate of return in the Tth period (the period from $T - 1$ to T) r_T^* then satisfies

$$r_T^* = \max_{i \epsilon S_U^{T-1}} m_T^{iT-1} - 1$$

At $T - 2$, the budget constraint is given by

$$M_{T-2} \geq \sum_{s=1}^{T-2} \sum_{i \epsilon S_F^s} c_{T-2}^{is}$$

Projects to be initiated are those with positive discounted present values DPV_{T-2}^i, where

$$DPV_{T-2}^i = -1 + m_{T-1}^{iT-2}/(1 + r_{T-1}^*) + m_T^{iT-2}/(1 + r_{T-1}^*)(1 + r_T^*)$$

where

$$r_{T-1}^* = \max_{i \epsilon \hat{S}_U^{T-2}} \{m_{T-1}^{iT-2} + m_T^{iT-2}/(1 + r_T^*)\} - 1$$

Here $\hat{S}_U^{T-2}$ is the set of projects available at time $T - 2$ but not initiated such that for any such project, the budget constraint at any future time is not violated.

In general, at time t, with budget constraint

$$M_t = \sum_{s=1}^{t} \sum_{i \epsilon S_F^s} c_t^{is}$$

projects are funded with $DPV_t^i\ (r_{t+1}^*, r_{t+2}^*, \ldots, r_T^*) > 0$, where

$$DPV_t^i = -1 + \sum_{s=t+1}^{T} m_s^{it} / \prod_{j=t+1}^{s} (1 + r_j^*)$$

and r^* satisfies $\max\limits_{i \epsilon \hat{S}_U^t} \{DPV_t^i(r_{t+1}^*, \ldots, r_T^*)\} = 0$,

where $\hat{S}_U^t$ is the set of projects available at time t but not initiated, so that for any such project no budget constraint from time $t + 1$ on is violated.

The opportunity cost rate of return vector r^* and the portfolio vector $(S_F^o, \ldots, S_F^{T-1})$ are thus chosen simultaneously so that the budget constraints are all satisfied and so that

$$i \epsilon S_F^t \quad \text{if } DPV^i\,(r_{t+1}^*, \ldots, r_T^*) > 0, \text{ while}$$

$$i \epsilon S_U^t \quad \text{if } DPV\,(.) < 0 \ .$$

An argument identical in all relevant respects to that underlying Proposition 1 may be used to establish Proposition 2.

Proposition 2

Assume that the government operates with a T-period horizon. Let M_t denote the amount of money available for government investment at time t, and let r^* denote the opportunity cost rate of return vector calculated as above and associated with the sequence of portfolios chosen under the opportunity cost rate of return rule. Then this portfolio maximizes social welfare.

Note that to the extent that choosing a project at time t leads to a tighter budget constraint in future periods, this acts to increase the opportunity cost rate of return in those later periods. All of the effects of the budget constraints are incorporated into the opportunity cost rate of return vector.

It should be made clear that the choice of projects to fund at any point in time t depends upon all previous choices of projects to fund, since the commitments under the earlier choices act together with the given funding limits to determine the relevant constraint set at any later date. The use of the backwards oriented dynamic programming approach may perhaps obscure the fact that all project choices are in fact made at time o; all information about constraint sets and the objective function is known at that time.[2]

Finally, in the steady-state case the finite horizon is replaced by an infinite horizon and it is assumed that the amount of funding available is constant at each point in time. It is easy to verify that the opportunity cost rate of return is constant over time, with the portfolio also being constant. Again, we can formalize this as follows.

[2]As was pointed out by one referee, the intertemporal dependence inherent in the third-best problem could be exhibited explicitly by an appropriate indexing notation, and the approach could be extended to cases in which lumpiness occurs. For notational simplicity and ease of interpretation of the model, we have retained our less explicit notation as applied to a world of divisible and scalable projects.

Proposition 3

Assume that the government operates with an infinite planning horizon. Let M denote the amount of money available for government investment at time t, assumed to be a constant independent of t. Then the opportunity cost rate of return is a constant over time, being such that

$$\max_{i \epsilon S_U} [\lim_{T \to \infty} DPV^i(r^*)] = 0$$

where

$$DPV^i(r^*) = -1 + \sum_{s=1}^{T} m_s^i/(1 + r^*)^s$$

and where S_F, the portfolio of funded projects, is constant over time, satisfying the conditions that

$$\sum_{i \epsilon S_F} c_t^i = M \text{ for all } t,$$

$$\lim_{t \to \infty} DPV^i(r^*) \geq 0 \text{ for } i \epsilon S_F \ .$$

The third-best rule reduces to the second-best rule if the level of government investment spending is set at the second-best steady-state optimum level, since the marginal government investment earns the opportunity cost rate of return in both cases. If government investment spending is less than the second-best optimum level, the government discount rate g under the third-best opportunity cost rate of return rule will be higher than the social rate of discount d. And $g < d$ if government investment spending exceeds the second-best optimum level, with the discount rate varying inversely with the constrained level of government investment spending. Because a high discount rate can lead to equity problems, discriminating against future generations, a Pareto superior strategy requires the funding of offsetting investment programs to provide the additional capital stocks needed to compensate future generations for costs imposed on them by the present generation.

QUALIFICATIONS TO THE THIRD-BEST APPROACH

The derivation of the government rate of discount as the opportunity cost rate of return in the third-best case assumes independence, divisibility, scaling, and fungibility of projects in the portfolio available to the government. The same is true of the second-best approach as well, of course, since the third-best approach reduces to the second-best if the level of government investment spending is set at its (second-best) optimal level. Violation of any of the underlying conditions can lead to significant changes in the choice of a discount rate for evaluating government projects.

Suppose, for example, that project costs and benefits are entirely nonfungible. In this case, the appropriate discount rate to use in comparing projects is the social rate of time preference, since what are being compared are streams of consumption. The third-best approach then becomes one of investing in projects on the basis of discounted present value of net benefits, using the social rate of time preference as the discount rate. The level of government investment spending determines a cut-off level of DPV, say DPV*, with all projects that are funded having DPV $\geq$ DPV*, and all unfunded projects having DPV $\leq$ DPV*. Fungibility is certainly an issue in many government projects, especially those involving public goods. However, in principle, positive net benefits could be taxed away from the recipients and subsidies could be paid in the case of negative net benefits, to render any government project fungible. The "in principle" proviso is important, however; excess burden losses associated with tax-subsidy schemes could overwhelm any efficiency gains from inducing fungibility, and the payment of subsidies could lead to a violation of the budget constraints that are an essential part of the third-best framework. On the other hand, it is not required that projects be perfectly fungible to establish the propositions above; there need only be sufficient fungibility at the margin to accomplish the intertemporal shifts of net benefits needed to generate a dominating net benefit stream. Fungibility is an important empirical issue that deserves further study.

Independence, divisibility, and scaling of projects are interrelated concepts. Independence means that the net benefit time stream associated with a project is the same, whatever is the portfolio of projects being funded. For example, if one project available to the government is to lease a warehouse and a second project is to buy the same warehouse, clearly independence is violated, since the net benefits from leasing depend on whether a warehouse is bought and vice versa. When there are dependencies among projects, one method of preserving the independence assumption is to aggregate over dependent projects, but this leads to a violation of the divisibility assumption. Scaling assumes that net benefit streams can be scaled upward or downward proportionately according to the amount invested, which is also a restrictive assumption concerning government projects. It is true that the third-best approach could, in principle, be revised to incorporate a somewhat more general framework covering cases of lumpiness and dependence among projects, and lack of scaling, but this would lead to a much more cumbersome formulation. This extension will not be attempted here.

There are two other important issues concerning the choice of a government discount rate in the fashion outlined above. First, it is well known that cost and benefit calculations are highly unreliable. As a consequence, there can be legitimate differences of opinion among knowledgeable individuals as to the appropriate merit ranking of proposed projects for a given government discount rate. In the approach outlined above, it was implicitly assumed that cost-benefit calculations provided accurate measures of the net social benefits of projects, so that projects should be funded in strict merit ranking order. Given the variability of cost and benefit estimates, it makes sense to introduce some flexibility into the choice procedure over projects, by setting the government discount rate somewhat lower than would be the case under a strict interpretation of the approach we have suggested. The amount of flexibility that should be built into the procedure would depend on the variability and bias of cost and benefit estimates, together with information on attitudes toward risk also built into the choice procedure. In any case, there certainly are convincing arguments for building some degree of flexibility into the choice process.

A second critical issue is the manipulability of the estimates for cost-benefit streams. Cost and benefit estimates are inherently uncertain. Moreover, even under the best of conditions, it is difficult to test the validity of the estimates (and especially benefit estimates). Finally, costs and benefits for a project may extend far into the future. For all of these reasons, the estimates chosen for the calculation may more than likely represent a "success-oriented scenario" than an objective expected scenario. The extent of such biases will be significantly influenced by the level of the government discount rate, when the discount rate is prespecified and known beforehand. In fact, one would expect a backlog of unfunded government projects under the current procedure, where such conditions prevail.

Another source of bias is a sample selection or "winner's curse" phenomenon. Even with unbiased estimates of net benefits, rational risk averse decisionmakers will include more projects in their portfolios with overestimates of net benefits than underestimates (see Quirk and Terasawa, 1986). On the other hand, when the discount rate is not prespecified, but it depends on the opportunity cost rate of return derived from the portfolio of unfunded projects as in the third-best approach, the nature and the degree of manipulation are quite different.

The current procedure imposes a 10 percent real rate to all projects, and gives proponents of projects a clear incentive to manipulate their estimates of benefits and costs so as to achieve a rate of return in excess of 10 percent. Under an opportunity cost rate of return approach, projects with positive net benefits discounted using that rate are automatically funded (ignoring flexibility margins). Hence there would be an incentive to engage in selective manipulation—to move an agency's most preferred projects to the head of the merit-ranking line.

There are no certain ways to eliminate this problem. However, one obvious possibility is to assign the task of evaluating (and perhaps performing) cost-benefit studies to an independent agency. In fact, this is recommended regardless of what approach is taken to the problem of choosing a discount rate for government projects. If the process of estimating costs and benefits is not reformed, no procedure will produce an efficient use of government investment funds.

Incentive compatible mechanisms should be investigated for possible application to the cost-benefit estimation problem to determine, e.g., if procedures can be altered to induce truthful revelation (or accurate reporting) of costs and benefits. The significant feature of revelation schemes, such as in the Vickrey-second-price auction and the Groves-Ledyard public goods mechanism, is that no participant can a priori influence the size of his own reward. In fact, the size of reward is determined by the actions of others that he cannot control. However, the issues of how best to elicit truthful information from the various participants in this particular investment, and how the information derived compares with that provided under current procedures, have not been fully investigated and require careful examination.[3]

It also is true that there are difficult problems of making comparisons between projects in different investment areas (e.g., defense versus highway projects), so that from a practical point of view, the third-best approach might better be applied within budget categories rather than across the whole range of government investment options. There are also computational and data allocation problems involved in implementing the third-best approach, given the vast number of proposed government projects to be examined. But it is important that approximations to the opportunity cost rate of return, based on believable cost-benefit estimates, be available to government decisionmakers if an efficient allocation of a specified government budget is to be achieved.

[3]Among other issues relating to truthful revelation are the costs associated with introducing incentive compatible systems, and the provision of incentives for discovering the true prospective time stream of costs and benefits.

RISK AND UNCERTAINTY

We have left to the last the discussion of the role of risk and uncertainty in specifying the social rate of discount or the government rate of discount. There has been a lively debate on this dating back to Hirshleifer's work in the early 1960s. We will not attempt to summarize that debate here since much has already been captured in the literature review. Instead we will state what appears to be a more or less consensus view concerning the risk problem.

This view is the following: Except for extraordinary cases, the social rate of discount on a risky government project should be the private risk-free rate of return on a comparable project, and net benefits of any project should be evaluated on the basis of their expected values. The extraordinary cases are cases in which the net benefits from a project are strongly correlated with national income; if the correlation is strongly negative, then the social discount rate for the project should be less than the private risk-free rate, and if the correlation is strongly positive, then the social discount rate should be greater than the private risk-free rate.

The argument underlying this is essentially the pooling argument. If the net benefits from different projects are mutually independent, then the law of large numbers can be invoked to argue that the net benefit from a sufficiently large portfolio of projects is essentially certain. Moreover, with the development of mutual funds and other private pooling devices, there appears to be no strong reason to believe that the government has special advantages over private markets in efficient pooling. Hence, on opportunity cost grounds, government projects should be evaluated and discounted on the same basis as comparable private projects. The need to adjust the social discount rate for high negative or positive covariances of net benefits with national income is also clear.

It might be asked why the private "risk-free" rate is appropriate rather than, say, the government Treasury bill rate? The answer is that the Treasury bill rate is really too risk-free, as Pauly has noted. Because the government can print currency, there is no default risk on Treasury bills. There is even no risk when calamities occur that lower the rate of return on essentially all projects in the society, as during a war or depression. In other words, Pauly argues that no private project can be completely default risk-free, since no private firm has the right to print legal tender to pay off its creditors. The problem is that the social risks of government projects funded through the sale of Treasury bills have to be borne by someone, and those are the taxpayers of the country. The appropriate risk-free rate to use is one that reflects social risks but not private risks. Since the Treasury bill rate excludes both of these, the private "risk-free" rate is a better rate to use. Although all of these arguments are again, strictly speaking, appropriate to a steady-state second-best optimum, they appear to represent the best available approach to adjustments for risk in the government rate of discount as well.

Applying this approach to a third-best world, except in extraordinary cases, the government ratio of discount should be equal to the private market risk-free rate on a project comparable to the marginal government project, and the expected value of discounted net benefits should be the criterion function for choosing the government project portfolio. Once again, there is a simultaneous choice of a portfolio and a discount rate, with projects being funded if discounted expected net benefits are positive (using the private market risk-free rate on the marginal project as the discount rate).

VI. CONCLUSIONS

- If the government discount rate is used to determine the level of government investment spending that will maximize intergenerational social welfare, the approach taken by the second-best theorists is indisputable. However, it is a formidable task to implement because of problems associated with evaluating the social rate of time preference.
  - The use of the consumer rate of interest (i) as the social rate of time preference can be justified in only very special circumstances; the ethical issues involved in choice of a social rate of time preference are not easily resolved.
  - There seems to be a consensus that there can be a multiplicity of social discount rates (d) depending on the nature of the finances, risks, and the degree of spillover effects of a given project.
  - The "opportunity cost" school approach can be derived as a special case of a more general "second-best approach."
  - The "shadow price approach," as generalized by Bradford and refined by Lind, is *formally equivalent to* the second-best approach. Although it uses a uniform discount rate (social rate of time preference), the approach adjusts the special features of individual cases by the choice of multipliers to compute consumption-equivalent costs and benefits.
- On the other hand, if the discount rate is used to *filter government projects, rather than to determine the level of government investment expenditure*, existing theories do *not* adequately address the problem. This is a "third-best" situation, and the discount rate needed is what we call the government opportunity cost rate (g). The government opportunity cost rate equals the social discount rate (d), if available government funding is equal to the optimum. However, if government funding differs from the second-best optimum, the government opportunity cost rate differs from d, and equals the highest rate of return that can be earned from the *portfolio of unfunded government projects*.
- The third-best approach is based purely on efficiency grounds, and hence does not require information regarding the social rate of time preference. By the same token, it does not address important equity issues. We believe these issues can better be addressed outside the framework of cost-benefit analysis.

- It is essential that unbiased estimates of costs and benefits be available whatever the approach taken to choice of a discount rate. Studies should be made of the incentives-compatible institutional arrangements that will induce more objective and accurate reporting of costs and budgets. Consideration should be given to strengthening the role of independent agencies in evaluating cost-benefit estimates prepared for government projects.
- Given that believable cost-benefit estimates can be produced, the opportunity cost rate of return should be calculated each year to measure the efficiency losses that choice of a portfolio other than the *third-best entails*. Ideally, from the point of view of economic efficiency, given reliable cost-benefit estimates, the discount rate would be set equal to the opportunity cost rate of return g, and a project would be funded if and only if its discounted present value was positive, using g as the discount rate.

BIBLIOGRAPHY

Arrow, K., "The Rate of Discount on Public Investments with Imperfect Capital Markets," in R. Lind (ed.), *Discounting for Time and Risk in Energy Policy*, Johns Hopkins University Press for Resources for the Future, Baltimore, Maryland, 1982, pp. 115–136.

——, "Discounting and Public Investment," in A. Kneese and S. Smith (eds.), *Water Research*, Johns Hopkins University Press for Resources for the Future, Baltimore, Maryland, 1966, pp. 13–32.

——, *Social Choice and Individual Values*, Cowles Foundation for Research in Economics, Yale University, Monograph 12, 1963.

——, and M. Kurz, *Public Investment, the Rate of Return, and Optimal Fiscal Policy*, Johns Hopkins University Press for Resources for the Future, Baltimore, Maryland, 1970.

——, and R. Lind, "Uncertainty and Evaluation of Public Investment Decisions," *American Economic Review*, 60, 1970, pp. 364–378.

Ballard, C., J. Shoven, and J. Whalley, "General Equilibrium Computations of the Marginal Welfare Costs of Taxes in the United States," *American Economic Review*, 75, 1983, pp. 128–138.

Baumol, W., "On the Social Rate of Discount: Comment on the Comments," *American Economic Review*, 60, 1970, p. 930.

——, "On the Discount Rate for Public Projects," *The Analysis and Evaluation of Public Expenditures: The PPB System*, Joint Economic Committee, 91st Congress, 1st sess., Washington, D.C., 1969, pp. 489–503.

——, "On the Social Rate of Discount," *American Economic Review*, 58, 1968, pp. 788–802.

Bradford, D., "Constraints on Government Investment Opportunities and the Choice of Discount Rate," *American Economic Review*, 65, 1975, pp. 887–900.

Broadway, R., *Public Sector Economics*, Winthrop Publishers, Inc., Cambridge, Massachusetts, 1979.

——, "Integrating Equity and Efficiency in Applied Welfare Economics," *Quarterly Journal of Economics*, November 1976.

Broome, J., "Trying to Value a Life," *Journal of Public Economics*, February 1978.

Browning, E., "The Marginal Cost of Public Funds," *Journal of Political Economy*, 84, 1976, pp. 283–298.

Buchanan, J., and R. Faith, "Trying Again to Value a Life," *Journal of Public Economics*, October 1979.

Burness, H. Stuart, "Impatience and the Preference for Advancement in the Timing of Satisfactions," *Journal of Economic Theory*, Vol. 6, 1973.

Cass, D., "Optimum Growth in an Aggregative Model of Capital Accumulation," *Review of Economic Studies,* 1965, pp. 233–240.

d'Arge, W., D. Schulze, and D. Brookshire, "Benefit-Cost Valuation of Long-Term Future Effects: The Case of CO_2," Workshop on the Methodology for Impact Analysis of Climate Change, Ft. Lauderdale, Florida, April 1980.

Dasgupta, P., "Resources Depletion, Research and Development, and the Social Rate of Return," in R. Lind (ed.), *Discounting for Time and Risk in Energy Policy*, Johns Hopkins University Press for Resources for the Future, Baltimore, Maryland, 1982, pp. 273–305.

Diamond, P., and D. McFadden, "Some Uses of the Expenditure Function in Public Finance," *Journal of Public Economics*, February 1974.

——, "The Opportunity Costs of Public Investment: Comment," *Quarterly Journal of Economics,* 82, 1968, pp. 682–687.

Dinneen, P. M., and T. H. Quinn, *Improving Milsatcom Acquisition Outcomes: Lease Versus Buy*, The RAND Corporation, N-2209-AF, January 1985.

Dixit, A., "Welfare Effects of Tax and Price Changes," *Journal of Public Economics*, February 1975.

Dreze, J., "Discount Rates and Public Investments: A Post Scriptum," *Economica*, 1974, pp. 52–61.

——, and A. Sandmo, "Discount Rates for Public Investment in Closed and Open Economies," *Economica*, 1971, pp. 395–412.

Eckstein, O., *Water Resource Development: The Economics of Project Evaluation*, Harvard University Press, Cambridge, Massachusetts, 1958.

Feldstein, M., "Does the United States Save Too Little?" *American Economic Review*, 67, 1977, pp. 116–121.

——, "The Inadequacy of Weighted Discount Rates," in R. Layard (ed.), *Cost-Benefit Analysis*, Penguin Education Books Ltd., Harmondsworth, Middlesex, England, 1972.

Fisher, A., "A Paradox in the Theory of Public Investment," *Journal of Public Economics,* 2, 1973, pp. 405–407.

Foldes, L., and R. Rees, "A Note on the Arrow-Lind Theorem," *American Economic Review,* 67, 1977, pp. 188–193.

Gale, David, "On Optimal Development in a Multi-Sector Economy," *Review of Economic Studies*, Vol. 34, 1967, pp. 1–19.

Hanke, Steve H., and James B. Anwyll, "On the Discount Rate Controversy," *Public Policy*, 28, 1980, pp. 171–183.

Hanke, S., and G. Mumy, "Public Investment Criteria for Underpriced Public Projects," *American Economic Review*, September 1975.

Harberger, A. C., *Project Evaluation: Collected Papers*, Markham Publishing Co., Chicago, 1974.

——, "Three Postulates for Applied Welfare Economics," *Journal of Economic Literature*, September 1971.

Haveman, R., "Policy Analysis and the Congress: An Economist's View," in R. Haveman and J. Margolis (eds.), *Public Expenditure and Policy Analysis*, 2d ed., Rand McNally College Publishing Co., Chicago, 1977.

Hirshleifer, J., "Investment Decisions under Uncertainty: Applications of the State-Preference Approach," *Quarterly Journal of Economics*, 30, 1966, pp. 252–277.

——, "Efficient Allocation of Capital in an Uncertain World," *American Economic Review*, 54, 1964, pp. 77–85.

——, J. DeHaven, and J. Milliman, *Water Supply: Economics, Technology, and Policy*, University of Chicago Press, Chicago, 1960.

James, E., "A Note on Uncertainty and the Evaluation of Public Investment Decisions," *American Economic Review*, March 1975.

Jones-Lee, M., "Trying to Value a Life: Why Broome Does Not Sweep Clean," *Journal of Public Economics*, October 1979.

Kneese, A., "Research Goals and Progress Toward Them," in H. Jarret (ed.), *Environmental Quality in a Growing Economy*, Johns Hopkins Press, Washington, D.C., 1966.

Kneese, A., S. Ben-David, D. Brookshire, W. Schulze, and D. Bolt, "Long-term Nuclear Waste Storage: An Economic and Ethical Perspective," Working Paper, Department of Economics, University of Wyoming, Laramie, 1983.

Koopmans, Tjalling C., "Stationary Ordinal Utility and Impatience," *Econometrica*, Vol. 28, No. 2, April 1960.

Layard, R. (ed.), *Cost-Benefit Analysis*, Penguin Education Books Ltd., Harmondsworth, Middlesex, England, 1972.

Lind, R. (ed.), *Discounting for Time and Risk in Energy Policy*, Johns Hopkins University Press for Resources for the Future, Baltimore, Maryland, 1982.

——, "Further Comment," *Quarterly Journal of Economics*, 78, 1964.

Marglin, S., "The Opportunity Cost of Public Investment," *Quarterly Journal of Economics*, 78, 1963a, pp. 274–289.

——, "The Social Rate of Discount and the Optimal Rate of Investment," *Quarterly Journal of Economics*, 78, 1963b, pp. 95–111.

McKean, R. N., "Tax Wedges and Cost-Benefit Analysis," *Journal of Public Economics*, February 1974.

——, *Efficiency of Government through Systems Analysis*, John Wiley & Sons, Inc., New York, 1958.

McKensie, G., "Measuring Gains and Losses," *Journal of Political Economy*, June 1976.

Mishan, E. J., *Cost-Benefit Analysis*, Praeger Publishers, new and expanded edition, New York, 1976.

Moss, W., "Some Uses of the Expenditure Function in Public Finance: A Comment," *Journal of Public Economics*, April–May 1976.

Oiesen, J. F., *A Theoretical Justification of Cost-Benefit Analysis*, Staff Study: draft report No. 55-213-U9-5, U.S. Department of Transportation, Transportation Systems Center, Cambridge, Massachusetts.

Patinkin, D., "Demand Curves and Consumer's Surplus," in C. Christ et al. (eds.), *Measurement in Economics*, Stanford University Press, Stanford, California, 1963.

Pauly, M., "Risk and the Social Rate of Discount," *American Economic Review*, 60, 1970, pp. 195–198.

Peck, M., and F. Scherer, *The Weapons Acquisition Process: An Economic Analysis*, Harvard University, Division of Research, Graduate School of Business Administration, 1962.

Pestieau, P., "Optimal Taxation and Discount Rate for Public Investment in a Growth Setting," *Journal of Public Economics*, 3, 1974, pp. 217–235.

Quirk, J. P., and K. L. Terasawa, "Sample Selection and Cost Underestimation Bias in Pioneer Projects," *Land Economics*, Vol. 62, No. 2, May 1986.

Ramsey, D., "On the Social Rate of Discount: Comment," *American Economic Review*, 60, 1970, pp. 919–924.

Ramsey, F., "A Mathematical Theory of Saving," *Economic Journal*, 38, 1928, pp. 543–559.

Richter, D., "Games Pythagoreans Play," *Public Finance Quarterly*, October 1977.

Samuelson, P., "Constancy of the Margin Utility of Income," in O. Lang et al. (eds.), *Studies in Mathematical Economics and Econometrics: In Honor of Henry Schultz*, Books for Libraries Press, Plainview, New York, 1968.

——, "Comment," *American Economic Review*, 54, 1964, pp. 90–96.

Sandmo, A., "Discount Rates for Public Investment under Uncertainty," *International Economic Review*, 2, 1972, pp. 287–302.

Schick, A., "A Death in the Bureaucracy: The Demise of the Federal PPB," in R. Haveman and J. Margolis (eds.), *Public Expenditure and Policy Analysis*, 2d ed., Rand McNally College Publishing Co., Chicago, 1977.

Schulze, W., and D. Brookshire, "Intergenerational Ethics and Depletion of Fossil Fuels," in J. Quirk et al. (eds.), *Coal Models and Their Use in Government Planning*, Praeger Publishers, New York, 1982, Chap. 10.

Schulze, W., D. Brookshire, and T. Sandler, "The Social Rate of Discount for Nuclear Waste Storage: Economics or Ethics?" *National Resources Journal*, Vol. 21, 1981, p. 811.

Searde, J., "Consumer's Surplus and Linearity of Engel's Curves," *Economic Journal*, September 1978.

Sen, A., "Approaches to the Choice of Discount Rates for Social Benefit-Cost Analysis," in R. Lind (ed.), *Discounting for Time and Risk in Energy Policy*, Johns Hopkins University Press for Resources for the Future, Baltimore, Maryland, 1982, pp. 325–353.

——, "Isolation, Assurance, and the Social Rate of Discount," *Quarterly Journal of Economics*, February 1967.

——, "On Optimizing the Rate of Saving," *Economic Journal*, 71, 1961, pp. 479–496.

Shishko, Robert, *The Discount Rate for Defense Decisionmaking: Some New Considerations*, The RAND Corporation, P-6227, November 1978.

——, *Choosing the Discount Rate for Defense Decisionmaking*, The RAND Corporation, R-1953-RC, July 1976.

Sjaastad, L., and D. Wisecarver, "The Social Cost of Public Finance," *Journal of Political Economy*, 85, 1977, pp. 513–547.

Staats, E. G., "Survey of Use by Federal Agencies of the Discounting Technique in Evaluating Future Programs," in H. Hinricks and G. Taylor (eds.), *Program Budgeting and Benefit Cost Analysis*, Goodyear Publishing Co., Inc., Pacific Palisades, California, 1969.

Stiglitz, J., "The Rate of Discount for Benefit-Cost Analysis and the Theory of Second Best," in R. Lind (ed.), *Discounting for Time and Risk in Energy Policy*, Johns Hopkins University Press for Resources for the Future, Baltimore, Maryland, 1982, pp. 151–204.

——, "Taxation, Corporate Financial Policy, and the Cost of Capital," *Journal of Public Economics*, 2, 1973, pp. 1–34.

Stockfisch, J. A., "Measuring the Social Rate of Return on Private Investment," in R. Lind (ed.), *Discounting for Time and Risk in Energy Policy*, Johns Hopkins University Press for Resources for the Future, Baltimore, Maryland, 1982, pp. 257–271.

Stokey, E., and R. Zeckhauser, *A Primer for Policy Analysis*, W. W. Norton & Co., Inc., New York, 1978.

Stuart, C., "Welfare Costs per Dollar of Additional Tax Revenue in the U.S.," *American Economic Review*, 74, 1984, pp. 352–362.

Tipping, D., "Time Savings in Transport Studies," *Economic Journal*, December 1968.

Tullock, G., "The Social Rate of Discount and the Optimal Rate of Investment: A Comment," *Quarterly Journal of Economics*, 78, 1964, pp. 331–336.

Usher, D., "On the Social Rate of Discount: Comment," *American Economic Review*, 60, 1970, pp. 925–929.

Vickrey, W., "Comment," *American Economic Review*, 54, 1964, pp. 88–90.

Von Weizsäcker, C. C., "Existence of Optimal Programmes of Accumulation for an Infinite Time Horizon," *Review of Economic Studies*, Vol. 32, 1965.

Weisbrod, B., "Income Redistribution Effects and Benefit-Cost Analysis," in S. B. Chase, Jr. (ed.), *Problems in Public Expenditure Analysis*, The Brookings Institution, Washington, D.C., 1968.

Williams, A., "A Note on 'Trying to Value a Life,'" *Journal of Public Economics*, October 1979.

Willig, R., "Consumer's Surplus without Apology," *American Economic Review*, September 1976.

Wilson, R., "Risk Measurement of Public Projects," Johns Hopkins University Press for Resources for the Future, Baltimore, Maryland, 1982, pp. 205–249.

Wolfe, J. N., "The Inadequacy of Weighted Discount Rates," in R. Layard (ed.), *Cost-Benefit Analysis*, Penguin Education Books Ltd., Harmondsworth, Middlesex, England, 1972.

———, "The Social Time Preference Rate in Relation to the Market Rate of Interest," in R. Layard (ed.), *Cost-Benefit Analysis*, Penguin Education Books Ltd., Harmondsworth, Middlesex, England, 1972.

———, "The Opportunity Costs of Public Investment," *Quarterly Journal of Economics*, May 1963.