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Choosing a Government Discount Rate: An Alternative Approach

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This paper examines the choice of a government discount rate, under the reasonable assumption that the level of government spending is determined in a "top down" fashion, by macroeconomic and political considerations, rather than in a "bottom up" fashion. It is shown that setting the discount rate at the maximal internal rate of return available from unfunded government projects leads to an efficient portfolio choice. Under current and foreseeable conditions, this implies a discount rate in the 10% or more real range, rather than the 2–4% real discount rate recommended by second-best theorists.

1

In 1972, the Office of Management and Budget directed most federal agencies to apply a 10% real rate of discount when calculating the present value of the costs and benefits of federal projects (OMB Circular A-94). (There are certain exceptions to this rule, including water projects, as discussed in Lyon [5].) This directive is still in force, but over the past several years, there has been an ongoing discussion in OMB, GAO, and CBO concerning possible changes in the government discount rate. Given that, over the past 35 years, 91-day Treasury bills have averaged a real rate of return of slightly less than one percent, this suggests that the present government discount rate is above the level that should be used in evaluating projects. This in fact appears to be the position implicit in almost all of the existing economics literature dealing with the choice of a government discount rate, whether it follows the "second best approach (see Lind [3], for a detailed review of the second best approach), or the so-called "opportunity cost" approach as in Harberger [1], and Ramsey [7]. Papers by Lind [4], Lyon [5], Hartman [2], Moore and Viscusi [6], and Schegra [8] in the recent issue of this journal devoted to the discount rate question also arrive at this conclusion.

In the present paper, we outline an alternative view of the government discount rate problem, one that results in the somewhat surprising conclusion that, under current and foreseeable budget conditions, the government discount rate should be set even higher than the present 10% real rate, not lower. The argument presented here is that the problem the discount rate is designed to solve in practice is the problem of identifying the portfolio of projects the government should fund in order to maximize the net benefits of government expenditures to the society. For any given aggregate level of government expenditures, the discount rate that achieves this objective is what we call the "opportunity cost rate of return," which turns out to be, roughly, the maximal internal rate of return available from the

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portfolio of unfunded government projects. Because there is no apparent shortage of projects to be funded under current budget conditions, even given the 10% real discount rate, it is clear that the current opportunity cost rate of return exceeds 10% real, which leads to our paradoxical conclusion that the government discount rate should be set even higher than the 10% level.

We will show that, for any given government budget, our choice of a discount rate is strictly better than the choice of any other rate such as, for example, the consumer rate of interest, or the Treasury borrowing rate, or the "second best" discount rate involving a weighted average of the social rate of time preference and the pre-tax corporate rate of return, except in the trivial case in which the choices are equivalent to our approach. The approach outlined here is strictly better in the sense that if the discount rate is set equal to the opportunity cost rate of return, with all projects with positive present value at that rate being funded and with no project funded with negative present value, then the net benefit time stream associated with the portfolio chosen under this rule can be spread over time so as to potentially dominate any other feasible portfolio. That is, the net benefits under our portfolio can be chosen so that they are at least as large in every time period as those under any other feasible portfolio and are strictly larger in some time periods.

2

In his recent paper, Lind [4] agrees that our approach is correct, given that the level of government expenditures is fixed, but he objects that the level of government expenditures should be treated as endogenous; in fact, he points out that one of the objectives of the choice of a discount rate is to determine the "correct" level of the budget, and not simply the portfolio of projects given a fixed budget. This is selling our approach too short. Since, as Lind agrees, the correct choice of a discount rate, given any budget, is the opportunity cost rate of return as outlined here, then in deciding between, say, two different levels of government expenditures, the correct approach is as follows. One calculates the opportunity cost rate of return for each of the two budget levels and uses these to determine the efficient portfolios of projects associated with the two budget levels, with the corresponding time streams of net benefits. A decision is then made between the two levels of government budgets, based on the time streams of net benefits, using whatever welfare criteria appear to be relevant. It is only at the second stage, after the efficient portfolio has been identified, that the choice of the appropriate funding level can be made.

The point is that the opportunity cost rate of return is an essential input not only into the decision as to what portfolio of projects the government should fund, but also as to the level of the budget as well. There is no way that we can decide on an "optimal" level of government spending without also choosing an efficient portfolio of projects on which the optimal budget is to be expended. A necessary condition for an optimal choice of a level of government spending, or for the choice of a government discount rate to be "optimal," is that this discount rate produces an efficient portfolio of government projects.

It might be asked what the problem is with using the consumer rate of interest, or the Treasury bill rate, or a weighted average of the consumer rate of interest and the pre-tax corporate rate of return, as suggested in the existing literature. One simple answer is that none of these approaches allows the identification of the specific projects the government should fund. Instead, these approaches identify only a set of projects, each of which is acceptable in the sense of having a positive present value at the specified discount rate. The trouble is that, under current and presently foreseeable future conditions, the cost of funding the acceptable set exceeds the government budget, and there is no direction at all given as to how the best projects are to be separated out of those making up the acceptable set. The consequence is that the opportunity is available for the executive and legislative branches to fund worse projects when better are available, in response to log rolling and other political incentives. Thus using any of the various alternatives suggested in the current literature leads almost certainly to choices of projects based on political considerations, rather than on inherent economic merit.

The economic rationale underlying these approaches is also flawed. The intuitive argument for using a weighted average of the consumer rate of interest and the pre-tax corporate rate of return as the government discount rate is that this represents the opportunity cost of a government project, since if the project is not funded, the money can be employed in the private sector. But the true opportunity cost of a government project is the value of the best available opportunity foregone because of the project, not simply the value of any available opportunity foregone. Under budget conditions such that there are available unfunded government projects promising a rate of return exceeding 10%, the opportunity cost clearly exceeds 10% as well, rather than being equal to the lower rate of return that could be earned in the private market. The approach to be outlined in this paper is very much an opportunity cost approach, as is indicated by our terminology identifying the"opportunity cost rate of return" as the government discount rate, but we look at the true opportunity cost of a government project rather than simply at the rate of return that could be earned if the funds were returned to the private sector.

Another way of looking at the problem with the approaches suggested by the existing literature is this. The second best approach under which the government discount rate is to be set equal to a weighted average of the social rate of time preference (under certain conditions, equal to the consumer rate of interest) and the pre-tax corporate rate of return, is valid (maximizes the social welfare function) in an environment in which government projects are funded if and only if the present value of a project is positive at that discount rate. But in practice, the present value test is only a necessary condition for funding a project—projects cannot be funded if they do not have positive present value, but not all projects with positive present value are necessarily funded. The various alternatives suggested by the existing literature all simply ignore this fact and present arguments that are, in fact, valid only if the government actually funds all projects with positive present value.

In contrast, at a second best optimum, the government discount rate is also equal to the "opportunity cost rate of return" as defined in this paper, that is, the maximal internal rate of return available from the set of unfunded government projects. This follows because, at a second-best optimum level of government spending, the portfolio of projects chosen must be efficient. Thus the approach of the present paper is completely consistent with the second-best approach in the case in which the second-best approach is valid, namely, when the government budget is chosen optimally; and the approach of the present paper leads to a strictly better portfolio choice than the second-best approach for all other budget levels.[1]

One of the criticisms that Lind makes of our approach is that it is going to be extremely difficult to actually calculate the "opportunity cost rate of return" in practice. It is a fact that the government has never, to our knowledge, established a data bank identifying and keeping current all proposed and implemented projects, and no doubt the bookkeeping necessary to implement such a Herculean task would be mind-boggling. On the other hand, it would seem that establishing a sufficiently high cutoff could limit the data bank requirements substantially without introducing a great deal of inefficiency into the system. In fact, what we would argue is that creating such a data bank is an essential and important task for the government regardless of what approach is taken to choosing a discount rate, simply because it would make it possible for the government to deal with its project choice problem as a portfolio problem, rather than on a piecemeal basis, as is done presently.

Beyond the data bank requirements of our proposed approach, the analytics mandate a dynamic programming solution algorithm. It scarcely seems likely that this will lead to important computational problems, given the creativity of our computer wizards, but it might be that approximations of various kinds would be needed to keep search costs within bounds. Lind also points out correctly that our approach requires the estimation of budget levels into the distant future and concludes that the lack of information concerning such magnitudes limits the applicability of our approach severely. What we would argue is that such informational problems are inherent in any attempt to evaluate programs that have costs and benefits extending into the indefinite future. The problems with estimating government budget levels into the indefinite future are certainly not of a different order of magnitude than, say, the problems with estimating into the indefinite future the fraction of investment proceeds that will be consumed and that which will be reinvested, and yet this second calculation is central to identifying the shadow price of capital and, hence, the second best calculation of a government discount rate. What we would suggest is that trends from the recent past be used to project future government budget levels, just as is done in projecting patterns of behavior in private markets. The informational problems do not appear to us to be overwhelming.

It seems to us that there is an uneven playing field being used in comparing our approach relative to those of the existing literature. The informational requirements of the second-best approach are strictly greater than those involved in the approach of this paper. To begin with, the second-best approach requires identification of the social rate of time preference. Nowhere in the literature does there exist even an algorithm for calculating the social rate of time preference from observed market magnitudes; instead, the literature simply assumes that the social rate of time preference can be identified with the consumer rate of interest, something which is strictly valid only under very restrictive conditions, e.g., the

[1]This assumes, as in the current budget condition, that the opportunity cost rate of return (r^*) is greater than the consumer rate of interest (i), or the "second best" rate (s) as estimated by Lind [3]. If the social rate of time preference is known, and the second-best rate (s) is greater than r^*, then s would be the appropriate discount rate.

case of an infinitely lived one-consumer economy. But even if the social rate of time preference can be identified with the consumer rate of interest, this is only at a steady state optimum, that is, at a level of government spending such that social welfare is maximized. In particular, since market rates of return, including the consumer rate of interest, depend in part on the level of government spending, this means that it is invalid in general to simply use the observed consumer rate of interest as a proxy for the social rate of time preference, unless one knows somehow that the level of government spending is already optimal. And how does one determine whether the level of government spending is optimal or nonoptimal? Even in the case in which, like manna from heaven, the value of the social rate of time preference is made known to the observer, there are informational problems with identifying the correct value of the government discount rate under the second-best approach. The only conceivable way we know that one can do this is to compare the opportunity rate of return as calculated in this paper with the weighted average of the social rate of time preference and the pre-tax corporate rate of return to see if there is equality between the two. Note that the pre-tax corporate rate of return, like other market magnitudes, is endogenously determined, so that identifying the "correct" pre-tax corporate rate of return involves a simultaneity problem with the opportunity cost rate of return. Thus, in order to implement the second-best approach, one must implement the approach of this paper as well, so that the informational requirements of the second-best approach are strictly greater than the requirements for calculating the opportunity cost rate of return. In addition, given the unresolved difficulties associated with actually calculating the social rate of time preference, we would argue that the information problems of the second-best approach, in fact, overwhelm those associated with our approach.

Moreover, whatever computational and informational problems exist in our approach, there is no doubt that it leads, conceptually, as Lind has noted, to the choice of an efficient portfolio of projects for any given budget level. And, in spite of computational and information problems, there is no doubt that, at present budget levels, the opportunity cost rate of return exceeds 10% real. Thus it is difficult to see how measurement difficulties with our approach, however severe, can lead to the conclusion that the government discount rate should be set far below its current level and to the conclusion that the correct discount rate is, say, 2% rather than 10%. It appears to us that the only grounds for such a conclusion would be convincing evidence that the positive effects of a lower government discount rate (higher level of government spending) would more than offset the negative effects (inefficient portfolio choices). The fact that there is a backlog of unfunded projects under the 10% rate makes this highly unlikely.

In connection with this, it should be made clear that there is nothing inherent in our approach that leads to discrimination against future generations because of the policy recommendation that the government discount rate should be at or above 10% real. In contrast to the second-best approach, which uses the government discount rate not only to determine the level of government spending, but also to allocate net benefits over future generations, our approach is much more in the classical economics tradition. The choice of an efficient portfolio of government projects provides the opportunity for all generations to be as well off as possible, given government budget levels. The allocation of the resulting benefits across generations is a separate issue, one that deserves to be decided on its own merits by the legislature and the executive, and is not prejudged by the choice of projects made under the opportunity cost rate of return rule.

Finally, some comments are in order concerning the possibility of bias in the calculation of the stream of net benefits of government projects. Cost–benefit studies for government projects are typically prepared under the sponsorship of the very agencies that benefit from implementation of the projects, so that there are incentives for overestimating net benefits and hence overestimating the rate of return to be earned from a government project. Under the approaches suggested in the current literature, market rates of return are used to evaluate government projects. If there is a systematic upward bias in net benefit estimates on government projects, there will be an excessive amount of government projects recommended for funding under, say, a second-best approach, or one using the Treasury bill rate or the consumer rate of interest as a discount rate. In contrast, the approach recommended by this paper in effect measures oranges by oranges, and not by apples. Any systematic bias in net benefit estimates has no effect at all on the portfolio of projects that is to be funded under the "opportunity cost rate of return" approach of this paper. That is, if all net benefit estimates on government projects are doubled or tripled, the same portfolio of projects is funded under our approach, while the second best approach would lead to an expanded set of projects acceptable for funding, since it takes net benefit estimates on government projects as directly comparable with net benefits earned on private projects.

3

The approach of this paper can be illustrated as follows. Our main interest is in the case of a steady state optimum, as is true of the second-best literature. However, to illustrate the calculation of the opportunity cost rate of return, we will use the following simple, non-steady state example first introduced by Hirshleifer to indicate the problems with using an internal rate of return approach. Suppose that the government has set aside $1 for investment at $t = 0$, and suppose that there is a two-period horizon. The portfolio of possible projects is the following:

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

Note that the internal rate of return on project A is 200%, as is the internal rate on project B. Projects C and D can be thought of as "market" projects; on the market, a return of 100% is always available. What does the opportunity cost rate of return approach imply about the investment decision? We will show that this approach implies that project B will be funded. If project B is funded, the portfolio of unfunded projects consists of A, C, and D, and the opportunity cost rate of return in this case is a vector, namely (200, 100). That is, the opportunity cost rate of return in the second period is 100%, since this is the only rate of return available on invested capital at $t = 1$. The first period opportunity cost rate of return is 200%, which is achieved by investing in project A. Using the opportunity cost rate of return vector as a 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 zero, 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 the rule of funding a project if the DPV of net benefits is positive (and rejecting funding for any project for which DPV is negative) 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.

How do we know that the portfolio chosen under the opportunity cost rate of return approach is in fact an efficient portfolio? The proof involves a simple dominance argument. In terms of the above example, suppose that project A were chosen instead of B, offering \$3 at $t = 1$ and \$0 at $t = 2$. Why is B a preferred choice relative to A? The reason is that, since the market alternative is available at $t = 1$, this means that the time stream available under project B can be transformed from $(-1, 0, 9)$ to $(-1, 4.5, 0)$, because borrowing in the market (at a 100% interest rate) allows the conversion of a \$9 benefit at $t = 2$ to a \$4.5 benefit at $t = 1$. Hence, by investing in B, we can generate a time stream of net benefits $(-1, 4.5, 0)$ that dominates the time stream under A $(-1, 3, 0)$. The same argument applies for B relative to C or D; hence B is certainly the preferred alternative.

4

The same basic principle holds in the general case. Consider the problem of allocating a fixed initial sum of money among a collection of projects, in the case of a T-period horizon. Let M denote the fixed amount of money available for investment at time $t = 0$. Suppose for simplicity that, at each point in time, the same portfolio of projects is available and that each project is divisible and scalable. Each project in the portfolio offers a certain stream of net benefits for T periods in the future following an investment of \$1 in the current period. The net benefit stream includes the consumption benefits resulting from "throw off" reinvestment of the proceeds of earlier investments, so that shadow price of capital considerations are assumed to have been taken care of in net benefit estimates. Because we are truncating the horizon, only payoffs up to and including time $t = T$ 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 of net benefits associated with project i, involving an investment of \$1 at time t, so that m^{it} can be written as

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

Let S_{F} denote the index set of funded projects using the opportunity cost rate of return rule, while 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 return for the Tth period (from $T - 1$ to T), then r_T^* satisfies

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

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 $T-1$:

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

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

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

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

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

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 any point in time t, the vector $(r_{t+1}^*,\ldots,r_T^*)$ is such that

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

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 planning horizon. Let M denote the amount of money available for government investment at $t=0$ 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 cost rate of return rule. Assuming independence and fungibility*[2] *of project net benefits, as well as divisibility and scalability, this portfolio is efficient.*

Proof. Under the opportunity cost rate of return rule, project i is funded if $\mathrm{DPV}^i(r^*)>0$, while project i is not funded if $\mathrm{DPV}^i(r^*)<0$. Suppose that a portfolio is chosen that differs from that picked under the opportunity cost rate of return rule, such that project i is dropped and project j (for which $\mathrm{DPV}^j(r^*)<0$) is added. Consider a time stream of net benefits.

$$m^k=\left(-1,m_1^k,\ldots,m_T^k\right)\qquad \text{where } m_t^k=m_t^j+\varepsilon.$$

Then $\mathrm{DPV}^k(r^*)<\mathrm{DPV}^i(r^*)$ for $\varepsilon>0$ sufficiently small, and hence the time stream m^k is available from project i. But $m_t^k>m_t^j$ for all $t>0$, hence any portfolio in which i is replaced by j yields a net benefit stream that is dominated by the opportunity cost rate of return portfolio. Clearly, so long as utility is monotone increasing in consumption, the opportunity cost rate of return portfolio produces an efficient portfolio.

[2]The implications of fungibility for government projects are discussed in the appendix.

A natural extension of Proposition 1 is to the case in which there is an active budget constraint on government investment expenditures in each period. Given a T-period horizon, let M_t denote the maximum allowable level of government investment 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_{F} 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

$$M_t \geq \sum_{s=1}^{t} \sum_{i \in S^s_{\mathrm{F}}} c^{is}_t, \qquad t = 1, \ldots, T-1.$$

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

$$\sum_{s=1}^{T-2} \sum_{i \in S^s_{\mathrm{F}}} c^{is}_{T-1}$$

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

$$\sum_{i \in S^{T-1}_{\mathrm{F}}} c^{iT-1}_{T-1} = M_{T-1} - \sum_{s=1}^{T-2} \sum_{i \in S^s_{\mathrm{F}}} c^{is}_{T-1}.$$

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

$$r^*_T = \max_{i \in S^{T-1}_{\mathrm{U}}} m^{iT-1}_T - 1.$$

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

$$M_{T-2} \geqslant \sum_{s=1}^{T-2} \sum_{i \in S^s_{\mathrm{F}}} c^{is}_{T-2}.$$

Projects to be initiated are those with positive discounted present values DPV^i, where

$$\begin{aligned} \mathrm{DPV}^i_{T-2} = {} & -1 + m^{iT-2}_{T-1}/(1 + r^*_{T-1}) \\ & + m^{iT-2}_T/(1 + r^*_{T-1})(1 + r^*_T), \end{aligned}$$

where

$$r^*_{T-1} = \max_{i \in S^{T-2}_{\mathrm{U}}} \{m^{iT-2}_{T-1} + m^{iT-2}_T/(1 + r^*_T)\} - 1.$$

Here 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

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

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

$$\mathrm{DPV}_t^i = -1 + \sum_{s=t+1}^{T} m_s^{it} \Big/ \sum_{j=t+1}^{s} (1 + r_j^*)$$

and r^* satisfies $\max_{i \in S_U^t}\{\mathrm{DPV}_t^i(r_{t+1}^*, \ldots, r_T^*)\} = 0$, where S_U^t is the set of projects available at time t but not initiated, such 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 $(S_F^0, \ldots, S_F^{T-1})$ are thus chosen simultaneously so that the budget constraints are all satisfied and we have

$$i \in S_F^t \qquad \text{if } \mathrm{DPV}^i(r_{t+1}^*, \ldots, r_T^*) > 0,$$

while

$$i \in S_U^t \qquad \text{if } \mathrm{DPV}(\cdot) < 0.$$

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

PROPOSITION 2. *Assume that the government operates with a T-period horizon, and that projects satisfy fungibility, independence, divisibility, and scalability. 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 is efficient.*

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 the 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 0; all information about constraint sets and the objective function is known at that time.[3]

[3]As was pointed out by Jonathan Cave, the intertemporal dependence inherent in third-best problems 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.

Finally, the steady state case is one in which 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. In the steady state case 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:

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, and assume that the set of potential projects is invariant over time. Then the opportunity cost rate of return is a constant over time such that*

$$\max_{i \in S_U} \left[\lim_{T \to \infty} \mathrm{DPV}^i(r^*) \right] = 0,$$

where

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

The efficient government portfolio is a constant over time, containing all projects for which $\mathrm{DPV}^i(r^*) > 0$.

What Propositions 1–3 establish is that, for any given budgeted time stream of government investment spending and in the informational setting specified, choosing the discount rate as the opportunity cost rate of return results in an investment portfolio that is unambiguously better than the portfolio that would be chosen using any other rule, including the second-best rule or any opportunity cost approach that differs from the third-best approach.

What can one say about the choice of a government discount rate that would be made under this approach relative to the present rate of 10% (real)? It would take empirical information on government projects which we do not presently possess to estimate the opportunity cost rate of return. However, since there currently exists an inventory of unfunded projects awaiting funding authorization, we can be confident that the opportunity cost rate of return is greater than 10% (real) under current funding levels (and greater than 7% real for water projects). Thus our approach would lead to a revision of OMB Circular A-94 in an upward rather than a downward direction. We arrive at our paradoxical result that the current 10% real rate of discount is too low, not too high, on simple economic efficiency grounds.

Because a high government discount rate can lead to equity problems discriminating against future generations, it might be thought that the discount rate should be adjusted downward to correct for this bias. We would take a different approach, namely, that equity problems should be solved outside the framework of cost–benefit analysis. In a strict application of the Pareto superiority rule, the portfolio of government projects should lead to positive net benefits for all generations, through investment set-asides, if needed, to provide the additional capital stocks required to compensate future generations for any costs imposed on them by the present generation. Thus the net benefits of the efficient government portfolio would be spread over all generations. Such investment set-asides would make it possible to resolve equity issues without sacrificing efficiency.

5

Finally, we might say something about the assumptions that we have employed to establish Propositions 1–3, namely, independence, divisibility, scalability, and fungibility. Divisibility and scalability are assumptions that could be dispensed with, at the expense of more complicated notation and proofs, but the underlying notion of the use of the opportunity cost rate of return based on the portfolio of available government projects as the government discount rate remains unchanged. We might also note that in the formal second-best literature, similar assumptions are implicit in the conclusions that the second-best rate is the internal rate of return on the marginal government project. Independence is also an assumption that is made for notational convenience.

Fungibility, which is also implicit in the second-best approach, appears to be more problematic, but we believe this is more a matter of terminology than of substance. What is required to establish dominance of the third-best portfolio is the ability to move net benefit time streams between generations, at the rates of return earned by available government projects. The way in which net benefits are shifted over time is the same in the government portfolio of projects as in the private portfolio. That is, net benefits can be shifted from the present generation to future generations only through investments in projects that generate future net benefit streams; and net benefits can be shifted backwards in time only through disinvestment in existing capital stocks, whether they are private or public. It appears that there is nothing special about government projects in this respect that makes them different from a fungibility point of view from private projects.

Finally, questions might be raised as to the implementability of this portfolio approach. In particular, what is required in this approach is information as to the prospective budgets for government investment spending over future periods, as well as information as to the time streams of benefits and costs of projects that will be available in future periods. No doubt, in implementing a portfolio approach, practical considerations would dictate steady state assumptions concerning budget levels and project portfolios, in the same way that steady state assumptions are employed in the second-best approach.

APPENDIX: FUNGIBILITY OF GOVERNMENT PROJECTS

Fungibility of net benefits in this paper is defined as the ability to move net benefits back and forth over time, through investment and disinvestment activities. In this context, there are no differences between government projects and private sector projects. However, in private sector projects, fungibility may readily be measured by the market's monetary valuation of the projects' worth (liquidity). In contrast, many government projects lack such ready-made fungibility indicators, which leads some to argue that those government projects are not fungible.

This appendix briefly explores the issues involved in the fungibility of government projects. Fundamentally, the fungibility depends on the degree of substitutability of benefits of a given investment stream with those of others both directly and indirectly.

For example, if the benefits are inputs to other investment activity, one can easily see the given benefits could be transferred from now to the future through this new investment. Or, if the given benefits are substituted to other investment outputs, then the benefits could be transferred back in time by exchanging the future benefits for the earlier resource claims of such an investment (this, of course, is commonly known as discounting.)

However, fungibility does not necessarily require the direct substitutability of benefits as illustrated above. Suppose benefits cannot be substituted to any other goods directly, but the level of the benefits could be varied through changes in operation and maintenance activities. If this is so, then it is possible by reducing a given net benefits stream to free up resources, which may be used to increase other investment activities. To the extent many government investment activities entail a large operation/maintenance expenditure, the level of fungibility may be more significant than it might first appear.

The magnitude of the released resources from the reduced operation is naturally larger than the associated reduction in the net benefits when marginal cost equals marginal valuation as in most optimal situations. In circumstances where a budget constraint on the operating costs limits the output below the unconstrained optimum, the magnitude of the released resources, vis-a-vis the reduced net benefits, depends on the relative sizes of the marginal cost and marginal valuation. If the marginal cost is greater than one half of the marginal valuation, then the released resources will be larger than the reduction in the net benefits, and the converse also holds.

To illustrate, consider an investment with the following net benefits stream $(-1, 0, 9)$. Suppose this investment corresponds to the situation where investing one dollar today buys the production capability in the third period with the marginal cost of $MC = 3 + 0.5Q$, and a constant marginal value of \$6. Then, the profit maximizing production occurs at $Q = 6$, with $MC = MV = \$6$ and with the net benefits of \$9. If, for some reason, we want to increase the disposable budget by cutting the scale of this operation, then the reduction of one dollar in net benefits (from \$9 to \$8) for this investment will produce a much larger savings of \$11 in operation costs. If the budgets for the operating costs and investments may be consolidated, then such savings could be used to fund other investment activities, thus enhancing the level of fungibility of the government investments.

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