United States General Accounting Office
GAO
Office of the Chief Economist

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Discount Rate Policy

Preface

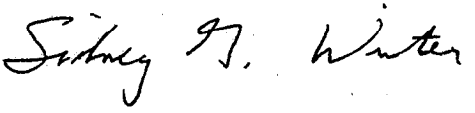
GAO conducts many analyses that require the evaluation of benefits and costs of public policies over time. These include analyses of public investment, regulatory, lease-purchase, and asset divestiture decisions. Proper analysis of such decisions generally requires present value analysis with an appropriate discount rate.

This document presents GAO's policy on the discount rate to be used for such analyses. In general, the discount rate for GAO analyses should be the interest rate on marketable Treasury debt with maturity comparable to that of the program being evaluated. This rate is appropriate for cases where benefits and costs are presented in current (nominal) dollars; when benefits and costs are in constant (real) dollars, the Treasury rate must be adjusted to reflect expected inflation. This document also provides guidance on using sensitivity analysis in cases where rates other than the current Treasury rate deserve consideration.

GAO's discount rate policy reflects the primary objectives of consistency with basic economic principles and feasibility of implementation. The policy is based on an extensive evaluation and was reviewed by outside experts.

The main purpose of this document is to provide GAO economists and other technical staff with a detailed description of GAO's discount rate policy and its rationale. This document can also alert the generalist manager and evaluator to the existence of this policy. GAO staff are encouraged to consult with their division's Economic Analysis Group or the Office of the Chief Economist to ensure that

analyses and interpretations using discount rates are appropriate.



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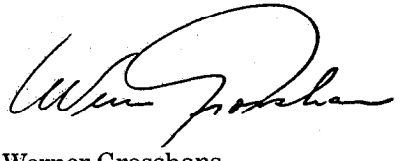

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Abbreviations

CBO	Congressional Budget Office
EAG	Economic Analysis Group
GAO	General Accounting Office
OCE	Office of the Chief Economist
OMB	Office of Management and Budget
WEFA	Wharton Econometric Forecasting Associates

Chapter 1

Overview

This document presents GAO's revised discount rate policy. Previously, GAO used a rate based on the Treasury borrowing rate for all types of discounting problems, including those related to public investment, regulatory, lease-purchase, and asset divestiture decisions (GAO, 1983, p. 17-8). GAO's review of its policy and the factors considered in its revision are described in this document. While the revised policy leaves the prior approach largely intact, it also includes increased guidance on sensitivity analysis and certain procedural modifications.

Document Organization

The remainder of this chapter summarizes GAO's revised discount rate policy. The justification for these revisions is discussed in chapter 2; conclusions are presented in chapter 3. The appendixes provide additional policy context for the revisions. Appendix I summarizes the objectives, scope, and methodology of our review. Appendix II discusses the policies in effect at the time of our review at GAO and the two other federal budget and oversight agencies—i.e., the Office of Management and Budget (OMB) and the Congressional Budget Office (CBO). Appendix III critiques these policies in the context of public investment, regulatory, lease-purchase, and asset divestiture decisions. The shadow price of capital approach to discounting—which, while not recommended here for base case GAO analysis, has important support in terms of economic theory—is discussed in appendix IV. Appendix V considers the treatment of tax revenues from projects whose ownership is being evaluated. While this matter is not literally a discounting issue, it often arises in conjunction with such issues and involves some similar questions regarding the source of investment funds.

Policy Summary

The basic principles of GAO's discount rate policy are as follows:

- GAO's base case discount rate should be the interest rate for marketable Treasury debt with maturity comparable to the program being evaluated.
- Sensitivity analysis should be used to address issues such as differing expectations about inflation and interest rates, private sector opportunity costs, and intergenerational effects of policies on human life.

These two principles were arrived at following an extensive analysis of both the theoretical and policy literatures on the discount rate. The views of experts in the field of public finance were also solicited.

In developing GAO's discount rate policy, the following considerations were particularly important:

- **consistency with basic economic principles,** and the related concern that resulting analysis withstand alternative assumptions; and
- **feasibility of implementation,** and the related concern that analytic results be comprehensible and accessible to policymakers.

The specifics of GAO's revised discounting policy are as follows:

Base case discount rate. The base case discount rate for GAO analyses should be the interest rate for marketable U.S. Treasury debt with maturity comparable to the term of the project or policy being evaluated.

Use of nominal or real rates. Where nominal benefits and costs are most readily available, analysts may use the nominal interest rate of the debt directly. Alternatively, in studies where real benefits and costs are available, analysts can subtract a projected inflation rate from the nominal rate to calculate a real discount rate.

Inflation rate sources. The source of the base inflation projection should be a leading independent

forecasting firm, such as DRI/McGraw-Hill or Wharton Econometric Forecasting Associates (WEFA).

Sensitivity analysis. Careful and systematic sensitivity analyses of the effects of alternative discount rates should be conducted. The nature of these analyses will vary depending on the salient aspects of the policy under consideration. Analysts should consult with their Economic Analysis Group (EAG) or the Office of the Chief Economist (OCE) to determine the appropriate type of sensitivity analysis. The following are examples of types of sensitivity analysis that may be appropriate:

1. Alternative inflation or interest rate forecasts may be considered where nominal or real interest rates are sensitive to differences between credible economic forecasts. Use of the base and nonbase cases of leading private and government forecasts is one possible method for selecting a range of rates. When real interest rates are unusually high or low and may be unlikely to persist, historical real rates of return could be used.

2. Private sector discount rates should be considered in the case of asset divestitures. Because Treasury interest rates are below those of the private sector, their use generally will yield a greater present value of future returns from an asset than would a higher private sector rate.[1] Consequently, financial analyses could imply that government ownership is preferable to private ownership even when there are no real efficiency gains from government ownership. Therefore, in addition to considering private sector interest rates as part of the analysis, analysts should note that considerations other than the government's financial position—such as views about the proper roles for the public

[1]Explicit consideration of the default risk facing lenders may partially reconcile the two valuations (see item 5, below). However, factors other than the default risk may also be involved.

and private sectors—can be relevant for asset ownership decisions.

3. Estimates of both private sector opportunity costs and the rate of time preference should be considered when evaluating regulatory decisions and public investments. The former will typically imply a discount rate greater than the Treasury rate; the latter will generally be lower. Where practical, analysis with the shadow price approach (see app. IV) may also be useful. Such analysis may be helpful in developing insights as to whether high, moderate, or low discount rate scenarios deserve particular attention.

4. Benefit-cost analyses with intergenerational human life effects present a particularly challenging case, since equity and compensation principle problems can limit the applicability of benefit-cost analysis (see, e.g., Sen, 1982). Policies that lead to minor changes in risks may be best evaluated by using market-based valuations and interest rates. If risk changes are not minor, however, market-based measures may not be as satisfactory. Such cases suggest that some sensitivity analysis with very low discount rates be provided. One justification of this approach arises if the value of lives is projected to increase at the rate of productivity or income growth and these growing values are then discounted at the rate of time preference (see, e.g., U.S. Environmental Protection Agency, 1987).[2] This approach can yield an effective real discount rate very close to zero for the future life benefits, as the rate of time preference may be small and close to the magnitude of the rate of productivity increase.

5. Analyses of policies with uncertain outcomes should consider the expected benefits and costs of the policies as the base case. In addition, policies

[2]This approach is consistent with assumptions that the value of life is proportional to output or that the income elasticity of the value of life determined on some other basis is equal to one.

that either increase or decrease social risks should, in principle, be evaluated so as to address preferences toward risk—i.e., risk aversion (see, e.g., Lind, 1982a, and app. III). In practice such an evaluation is likely to consider risk-adjusted discount rates, although such rates will generally be hard to determine objectively.[3] One possible approach to estimating risk-adjusted discount rates is by considering the rates of return on comparable private sector activities. Risk adjustment could imply using rates above or below base case rates to evaluate future benefits, depending upon whether the policies increase or decrease the variability of future social welfare. Analogously, future costs that increase (decrease) portfolio risk would face relatively low (high) discount rates.

6. Consideration of other agencies' discount rates may be useful where GAO analyses alter assumptions besides the discount rate and are contrasted with the analyses of OMB or other agencies. This approach would clarify the different effects of the discount rate and other assumptions. The approaches used by OMB and others are discussed in appendixes II and III.[4]

[3]In theory the issues of risk and intertemporal evaluation are distinct; therefore, interest rates may not be an ideal method of reflecting relative risks (see, e.g., Lind, 1982a, pp. 64-67).

[4]Given simple time streams of benefits and costs, internal rate of return can also be a useful summary measure for illustrating the attractiveness of projects under alternative discount rates. Thus, if a program has an internal rate of return well above the Treasury rate, it will generally have positive net present value at discount rates slightly above or below the Treasury rate, and extensive sensitivity analysis may be unnecessary. (Note, however, that if cash flows or net benefits change sign more than once, a project can have multiple internal rates of return. Problems may also arise with the internal rate of return method of analysis if reinvestment at the internal rate of return cannot be assumed. Thus, care should be taken when considering use of this measure.) Recent theoretical work also suggests that rates of return can be appropriate decision criteria under constrained budgets (Dorfman, 1981; Cantor and Lippman, 1983).

Chapter 2

Rationale

The goal of determining a discount rate policy is to promote sound decisionmaking. The primary considerations in developing the present policy have been consistency with basic economic principles and feasibility of implementation.

Meeting these objectives required making tradeoffs and judgments. The technical literature on the discount rate, for example, is one of the most extensive in the field of microeconomics.[1] Alternative theoretical models suggest different formulations for the discount rate, and these rates can be project-specific or require use of data that are often unavailable. Regarding ease of implementation, GAO performs dozens of studies each year that require present value analysis. These studies must be produced under time and resource constraints. While the analyses must meet high standards of credibility, they must also be meaningful to the Congress and other decisionmakers who are not specialists in economic analysis.

Major Policy Options: An Overview

The options available for discounting that receive primary attention in the literature are

- **a rate of time preference,** generally based on an after-tax return available to individuals or a rate of economic growth (see, e.g., Gramlich, 1981, pp. 101-108; and Lind, 1990);
- **an opportunity cost rate,** based on the marginal pretax return to capital (see, e.g., Baumol, 1968; OMB, 1972; Mikesell, 1977; and Australian Department of Finance, 1987);
- **a weighted average of the rate of time preference and the opportunity cost rate,** where the weights generally reflect the portions of the public activity's costs drawn from consumption and investment, respectively (see, e.g., Baumol, 1969;

[1]For surveys of this literature, see Mikesell (1977), Gramlich (1981), Lind (1982a and 1990), and Lyon (1990).

Haveman, 1969; Ramsey, 1969; Edwards, 1985; and Burgess, 1988);

- **a shadow price of capital approach,** where the share of public activity costs drawn from investment—and the share of benefits going to investment—are imputed a return based on the opportunity cost rate, and all costs and benefits are then discounted using the rate of time preference (see, e.g., Dasgupta, Marglin, and Sen, 1972; Feldstein, 1972; Bradford, 1975; and Lind, 1982a); and
- **a rate based on Treasury borrowing costs** (see, e.g., GAO, 1983; OMB, 1984 and 1986; Hartman, 1990; and Lind, 1990).

The arguments surrounding these options are briefly outlined below.

Rate of Time Preference

The strength of this approach is that it may represent individuals' or society's preferences with respect to choices between current and future consumption. It generally implies the lowest discount rate of the five approaches. The approach can roughly be viewed as providing a necessary, but not sufficient, hurdle rate of return for an investment.[2]

The key problem with the time preference approach is that it would not generally be optimal from an efficiency standpoint for society to take funds from a project yielding the private sector pretax return (e.g., 10 percent) in order to invest in a lower return public project (yielding, say, 8 percent), even if this latter project yields more than the time preference rate (e.g., 3 percent). Also, individuals may face different rates of time preference, for example, based

[2]In theory there are some exceptions to this generalization, although it is not clear how important they would be in practice. The shadow price approach could, for example, be equivalent to using a lower effective discount rate than the rate of time preference, if the shadow price attributed to capital applies to a larger fraction of benefits than of costs.

on their tax rates and borrowing and investment opportunities.[3]

Opportunity Cost Rate

The opportunity cost rate reflects the value of funds to the private sector. This approach roughly provides a sufficient hurdle rate for an investment, but it may also overstate the return needed for an attractive policy.[4] The problem is that while funds used for the public policy could, in principle, have been invested at the private sector rate, it is not clear that they would have been so used in the absence of the public activity (Feldstein, 1972, p. 319). OMB's policy of using a 10-percent real discount rate for public investment and regulatory impact analyses is based on the opportunity cost principle (OMB, 1972; Stockfisch, 1969).

Weighted Average Discount Rate

The weighted average discount rate attempts to address the actual use of funds in the absence of the public policy. In its simplest form, the approach weights the share of costs drawn from consumption by a rate of time preference and the share drawn from investment by an opportunity cost rate. As with the previous cases, there are measurement challenges associated with this approach. There are also conceptual difficulties with this approach, as discussed below.

[3]Nearly half of all households have savings of $2,000 or less (Hausman and Poterba, 1986), for example, and thus may be liquidity constrained. To address this type of problem, Haveman (1969) suggests a weighted average approach that reflects the interest rates faced by different income classes. Sources of funds and opportunity costs can be difficult to estimate, though.

[4]As in the time preference case, there are exceptions to this generalization. For example, the opportunity cost rate can understate the needed return in some cases. The shadow price approach, for example, could be equivalent to using a higher effective discount rate. This outcome depends on both the value of the shadow price of capital and the share of the proposed activity's costs drawn from capital.

Shadow Price of Capital

Feldstein (1972) examined the theoretical difficulties associated with using one weighted rate to represent the combined effects of two different rates (the rates of time preference and opportunity cost). He and other researchers (see, e.g, Dasgupta, Marglin, and Sen, 1972; Bradford, 1975; Lind, 1982a; and Scheraga, 1990) have suggested the shadow price method as a superior basis for discounting. This approach essentially involves compounding a return to capital costs (and capital benefits) based on the pretax rate of return to capital and then discounting both benefits and costs with a rate based on the rate of time preference.

While conceptually attractive, this approach presents major empirical challenges to implementation. It is extremely sensitive to the technical assumptions made about the incidence of costs, the propensities to save and reinvest, and the opportunity cost and time preference rates (Mendelsohn, 1981; Lyon, 1990). While these parameters can be estimated, the shadow price approach can, within realistic ranges of parameter uncertainty, give very different results. These issues are considered in some detail in appendix IV.

Treasury Borrowing Cost

This final approach is one practical measure of the government's opportunity costs. It is the basis for the GAO policy set forth in this report as well as prior GAO policy (1983, p. 17-8). It is also the basis for CBO's discount rate for public investment analysis and for both CBO's and OMB's discount rates for analyses of lease-purchase decisions (OMB, 198[illegible] and 1986; Hartman, 1990).[5]

For lease-purchase or budgeting decisions—where funding, as opposed to the creation of real benefits

[5]CBO specifically assumes that the real yield on Treasury debt is 2 percent. It recommends a sensitivity analysis of ± 2 percent to capture the potential variability of real yields (Hartman, 1990, p. S-4).

and costs, may be viewed as the principal issue—this approach appears satisfactory. In addition, the Treasury rate approach may have attractive social welfare properties in open economies, where government borrowing does not significantly raise interest rates or displace domestic private investment (Edwards, 1985; Hartman, 1990; Lind, 1990).

For other cases, however, the Treasury rate approach may have drawbacks. For both regulatory and public investment analyses, for example, the government's borrowing cost may reflect neither the social pretax return to capital nor individual (or social) preferences for future health or other benefits. The pretax return to private capital will generally be greater than the Treasury interest rate, while individuals' rates of time preference could be lower or higher (Moore and Viscusi, 1990, p. S-61). For asset divestiture analyses, use of the Treasury rate would tend to give assets greater value to the government than the private sector would estimate using its required rates of return. Thus, a bias in favor of government ownership of capital could be created. OMB uses private sector interest rates when evaluating asset divestiture decisions (OMB, 1988); CBO has also considered this approach (CBO, 1989; Hartman, 1990).

In addition, even the relatively straightforward Treasury rate approach entails empirical questions. Both nominal and real Treasury rates can vary substantially over a period of a few years (see app. III), which leads to a question of whether the discount rate should vary correspondingly. There is also the problem of properly matching the time stream of the project's benefits and costs to the appropriate maturity of debt. The Treasury rate approach recommended in this revised policy is appropriate given reasonably stable real interest rates and a relatively flat yield curve. If either of these conditions change, it might be appropriate to revise this guidance or to rely more heavily on sensitivity analysis.

Strengths and Limitations of the Treasury Rate Approach

The key strengths of the Treasury rate approach are as follows:

- Because the policy reflects one market-based, observable measure of the time value of money, it is easily implemented. The information needs are much less than with the shadow price or weighted average approaches.
- The policy is intuitively meaningful to decisionmakers and nonspecialists as one measure of the cost of programs and society's tradeoffs between present and future monetary values. The measure is also useful for budget documents—e.g., for credit reform and imputed interest calculations—because it reflects actual federal expenditures, even if it may not always exactly reflect true social economic costs.
- The policy's measure of social opportunity cost may be particularly useful if marginal investments are funded by federal debt and capital markets are open so that government borrowing does not significantly raise interest rates or displace domestic private investment (Edwards, 1985; Hartman, 1990; Lind, 1990).
- The policy is objective in the sense that once guidelines are determined, the resulting interest rate calculation cannot be manipulated by analysts.
- The rate can be close (i.e., within 100 or 200 basis points) to a weighted average discount rate, given fractions of funding drawn from consumption of 60 to 90 percent (see app. III). The weighted average approach, in turn, can yield results similar to the shadow price approach under special circumstances (Sjaastad and Wisecarver, 1977; McDonald, 1981).

The key limitations of the Treasury rate approach are:

- The Treasury rate equals neither the pretax return to domestic capital nor the post-tax return to domestic lenders. It is thus not necessarily directly related to costs imposed on or benefits experienced by the private sector.

- The Treasury rate—and the weighted average discount rate (to which the Treasury rate may be close)—can both differ significantly from the discount rate equivalent to use of the shadow price approach (see, e.g., McDonald, 1981, and app. IV).
- The Treasury rate, both in nominal and real terms, can vary significantly over a period of a few years. Real yields in the early 1980s were at times above 7 percent, while they were negative in some earlier years. Current real rates are about 4 percent. Project attractiveness could vary substantially depending on the year of analysis, which may not be appropriate if the calculated rates will not persist for the life of the policy.
- The Treasury rate approach can lead to a bias toward federal ownership of capital, loans, and guarantees, because it implies a lower rate of return than the private sector requires. The main theoretical reason for this difference in rates is that the Treasury approach does not reflect a risk premium (to adjust for risk aversion) or, for returns to equity, corporate income taxes.[6]
- In their most theoretically rigorous forms, the shadow price and weighted average approaches imply that project-specific discount rates are appropriate (see, e.g., Lind, 1982a; Burgess, 1988; and Lyon, 1990). The Treasury rate approach does not reflect the project-specific factors that yield these different rates.
- Even in the case of lease-purchase or asset divestiture decisions—which tend to be largely financing issues—real resource levels may be affected, if only on a secondary level. For example, constraints on borrowing could cause purchases to be funded via taxes which cause relative price changes and welfare costs, and hence real resource changes. The Treasury rate may not capture all of these effects.

[6]See appendix V for more on the issue of corporate taxes.

While the Treasury rate approach has limitations, these may be significantly reduced by careful sensitivity analysis, as discussed in chapter 1. This analysis can address such concerns as expectations about inflation and interest rates, private sector opportunity costs, and long-term effects on human life. Sensitivity analyses can also be carried out to clarify differences between GAO assumptions and those of other analysts.

The introduction of additional sensitivity analysis could reduce the mechanical aspect of GAO policy and increase the role of expert judgment. It could also lead to complaints from decisionmakers that there is not one answer, but two or three. If basic economic principles are ambiguous for some cases, or if these principles suggest some merit in rates besides the Treasury rate, however, then the approach of reflecting these alternatives through sensitivity analysis is preferable to omitting their analysis. Under the recommended GAO policy, the Treasury rate is still taken to be the base case. Statements about the relative importance of sensitivity analyses will have to withstand scrutiny at a number of levels, including reviews by the division, EAG, and OCE.

Detailed Procedural Issues

Several detailed procedural issues surround use of the Treasury rate approach. The first concerns the use of real versus nominal rates. Earlier GAO policy assumed that all quantities would be measured in nominal terms. This approach is unnecessarily rigid for regulatory and other analyses that consider benefits and costs that are reported in real terms. Therefore, under the revised policy, nominal rates may be used with nominal benefits and costs, and real rates—equal to the nominal rates minus forecasted inflation—may be used with real quantities.

Second, the recommended sources of the base case inflation projections are the leading independent forecasters (e.g., DRI/McGraw-Hill or WEFA). This

approach has the benefit of using forecasts that are more frequent and of longer duration than OMB or CBO forecasts. It also avoids any political influences that could, in principle, affect forecasts from government sources. Analysis of the accuracy of forecasts suggests that the recommended approach should also be more accurate than an approach based on simple extrapolation of recent trends (McNees, 1988).

A third issue involves matching the maturity of the Treasury debt to the stream of benefits and costs from the public activity. Prior GAO policy involved averaging the yields of publicly traded Treasury issues with maturities between one year and the length of the project (GAO, 1983, pp. 17-14 to 17-16). This averaging approach used the published yields in the Wall Street Journal without carefully adjusting for the number of issues with maturities in different years or for the specific time streams of project benefits and costs.

The revised policy is to match debt maturity to project length. This method does not capture the fact that benefits usually accrue throughout a project's lifespan and are not heavily weighted toward the terminal period, as in repayment of debt principal. Nevertheless, the simple maturity-matching approach is easier than an averaging approach, and has consequently been used in some GAO studies. By placing less weight on short-term debt yields, this approach would tend to raise interest rates slightly over those calculated using the prior GAO method. For 20-year projects initiated over the period 1970-88, however, the average increase would have been only 36 basis points. This small difference arises because the yield curve is generally nearly flat for maturities of 3 years or more.

The simple maturity-matching approach has been selected for the base case because—although essentially as sound in practice—it is easier to implement

than the averaging approach. Also, the prior policy of averaging of yields can provide a false sense of accuracy. Nominal and real rates can both change by much more than 36 basis points over periods of a few months. In addition, the Treasury rate itself, as discussed earlier, will often be an imperfect proxy for an ideal discount rate. Additional emphasis on sensitivity analysis is likely to be more useful than averaging yields of different maturities at a single point in time. OMB (1986) uses maturity matching where it relies on the Treasury rate.

Chapter 3

Conclusions

Under the revised policy, GAO's discounting continues to be based on the Treasury borrowing rate. This approach has several strengths, including its relevance to federal financial decisionmaking and its feasibility for implementation. The Treasury rate also has attractive theoretical properties in open economies where federal borrowing does not crowd out domestic private investment. In addition, the Treasury rate can be close to the rate implied by the weighted average approach.

Moreover, an empirical and theoretical consensus in favor of an alternative approach has not yet emerged. Given the need for continued empirical and theoretical research and consensus on the discount rate, other approaches that are currently theoretically favored (such as the shadow price, weighted average, and risk-adjusted approaches) will be difficult to apply in an objective and easily implemented manner. Thus, it is reasonable to conclude that the uncertainties entailed by alternative approaches are too great at this time to require substantial changes from the prior policy.

Nevertheless, the alternative approaches can produce useful insights in appropriate cases. Therefore, sensitivity analysis should be given careful attention, and it should be recognized that, although GAO's base case policy is to use the Treasury rate, the rates implied by the sensitivity analysis can also be valid.

Overall, GAO's discount rate policy should be viewed as one responsible and acceptable approach given the current state of knowledge and the agency's objectives of consistency with basic economic principles and feasibility of implementation. The recommended policy should maintain GAO's ability to provide useful and objective analyses of a wide range of public issues.

Appendix I

Objectives, Scope, and Methodology

Work was begun in September 1987 to provide a firm basis for and any needed modifications to GAO's discount rate policy set forth in chapter 17 of the agency's Project Manual (GAO, 1983). The work included an extensive and detailed review of the literature on the discount rate. New theoretical and applied economic analyses of discount rate issues were undertaken when needed; these included analyses of issues surrounding the shadow price of capital and weighted average discount rates.

An introduction to the research findings was first presented in March 1988 at GAO's annual Technical Conference. Subsequently, in June 1988, a draft with options and recommendations for the treatment of key issues was circulated for comment within GAO. Technical results from the research were presented at a session of the American Economic Association meetings in New York in December 1988. The papers from this session were published in a special issue of the Journal of Environmental Economics and Management (see Hartman, 1990; Lind, 1990; Lyon, 1990; Moore and Viscusi, 1990; Portney, 1990; and Scheraga, 1990).

A draft document presenting GAO's proposed discount rate policy was sent to 20 experts for comment in August and September 1990. In November 1990 letters were sent to all parties who had not yet responded. In total, written comments were received from eight of the experts:

- William J. Baumol, Professor of Economics, Princeton University and New York University;
- Barry P. Bosworth, Senior Fellow, Brookings Institution;
- David F. Bradford, Professor of Economics and Public Affairs, and Associate Dean, Woodrow Wilson School of Public and International Affairs, Princeton University;
- Edward M. Gramlich, Professor of Economics and Public Policy, University of Michigan;

- Charles W. Howe, Professor of Economics, University of Colorado;
- Robert Mendelsohn, Associate Professor, School of Forestry and Environmental Studies and Department of Economics, Yale University;
- Ahmad Al-Samarrie, Associate Director of Economic Policy, Office of Management and Budget (OMB); and
- W. Kip Viscusi, Professor of Economics, Duke University.

In lieu of receiving written comments from one expert at Resources for the Future, a seminar was presented there in November 1990 to elicit a variety of expert views.

In general, the comments received from the expert reviewers of the draft were favorable. Consequently, only minor wording changes were made in response to the comments; the basic analysis and policy recommendations remain unchanged. Nonetheless, the analysis and recommendations are those of GAO and not necessarily those of the reviewers.

Randolph M. Lyon was project manager for this study. Katherine L. Crosby was the typist.

Current Federal Policy

In principle the discounting policies of OMB, GAO, and the Congressional Budget Office (CBO) can affect virtually all federal investment, regulatory, lease-purchase, and asset divestiture programs through their impacts on either executive or legislative decisions. In practice, of course, policymakers consider a range of policy dimensions besides the quantifiable net economic benefits. In addition, the discounting policies of other parties—including agencies such as the Environmental Protection Agency and the Department of Energy —are also important. Nevertheless, the discounting policies of the oversight agencies are focused on here because of their roles, impacts, and diverse natures.

OMB Policy

OMB's discount rate policy guides the benefit-cost analyses of all executive branch agencies. Its policy is primarily based on the principle of opportunity cost, though the implementation of this principle varies somewhat across different types of issues.

OMB's current policy is that a 10-percent real discount rate should be used for most analyses (OMB, 1972). Although this 10-percent rate is probably the most well-known aspect of OMB's discounting policy, there are some important exceptions to it.

- Agencies are allowed to use alternative discount rates when these can be justified. The acceptable bases for such justifications are not spelled out by OMB, however.
- For lease-purchase decisions, OMB (1986) states that executive agencies should use a rate based on Treasury borrowing costs. Specifically, the rate reflects the interest rate on debt of maturity equal to the length of the project, plus one-eighth percent, which is intended to represent the Federal Financing Bank charge to agencies that borrow from it.
- Water project investments—pursuant to the Water Resources Development Act of 1974, Public Law 93-251—must also be analyzed with a rate based on

Treasury borrowing costs. (U.S. Water Resources Council, 1974 and 1978). In this case, the rate is based on the yield of debt with maturity of 15 years or more. Unlike the lease-purchase case, there is no extra charge of one-eighth percent in this case. Also, the rate cannot change by more than one-quarter percent from one year to the next. Finally, although the water project approach requires the use of nominal interest rates, the amounts to be discounted are benefits and costs in real terms.

- For asset divestitures, OMB has endorsed the use of market interest rates for comparable private sector ventures to determine the value of the asset to the government. Specifically, to place a value on loans made by the government—for purposes of loan asset sales, prepayments, and related credit reforms—OMB believes that the government should use the same rates as the private sector (OMB, 1988 reprinted in GAO, 1989a). The Department of Energy also has used private sector rates that differ from OMB's 10-percent rate in determining, for divestiture analyses, the government's value for the Great Plains Coal Gasification Project and the naval petroleum reserves.

OMB reexamined the discount rate policy presented in its Circular A-94 (1972) in 1986-87 because of concerns that the 10-percent real rate may be relatively high. However, this work was suspended because there was no consensus among the experts assembled by OMB. OMB intends to reexamine its policy in the future.

GAO Policy

As a congressional agency, GAO is not bound by OMB policy. GAO's policy before the revisions discussed here was that its discount rate should be based on the average nominal yield of marketable Treasury debt with remaining maturities between one year and the length of the project being evaluated (GAO, 1983). The benefits and costs valued were similarly assumed to be in nominal terms. Where they were in real terms, GAO estimated a

real discount rate by subtracting forecasted inflation from the Treasury rate.

Earlier GAO policy did not explicitly distinguish among discounting for public investment, regulatory, lease-purchase, or asset divestiture analyses. It did, however, recognize that there is controversy surrounding the appropriate discount rate for the federal government, and it suggested the importance of conducting—and if appropriate, reporting—sensitivity analyses with the discount rate.

The revised GAO policy as documented here reflects prior policy, with two main modifications. The revised policy (1) is based on matching programs with Treasury debt of comparable maturity, rather than using an average yield of a range of debt issues and (2) emphasizes the potential role of sensitivity analysis in cases where public investment or regulatory decisions can merit the use of discounting approaches that differ from the Treasury rate approach.

CBO Policy

CBO is also a congressional agency and has determined its own discount rate policy. CBO policy is that the discount rate for most analyses should be based on the real yield of Treasury debt. This yield is estimated to be 2 percent (Hartman, 1990, p. S-4). CBO also recommends a sensitivity analysis of ± 2 percent to capture the potential variability of real yields.

One potential exception to these principles is that for valuing assets such as loans made by the federal government, CBO has, in draft analyses, considered using comparable private sector interest rates. However, CBO's recent report on credit reform notes that there are three alternative approaches to discounting in this case. These approaches entail using: (1) private market rates on risky assets that implicitly reflect defaults, (2) Treasury interest

rates with explicit recognition of defaults, or (3) a rate slightly above the Treasury rate (to account for uncertainty) with explicit recognition of defaults (CBO, 1989, pp. 39-41; Hartman, 1990, p. S-7).

Appendix III

Oversight and Budget Agency Policy: A Critique

The discount rate policies of all three oversight and budget agencies—OMB, GAO, and CBO—reflect objectives that include consistency with basic economic principles and ease of use by analysts and policymakers. Despite these shared objectives, the agencies' policies differ significantly for all cases except lease-purchase analyses. This appendix analyzes the logic behind the agencies' positions and describes some of the associated problems.

Public Investment and Regulation

OMB's 10-percent rate is consistent with an estimate of the pretax rate of return on private capital—also termed the opportunity cost of capital. The basic logic is that instead of investing in lower return public opportunities, it is better to invest in higher return private projects. This approach has had important support (see, e.g., Baumol, 1968; Stockfisch, 1969; Mikesell, 1977; and Australian Department of Finance, 1987).

On the other hand, the opportunity cost approach has been criticized for overstating the returns actually required by individuals or society on investments (see, e.g., Gramlich, 1981, p. 108). An approach based on the shadow price of capital, for example, would generally imply a different discount rate (see, e.g., Feldstein, 1972). The shadow price approach explicitly distinguishes between the portion of costs drawn from consumption and the portion drawn from investment. It could yield results equivalent to discounting with interest rates either below or above the opportunity cost of capital, depending on the assumptions about such values as the share of costs borne by investment, the reinvestment rates for income from capital, and the rate of time preference.

Alternatively, an approach based on a weighted average of the consumer's rate of time preference and the opportunity cost of capital would, in its simplest form, imply a lower discount rate than the

opportunity cost approach.[1] Another view is that the discount rate should reflect time preference alone (Gramlich, 1981; Lind, 1990). Gramlich (1981) derives a social rate from an optimal growth model. Lind (1990), on the other hand, suggests using the marginal interest rate facing consumers. An approach based on the Treasury's real costs of funds would also generally imply a lower discount rate than OMB's approach.

In contrast to OMB, GAO and CBO base their analyses of public investment decisions on the Treasury borrowing rate. This rate has been justified by GAO as reflecting the government's costs for funds; the alternatives of borrowing more or retiring debt have been viewed as the relevant verifiable alternatives. Others have argued for this rate based on the premise that lending to the federal government at the Treasury rate—given open capital markets—does not distort U.S. private investment and consequently represents the marginal social cost of federal programs (Hartman, 1990; Lind, 1990).

Criticisms of the Treasury rate approach include the concern that approaches based on the shadow price of capital or a weighted average discount rate may better indicate the costs of taxation and regulation as well as social time preference. In particular, the prescriptive value of the government borrowing rate may be hard to justify where a regulation—such as an environmental policy—imposes costs on the private sector that are unrelated to the raising of federal funds.

[1]It is widely agreed that distortions caused by business and personal income taxes cause the rates of time preference to be below the opportunity cost. Both Haveman (1969) and Lind (1990) suggest, however, that some consumers may have relatively high rates of time preference, as evidenced by their willingness to borrow at high rates of interest. (For more on the weighted average approach, see, e.g., Baumol, 1969; Haveman, 1969; Ramsey, 1969; Dreze, 1974; Harberger, 1976; Sjaastad and Wisecarver, 1977; Edwards, 1985; and Burgess, 1988).

The Treasury rate can, however, approximate a weighted average discount rate based on the extent to which marginal tax or regulatory burdens fall upon consumption and investment—especially if these burdens fall somewhat more heavily on investment than investment's share of national product. Since the weighted average discount rate approach can, under special circumstances, yield results similar to the shadow price approach, this may be a useful argument for considering the Treasury rate.[2]

In its simplest form the weighted average discount rate, w, is defined as

$$w = (i\ c) + [r\ (1 - c)] \qquad \text{(III.1)}$$

where the first term is the rate of interest faced by consumers, i, times the marginal funding drawn from consumption, c; and the second term is the return to capital in the private sector, r, times the fraction of funding drawn from investment (1 - c). The analysis assumes that the return on Treasury debt, b, equals the return to corporate capital, r, net of corporate taxes. Defining t_c as the corporate tax rate implies

$$b = (1 - t_c)r. \qquad \text{(III.2)}$$

The net return to consumers is assumed to equal the return to Treasury debt after personal income taxes, t_p:

$$i = (1 - t_p)b. \qquad \text{(III.3)}$$

Substituting equations III.2 and III.3 into III.1 implies w = bf, where f is defined as $[c(1 - t_p)] + [(1 -$

[2]Both Bradford (1975) and Sjaastad and Wisecarver (1977) demonstrate the equality between the weighted average approach and the shadow price approach under some simplifying assumptions. McDonald (1981) discusses some limitations of these assumptions.

c)/(1 - t_c)]. The relationship between w and b is therefore determined by f.

Table III.1 presents a series of estimates of f. It indicates that, depending on the estimates of c, t_c, and t_p, f can be very close to 1.0. This in turn implies that the Treasury rate, b, could be a good estimate of w. For example, if c = 0.8, t_c = 0.35, and t_p = 0.3, then f = 0.87, implying that the Treasury borrowing rate would be slightly above the weighted discount rate.

Table III.1 demonstrates that the two rates are within 10 to 20 percent of each other under a wide range of assumptions. This result implies that, given current interest and tax rates, the two nominal discount rates could often be within 100 or 200 basis points of each other; this is well within the range generally considered in a sensitivity analysis. Finally, note that if borrowed funds are included as another input into the weighted average discount rate formulation (as in Edwards, 1985), this could pull the weighted average even closer to the cost of borrowing.

Table III.1: The Weighted Average Discount Rate as a Fraction of the Treasury Borrowing Rate

	Aggregate marginal propensity to consume from tax revenue = 0.5					
	Corporate income tax rate					
Personal income tax rate	0.25	0.3	0.35	0.4	0.45	0.5
0.2	1.07	1.11	1.17	1.23	1.31	1.40
0.25	1.04	1.09	1.14	1.21	1.28	1.38
0.3	1.02	1.06	1.12	1.18	1.26	1.35
0.35	0.99	1.04	1.09	1.16	1.23	1.33
0.4	0.97	1.01	1.07	1.13	1.21	1.30

	Aggregate marginal propensity to consume from tax revenue = 0.8					
	Corporate income tax rate					
Personal income tax rate	0.25	0.3	0.35	0.4	0.45	0.5
0.2	0.91	0.93	0.95	0.97	1.00	1.04
0.25	0.87	0.89	0.91	0.93	0.96	1.00
0.3	0.83	0.85	0.87	0.89	0.92	0.96
0.35	0.79	0.81	0.83	0.85	0.88	0.92
0.4	0.75	0.77	0.79	0.81	0.84	0.88

Aggregate marginal propensity to consume from tax revenue = 0.6					
Corporate income tax rate					
0.25	0.3	0.35	0.4	0.45	0.5
1.01	1.05	1.10	1.15	1.21	1.28
0.98	1.02	1.07	1.12	1.18	1.25
0.95	0.99	1.04	1.09	1.15	1.22
0.92	0.96	1.01	1.06	1.12	1.19
0.89	0.93	0.98	1.03	1.09	1.16

Aggregate marginal propensity to consume from tax revenue = 0.7					
Corporate income tax rate					
0.25	0.3	0.35	0.4	0.45	0.5
0.96	0.99	1.02	1.06	1.11	1.16
0.93	0.95	0.99	1.03	1.07	1.13
0.89	0.92	0.95	0.99	1.04	1.09
0.86	0.88	0.92	0.96	1.00	1.06
0.82	0.85	0.88	0.92	0.97	1.02

Aggregate marginal propensity to consume from tax revenue = 0.9					
Corporate income tax rate					
0.25	0.3	0.35	0.4	0.45	0.5
0.85	0.86	0.87	0.89	0.90	0.92
0.81	0.82	0.83	0.84	0.86	0.88
0.76	0.77	0.78	0.80	0.81	0.83
0.72	0.73	0.74	0.75	0.77	0.79
0.67	0.68	0.69	0.71	0.72	0.74

Aggregate marginal propensity to consume from tax revenue = 1.0					
Corporate income tax rate					
0.25	0.3	0.35	0.4	0.45	0.5
0.80	0.80	0.80	0.80	0.80	0.80
0.75	0.75	0.75	0.75	0.75	0.75
0.70	0.70	0.70	0.70	0.70	0.70
0.65	0.65	0.65	0.65	0.65	0.65
0.60	0.60	0.60	0.60	0.60	0.60

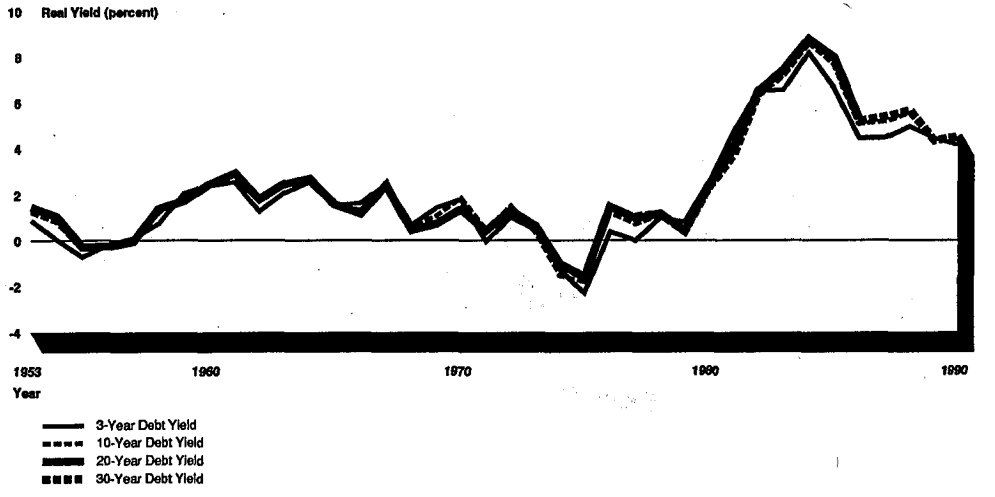
While the Treasury rate can be close to a weighted average rate, it is also important to note that the weighted average approach can yield very different results than the shadow price approach (see, e.g., McDonald, 1981, and app. IV). Although there is much interest in the weighted average approach, Feldstein (1972), among others, has argued that it is theoretically inferior to the shadow price approach.

Another feature of the Treasury rate approach is that the implied real rate can vary substantially

over time. Figures III.1 and III.2, for example, show the real interest rates yielded by 3-, 10-, 20-, and 30-year Treasury debt under alternative assumptions about inflation. Figure III.1 reflects the naive expectation that the inflation rate in the year of issue would continue for the life of the debt. Figure III.2 is based on the average actual realized inflation over the lives of the different issues.[3] Both figures suggest that there has been considerable variation in real rates, especially over the last decade. Such rates could imply the recommendation of very different public investment policies in different years. This type of highly variable discount rate does not seem to have been a significant concern in the public finance literature on discounting.

[3]For issues whose maturity has not been reached, the average realized inflation through 1990 is used.

Figure III.1: Real Yields Based on Issue-Year Inflation Rates



The water project evaluation guidelines, however—which limit year-to-year changes in the discount rate based on Treasury debt yield—do reflect concerns with variable rates over time (U.S. Water Resources Council, 1974 and 1978).[4] These guidelines have been criticized for being theoretically inconsistent in their use of a nominally determined interest rate to discount real benefits and costs (Carroll, et al., 1979, pp. 4-5). Interestingly, however, the nominal rates implied by the water project guidelines have generally been below the 10-percent real rate that OMB would otherwise recommend. In addition, the water project policy has been criticized for applying different rates to different types of investments—with water projects being favored—which could lead to inefficiencies. However, the

[4]CBO's policy of a fixed real interest rate is another possible approach to this problem.

Figure III.2: Real Yields Based on Actual Inflation to Date

shadow price of capital approach could also implicitly apply unequal rates by its differential weighting of the costs and benefits of different types of projects. In particular, the long lifespans of water projects and the fact that hydropower and flood prevention projects may provide some investment-type benefits might lead a shadow price approach to imply results comparable to a standard discounting approach using relatively low discount rates.

Lease-Purchase Decisions

One discounting policy area in which OMB, GAO, and CBO all largely agree is the rate for lease-purchase decisions. In this case, all of the agencies recommend using a rate based on the Treasury interest rate. The logic of this policy is that where the government will use an asset that will need to exist—such as a building or computer system—the policy decision is primarily a financial one

revolving around asset ownership by the government or the private sector. Either via leasing or purchasing, the real investment in the asset will be made by one of the sectors. In the lease-purchase case, therefore, it is believed to be inappropriate for the government to incur real (net of tax) lease costs greater than real borrowing costs associated with purchases in order to use an asset.

OMB and GAO—the latter under its revised policy—take the approach of matching the debt length to the project length in this case. GAO's prior policy used an average of debt yields through the lifespan of the project to approximate the effects of a yield curve. By averaging in returns on shorter length debt, this approach gave a rate that was generally slightly below the maturity-matching rate. On average, the differential has only been 36 basis points for a 20-year project over the 1970-88 period. GAO's earlier approximation was not very precise, as it did not weight the Treasury's marginal costs of funds, but rather took a simple average of published rates on actively traded debt issues.[5]

Asset Divestitures

Like lease-purchase decisions, asset divestiture decisions primarily involve questions of ownership as opposed to real investment. Examples of such assets include the Great Plains Coal Gasification Project, federal loans, and the Postal Service. In the first two cases, sales of federal assets to the private sector have been implemented; in the last case, they have been suggested (President's Commission on Privatization, 1988).

[5]OMB recommends adding a one-eighth percent penalty to the Treasury rate to reflect Federal Financing Bank costs. It is not clear that marginal borrowing actually incurs these costs, however.

Except in the credit program case, OMB has not issued guidelines for the discount rates to be used in asset divestitures. Executive agencies such as the Department of Energy have used private sector interest rates to evaluate assets such as the Great Plains Project and the naval petroleum reserves, however, which suggests OMB's acceptance of this exception to the 10-percent guideline. OMB has argued for the use of market interest rates in valuing outstanding loans.[6] The market is assumed to be the best available judge of loan default risk and servicing costs, and the risk premium assessed by investors has been argued to apply to federal ownership of these assets, too.

In contrast, GAO (1989b) has argued that the loans should be valued after subtracting costs such as expected defaults, but that the interest rate used to discount should reflect the government's borrowing costs. Assuming that expectations of default and related expenses are equivalent for the government's and private sector's analysts, the GAO approach would tend to yield a higher value for the outstanding loans because it would not apply a risk premium to future receipts. On the other hand, GAO recognizes that the private sector is only likely to bid its own value for the loans or other assets; therefore, the agency has considered private sector interest rates as part of its sensitivity analyses (GAO, 1988). GAO has also recognized that policy considerations such as the appropriate role of the government in the economy and the improvement of public management practices can be valid considerations in making divestiture decisions.

OMB's approach has the merit that no bias is created for public over private ownership of the loans. In contrast, GAO's approach could lead to more loans being retained by the government. GAO's policy, however, does not distort choices between

[6]CBO also considers this approach (CBO, 1989, pp. 39-41; Hartman, 1990, p. S-7).

credit programs and other programs, such as grants or direct provision of government services. All of these alternative programs would be evaluated at a risk-free Treasury rate. In contrast, OMB—and potentially CBO—might, in principle, evaluate different types of aid at different discount rates. In CBO's case, noncredit alternatives might be evaluated with the Treasury rate, which is below private market interest rates and Treasury rates plus an added risk premium. In OMB's case, noncredit alternatives could face the 10-percent real interest rate which may be above the real rate faced by comparable credit programs. Depending on the streams of benefits and costs, these approaches could make credit programs either relatively more or less costly than alternatives evaluated at a comparable discount rate.

In practice the risk premiums associated with credit programs due to risk aversion (i.e., after adjusting future benefits and costs for expected events) may be fairly small. Bosworth, Carron, and Rhyne (1987, p. 164) suggest a premium of about 50 basis points for federal credit programs. In this case, therefore, risk adjustment may be of fairly modest empirical significance for the government. The key issues may be the estimates of default costs and the investors' familiarity with the loans, which OMB recognizes may initially lead to inaccurate and inappropriate valuations (OMB, 1988, p. 3, reprinted in GAO, 1989a, p. 55).

Nevertheless, the question of whether the government should use risk-adjusted rates is an interesting one. If the government decides to use risk-adjusted discount rates more widely, the implications could reach much farther than is generally recognized. Lind (1982a, pp. 89-90 and 1982b, pp. 447-48) suggests, for example, that projects such as energy research, which may help stabilize the U.S. economy against shocks, should receive analysis at risk-adjusted discount rates that are below the base case rate. This position follows from the logic of

risk aversion and the capital asset pricing model, under which future benefits that reduce portfolio risk are worth more than their simple expected values. On the other hand, future benefits of policies that are positively correlated with gross national income, or otherwise increase the variability of social welfare, should be discounted with rates above the base case.[7]

Note, however, that these principles could apply to a much larger share of federal programs. Specifically, the argument could be made that programs such as the Strategic Defense Initiative and, more generally, the entire defense budget are forms of social insurance. That is, defense spending in principle reduces the extent of negative outcomes, yet has a cost in terms of reduced nondefense consumption during peacetime. While true benefit-cost analysis—as opposed to cost-effectiveness analysis—may be only infrequently applied to weapons systems, the logic of risk-adjusted rates could call for relatively low rates to be used where defense programs with insurance-types of benefits are subjected to full benefit-cost analysis.

It could also be argued that even traditional domestic programs—from the system of justice to social welfare programs—provide increased social stability. In both the defense and general government cases, however, rigorous objective application of risk-adjusted rates would be difficult because (1) the portfolio being stabilized is national welfare (in a broader sense than gross national product or financial market returns) and (2) there is no clear market analog to the types of activities and risks addressed by many of the federal programs.

[7]Future costs that increase (decrease) portfolio variability should be discounted with rates below (above) the risk-free rate.

Appendix IV

The Shadow Price of Capital

The most fundamental differences in discount rate policies across federal agencies appear to be in the areas of public investment and regulation. These areas—unlike lease-purchase and divestiture decisions—require true social benefit-cost analysis rather than financial analysis. The shadow price of capital approach has recently received considerable interest as an approach to such benefit-cost analyses because it resolves the dilemma resulting from unequal rates of opportunity cost and time preference. This appendix discusses the shadow price of capital approach and whether it is currently a good basis for oversight agency policy.

The shadow price of capital approach is based on a distinction between the values of the shares of costs, I_t, drawn from consumption, c, and from investment, 1 - c. The funds drawn from investment are imputed a rate of return equal to their opportunity cost, which yields a shadow price, S. These future imputed capital costs—as well as future consumption benefits—are then discounted back to the present at the rate of time preference, i. Thus if all benefits, B_t, are consumed, the present value of a public program using this method would be

$$\sum_{t=0}^{T} \frac{B_t - [(1 - c)S + c]I_t}{(1 + i)^t} \qquad \text{(IV.1)}$$

Where the opportunity cost is greater than the rate of time preference—as would be caused by taxes on capital income—the shadow price approach will imply that a dollar drawn from investment reduces the project's present value more than does a dollar drawn from consumption. Similarly, investment benefits will also be worth more than consumption benefits.

Depreciation and Reinvestment

One of the most important issues surrounding the shadow price approach is the treatment of depreciation and the rate of reinvestment of returns from capital. This issue, which may seem minor in other contexts, can dramatically affect the calculated shadow price of capital, changing it from just over 1.0 at low rates of reinvestment to infinity at high rates. Because costs are typically incurred early in a program, these changes in the shadow price can lead to major changes in the present value of the costs of a proposed public policy, with resulting major impacts on the policy's economic desirability.

The proper assumptions about reinvestment of capital income have been considered by several investigators (Bradford, 1975; Mendelsohn, 1981; Lind, 1982a; Lyon, 1990). Bradford's analysis of the shadow price considered an investment that lasts for one period and then returns both principal and interest. A certain fraction of this return of principal and interest is then reinvested. This approach leads to a shadow price of $(1 + \rho)(1 - s)/[(1 + i) - s(1 + \rho)]$, where ρ is the net return to capital, i is the rate of time preference, and s is the rate of savings from the gross return, $1 + \rho$ (Bradford, 1975, p. 893). Bradford did not explicitly consider reinvestment to prevent capital depreciation. Thus, even at fairly high savings rates, a portion of the original capital stock is likely to be consumed. This approach, therefore, led to relatively low estimates of the shadow price of capital (see case I in table IV.1).

This problem of low estimates was recognized by both Mendelsohn (1981) and Lind (1982a). These authors then considered a situation where all original capital was reinvested and the savings fraction, σ, applied only to ρ, the return net of depreciation. This approach yields an expression $(\rho - \sigma\rho)/(i - \sigma\rho)$ for the shadow price, generally implying much higher shadow price values than Bradford's assumptions (see case II in table IV.1).

Table IV.1: The Shadow Price of Capital Under Alternative Assumptions

Rate of time preference (i) and Case		Savings rate (s,σ)								
		0.10			0.20			0.30		
		Return net of depreciation (ρ)								
		0.05	0.10	0.15	0.05	0.10	0.15	0.05	0.10	0.15
0.02	Case I[a]	1.03	1.09	1.14	1.04	1.10	1.17	1.04	1.12	1.19
	Case II[b]	3.00	9.00	27.0	4.00	∞	∞	7.00	∞	∞
0.05	Case I	1.00	1.05	1.11	1.00	1.06	1.12	1.00	1.07	1.14
	Case II	1.00	2.25	3.86	1.00	2.67	6.00	1.00	3.50	21.0
0.08	Case I	0.97	1.02	1.07	0.97	1.02	1.08	0.96	1.03	1.10
	Case II	0.60	1.29	2.07	0.57	1.33	2.40	0.54	1.40	3.00

[a]For case I, the gross rate of return is $1 + \rho$; the rate of depreciation is 1; and the savings rate, s, applies to the gross return.

[b]For case II, the savings rate, σ, applies to the return net of depreciation, ρ.

Source: Adapted from Lind (1982a, p.50).

Lind (1982a, pp. 51-54) went on to develop a series of more complex expressions for the shadow price. He particularly focused on the case of an asset with a finite lifespan that is assumed to depreciate in a straight-line manner. These assumptions yield a fairly complex expression for the shadow price and require an estimate of the lifespan and gross returns of the capital displaced by the public activity.

If the marginal investments displaced by a public activity all have the same return net of depreciation, however, this more complex case may not usually need to be considered. In particular, the work of Hulten and Wykoff (1981) suggests that geometric depreciation is a better model of true economic depreciation than straight-line depreciation. It is straightforward to develop expressions for the shadow price that explicitly reflect the rate of geometric depreciation, d. Where savings is a fraction

of the return prior to depreciation, r, the shadow price is (r - sr)/(i + d - sr); where savings is a fraction of the net return, the shadow price is given by the Mendelsohn-Lind expression, $(\rho - \sigma\rho)/(i - \sigma\rho)$.[1] The shadow price examined here represents the social value of capital. The necessary and sufficient condition for this value to be greater than 1, given geometric depreciation, is for the return net of

[1]The shadow price of capital is the present value of the future consumption yielded by a unit of capital. Define S as the shadow price of capital; r as the gross rate of return from capital prior to depreciation; d as the rate of depreciation; s as the rate of savings from the gross return, r; C_t and K_t as the undiscounted consumption and capital stock in year t, respectively; and i as the rate of time preference. Consider a unit of investment made in year 0. After one year this investment yields a gross return of r, allowing consumption, C_1, equal to r (1 - s). The capital stock at this time, K_1, is (1 -d) + sr. Similarly, in year 2 there is a gross return of r(1 - d + sr), and $C_2 = (r - sr)(1 - d + sr)$ while $K_2 = (1 - d + sr)(1 - d) + [sr(1 - d + sr)] = (1 - d + sr)^2$. For year 3, comparable values are $C_3 = (r - sr)(1 - d + sr)^2$ and $K_3 = (1 - d + sr)^3$. By induction the present value of consumption, S, can be expressed as:

$$S = \frac{(r - sr)}{1 + i} + \frac{(r - sr)(1 - d + sr)}{(1 + i)^2} + \frac{(r - sr)(1 - d + sr)^2}{(1 + i)^3} + \ldots$$

$$= \frac{(r - sr)}{1 + i}\left[1 + \frac{1 - d + sr}{1 + i} + \frac{(1 - d + sr)^2}{(1 + i)^2} + \ldots\right]$$

$$= \frac{(r - sr)}{1 + i}\left[1 - \frac{(1 - d + sr)}{1 + i}\right]^{-1}$$

where $sr < i + d$ (otherwise S is infinite). The above expression simplifies to $S = (r - sr)/(i + d - sr)$.

An analogous expression can be derived where it is assumed that funds are always set aside to cover depreciation of the original capital investment. In this case, define ρ as the return net of depreciation and σ as the rate of saving from this net return. Therefore, $\rho = r - d$ and $\sigma\rho = sr - d$. Substituting ρ and σ into the prior expression for S and simplifying yields $S = (\rho - \sigma\rho)/(i - \sigma\rho)$.

Thus, these last two expressions for S are alternative ways of expressing the shadow price of capital in the presence of geometric depreciation. The former equation is used when the savings rate applies to the gross return, while the latter equation is used when the savings rate applies to the return net of depreciation.

depreciation to be greater than the rate of time preference.

As table IV.1 suggests, the shadow price estimates are very sensitive to the values of rates of opportunity cost, time preference, and reinvestment of returns from capital. Unfortunately, estimates of these parameters are uncertain. In fact, in the case of reinvestment, the estimates may be largely educated guesses due to a lack of relevant empirical work.

Cost Incidence, Capital Displacement, and Aggregation

In contrast to the treatments of depreciation and reinvestment—which have received a fair amount of attention in the shadow price literature—the issues of cost incidence, capital displacement, and aggregation have been relatively overlooked. For accurate application of the shadow price method, however, these issues are central because costs can receive substantially different weights depending on whether they are borne by consumption or investment.

Figures IV.1 and IV.2 show the effects of different assumptions about the shares of costs drawn from consumption and investment. Both figures consider projects with all costs incurred in year 0 and with benefits that follow at an even rate for 5, 15, 30 or 100 years. The streams of annual benefits vary by project length and assumed shadow price and are calculated as those needed to produce a net benefit of 0 using the shadow price approach. The rate of time preference is assumed to be 0.04. The internal rates of returns of the resulting streams were then calculated using the standard approach that measures the costs prior to application of the shadow price. These internal rates of return are measured on the vertical axis. They correspond to the standard discount rates that would give results equivalent to the shadow price method for projects with initial costs and then steady benefits.

Figure IV.1: Implied Internal Rate of Return or Discount Rate Versus the Shadow Price of Capital: 100 Percent of Costs From Investment

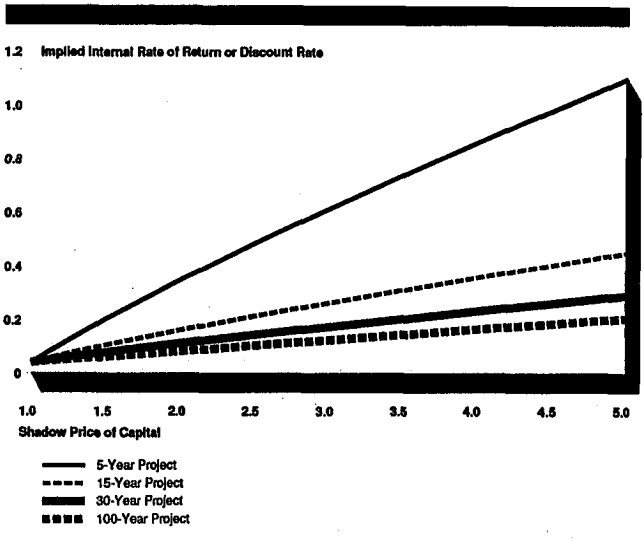
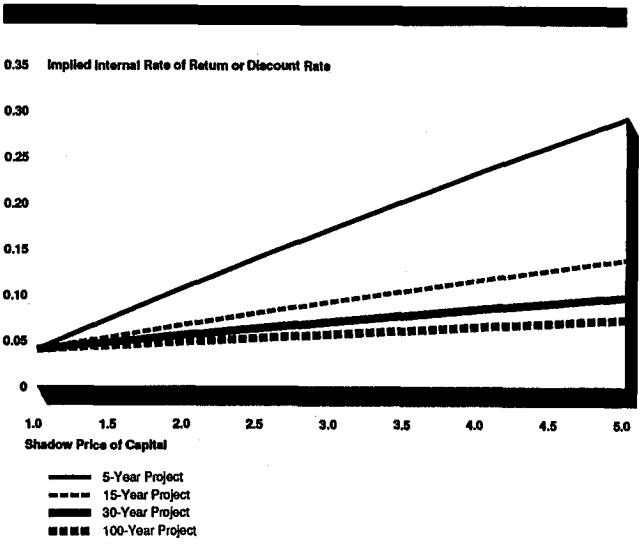


Figure IV.2: Implied Internal Rate of Return or Discount Rate Versus the Shadow Price of Capital: 20 Percent of Costs From Investment



The figures differ in the shares of program costs assumed to be borne by investment. Figure IV.1 assumes that all costs come from investment; figure IV.2 assumes that only 20 percent are drawn from

investment. Thus, if a project has initial costs drawn from investment followed by 5 years of pure consumption benefits, it must yield a 20-percent rate of return if the shadow price is 1.5 and a 61-percent annual return if the shadow price is 3.0 (fig. IV.1). Alternatively, if only 20 percent of the cost is from investment, then the necessary rates of return are 7 percent and 17 percent, respectively (fig. IV.2). The figures clearly demonstrate the sensitivity of project feasibility to assumptions about cost incidence and the shadow price.[2]

A key question, therefore, is how the quantity of productive private capital changes in response to a regulation or public investment. The capital market in turn will reflect the incidence of the regulation or funding mechanisms.

The problems associated with analyzing the incidence of regulations or of taxes used to fund public investment should suggest the complexity of this issue. A first step in the case of taxes may be to distinguish between the portion of taxes paid by consumers versus firms. In the case of payroll taxes and personal income taxes on wages, it is fairly well agreed that labor bears the burden due to its relatively inelastic supply. The personal income tax also affects savings incentives, however. To the extent that new investments are funded by average revenues, aggregate studies of the effects of taxes on savings may be acceptable. Where changes in tax

[2]Using the expressions for the capital recovery factor and the present worth of a uniform series, the relationships illustrated in figures IV.1 and IV.2 can be shown to be represented by $[(1 + \delta)^n - 1][\delta(1 + \delta)^n]^{-1} = [(1 + i)^n - 1][i(1 + i)^n[(1 - c)S + c]]^{-1}$, where δ is the discount rate measured on the vertical axis; n is the lifespan of the project; i is the rate of time preference; c is the fraction of costs borne by consumption; and S is the shadow price, presented on the horizontal axis. Alternative scenarios, such as where costs are incurred over a series of years or where a portion of benefits are invested, can also be considered. The latter case, in particular, reduces the necessary rates of return for the projects because in this case the shadow price would also apply to a portion of the benefits.

rates primarily affect high income taxpayers, however, the effects on savings may be different.

Unfortunately, there is relatively little current data on the marginal propensities to save by income class. These data are not currently collected by the Federal Reserve Board Survey of Consumer Finances or the Bureau of Labor Statistics Survey of Consumer Expenditures. Of the few studies available, one dates from three decades ago (Friend and Schor, 1959, cited in Gordon, 1987, pp. 480-81). This study shows saving rates of 30 percent and above for the highest income Americans. If these high rates of saving are relevant to marginal changes in income taxes, they could affect both the share of costs borne by capital and the reinvestment rates for capital income. The corresponding impacts of the shadow price of capital could be much higher than if average propensities to save are used to estimate costs. On the other hand, more recent studies have not found that savings propensities necessarily rise with income (Blinder, 1975; Musgrove, 1980).

While treatment of personal taxes is challenging, the incidence of the corporate income tax is one of the major unresolved issues in public finance; it is not clear to what extent this tax reduces investment or consumption. Moreover, even to the extent that this tax reduces investment, one would need to distinguish between the reductions in corporate versus noncorporate capital, as capital in these sectors could have very different pretax returns—and thus very different shadow prices.

In this context, note that the logic of the shadow price method will generally require a different shadow price to be applied to each of the different

types of corporate and noncorporate capital displaced. In particular, if costs are borne by consumption and two types of capital, the present value of a program would be

$$\sum_{t=0}^{T} \frac{B_t - [f_1 S_1 + f_2 S_2 + 1 - (f_1 + f_2)]I_t}{(1+i)^t} \qquad \text{(IV.2)}$$

where f_1 and f_2 are the fractions of costs borne by the two types of capital; S_1 and S_2 are the respective shadow prices of capital; and $1 - (f_1 + f_2)$ is the share of costs borne by consumption. Alternatively, the term in brackets can be expressed as $(1 - c)S_w + c$, where c is the marginal propensity to consume; S_w is a weighted average of the shadow prices; and the weights on S_1 and S_2—w_1 and w_2—are $f_1/(f_1 + f_2)$ and $f_2/(f_1 + f_2)$, respectively.

In general, however, a simple weighted average of the returns to these different types of capital will not yield the appropriate shadow price. Rather, the weighted average of shadow prices (the theoretically correct approach) will be greater than the shadow price determined using the simple weighted average of interest on displaced capital, whenever the rate of savings net of depreciation, σ, is positive (Lyon, 1990).

The issue of multiple shadow prices is of much more than academic interest. OMB's 10-percent rate, which is often used as a benchmark for the pretax return to capital, is consistent with Stockfisch's (1969) estimated weighted average of returns to unregulated corporate, public utility, and noncorporate capital. Stockfisch estimated that 70 percent of corporate capital earned 16.5 percent and 30 percent earned 11.5 percent before taxes and inflation. These estimates implied a weighted average return of 15 percent for the corporate sector. The 60 percent of total capital in the

noncorporate sector was assumed to earn 10 percent. Stockfisch's approach implied a 12-percent overall return before inflation, or about 10 percent after inflation.

Depending on the rates of saving and time preference assumed, the shadow price derived using this 10-percent rate can differ little or markedly from the weighted average shadow price. Where $\sigma = 0.1$ and $i = 0.04$, the shadow price of the weighted average return, $\rho_A = 0.10$, is 3.0. The weighted average shadow price (calculated using the deflated returns) is 3.1. At $\sigma = 0.25$, however, the shadow price of the 10-percent return is 5.0, while the weighted average shadow price is 10.4—which would cause the true present value capital cost to be more than double the value approximated using the weighted average interest rate.

A final issue associated with estimating the incidence of costs upon capital concerns the need to evaluate the product and factor markets of regulated (as well as taxed) industries carefully. If product demand is very inelastic, for example, consumers may primarily bear the burden of regulatory costs through reduced consumption. On the other hand, if demand is very elastic, producers may bear the burden, and in turn domestic capital may be reduced.

This result suggests that the extent to which industries subject to environmental or related regulations compete internationally will be important. If the price of steel or autos is largely determined by foreign producers not subject to U.S. regulations, domestic producers may not be able to pass on costs, and domestic capital may be reduced. In contrast, regulations affecting an industry where imports are less important—such as, perhaps, petroleum refining and marketing—may be largely passed on to consumers. This type of result suggests that the discounting procedure may implicitly tip

certain regulatory choices in favor of some industries and against others by weighting their costs differently. Such effects may be appropriate from an efficiency standpoint, and even standard discounting procedures affect different industrial regulations differently. Nevertheless, such differential weighting of costs—particularly where based on uncertain and sensitive parameters—may raise interindustry (and other) equity controversies.

Conclusions

The following conclusions can be drawn regarding the shadow price approach:

- Assuming that geometric depreciation adequately describes economic depreciation, then the shadow price of capital can be estimated using the equations derived in footnote 1 (p. 44) of this appendix. This approach means that estimates of the lifespans of displaced capital are not necessary.
- The notion of one shadow price of capital is misleading. Rather, if different types of displaced capital have different social returns—due to unequal tax treatment, for example—then the appropriate shadow price of capital is a weighted average of individually calculated shadow prices. A single shadow price calculated using a weighted average of interest rates from the different types of capital will generally understate the true cost of the contemplated public activity.
- The shadow price approach requires increased awareness of the incidence of program costs. Incidence affects the estimates of the marginal propensity to consume and the fractions of different types of capital displaced. Small differences in these weights can have major impacts on the present values of costs because of the multiplication by the shadow prices. Two important aspects of the incidence issue are the existence of unresolved tax and regulatory incidence questions.
- Reinvestment rates also can dramatically alter shadow price estimates. Unfortunately, available estimates of aggregate U.S. savings rates may be

unrepresentative of the marginal rates of high income taxpayers or recipients of capital income. More empirical research in this area may be essential to accurate use of the shadow price method.

Given the advantages and difficulties of the shadow price method, its use by GAO should be judicious, since the approach could either weaken or improve discounting procedures. Continued use of traditional approaches, with sensitivity analysis, appears likely to remain appropriate for the near future.

Weakening of GAO discounting procedures could occur if the shadow price approach is used to manipulate the outcomes of analyses. Because the values of most of its key parameters are uncertain and, in some cases, project-specific, it is susceptible to this danger.

One example of an uncertain value is the rate of time preference. Given current empirical measures such as long-term growth rates and historic investment yields, it may be hard to determine the rate of time preference objectively. Yet, at a 10-percent opportunity cost and a 20-percent savings rate, the difference between time preference rates of 4 percent and 2 percent implies the difference between shadow prices of 4 and infinity. Cost incidence, savings and reinvestment rates, and real returns for different types of displaced capital all present areas for technical assumptions that could dramatically alter perceived program costs.

Because the shadow price approach is new, there is the added danger that decisionmakers who are neither economists nor specialists in this field will be unaware of the effects of the alternative assumptions. In contrast, policymakers are increasingly aware of the differences between real interest rates of 4 percent and 10 percent as used by the traditional discounting approach.

Despite these cautions, however, it is valuable to continue to explore and develop approaches such as the shadow price method. If the shadow price approach is correct, it implies that neither OMB's 10-percent rate nor GAO's Treasury rate is correct for all analyses. Similarly, a simple weighted average rate, based on opportunity cost and time preference, is also not a general solution. A theoretically preferred approach would imply using a project-specific rate that could be above OMB's rate or below GAO's rate or between these rates, depending on the problem. Where public investments or regulations could have major impacts, the careful estimation of the shadow price may be worthwhile.

Realistically, sufficiently accurate empirical estimates needed to use the shadow price approach on a widespread basis do not appear to be generally available. Although this situation may be different in a decade, for now it appears likely that most public agencies will elect to maintain clear, simple discounting rules with sensitivity analysis. The shadow price approach can supplement this analysis, however, with insights about which portion of the sensitivity analysis—such as the low, moderate, or high discount rate scenarios—may be theoretically preferred.

Appendix V

Tax Revenues From Asset Divestitures

While not literally a discounting issue, the treatment of tax revenues from projects whose ownership is being evaluated often arises in conjunction with discounting issues and involves some similar questions regarding the source of investment funds. The specific question addressed here is whether the corporate income tax revenues associated with the sale of a federal asset to the private sector should be considered incremental revenues.

The base case assumption for GAO analysis should be that the corporate taxes from the newly privatized asset be counted as incremental. The justification for this assumption is that asset divestiture to private corporations subject to U.S. taxes will be offset by reduced holding of Treasury debt by individuals, institutions, or foreign investors that generally are not subject to U.S. corporate taxes. The personal income taxes that would be paid by U.S. citizens on Treasury debt interest are assumed, in this base case, to be offset by personal income taxes on capital gains and dividend income from the corporate investment.

A sensitivity analysis that assumes that not all corporate tax revenues are net additions, however, can be justified by the possibility that these revenues are at least partially offset by reduced revenues elsewhere. For example, if the corporate income from the privatized asset is largely untaxed at the personal level, there could be a net reduction in personal income tax revenues since private holdings of Treasury debt may have been fully taxable.[1]

[1]On the other hand, tax revenues are a product both of tax rates and rates of return. Even if capital gains generated by corporate income are subject to lower effective personal income tax rates than is the interest income generated by Treasury debt–as would be the case if not all capital gains are realized—the privatized asset may still yield comparable personal income tax revenues because it typically would have a higher rate of return than the Treasury debt.

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