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SELECTION OF A DISCOUNT RATE FOR USE IN NRC
REGULATORY ANALYSES AND APPLICATION OF DISCOUNT
RATES TO FUTURE AVERTED HEALTH EFFECTS

O.H. Paananen
P.L. Hendrickson

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SUMMARY

The principal objective of this report is to provide background information and recommendations on the use of discount rates in the regulatory analysis process. The report focuses on two issues:

- selecting the appropriate discount rate or rates to use when conducting a regulatory analysis
- applying the selected discount rate to future health-related benefits estimated to result from alternative regulatory actions.

Recommendations related to these two issues are included in Section 6 of the report.

The U.S. Nuclear Regulatory Commission (NRC) voluntarily prepares regulatory analyses of proposed regulatory actions. The current NRC Regulatory Analysis Guidelines (NRC 1984, p. 4) provide that "monetary costs and benefits should be expressed in present value through the use of an annual discount rate of 10%." Current NRC practice is generally to discount costs at a base real discount rate of 5% and not to discount future health-related benefits. NRC is apparently free to set its own discount rate policy. No discount rate guidance which NRC is obligated to follow was found. A recent court case involving the Environmental Protection Agency (EPA), however, suggested that EPA must discount benefits as well as costs when performing a benefit-cost analysis of a proposed regulation.

The Office of Management and Budget (OMB) has issued guidance for preparing regulatory impact analyses (OMB 1992) and updated its Circular A-94 in November 1992 which provides guidance for selecting discount rates (57 FR 53519). The OMB guidance is that both the benefits and costs associated with proposed regulatory actions are to be discounted at a base real discount rate of 7%. Because it is an independent agency, the NRC is not required to follow the OMB Guidance.

The debate during the last half century among economists concerning the appropriate discount rate to use in benefit-cost and regulatory analyses has led to a number of conclusions about the theoretical basis for choice of a discount rate. The literature on the "second-best" approach has been particularly fruitful in this regard. The conclusions derived from the second-best approach is that the social rate of time preference represents the correct measure of the social discount rate for benefit-cost analysis.

Given that the social rate of time preference is the correct choice for the discount rate, problems still remain in accounting for tax and risk effects on the different opportunity costs of consumption and investment that are displaced by investment in public projects or regulatory implementation. Further, the opportunity costs of consumption and investment must be linked to the social discount rate, as reflected by the social rate of time preference.

The shadow price of capital (SPC) approach does provide a link between the private (consumer and producer) rates of discount. Assuming that time preferences of individuals reflect the social rate of time preference, the SPC approach also brings together the social rate of time preference and the private consumption discount rate. As a result, the SPC approach provides a straightforward, theoretically sound approach that links private and social discount rates for benefit-cost analysis.

While the theoretical basis for selection of a discount rate has become clearer in recent years, the application of a discount rate to future averted health effects has not. A number of approaches to adjusting the social discount rate or modifying the benefit-cost procedure have been explored. While there is no consensus on the method to adjust the social discount rate downward in response to concerns about intergenerational effects, there is general agreement that the "correct" rate for use in intergenerational comparisons falls between the social rate of time preference (as reflected by consumer opportunity cost) and zero.

Attempts to modify the benefit-cost efficiency criterion have not provided any clear guidance about what the "correct" social discount rate should be. Research findings from modification of the benefit-cost methodology suggest that, if the usual efficiency criterion of benefit-cost analysis is unacceptable, some "fair" decision mechanism or process (e.g., democratic voting process) be used to guide government policy on intergenerational matters.

ABBREVIATIONS

ALARA	As Low as Reasonably Achievable
CAPM	Capital Asset Pricing Model
CFR	Code of Federal Regulations
DCF	Discounted Cash Flow
DOT	U.S. Department of Transportation
E.O.	Executive Order
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
FDA	Food and Drug Administration
FR	Federal Register
NHTSA	National Highway Traffic Safety Administration
NRC	U.S. Nuclear Regulatory Commission
NRR	Office of Nuclear Reactor Regulation
OMB	Office of Management and Budget
OSHA	Occupational Safety and Health Administration
RIA	Regulatory Impact Analysis
ROE	Return on Equity
SPC	Shadow Price of Capital
U.S.C.	United States Code

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1.0 INTRODUCTION

The principal objective of this report, prepared by Pacific Northwest Laboratory,⁽¹⁾ is to provide background information and recommendations on the use of discount rates⁽²⁾ in the regulatory analysis process. Specifically, the scope of the report is focused on two issues:

- selection of the appropriate discount rate or rates to use when conducting a regulatory analysis, and
- application of the selected discount rate to future averted health effects estimated to result from alternative regulatory actions.

This introductory section contains information on the role of the discount rate in regulatory analyses prepared by the U.S. Nuclear Regulatory Commission (NRC), NRC's historical and proposed policies on discount rates, and monetization of health effects. Section 2 covers legal and regulatory guidance for selection and application of discount rates. Section 3 discusses the theoretical basis for selection of an appropriate discount rate for NRC regulatory analyses. Section 4 contains some perspectives on discounting future averted health effects. Section 5 discusses discount rate practices in selected federal agencies. A concluding section contains recommendations.

1.1 REGULATORY ANALYSIS AND THE ROLE OF THE DISCOUNT RATE

A regulatory analysis is a structured evaluation of the relevant factors associated with the making of a regulatory decision. Although the NRC has never had a statutory mandate to conduct regulatory analyses, it voluntarily began performing such analyses in 1976, two years after the NRC was established under the Energy Reorganization Act of 1974. The analyses

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- (1) Pacific Northwest Laboratory is operated by Battelle Memorial Institute for the U.S. Department of Energy under Contract DE-AC06-76RLO 1830
- (2) The discount rate is the interest rate used in calculating the present value of expected yearly benefits and costs (57 FR 53526, November 10, 1992).

prepared before 1983 were termed value/impact analyses and were prepared according to value/impact guidelines issued by NRC in final form in December 1977 (SECY-77-388A).

In February 1981, President Reagan issued Executive Order (E.O.) 12291. The Order requires all agencies within the definition at 44 U.S.C. 3502(1) [excluding independent agencies within the definition at 44 U.S.C. 3502(10)] to prepare a Regulatory Impact Analysis for all major rules and directs that regulatory actions are to be based on adequate information concerning the need for and consequences of proposed actions. Moreover, actions are not to be undertaken unless there is a positive net value to society.

The NRC is an independent agency as defined at 44 U.S.C. 3502(10). Consequently, it is not within the definition of "agency" in section 1 of E.O. 12291 and is not required to comply with the Order. Nevertheless, the Commission determined that clarifying and formalizing the NRC value/impact procedures then in place for analysis of regulatory actions would be desirable to enhance the effectiveness of NRC regulatory actions and to meet the spirit of E.O. 12291.

NRC issued its Regulatory Analysis Guidelines in 1983 (NRC 1983). Later that year a guidance document (the "Handbook") for preparation of regulatory analyses was issued (Heaberlin et al. 1983). Revision 1 to the Regulatory Analysis Guidelines (the "Guidelines") was issued to include appropriate references to the Handbook (NRC 1984). Both the Regulatory Analysis Guidelines and the Handbook are currently under revision by the Office of Nuclear Regulatory Research.

As used by the NRC, a regulatory analysis consists of the six steps described in Section III(B) of the Guidelines (NRC 1984). Section (III)(B)(4)(a) of the Guidelines instructs the analyst to estimate the benefits and costs of the alternatives under consideration. The analyst is further instructed that those benefits and costs expressed in monetary terms are to be discounted to present value.

The Regulatory Impact Analysis Guidance issued by the Office of Management and Budget (OMB) contains the following statement on the need for discounting when performing a regulatory analysis:

The monetary values of benefits and costs occurring in different years should be discounted to their present values so that they are comparable. This is not the same as correcting for inflation. An inflation adjustment is made with a price index, whereas discounting to present value is done with a discount rate. Benefits and costs expressed in constant (i.e., unaffected by inflation) dollars must further be discounted to present values before benefits in different years can be added together to determine overall net benefits. ... Discounting takes account of the fact that resources (goods or services) in a given year are worth more than identical resources in a later year. The underlying reason for this is that resources can be invested so as to return more resources later. Partly because of this productivity of investment, individuals value consumption in earlier years higher than consumption in later years. (OMB 1992, p. 727)

1.2 NRC'S HISTORICAL DISCOUNT RATE POLICIES

NRC's present discount rate policy as stated in the Guidelines (NRC 1984, p. 4) is that "monetary costs and benefits should be expressed in present value through the use of an annual discount rate of 10%." The 10% discount rate referred to in the Guidelines is a real discount rate, i.e., a discount rate after adjustments for inflation have been taken into account. The Guidelines are not explicit on this point, but it is apparent because the Guidelines instruct the analyst to convert all benefits and costs expressed in monetary terms to constant dollars (NRC 1984, p. 4), and because the 10% rate is based on the 10% real discount rate designated in the March 1972 version of OMB's Circular A-94. The Handbook suggests that the analyst use one or more additional discount rates to indicate the sensitivity of the results to the choice of discount rate (Heaberlin et al. 1983, p. C.2). The Office of Nuclear Reactor Regulation's (NRR 1986, p. 6) supplementary regulatory analysis guidance indicates that the analyst should use a 5% real discount rate to test the sensitivity of the results to the discount rate. Notwithstanding the existing guidance in these documents, the current NRC practice is to use a 5% real discount rate in regulatory analyses and a 10%

real discount rate for sensitivity analysis. Neither the Guidelines, the Handbook, nor the NRR supplementary guidance specifically discuss the issue of discounting future averted health effects associated with a proposed regulatory action. Nevertheless, NRC practice when preparing regulatory analyses is not to discount future averted health effects.

1.3 NRC's HISTORICAL AND PROPOSED POLICY ON MONETIZING HEALTH EFFECTS

The Guidelines (NRC 1984, p. 4) include the statement that "where possible, costs and benefits should be expressed in safety, occupational exposure, or monetary terms." No further guidance is provided in the Guidelines on the issue of monetizing averted radiation exposure and associated health effects. Current NRC practice when conducting regulatory analyses is to compare the estimated costs and dose savings of a proposed action with a figure of \$1000/person-rem. The \$1000/person-rem figure is assumed, in many cases, to capture both health effects and offsite consequences such as property damage. The NRC first used the \$1000/person-rem figure when it was added in 1975 to Appendix I to 10 CFR Part 50. The value currently appears at 10 CFR 50, App. I(Sec. II)(D) in a paragraph relating to items to include in a license applicant's radwaste system. Additional background information on the history of NRC's use of the \$1000/person-rem valuation is included in a draft report prepared at Brookhaven National Laboratory.⁽³⁾ The Handbook suggests that the analyst use a range of values to monetize health effects, one of which should be \$1000/person-rem (Heaberlin et al. 1983, p. 3.15).

The most current predecisional draft of Revision 2 to the Guidelines instructs the analyst to use the \$1000/person-rem figure (in 1993 dollars) as a surrogate for "all offsite consequences (health related impacts and dollar values for offsite cleanup, contamination, and property damage values) of severe power reactor accidents, and as a reference point or baseline where offsite consequences are not involved such as for occupational exposure,

(3) V. Mubayi, et al., Brookhaven National Laboratory, Cost-Benefit Considerations in Backfit Analysis, Section 2.4.1, January 1992.

non-power reactor accidents, and as low as reasonably achievable (ALARA) determinations associated with cleanup of contaminated sites." This position is, however, identified as an interim position in the draft. A final position regarding the \$/person-rem figure is to be issued after the NRC staff's review and analysis of the issue is complete.

2.0 LEGAL AND REGULATORY DISCOUNT RATE GUIDANCE

The purpose of this section is to describe any legal or regulatory guidance affecting NRC's selection of a discount rate(s) to use in regulatory analyses and the application of such rate to future averted health effects. No guidance of a legal or regulatory nature that is binding on the NRC was found. In particular, no statutory guidance was found related to selection and use of a discount rate by the NRC. There is material, however, that provides guidance for the NRC in reaching decisions on appropriate selection and use of discount rates. This material is discussed in this section with special attention given to OMB's "Regulatory Impact Analysis (RIA) Guidance" and OMB's recent "Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs." These OMB guidance documents are also referred to later in this report.

2.1 OMB'S REGULATORY IMPACT ANALYSIS GUIDANCE

OMB's RIA Guidance appears as Appendix V in the document Regulatory Program of the United States Government: April 1, 1991 - March 31, 1992 (OMB 1992, p. 723). The RIA Guidance was first published in draft form in the Regulatory Program document for 1987-1988. Six federal agencies commented on the draft Guidance (OMB 1991, p. 33). The final RIA Guidance was initially published as Appendix V in the 1991 Regulatory Program document (OMB 1991, p. 653). Federal agencies subject to E.O. 12291 are to follow the OMB RIA Guidance when preparing a RIA under the requirement in Section 3 of E.O. 12291.

The NRC is an independent regulatory agency and consequently is not subject to E.O. 12291 or the OMB RIA Guidance. Nevertheless, the OMB RIA Guidance merits consideration because other federal agencies are following it and because the Guidance received considerable review during its development.

The OMB RIA Guidance adopts the following positions related to the scope of this report:

- The monetary values of both benefits and costs should be discounted to present value so that they are comparable (OMB 1992, p. 727).
- The discount rate should not be adjusted to account for the uncertainty of expected future benefits and costs (OMB 1992, p. 728).
- Federal agencies should generally perform discounting using a single discount rate, and, when appropriate, perform additional analysis using the more complex shadow price of capital (SPC) methodology (OMB 1992, p. 727).
- Both benefits and costs which are monetized and those which are not monetized should be discounted (OMB 1991, pp. 33,34).

The OMB RIA Guidance references OMB Circular A-94 for the appropriate discount rate to use (OMB 1992, p. 727). Circular A-94 was issued in June 1969 and revised in March 1972. The March 1972 version of Circular A-94 was recently replaced by a revised Circular A-94, which OMB issued under the title "Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs." These Guidelines are discussed in the next section.

2.2 OMB'S GUIDELINES AND DISCOUNT RATES FOR BENEFIT-COST ANALYSIS OF FEDERAL PROGRAMS

On November 10, 1992, OMB issued its "Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs" (57 FR 53519-53528). A summary of the Guidelines was earlier published for comment in the Federal Register (57 FR 35613, August 10, 1992). The Guidelines contain general guidance on conducting benefit-cost and cost-effectiveness analyses and on the discount rates to be used in evaluating federal programs whose benefits and costs are distributed over time. The OMB Guidelines are directed at Executive Branch agencies and are not binding on the NRC.

The OMB Guidelines adopt the following positions related to the scope of this report:

- The standard criterion for deciding whether a government program can be justified on economic principles is net present value--the discounted

monetized value of expected net benefits (i.e., benefits minus costs) (57 FR 53520).

- In addition to net present value, other summary effectiveness measures can provide useful supplementary information, e.g., the number of injuries prevented per dollar of cost (both measured in present value terms) (57 FR 53521).
- All future benefits and costs, including non-monetized benefits and costs, should be discounted (57 FR 53522).
- For the base case analysis, net present value should be computed using a real discount rate of 7%⁽⁴⁾ (57 FR 53523).
- Analysis of the sensitivity of results to choice of discount rate should be considered; a discount rate higher than 7% should be used in such sensitivity analysis if the main cost of an alternative regulatory action is to reduce business investment⁽⁵⁾ (57 FR 53523, 53524).
- Use of the SPC to value benefits and costs is the analytically preferred means of capturing the effects of government projects on resource allocation in the private sector; to use this method accurately, the analyst must be able to compute how the benefits and costs of a program or project affect allocation. For Executive Branch agencies, OMB concurrence is required if the SPC approach is used in place of the base case discount rate (57 FR 53523).

Again, because the NRC is an independent regulatory agency, it is not subject to OMB's Guidelines in revised Circular A-94. Nevertheless, the Guidelines merit consideration because other federal agencies are following the Guidelines and because the Guidelines received considerable review during their development.

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- (4) OMB notes that the 7% rate approximates the marginal pre-tax rate of return on an average investment in the private sector in recent years. OMB plans to update Circular A-94 in the future if the 7% rate changes significantly (57 FR 53523).
- (5) Most NRC regulations ultimately have the effect of reducing business investment because the cost of complying with the regulation is paid with funds that otherwise might be available to the licensee for investment.

2.3 ADMINISTRATIVE CONFERENCE OF THE UNITED STATES

The Administrative Conference of the United States is an independent agency of the United States whose purpose is to develop improvements in the legal procedures by which federal agencies administer regulatory, benefit, and other government programs (1 CFR Part 301). Two recommendations of the Conference relate to this report.

Recommendation 79-4, "Public Disclosure Concerning the Use of Cost-Benefit and Similar Analyses in Regulation," appears at 1 CFR 305.79-4. Recommendation 79-4 includes the following statement:

Agencies, as general policy though not necessarily by binding rule, should adopt the practice of addressing, in their public notices of particular proceedings in which cost-benefit or similar analyses are to be use, the following points: ... (e) The agency's methods for evaluating intangible costs and benefits, for discounting future costs and benefits, and for taking account of distributional effects arising under the selected methodology, to the extent such issues are involved in the analyses.

Recommendation 88-7, "Valuation of Human Life in Regulatory Decisionmaking," appears at 1 CFR 305.88-7. Recommendation 88-7 contains the following statement:

When an agency adopts a regulation that is intended to reduce the risk to human life, based on a judgment that the associated compliance costs are justified, the agency should disclose the dollar value per statistical life used for the purposes of that determination. ... Whenever agencies choose to discount costs and benefits in implementing (the preceding statement), they should clearly and fully disclose what rates they are using, the methodology that generated those rates, and the sensitivity of outcomes to the particular rates applied.

2.4 COURT CASES

On occasion, courts are asked to review the appropriateness of a discount rate used by a federal agency. This issue could be raised, for example, in a review of a regulation promulgated by an agency or in the

issuance of an environmental impact statement (EIS). Several cases involving review of EISs have determined that an inappropriate discount rate was used in the analysis (Mandelker 1992, section 10.08[3]).

A case decided in October 1991 involving a final regulation of the Environmental Protection Agency (EPA), Corrosion Proof Fittings v. EPA, 947 F.2d 1201 (5th Cir. 1991), indicates that federal courts are, in some cases, willing to look very closely at the discount rate selected by a federal agency in a regulatory action involving health-related benefits. The case involved a review of a regulation issued by EPA under the Toxic Substances Control Act, which prohibited the future manufacture, importation, processing, and distribution of asbestos in almost all products. The U.S. Court of Appeals for the Fifth Circuit vacated the regulation and remanded it to EPA for reconsideration because of EPA's failure to 1) evaluate a less burdensome regulatory alternative and provide a reasonable basis for the benefits of the chosen alternative, and 2) provide sufficient opportunity to the public to comment on exposure estimates used by EPA in quantifying the benefits of the regulation. In reaching its decision in the case, the court expressed concern about EPA's approach to discounting benefits and to the time period chosen for discounting benefits. The court made the following statement regarding discounting health-related benefits:

Although various commentators dispute whether it ever is appropriate to discount benefits when they are measured in human lives, we note that it would skew the results to discount only costs without according similar treatment to the benefits side of the equation. Adopting the position of the commentators who advocate not discounting benefits would force the EPA similarly not to calculate costs in present discounted real terms, making comparisons difficult. Furthermore, in evaluating situations in which different options incur costs at varying time intervals, the EPA would not be able to take into account that soon-to-be incurred costs are more harmful than postponable costs. Because the EPA must discount costs to perform its evaluations properly, the EPA also should discount benefits to preserve an apples-to-apples comparison, even if this entails discounting benefits of a non-monetary nature. (947 F.2d 1218)

The court also noted that the appropriate time from which to discount future health effects is when the injury occurs and not when the exposure that results in the injury occurs (947 F.2d 1218).

The Corrosion Proof Fittings case has no binding effect on the NRC. Nevertheless, the case could be cited as precedent in any future case involving NRC or another regulatory agency involving application of discount rates. Moreover, the case is instructive for the approach it takes. The court in this case clearly favored discounting health-related benefits as well as costs and using the time the health-related effect becomes apparent as the appropriate time from which to discount.

3.0 THEORETICAL BASIS FOR CHOICE OF AN APPROPRIATE DISCOUNT RATE

The initial discussions and studies in the United States concerning the choice and application of discount rates for government programs came from the use of benefit-cost analysis in the 1950s to evaluate resource investment policies by federal water agencies, principally the U.S. Bureau of Reclamation and the U.S. Army Corps of Engineers (Kneese 1984). Development of water resources involves investment relatively early in the life of a project, while the benefits from the projects begin to accrue several years after the initial costs. The issue of discounting received renewed interest in evaluations of national energy policy options during the late 1970s, where again large investments in the early years of projects produce benefits many years beyond the investment period, as noted by R. Lind (1982, p. 1):

Not since the late 1950s and 1960s, when the economic evaluation of federal water projects centered on the selection of discount rates to be used in policy analysis, has this issue been as important as it is now in connection with national energy policy. ... To evaluate these options we must weigh the future benefits against the present costs. Therefore, the weight we give to benefits and costs at different times is critical and is determined by the discount rate we use.

More recently, attention has also turned to discount rates for regulatory analyses aimed at lessening health risks from toxic materials and environmental pollution and enhancing product safety (Gillette and Hopkins, 1988). The use of regulatory impact analysis to evaluate the effect of proposed regulatory actions was also emphasized by President Reagan in Executive Order (E.O.) 12291, as discussed in Section 1.1. As with water resources and energy-related projects, regulation of health risks entails early cost outlays followed by benefits that accrue years into the future.

This section of the report will discuss the theoretical basis for use of discount rates in benefit-cost analysis generally, and in regulatory analyses performed by the NRC. Current views from the economics literature concerning what discount rate(s) should be used to guide efficient choices are

summarized.⁽⁶⁾ Possible discount rate adjustments for private vs. public funding, inflation, taxes, and risk are examined. Finally, the current view on the appropriate measure of the social discount rate and the approach to applying discount rates in benefit-cost analyses is discussed.

3.1 PURPOSE AND GOAL OF USING DISCOUNT RATES

Benefit-cost analysis is based on the premise of welfare economics that the critical question in evaluating a proposed public project or regulatory action is how it affects the well-being of members of society, and what society's resulting preferences are concerning the effects of that action. Society's preferences are expressed in terms of the comparison of benefits (gains) and costs (losses) to consumers and producers that result from implementing the proposed public project or regulatory action. If the sum of the benefits to members of society exceeds the sum of the costs to members, then society as a whole is better off with the action. The change is preferred because members of society (consumers and producers) have obtained a net benefit from the action. Society is better off reallocating the resources needed to implement the public project or regulatory action, so the reallocation represents a more efficient use of scarce resources.

Two basic issues arise when applying this social welfare principle of efficiency in evaluating public projects or regulatory actions. First, the benefits and costs of an action may fall on different members of society. Some groups in society may receive all the benefits while other groups may pay all the costs. In general, the benefits and costs of a regulatory action will not fall equally on each member of society. In practice, a concept of "potential compensation" is introduced into the evaluation of regulatory actions. Society is considered to be better off, and its scarce resources are used more efficiently, if the regulatory change produces benefits that exceed the costs such that those in society who benefit can potentially compensate

(6) The term "efficient" in this paper refers to the use of society's scarce resources to enhance the well-being or welfare of its members. This concept is discussed further in Section 3.1.

those who bear the costs and still remain better off than before the regulatory action was implemented. A potential improvement is defined as a change which, if costless transfers for compensation among members of society are assumed, can make all members of society better off (Mishan 1976). Whether such compensation is undertaken is an issue of social equity separate from the efficiency criterion underlying benefit-cost analysis. This is an important point to emphasize. Use of benefit-cost analysis can provide guidance for efficient use of resources, but it does not provide a framework for allocating costs and benefits among existing members of society or members of society over time.

Second, use of scarce resources to implement a regulatory action means the resources were diverted from investment in some other use, resulting in an opportunity cost from the lost return over time. The monetary values of streams of costs and benefits to society over time need to be adjusted to reflect the opportunity cost of foregone resource uses and to place benefits and costs on a common present value basis. The adjustment rate is the "social" discount rate, which is the conceptual underpinning for any discount rate chosen for benefit-cost analyses. Ideally, the social discount rate represents a measure of the rate at which the present value of future costs and benefits are discounted to reflect the time preference of society as a whole (Mishan 1983, p. 119). Thus, from a theoretical point of view, the social discount rate is the essential tool in determining the present value of costs and benefits to society over time from a government project or regulatory action and is a necessary part of the benefit-cost framework in determining the efficient allocation of resources over time.

While the conceptual basis for use of a social discount rate is relatively straightforward, the choice of the actual discount rate to use in government projects and regulatory analyses is less clear. Several factors can affect the choice of a "correct" discount rate to use for any regulatory analysis.

3.2 THEORETICAL MEASURES OF THE SOCIAL DISCOUNT RATE

Discount rates can enter into regulatory analyses in two ways. First, discount rates can be used to calculate society's present value of costs and benefits of a proposed regulatory action. Second, discount rates can be used to simulate private sector investment behavior by evaluating the required investment to achieve regulatory compliance in terms of the opportunity costs of other private sector investments which were foregone. The first view is centered on efficient allocation of resources for society as a whole. The second view is concerned with efficient allocation of private sector funds. While both views involve efficient use of resources, the set of possible discount rates available to choose for a social discount rate can be different.

3.2.1 Concepts Related to the Choice of a Discount Rate

The social discount rate chosen for regulatory analysis must in some manner reflect individual consumer preferences, individual producer preferences, and the preferences of society if preferences as a whole differ from the collection of individual preferences.

There are four concepts which are central to the choice of an appropriate social discount rate for use by the NRC and other federal agencies (Lind 1982, pp. 21,22):

- the social rate of time preference
- the consumption rate of interest
- the marginal rate of return on private investment
- the opportunity cost of a public investment.

One or more of these concepts are drawn on in the economics literature as a basis for the appropriate rate of discount. Each of these theoretical concepts will be discussed briefly.

The social rate of time preference is the rate at which society as a whole, through social (governmental) action, is willing to trade present benefits and costs for future benefits and costs. In other words, the social rate of time preference is the discount rate that governs the public investment behavior of society as a whole. In a perfectly competitive economy where the individual marginal rates of time preference (consumption rate of interest) are assumed the same for everyone, the social rate of time preference will be the same as the consumption rate of interest and the marginal rate of return of private investment.

The consumption rate of interest, or opportunity cost of consumption, represents the cost of a tradeoff between present and future consumption for individual consumers. In an idealized perfect lending market where consumers can borrow or lend as much as they wish at some given interest rate, consumers will adjust their pattern of consuming and saving so that the benefit (marginal utility) of a dollar's worth of consumption tomorrow (with earned interest) is equated to the benefit from a dollar's worth of consumption today. The rate of return on withheld consumption that is needed to induce individuals to give up present consumption for consumption in the future is the consumption rate of interest. If present consumption is curtailed because investment funds were used to finance government projects or to comply with regulatory actions rather than to provide goods for consumption, the opportunity cost of the foregone consumption is measured by this rate. For example, if consumption is decreased by the displacement of private capital to comply with a regulatory action rather than to increase private sector capacity to produce consumption goods, then the consumption rate of interest should play a role in discounting costs and benefits.

The marginal rate of return on private investment, or the opportunity cost of private investment, determines the rate of investment made by individual producers. Individual producers will invest in new capital projects until the last dollar invested yields a rate of return equal to the producer's cost of borrowing capital, reflected by the market interest rate. The appropriate marginal rate of return from the firm's point of view is the pre-tax rate of return from investment, where the pre-tax rate of return is

the combination of the producer's cost of borrowing plus the relevant marginal tax rate. If a regulatory action requires use of private sector funds to implement the regulation, as NRC actions normally do, the opportunity cost of foregone private investment is a relevant discount rate for consideration as the social discount rate.

The opportunity cost of private investment for any individual producer will be affected by market perceptions of the riskiness and capital structure of the individual producer. This adjustment of individual firms' perceptions of risk can lead to different rates of return on investment for society as a whole and for individual firms within society. The effect of risk on the choice of discount rates is discussed more fully in Section 3.2.3.

The opportunity cost of a public investment is the cost of government investment spending representing the rate of return that can be earned from the best alternative public or private investment. In an ideal world, all public investments under consideration would be compared with alternative investments, with those yielding the highest rate of return undertaken first. For example, if the rate of return on an alternative public or private investment is higher than a proposed regulatory action, the proposed action should be replaced with one of the alternatives. Under these conditions, investments in the public and private sectors would yield the same rate of return, and thus the same discount rate. This rate of return is measured by the marginal rate of return on private investment. Investment in public and private sector projects would result in a "first-best" allocation of scarce resources in such an ideal context. The appropriate rate of discount in this "first-best" world would be the market interest rate.⁽⁷⁾ This basic result is widely held by economists and is well summarized by Arrow (1966, p. 25):

Thus, the optimal rule for public investment is that it uses the rates of return to private capital. But

(7) Such "first-best" results assume a perfectly competitive economy, absence of risk and uncertainty, and costless market transactions. Otherwise, definition of the market rate of interest becomes unclear.

this is only valid in the context of a more inclusive policy in which aggregate capital is being adjusted to a long-run position where the natural rate of interest is governing... . A perfectly competitive capital market will achieve this optimum.

Clearly, investments undertaken within the private sector will be based on the return to private capital. The significance of Arrow's conclusion is that all public investment decisions involving public or private funds should use a discount rate based on the private rate of return on capital.

In reality, such a "first-best" world, with ranking of all public and private investments in a perfectly competitive marketplace, does not exist. A "second-best" world (with distortions leading to differences between consumer discount rates, producer discount rates, and the social rate of time preference) will occur. Projects and regulatory actions initiated by various government agencies may not be directly compared with private sector alternatives for several reasons. First, the consumption rate of interest and the marginal rate of return on private investment are not likely to be the same because of tax and risk effects. Second, projects or regulatory actions may have differential impacts on consumers and producers. Definition of the appropriate discount rate for public investments, whether the funds come from the private or the public sector, then depends on approaches relating the opportunity costs of foregone consumption and private investment to the social rate of time preference to establish an appropriate social discount rate for projects and regulatory actions using both public and private funds.

3.2.2 Tax Effects on Discount Rates

One of the major reasons why the consumption rate of interest and the marginal rate of return on capital may differ is distortion caused by the tax structure. A simple example is useful in demonstrating the tax "wedge"

between consumer and producer rates of return.⁽⁸⁾ The example is based on the following assumptions:

- The marginal personal income tax rate is 30%.
- The after-tax rate of return required by consumers (the consumption rate of interest) is 5%.
- The marginal corporate income tax rate is 40%.

Under these assumptions, the before-tax rate of return required by consumers is $(5\%)/(.70) = 7.1\%$ for consumers to pay 30% of their return as taxes and still receive a 5% return. In turn, the corporation must earn a pre-tax return of $(7.1\%)/(.60) = 11.8\%$ to be able to provide a return of 7.1% after paying corporate income taxes.

Given the presence of income taxes, consumers will not forego present consumption and invest unless the before-tax marginal return to private investment is significantly greater than the consumption rate of interest. Thus the presence of income taxes in the economy effectively causes the consumption rate of interest to differ from the marginal rate of return on capital. In turn, it is not clear which of these rates should be used for the social discount rate.

J. Stiglitz (1982, pp. 201, 202) found that, depending upon the nature of tax instruments used by the government, the social discount rate should be made equal to the social rate of time preference or the marginal rate of return on private capital or, in some scenarios, not made equal to any measure.

In summary, Stiglitz (1982, p. 202) argues that

The distortionary consequences of taxation and the implications of imperfect risk markets are significant. Both lead to social rates of discount that normally exceed the consumer rate of interest.

(8) The example used here is similar to those developed by Lind (1982, p. 28), and Quirk and Terasawa (1987, pp. 25, 26).

Indeed, under not unreasonable circumstances, they may exceed the producer rate of interest.

3.2.3 Effects of Risk on Discount Rates

The riskiness of an investment alters the acceptable rate of return investors require before they will allocate funds to the project. Risk occurs when variation in the future stream of earnings from an investment is present because of variation in economic outcomes such as future macroeconomic conditions, prices, and market conditions.

The economics literature concerning risk and the rate of return (discount rate) for projects and regulatory actions follows from the theory of economic markets under uncertainty, primarily the capital asset pricing model (CAPM). The general framework is summarized by Wilson (see Lind 1982, p. 61):

Therefore, the question of riskiness of an asset from an individual perspective depends on how the addition of the asset or source of income affects the overall variability of income from the total portfolio. This variability will in general depend both on the variance of the return to that asset and the covariance of its return with the return of the total portfolio.

At the individual investor/consumer level, the riskiness of an asset or investment will depend on the opportunities individuals have to diversify their portfolio through securities markets or insurance. The CAPM provides a theoretical basis for relating the required rate of return on an asset to the riskiness of that asset at the individual producer or consumer level. However, the theoretical framework of CAPM does not yield a simple procedure for equating the producer's rate of return and the discount rate for risk, as noted by Myers and Turnbull (1977, p. 331):

The good news is that it is possible to value capital investments using relatively simple formulas derived from CAPM... . The bad news is that the right asset beta (the measure of risk) depends on project life, the growth trend of expected cash flows, and other

variables which are not usually considered important in assessing business risk.

For the individual producer, obtaining a specific premium to account for riskiness by adjusting the marginal rate of return on private investment to account for riskiness is at best difficult. Jeffery Marshall (Marshall 1990, p. 19) summarizes this position when analyzing the relationship between the risk-adjusted return on equity (ROE) for a utility and the private discount rate of utility investors:

The two most widely used equity valuation methods are the discounted cash flow (DCF) and the capital asset pricing model (CAPM). ... The two methods may calculate an acceptable discount rate, but not address the proper ROE.

Thus, the presence of riskiness for investments tends to further separate any relationship between the consumption rate of interest and the marginal rate of return on private investment. In turn, guidance for selecting the appropriate social discount rate is made more difficult.

3.3 APPROACHES TO SELECTING AND APPLYING DISCOUNT RATES

Three major approaches to selecting and applying discount rates based on one or more of the concepts outlined in Section 3.2.1 have been used since the initial application of benefit-cost analysis in the 1950s. The approaches are typically identified as the opportunity cost approach, the second-best welfare economics approach, and the shadow price of capital (SPC) approach.⁽⁹⁾

The opportunity cost approach was initially identified in work done by Baumol (1968). While the approach is not the oldest of the three, it has probably enjoyed more direct application in determining the appropriate rate in benefit-cost analyses, in large measure because the 1972 OMB Circular A-94

(9) The terminology for the three approaches follows that of Quirk and Terasawa (1987, p. viii) and Lind (1982, p. 39).

established a discount rate for federal benefit-cost analyses based on an estimate of the inflation-adjusted opportunity cost of private investment (the marginal rate of return on private investment).

The second-best welfare economics approach has enjoyed the most prolonged exposure in the economics literature, starting with F. Ramsey in 1928, who studied the problem of intergenerational equity and concluded that the appropriate social discount rate for the satisfaction of future generations was zero. The second-best approach takes the wider societal view as the analytic framework to be used, with the social rate of time preference as the appropriate social discount rate. If, as discussed earlier, perfect markets exist, the social discount rate found using the second-best approach will be the same as the rate found under the opportunity cost approach. Given that imperfect markets, tax distortions, and risk effects do occur, the social discount rates determined by the two approaches will not be the same.

The SPC approach is an attempt to bring together elements of the opportunity cost and second-best approaches by evaluating government projects and regulatory actions in terms of their effects on future consumption. The SPC approach is currently viewed by most economists as the most promising approach for selecting and applying a social discount rate. Lyon (1990, pp. S-38, S-39) notes:

In practice the most fundamental disagreement across federal agencies appears to be in the areas of public investment and regulation, which require true social benefit-cost analysis, as opposed to the financial analyses surrounding lease-purchase or divestiture decisions. While there are differences in the latter cases, the differing analyses can be fairly readily compared. In the cases of public investment and regulation, the questions facing both decision-makers and analysts are deep. The shadow price of capital approach has received considerable interest lately precisely because it suggests a resolution to the dilemma resulting from unequal rates of opportunity cost and time preference.

A brief summary of the opportunity cost and the second-best approach is given below, followed by a more extensive description of the SPC approach.

Also discussed is a modified two-stage SPC approach which has recently been applied in federal policy analyses and which may play a useful role in NRC regulatory analyses.

3.3.1 The Opportunity Cost Approach

Two measures of opportunity cost were discussed earlier in this section as concepts central to selecting a social discount rate: the opportunity cost of consumption, and the opportunity cost of private investment. Both measures have been applied in the opportunity cost approach to social discount rates. Baumol argued that the appropriate discount rate for public projects using either public or private sector funds was "... the opportunity cost of postponement of receipt of any benefit yielded by a public investment" (Baumol 1968, p.788). Baumol recognized the problem of the "wedge" between the opportunity cost of consumption and the pre-tax opportunity cost of private investment, a wedge caused by corporate income taxes. Given the choice between these two opportunity costs, Baumol argued that the social discount rate should reflect the rate of return that resources diverted for public projects or implementation of regulatory actions could earn in private investments; i.e., the marginal rate of return on private investment was the relevant social discount rate.

The opportunity cost approach was subsequently expanded by Haveman (1969) and Harberger (1971) to derive a social discount rate that recognized the opportunity cost of both consumers and producers. The idea is that the social discount rate should reflect both the consumption rate of interest on any foregone consumption and the marginal rate of return on private investment for any foregone private investment. This is accomplished by deriving a weighted average of the two opportunity costs. The weights are established in terms of the percentage of investment funds for a public project or to implement a regulatory action that is drawn from consumption and from private investment. This expanded opportunity cost approach is summarized by Haveman (1969, p. 950):

... Because the incidence of [costs] falls on both consumers and businesses, both consumption spending and investment spending get displaced. Hence the private sector interest rates relating to both borrowing-saving-consuming decisions (rate of time preference) and business investment borrowing decisions (rate of return before taxes) must be reflected in the social opportunity cost rate of discount.

For example, based on the assumptions used earlier (Section 3.2.2), the consumer rate of interest was 5%, and the corporate before-tax required rate of return was 11.8%. If we assume further that the funds for a public project or regulatory action are taken 80% from private investment funds and 20% from consumption spending, the weighted opportunity cost estimate of the social discount rate is

$$(5\%)(0.20) + (11.8\%)(0.80) = 10.4\%$$

The social discount rate derived using the weighted opportunity cost approach will always fall between the consumer rate of interest and the pre-tax marginal rate of return on private capital.

The opportunity cost approach has been criticized by Usher (1970) and Arrow and Kurz (1970), among others, on several counts. Much of the criticism has centered on issues of the tax revenue effects of financing a public project and is not relevant here since NRC regulatory actions are funded from private investment. However, the opportunity cost approach clearly is sensitive to the personal and corporate marginal income tax rates, while the ideal social discount rate (the social rate of time preference) does not change with modifications in tax policy. In addition, since the weighted opportunity cost estimate of the social discount rate will reflect tax distortions (and risk effects), the estimate will in general not be the same as the social rate of time preference. Finally, the social discount rate derived from the opportunity cost approach was criticized by Marglin (1973) because it did not capture the full effect on future consumption. If private investment in production facilities is given up to invest in implementation of a regulatory action, the result is a stream of diminished consumption in the future, in addition to the direct decrease in consumption spending. For

example, a regulatory action may directly reduce consumption because companies will raise the price of the product or service subject to the regulation in order to cover costs of regulatory compliance. But consumption may also be less in the future because companies invested in equipment to implement the regulation and, thus, were not able to expand their output to provide for increased future consumption. The weighted opportunity cost approach does not capture the full effect of such a regulatory action on private consumption, because the foregone future consumption associated with foregone investment is not included.

3.3.2 The Second-Best Approach

The second-best approach has grown from the proposition that analysis of the "first-best" world, with perfect competition, no income taxes and riskless investments, does not provide effective real-world guidance for determining the social discount rate to be used in benefit-cost analyses. Therefore, researchers have concentrated on finding a "second-best" solution where distortions, such as tax effects, are taken into account. The approach is summarized by Quirk and Terasawa (1987, pp. 25, 26):

The second-best literature formulates the problem as that of choosing a time path of government investment spending to maximize the discounted present value of social welfare, in an economy where the private sector operates as a competitive system, but with the corporate income tax creating a wedge between the consumer rate of interest and the pre-tax corporate rate of return. The discount rate used to calculate the present value of social welfare is the social rate of time preference.

The second-best approach differs from the opportunity cost approach in several ways. First, and most fundamentally, determination of the social discount rate is related to a single concept, the social rate of time preference. Second, by having the objective of maximizing social welfare, the approach concentrates on the stream of consumption by society over time, since social welfare (or satisfaction, using Ramsey's terminology) is a function of consumer preferences. Third, the second-best approach involves

intergenerational choice when choosing the path over time to maximize the discounted present value of social welfare.

The difficulty in applying the second-best approach lies in determining the actual real-world measure to define as the social rate of time preference. Clearly the marginal rate of return on private investment is not a good measure of social time preference because of tax and risk effects. As a result, some authors have defined the social rate of time preference for the economy as equal to the consumption rate of interest. Dasgupta (1982, p. 277) uses the consumption rate of interest as the social discount rate in his use of intertemporal social welfare functions to formulate optimal growth rate models under second-best conditions:

Let $\{C_t\}$ be a feasible consumption sequence [of aggregate consumption over time]. We shall call that rate at which it is found just desirable to substitute consumption at some period t for that in the next period $(t + 1)$, the consumption rate of interest between t and $t + 1$.

Dasgupta finds that, under no circumstances in the optimal growth model used, is the optimal consumption the same for each future generation, suggesting that optimal growth paths under second-best conditions may involve serious intergenerational equity problems. The concept of consumption rate of interest developed by Dasgupta is a purely theoretical one, but is a concept commonly used in growth model approaches to determining the stream of social welfare over time. However, Dasgupta does not develop any specific value or empirical basis for a measure of the consumption rate of interest.

Stiglitz (1982) developed a general methodology for performing analyses under a variety of potential distortions of the economy, with particular emphasis on the choice of the social discount rate. Lind (1982, pp. 99) summarizes Stiglitz's approach:

Stiglitz's paper contains an excellent discussion of what one would need to know to analyze a public investment decision, and in particular, the appropriate rate of social discount in an economy that is nonoptimal. He states that it is necessary to explore

constraints on government action in order to determine the relationship between the total effects of a government investment or policy and the direct effects. To determine this relationship Stiglitz states that "one needs to have a theory of the structure of the economy, including statements about government behavior."

In other words, Stiglitz found that the correct choice of the social discount rate required an understanding of how various market imperfections affect the private economy and an approach to at least specify scenarios about government policy (Lind 1982, p. 157):

Although a full-blown theory of government and a fully specified model of our economy are probably beyond what we can expect soon, we can specify scenarios about government policy (for instance, how it responds to any balance-of-payments deficit resulting from undertaking a project) and make reasonable assumptions about the structure of the economy to reach some conclusions for broad classes of public projects.

Under various government scenarios and structural imperfections of private markets, Stiglitz found that the social discount rate would vary and would not necessarily be equal to any of the conceptual measures of the social discount rate discussed in Section 3.2.1. Stiglitz summarizes his results (1982, p. 153):

Our analysis casts doubt on the general validity of any of these simplistic approaches; we identify some important cases in which, for instance, the social rate of discount may not lie between the producer's and consumer's rates of interest. We find other cases in which, even in the long run, the social rate of discount is not equal to the pure social rate of time preference.

Stiglitz's conclusions typify much of the research using the second-best approach. Others, such as Sen (1982, p. 303) have found that the basic conceptual measure, the social rate of time preference, may vary depending on the assumptions made on valuing the welfare of future generations. Thus the theoretical work using the second-best methodology has clarified the complexities involved in selecting the "correct" social discount rate, but does not offer clear guidance for selecting an actual real-world proxy to use as the appropriate social discount rate.

Lind (1982) provided a notable exception to this ambiguity in selecting a social discount rate. Lind defined the social rate of time preference (and hence the appropriate social discount rate) as the consumption rate of interest reflected in the risk-free return on a safe asset such as U.S. Treasury bills (1982, pp. 84-87).

In summary, the second-best approach has not been very successful in leading decision-makers and analysts to a pragmatic estimate of the social discount rate. Quirk and Terasawa (1987, p. 27) have summarized the second-best contribution to the choice of a social discount rate:

While the approach adopted by the second-best theorists is formally the correct way to go, it leaves the problem of specifying a social rate of discount unresolved until one can determine the "correct" value of the social rate of time preference... . In any case, no attempts are made in the literature to assign a numerical value to the social rate of time preference (with the sole exception of Lind, 1982).

While the literature based on the second-best approach has not provided specific directions or practical guidelines for selecting an appropriate discount rate, the research findings have directed attention to the use of a single discount rate based on the social rate of time preference, rather than a weighted average of two or more rates, as used in the opportunity cost approach. Further, the objective under the second-best approach is to choose the set of public projects and regulatory actions that maximize social welfare over time. Since consumer preferences are the basis for social welfare, some measure of consumer time preference is the appropriate measure of the social rate of time preference, and hence the social discount rate.

3.3.3 The Shadow Price of Capital Approach

Eckstein (1958) and Bradford (1975) initially developed the shadow price of capital (SPC) approach. Lind (1982) has developed the most systematic discussion and application of the SPC framework and provides a clear summary of the objective of the approach (1982, p. 39):

In this section we develop a framework of analysis that separates consideration of social time preference from consideration of the effects of a public investment on private capital formation and the opportunity cost of displacing private investment. The social rate of discount is set equal to the social rate of time preference and the effects on private capital are accounted for using the concept of the "shadow price" of capital.

Lyon (1990, p. S-39) offers a general description of the SPC approach:

The approach is based on the distinction between the values of the share of costs, I_c , 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... . Where the opportunity cost [of capital] 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.

The SPC approach draws on two important results obtained from the opportunity cost and second-best approaches. First, explicit recognition is given to the conclusion that the discount rates used in benefit-cost analyses should reflect the opportunity cost of foregone private sector investment, including tax effects on the marginal rate of return in the private sector. Second, the social rate of time preference is taken as the appropriate measure of the social discount rate, as proposed under the second-best approach. The conceptual link between the opportunity cost and second-best approaches is the shadow price of capital, which Lind (1982, p. 39) defines as

The shadow price of capital is simply the present value of the future stream of consumption benefits associated with \$1 of private investment discounted at the social rate of time preference.

Thus the opportunity cost of capital invested in a public project or to implement a regulatory action becomes a shadow price reflected through the opportunity cost of lost consumption benefits from displaced private

investment. Kolb and Scheraga (1990, p. 383) describe the translation of investment to consumption:

When a dollar's worth of private consumption is diverted to a public project, the opportunity cost is one dollar. But when private investment is diverted, the opportunity cost is greater than one dollar - it is the stream of consumption that would have resulted from such an investment. The SPC is defined as the present value of the future consumption stream yielded by a dollar's worth of investment today in productive capital.

A simple example can clarify the SPC approach and its relationship to the opportunity cost approach.⁽¹⁰⁾ Suppose, as assumed earlier in Sections 3.2.2 and 3.3.1, that the consumption rate of interest is 5%, and the pre-tax rate of return is 11.8%. To further simplify, assume the social rate of time preference is equal to the consumption rate of interest at 5%. At the end of one year, the pre-tax return on private investment would be 1.118 times the original investment, and the social return from a public project or regulatory action would be 1.05 times its investment.

As Lind (1982, p. 40) points out, given these assumptions, it is appropriate to treat the present value of future consumption provided by private investment (the SPC) at the end of one year as the ratio of the return from private investment to the social return from the public project or regulatory action. This ratio represents the pre-tax return from investment discounted at the end of one year at the social discount rate (the social rate of time preference). In the example the SPC ratio is $1.118/1.05$, which measures the present value after one year of consumption foregone from private investment displaced for public projects or implementation of regulatory actions. It is useful to note that, without personal and corporate tax effects, the marginal return on private capital would be the same as the consumption rate of interest, and the SPC would equal one. Thus the SPC approach adjusts for the tax "wedge" between consumer opportunity cost and producer opportunity cost and evaluates foregone investment in terms of its

(10) This example is based on examples developed by Lind (1982) and Kolb and Scheraga (1990).

resulting foregone consumption. The SPC approach then allows use of the correct concept for discounting, the social rate of time preference, in evaluating public investments and regulatory actions that displace private investment and consumption.

Because the relevant social discount rate under the SPC approach is based on the consumption rate of interest rather than the pre-tax marginal return on capital or a weighted average of the two rates, the SPC approach results in less bias toward long-term benefits than does the opportunity cost approach. Lind (1982, p. 41) describes this result:

Using a shadow price to account for effects on private capital formation and then discounting at the social rate of time preference yields results substantially different than those from discounting public investments using the rate of return on private capital in some important cases. In particular, when the benefits from an investment accrue far into the future, as is true in many energy investments, using a discount rate equal to the marginal return on capital, as opposed to taking the opportunity cost of capital displacement into account through the shadow price on capital and then discounting at the social rate of time preference, improperly biases the evaluation against projects that pay out over a long period of time... . Thus, not only does the wedge between the marginal rate of return on private investment and the social rate of time preference cause underinvestment, it also creates a bias toward short-term projects.

The SPC approach provides a number of attractive features for decision-makers faced with the task of choosing an appropriate social discount rate to use in NRC regulatory analyses. The approach does take into account the cost of displaced private investment that results from a project or action, recognizing that the opportunity cost of foregone private investment is an important consideration for NRC actions. Through use of the shadow price of capital measure, investment opportunity costs are translated into consumption opportunity costs, which can be discounted at the social rate of time preference. Using the social rate of time preference as the appropriate discount rate is, as noted by Quirk and Terasawa (1987, p. 27), " ... formally the correct way to go." A proposed NRC regulatory action (as any other agency action) needs to be evaluated in terms of the discounted value of

its social costs and benefits. Use of the "correct" social discount rate (the social rate of time preference) also reduces the bias toward short-term projects.

Lind (1982, p. 41) describes the application of the SPC approach in benefit-cost analysis:

The procedure in benefit-cost analysis should be to multiply project costs, to the extent that they represent a displacement of private capital, by this shadow price of private capital and add these costs to those that represent a displacement of present consumption to obtain the project's consumption costs in each year. A similar adjustment has to be made on the benefit side, and the adjusted stream of benefits and costs should then be discounted at the social rate of discount. To make this procedure operational, we need to be able to compute the shadow price on private capital, to estimate the share of each dollar of project costs that comes from displaced private investment and consumption, and to estimate the impact that future benefits from the project will have on private investment.

While the SPC approach is generally viewed as the correct way to apply benefit-cost analysis, the procedure has been adopted slowly by federal agencies because of perceptual drawbacks and difficulties in application. Kolb and Scheraga (1990, p. 383) note two drawbacks:

The first is one of perception: It does not appear reasonable to those unfamiliar with the discounting literature to "arbitrarily" raise the costs of a government regulation relative to benefits. This appears to create a significant bias within the analytical evaluation framework against the government action.

The second is that the application of the technique becomes quite complicated and cumbersome in situations where initially displaced capital is recouped through cost recovery, which often is the case for environmental regulations. If the effect of the cost recovery on future capital flows is not taken into consideration (and the existing literature is not clear on this point), the technique is easier to implement, but then overstates costs relative to benefits.

The second point is an important drawback for use of the SPC approach in analysis of proposed NRC regulations. For example, if the NRC issues a

regulation regulating some aspect of nuclear power generation by a public utility, the cost of implementing that regulation will be reflected in the rates utility customers pay over time. Thus, over time the utility will recoup the initial cost of implementing the regulation. The investment that was initially displaced will then become available for other investment opportunities over time. When cost recouping occurs, the shadow price of the initially displaced capital overstates the cost of the regulation if adjustment for the replacement of those investment funds is not included in the benefit-cost analysis.

Application difficulties can also occur because of uncertainty about the consumer, producer, and social discount rates used to derive SPC estimates. Estimating the SPC requires information on the pre-tax marginal rate of return to private investment, the consumption rate of interest, and (if not assumed equal to the consumption rate of interest) the social rate of time preference. For example, the real (adjusted for inflation) yield on treasury bills can be considered as a proxy for the consumption rate of interest (Lind 1982, p. 87). Historical, real (adjusted for inflation) rates on 3-year treasury debt has varied during the last 20 years from about -2 % in 1975 to +8 % in 1985, making it unclear what rate is the appropriate proxy for the consumption rate of interest. Use of the consumption rate of interest (or the national rate of saving) as a measure of the social rate of time preference may not be correct. Hausman (1979) found empirical evidence that individual consumer discount rates may differ significantly from market interest rates, implying that using the consumption rate of interest as the social rate of time preference may be inappropriate. Given such uncertainties, Lyon (1990, p. S-40) estimated the SPC under alternative assumptions about the pre-tax marginal return on private investment, the social rate of time preference, and the personal rate of saving. Depending on the reinvestment rate of the funds used for a public project or to implement a regulatory action, Lyon's estimates of the SPC ranged from less than one to infinity.⁽¹¹⁾ Lyon also notes that displaced

(11) The extreme values of SPC estimated by Lyon occur at values for the rate of saving and reinvestment that have not been empirically observed in the U.S. (e.g., 30% rate of saving).

capital may have different shadow prices of capital because of different tax treatments, resulting in the need for the SPC to be constructed from a weighted average of individually calculated shadow prices. Lyon (p. S-45) concludes:

Given these difficulties, a relevant question is whether current federal discounting practice would be improved or weakened by use of the shadow price method. At this time, it appears that both outcomes are possible. This judgement in turn suggests that the approach be considered by oversight and budget agencies, but that its use be judicious. Continued use of traditional approaches, with sensitivity analyses, appears likely to remain appropriate for the near future.

Where public investments or regulations could have major impacts, careful estimation of the shadow price may well be worthwhile. Similarly, unless one is extremely risk-averse, weaknesses of the shadow price approach should not lead one to ignore altogether its strengths and insights.

3.3.4 A Two-Stage Shadow Price of Capital Approach

Kolb and Scheraga have developed an extension of the SPC approach that addresses the problem of estimating the SPC when initially displaced capital is recouped through cost recovery (Kolb and Scheraga 1990, Scheraga 1990). Scheraga (1990, p. S-67) summarizes the capital recouping problem and the proposed two-stage approach:

Most of the models used to calculate the shadow price of capital implicitly assume that the capital stock remains permanently lower once private capital is displaced. This is equivalent to assuming that the capital costs imposed by regulations are not passed through to consumers. Since this assumption is inappropriate for environmental (and other types of) regulations, Kolb and Scheraga developed an alternative two-stage discounting procedure that is a variant of the SPC approach. The two-stage procedure is a simplified method for implementing an SPC model in the special case where initially displaced capital is recouped over the lifetime of the environmental investment. The estimated capital costs of a regulation first are annualized using the marginal rate of return on capital. Benefits and costs then are discounted at the social rate of time preference.

An example based on Kolb and Scheraga (1990, pp. 384, 385) is useful in comparing the standard SPC approach and the two-stage SPC approach when recouping of displaced private capital occurs. Suppose a regulatory action displaces \$1000 of private capital in period 0, and that this capital is recouped over the 10-year lifetime of the equipment purchased to implement the regulation. If the effect of recouping the initial displaced investment is taken into account under the standard SPC approach, assumptions on the rate of payback, the rate of interest applied to the unpaid balance, and the rate of reinvestment of the recouped funds must be made to derive a complete estimate of the net cost of private capital. In turn, this cost of capital would be translated into foregone consumption using an SPC estimate.

The two-stage approach simplifies the process of estimating the net cost of capital when recouping occurs. Under the two-stage procedure, the \$1000 initial investment displaced would be annualized over ten years (the economic life of the equipment) at the marginal rate of return on private investment, and the resulting cost stream would then be discounted at the social rate of time preference. This simplified approach avoids the need for assumptions on payback, the rate of interest on unpaid balances, and the rate of reinvestment. Unless there is evidence that the process of recouping the initial displaced investment varies over time (e.g., recouping is concentrated in the early years of the economic life of the equipment), the simplified two-stage SPC is easier to apply and perhaps more easily understood.

Kolb and Scheraga (1990, pp. 386, 387) compared the results of using the conventional approach (the opportunity cost of private investment) with a social discount rate of 10%, as suggested by OMB, to the results of using the two-stage SPC approach.⁽¹²⁾ The authors assumed an initial capital expenditure for a regulatory control device that is expected to last for 20 years, and then considered five cases with different patterns of benefit streams over time. In the "short-term" benefit stream, benefits accrued at a

(12) The OMB guidance for the opportunity cost of private capital has been revised to 7% since the Kolb and Scheraga publication (see Section 2.2).

uniform rate each year over the 20-year period of economic life of the equipment. In the most long-term case, benefits were zero for the first 20 years, and then accrued at a uniform rate each year for the next 50 years.

Kolb and Scheraga found that the resulting benefit-cost ratios were the same under either the conventional or the two-stage SPC approach for the short-term case where the incidence of costs and benefits occurred over the same time period. However, as the incidence of benefits occurred farther into the future than did costs, the benefit-cost ratios obtained from the conventional and two-stage SPC approach diverged, with the two-stage SPC approach yielding greater benefit-cost ratios. In the most long-term case, the ratio of discounted benefits to costs derived with the two-stage SPC approach was 5.5 times the ratio derived with the conventional approach.

These findings by Kolb and Scheraga suggest that the two-stage SPC approach provides a more accurate estimate of discounted costs and benefits than the conventional approach when the streams of benefits and cost have different time paths. Scheraga (1990, p. S-69) concludes:

The use of the conventional single-rate approach will understate benefits relative to costs, particularly in cases where benefits are long term relative to costs or when there are significant lags between the time costs are incurred and benefits realized.

Application of the two-stage variant of the SPC model, which is appropriate under these circumstances (regulatory actions with recouped capital costs), greatly simplifies the problem and mitigates the concerns about reinvestment.

While the two-stage SPC approach does simplify the process of estimating costs with reinvestment of recouped funds, estimates of discounted benefits and costs using the SPC approach in general (either the standard or the two-stage form) are very sensitive to the values chosen for the rates of opportunity cost and the social rate of time preference, as shown by Lyon (1990, p. S-40).

As noted earlier in Section 3.3, the SPC approach is currently viewed as the most promising procedure for selecting and applying discount rates in benefit-cost analyses. The theoretical foundation of the SPC approach (drawn in large part from the second-best framework) provides a sound analytical context. The relative lack of ambiguity in the role of consumer opportunity costs, producer opportunity costs, and the social rate of time preference in the SPC approach make its application for real-world policy analyses tractable.

Further, the two-stage SPC technique seems to be a valuable extension of the basic SPC approach in situations where the initial displaced investment will be recouped over time and where benefits accrue over a long period relative to costs. Thus the two-stage SPC approach holds particular promise for analyses of the benefits and costs of proposed regulatory actions, such as those done by the NRC. The caveat to the promise of either SPC approach is the sensitivity of results to the values of the parameters used to derive discounted benefits and costs. Lyon (1990, p. S-45) concluded that careful estimation using an SPC approach may well be worthwhile in cases where proposed regulations could have major impacts.

3.4 SUMMARY

The nearly half century of debates and controversy concerning the appropriate social discount rate has led to some relatively sound conclusions concerning the theoretical basis for the choice of a discount rate. The literature on the second-best approach in particular has been important in this regard. Clearly, the correct social discount rate for use in benefit-cost analyses of proposed public projects or regulatory actions is the social rate of time preference. This result holds whether the proposed project or action is funded with public monies or with displaced private investment.

Given that the social rate of time preference is the correct choice for the social discount rate, problems still remain. Public projects and regulations have impacts on private consumption and private investment. Distortions in the structure of the economy imply these rates are not likely

to be the same, and some way of reconciling the differences is required. Further, the opportunity costs of consumption and investment must be linked to the social rate of time preference to trace displaced private consumption and investment effects to the evaluation of social benefits and costs.

The SPC approach provides the link between the relevant private (consumer and producer) rates of discount by transforming the cost of displaced investment from a public project or regulation into the cost of consumption foregone because of the displaced investment. Assuming that time preferences of individual consumers reflect the social rate of time preference, the SPC approach brings together the "correct" social discount rate with a relatively straightforward procedure to apply the theoretically correct discount rate in benefit-cost analyses.

4.0 PERSPECTIVES ON DISCOUNTING HEALTH EFFECTS

Regulation of health and safety hazards typically requires expenditure of societal resources. Because those resources are limited, the costs of compliance with health and safety regulations mean foregoing alternative resource uses. Society as a whole will be better off if its scarce resources are used efficiently; that is, the resources are used in a manner that maximizes the well-being, or welfare, of society. As noted in Section 3.1, benefit-cost analysis is one way to represent the gains and losses of society in choosing an efficient (welfare-maximizing) allocation of scarce resources. However, many people have deep ethical reservations about making public investment and regulatory decisions affecting an individual's health and life on the basis of efficient resource use. Such ethical controversies are evident in the present ongoing debate about the limits on expenditures to maintain life. These ethical reservations become more pronounced when the health and life of future generations are affected by investment and regulatory decisions of the present generation. In this section we summarize viewpoints on using the benefit-cost efficiency approach to value future health and life, possible modifications to the benefit-cost methodology, and other possible approaches to making decisions on public investment and regulations with intergenerational effects.

In general, determination of the efficient allocation of resources requires weighing the expected gains (benefits) against the expected losses (costs) to society and establishing regulatory mandates when the sum of benefits exceeds the sum of costs to society. When government initiates public projects or regulatory actions that have effects over time, the activity affects the consumption patterns, and hence social welfare, of future generations as well as the present generation. This is particularly true when regulatory actions are considered today that will have potential effects on the health of individuals in future generations. Applying discount rates on benefits to future generations seems to represent "discounting future human lives." This concern raises issues on how to compare different generation's

welfare or utilities when the value of human life is involved.⁽¹³⁾ Gillette and Hopkins (1988, pp. 55, 56) provide a framework for these issues:

This temporal disparity of costs and benefits raises issues of both philosophical and economic importance. These issues center on the use of discounting to enhance the comparability of regulatory options.

As an economic matter, any comparison of costs and benefits of a particular regulation should place these effects on a common basis by referring to their values at the same point in time. Discounting accomplishes that task.

Thus, from an economic point of view, time patterns of cost and benefits should be converted to present value measures by applying the social discount rate, based on the appropriate rate of social time preference. While this conclusion follows in a straightforward manner from analysis of opportunity costs, the application of discounting to decisions affecting the safety and lives of members of future generations is controversial. In particular, there is considerable discomfort in applying discounting in benefit-cost analyses when the effects on future generations are far in the future, as, for example, is the situation with many nuclear wastes. Lind (1982, p. 11) summarizes this concern:

A striking case in point is nuclear power and the problem of nuclear waste disposal. Suppose that we could put the waste in containers that would safely last two thousand years but then might release the waste into the environment raising the possibility of large-scale contamination. In this case, the potential costs to future generations would begin thousands, not just hundreds, of years in the future. Discounting those costs at any positive rate would make them appear minuscule.

Concerns about use of the benefit-cost analysis and its associated discounting procedure on future health benefits fall into two broad

(13) The term "utility" in this context means the satisfaction or well-being of individuals in society. The collection of all the individual levels of utility in a generation defines the overall welfare of that generation.

categories. First, there is concern about the appropriate discount rate. In discussing his example quoted above, Lind (p. 12) notes:

If we discount benefits and costs at a positive rate, are we not putting less value on the welfare of future generations than our own? Or, put differently, if we were egalitarian among generations living now and in the future, wouldn't this require that we use a zero rate of interest in benefit-cost analysis? This position accepts the benefit-cost framework, but argues for a zero discount rate on the grounds of intergenerational equity.

Second, there is concern that the efficiency criterion that benefit-cost analysis is based upon may not be the correct approach to use in evaluating government policy decisions that have potential effects on the health and lives of generations far into the future. This concern raises questions about the philosophical foundation of benefit-cost analysis itself as a tool to evaluate public investments and governmental regulations. The philosophical debate thus centers on different views of intergenerational fairness and justice. Mishan (1976, p. 22) represents one such view:

More attention of late has been directed to the questions of equity and distribution (in benefit-cost analysis). The question of equity in traditional benefit-cost analysis dwells on whether the potential distribution of net benefits from members of society who do benefit from an action are actually distributed to members of society who did not benefit. For intragenerational cases, whether distribution occurs will depend on transactions cost, and the potential compensation principle clearly provides the correct measure of the merit of government actions. When the incidence of benefits and costs falls upon different generations, the criterion of potential compensation of net benefits is less clear. Other "social" points of view can yield other criteria.

Thus Mishan believes that the benefit-cost approach is applicable in analyses of relatively short-term streams of costs and benefits, but is less willing to apply the approach when intergenerational issues become involved.

In Section 4.1, different approaches to modifying the "correct" discount rate to achieve intergenerational equity are surveyed. The major philosophical criticisms of the economic welfare theory foundation of

benefit-cost analysis are summarized in Section 4.2 and suggested possible alternative criteria are noted.

4.1 ADJUSTING THE SOCIAL DISCOUNT RATE FOR INTERGENERATIONAL EQUITY

Proposed adjustments of the social discount rates from the "correct" social rate of time preference discussed in Section 3 have involved arguments about using different rates for different types of proposed public projects. For example, Arrow (1963) has argued that the social rate of discount should be lower for larger public projects because of external benefits (e.g., increases in national income because of more employment due to large project), and perhaps should be set at zero for very large (long term) public projects. Arrow's approach involves intergenerational issues implicitly in the sense that long-term projects would tend to be evaluated using lower social discount rates. Arrow did not discuss the intergenerational issue of future health effects, but initiated the idea that it is reasonable for discount rates to differ, depending on the nature of the government activity involved.

Ramsey (1928, p. 558) specifically argued that the appropriate rate for discounting the benefits of future generations was zero:

The rate of interest determined in an atomistic competitive market need not have any normative significance in the planning of collective investment. One point should perhaps be emphasized more particularly; it is that we do not discount later enjoyments in comparison to earlier ones, a practice which is ethically indefensible and arises merely from the weakness of the imagination.

Ramsey specifically believed the utility of each generation should be weighed equally, implying a social discount rate of zero for any public project or regulation with intergenerational effects (but not necessarily for projects and regulations whose costs and benefits fall within a single generation).

Selection of a zero discount rate poses difficulties in the benefit-cost framework. Quirk and Terasawa (1987, pp. 12, 13) summarize the major problem:

However, the use of a zero discount rate creates a basic difficulty in determining the optimal saving-investment policy, since the appropriate integral may not converge. As Koopmans (1960) pointed out, this (zero discount rate) implies that the (benefit-cost) criterion cannot be sensitive to consumption in any period, and that following any time path for any finite period of time is consistent with optimality. This means roughly that the interests of any one generation can be sacrificed for any other.

Essentially, the problem caused by using a zero discount rate in a benefit-cost analysis is that it disconnects government choices to invest in public projects or regulatory actions from private choices to consume and invest, which are affected by non-zero opportunity costs. Investment in public projects and implementation of regulations will tend to be biased upward, since private opportunity costs are effectively excluded.

In a sense, Mishan, Arrow, and Ramsey take a "middle ground" position on using benefit-cost analysis, since all three are comfortable with applying the standard discounting procedure for short-term projects or regulations, but would either move away from the basic benefit-cost approach or alter (lower) the discount rate for long-term evaluations.

The problem of establishing a basis for use of a zero or lowered social discount rate has led economists to look for reasons why the discount rate might be below the social rate of time preference for projects and regulations when long time periods are involved. Work on determining an approach to lower discount rates for projects where benefits accrue to future generations has usually been applied to consideration of future health and/or environmental effects on future generation from regulatory actions now. One important approach has been to consider "intergenerational externalities," that is, intergenerational effects from a proposed public project or regulation that are not captured in benefit-cost analyses. For example, public investment may help pull the national economy out of a recession, resulting in more private investment than would have occurred without the public project. This increased investment would in turn provide future generations with a more productive economy, but would not be measured as part of the direct benefits from the public investment. Similarly, regulations to control toxic materials

may stimulate investment and research that will make future generations better off but are not measured in the calculation of future benefits. In these examples, a lower social discount rate can be justified to reflect future benefits (from additional investment that stimulates economic growth or provides better future health facilities) that were not captured in the analysis. This result follows from the externalities, because the added benefits which accrue imply that the opportunity cost of displaced investment to implement regulations, for example, is lower because of induced investment not directly related to the regulatory action.

In order to incorporate such macroeconomic effects into the standard benefit-cost framework, a general equilibrium approach which considers the full economy when calculating the benefits and costs of a government project or regulation has been proposed. For example, Hazilla and Kopp (1990) developed a general equilibrium model of the United States economy to estimate the macroeconomic and intertemporal effects of environmental quality regulations. Estimates of the social benefits and costs of the regulations were derived from simulations using the general equilibrium model. The authors conclude (1990, p. 871):

It is difficult to overemphasize the importance of approaching policy analysis from a general equilibrium perspective. This emphasis is reinforced by our finding that while only a subset of industries are directly affected under the regulation scenarios, all productive sectors ultimately are affected over time by the regulations... . Failure to quantify and account for these intertemporal phenomena in a benefit-cost analysis will likely lead to errors of unknown magnitude.

A general equilibrium approach does represent the theoretically correct approach to capturing externalities arising from public projects or regulations. However, development of such models is a complex process and may not be justified, except in cases where major policy actions or public projects are proposed that are likely to have significant external effects on the economy. Since development of such general equilibrium models is probably impractical for most benefit-cost analyses, a pragmatic technique to account for macroeconomic externalities over time would be to use a lower social

discount rate to reflect the positive benefits of externalities. The problem with this technique is that, given the unknown magnitude of the externalities, it is difficult to quantify what the appropriate lower discount rate should be.

Intergenerational externalities may also exist when private and social rates of discount are compared. Sen (1961, 1967, 1982) and Marglin (1975) proposed the social rate of discount be lower than private rates (i.e., the consumption rate of interest) because individual consumption and saving behavior does not necessarily reflect the behavior of society as a whole. This effect, the "isolation paradox," means that using the consumption rate of interest or the private rate of saving as a proxy for the social rate of time preference results in a social discount rate that is too high. The isolation paradox results when individuals either consume more or save less over time than is socially optimal. Individual consumption and savings patterns differ from the socially optimal patterns in part because of different time horizons between individuals and society as a whole. Individuals, with shorter time horizons, are less willing to trade off present consumption for future consumption (the consumption rate of interest) than is society as a whole. Clearly, the longer the time period before benefits accrue to future generations, the greater will be the difference between private discount rates and social discount rates. As a result, use of the consumption rate of interest (or any private rate) as the social discount rate will undervalue future social benefits and will undervalue them more severely for long-term effects. Sen (1982, p. 350) argues that this basic difference between individual and social discount rates requires that the issues of intergenerational effects and the composition of the effects (e.g., irreversibility of the effects) from a proposed project or regulation on society must involve ethical consideration of future generations when determining the social discount rate:

There is, in fact, very little scope for avoiding a deliberate ethical exercise in choosing appropriate rates of discount for social benefit-cost analysis... . I do not doubt that different compromises can be reached about the relative importance to be attached to these various considerations. But the least we should

require is that attention be paid to the competing claims of these different influences and that the process of choosing discount rates for social benefit-cost analysis be made more reasoned and more explicit. The search has to be more than an intellectual blindman's buff.

Sen (1982, p. 357) illustrates his viewpoint with an example:

Suppose the investment project in question will eliminate some pollution that the present generation will impose on the future. Even if the future generation may be richer and may enjoy a higher welfare level, and even if its marginal utility from the consumption gain is accepted to be less than the marginal welfare loss of the present generation,⁽¹⁴⁾ this may still not be accepted to be decisive for rejecting the investment when the alternative implies long-term effect of environmental pollution. The avoidance of oppression of future generations has to be given a value of its own.

While Sen's results may be ethically correct, the problem of choosing a specific social discount rate remains, since no attempt has been made to assign a numerical value to the adjusted social rate of discount or to give a range of appropriate values that could be used to test the sensitivity of the social discount rate in benefit-cost analyses. While Sen and others show that ethical considerations are unavoidable when intergenerational health and life considerations are involved, the conclusions, as with the second-best literature surveyed in Section 3.3.2, do not provide real-world mechanisms to choose social discount rates.

Another approach to resolving the issue of intergenerational equity within the benefit-cost framework has been to examine how the length of time over which a project or regulation yields cost and benefits may affect the choice of the appropriate social discount rate. Research by Cropper, Aydede, and Portney (1991, 1992) has shown that individual rates of time preference vary as the length of time for effects from a government project or regulation

(14) That is, the sum of discounted benefits are less than the sum of discounted costs, using a measure of the consumption rate of interest as the discount rate.

changes. Cropper, Aydede, and Portney (p. 2) state the topic of their survey research efforts:

The subject of this paper is individuals' marginal rates of substitution between lives saved at different points of time. By interviewing random samples of individuals, and confronting them with choices between hypothetical pairs of life-saving programs, we infer marginal rates of substitution for lives saved at different times.

The objective of the research was to determine if individuals generally have different rates of substitution between, say, lives saved by a government health regulation imposed now, and lives saved by a government health regulation imposed at different points in the future. If the willingness to trade off life-saving programs declines over longer periods, the appropriate social discount rate also should decline. Cropper, Aydede, and Portney found (pp. 10, 11):

The results we have presented focus on choices between life-saving programs over long horizons: 25, 50, and 100 years. One of our most striking findings is that, over horizons as long as these, a significant share of respondents seems unwilling to choose any future oriented program, primarily because they feel society will find a way to save people in the future anyway.

If we eliminate respondents who feel it is unnecessary to make a trade-off between lives saved today and in the future ... people do not discount at a constant exponential rate. If discount rates are computed under the assumption they vary with time, the mean annual discount rate is 7% today and 0% in 100 years.

The authors urge cautious interpretation of the specific discount rates found in the study, but do feel there is clear evidence that discount rates tend to fall for many individuals as the time frame of future life-saving regulations becomes longer. However, it is important to note that a significant proportion of individuals surveyed felt that giving up current lives to save lives in the future was unjustified.

Given the empirical results obtained by Cropper, Aydede, and Portney, researchers have attempted to construct formal mathematical models that result

in a declining social discount rate as the time horizon for public projects or regulation becomes longer. Kula (1991) and Harvey (1992a, 1992b) have attempted to develop formal adjustment procedures for the social discount rate to apply in benefit-cost analyses. Harvey (1992b, p. 3) states:

These empirical findings that individual preferences often violate constant discounting do not imply that the social preferences used in a prescriptive discounting model also should violate constant discounting. The findings do, however, shift the burden of proof. Unless there are persuasive normative objections to the social preferences represented by non-constant discounting, it should be justifiable to include such preferences in a prescriptive model of social preferences.

Harvey (1992b, p. 6) proposes a proportional-discounting model, where the initial social discount rate is weighted over time in the form $a_t = b/(b + t)$, where b is the initial discount rate, t is the number of years after initiation of a regulatory action, and a_t is the adjusted discount rate used in the benefit-cost analysis. An initial discount rate of 7% would decline to about 0.3% in 25 years and would approach zero as t became larger. Harvey believes such an approach may be useful when using benefit-cost analysis to evaluate projects or regulations, such as those involving health and environmental benefits, where long time frames are often involved. Harvey (1992b, p. 14) summarizes:

This decision analysis study is intended both to illustrate non-traditional methods of discounting and to provide insight for a particular policy choice... . For the future use of non-traditional methods of discounting, such questions will require the judgement and work of many people having a variety of perspectives.

In summary, there are both theoretical and empirical grounds for using lower or declining social discount rates when evaluating health benefits that accrue to future generations. At this time, however, research on procedures to select the appropriate lower rate of discount or to formulate the correct rate of decline of the social discount rate over time is in its preliminary stages. Perhaps the only accepted proposition that has come forth from this research approach is that the social discount rate is not zero, or at least is

not zero unless the time frame for comparison of costs and benefits is very long.

4.2 ALTERNATIVE CRITERIA FOR WEIGHING FUTURE HEALTH EFFECTS

Given the ethical issues entangled in the concept of applying a nonzero discount rate to intergenerational health effects, an extended philosophical debate on the appropriate way to view future health and life has occurred.

One approach has been to keep the framework of economic analysis, but consider the effects of alternatives to the use of benefit-cost analysis as the decision criterion. Ben-David, Kneese, and Schultze (1979) followed this approach. They evaluated the outcomes of using four different ethical criteria (utilitarian, Rawlsian, Nietzschean, and libertarian) in benefit-cost analysis. The objective of their analysis was the following:

... explore the implications of weighing benefits and costs with the ethical systems described above. We are thus imposing a set of external ethics on particular benefit-cost problems rather than trying to incorporate ethical values of individuals into the calculation of benefits and costs.

The authors found that when uncompensated risk, such as health or mortality risks caused by unregulated actions of the present generation, was imposed on future generations, the four ethical criteria usually reject the unregulated actions of the present generation, even if the benefits to the present generation outweigh the benefits to future generations. Thus, use of alternative ethical criteria in the benefit-cost framework may lead to different social choices than the choices implied by traditional benefit-cost analysis under a variety of different ethical structures.

Schultze, Brookshire, and Sandler (1981) also follow this approach by comparing the results obtained from the underlying theoretical framework of benefit-cost analysis to other ethical positions. The authors summarize their approach and findings:

First, the utilitarian ethic is used to explore the notion that the proper goal for society is to pursue the good of the whole, or the greatest good for the greatest number. Second, we focus on a simplified libertarian viewpoint where the protection of individual rights is more important than the good of the whole. These criteria are consistent with the notion of economic efficiency... . Alternatively, the position can be taken that outcomes do not necessarily matter, but the procedure leading to an outcome should be fair. As an example of a procedural or process ethic, we consider a democratic (voting) ethic.

We show that decision outcomes for nuclear waste storage may be economically inefficient for such ethics which effectively ignore economic efficiency in evaluating outcomes. However, this economic "inefficiency" can be viewed as an additional necessary economic cost of achieving a "fair" or desirable decision process.

Their conclusion that the procedure or process of reaching a decision on projects or actions with intergenerational effects is similar to Sen's recommendation that the process of choosing social discount rates may be as important as the actual rate chosen.

Other participants in the debate over intergenerational justice reflect different views which tend to reject the discounted benefit-cost framework. Ramsey, as noted above in Section 4.1, felt intergenerational justice could be achieved only if the welfare of future generations is valued the same as the well-being of the present generation. This view is extended by Parfit (1986). Gillette and Hopkins (1988, pp. 60, 61) provide a succinct summary of Parfit's views:

Derik Parfit has argued, for instance, that applying a social discount rate of x percent per year tends to ignore future events as "morally trivial," at least in a situation where decision makers literally "discount lives" by finding the number of future lives is equivalent to a smaller number of present lives... . Parfit concludes that the opportunity cost explanation for discounting does not justify the use of the procedure.

Parfit does not believe that future benefits should be weighed against current costs without reference to the timing of either the benefits or the costs. Instead, he proposes (p. 484) that the time patterns of costs and benefits should be presented without use of a discount rate:

Conclusions that are established by such (opportunity cost) calculations could be re-expressed in a temporally neutral way. When describing the effects of future policies, economists could state what future benefits and costs there would be, at different times, in a way that used no discount rate. The arguments that appeal to opportunity costs could be stated in those terms.

The problem of intergenerational justice is further compounded if the preferences of future generations differ from those of the present generation, which is likely. Gillette and Hopkins (1988, pp. 59, 60) provide an example:

Assume, for instance, that future generations value wilderness areas less highly than the current generation does. If that change were to materialize, future generations would look askance at current decisions to forgo technological advances in order to preserve natural settings for posterity.

If the preferences of future generations are indeed anticipated to be different from those of the present generation, applying any technique that attempts to compare changes in well-being between generations is inappropriate, since the pattern of future preferences is unknown. In situations where the health and lives of a large number of future generations are potentially affected by decisions of the present generation, using a process viewed as "fair" by individuals in society (e.g., using the democratic process) to reach decisions may be the most appropriate approach.

4.3 SUMMARY

Several approaches to adjusting the social discount rate to address intergenerational equity have been explored. All approaches suggest that the social discount rate should be reduced when intergenerational effects are encountered, particularly when the health and lives of future generations are at stake. Intergenerational externalities play an important role in arguments for lower discount rates. However, no specific guidance has been forthcoming on how much the adjustment to the social discount rate should be, or how the adjustment depends on the length of time involved.

While there is no consensus on the procedure for adjusting the social discount rate, there is general agreement that the appropriate social discount rate is not zero. Both empirical and theoretical results support this conclusion. Survey results indicate that individuals have positive rates of time preference with respect to valuing lives in the future. Economic theory leads to the conclusion that zero social discount rates effectively disconnect the government investment process for private markets. Thus the "correct" social discount rate when intergenerational equity is important falls somewhere between the social rate of time preference (as discussed in Sections 3.3.2 and 3.3.3) and zero.

If the benefit-cost framework is modified to employ different ethical criteria, the concept of a "correct" social discount rate becomes difficult to address. Research using this approach suggests that the pattern of benefits and costs over time be presented without reference to a social discount rate, and some "fair" decision process (e.g., a democratic voting process) be used to guide government policy on intergenerational matters.

Quirk and Terasawa (1987, p. 14) provide a good summary of the intergenerational equity issue in benefit-cost analysis:

In summary, one can say both a great deal and very little from the intergenerational point of view as to what rate of discount should be used in government benefit-cost analysis. If one should agree that all ethical intergenerational equity issues can be summarized in the (adjusted) value of the social rate of time preference, then one could compute the proper social discount rate... . However, it is unrealistic to assume that one could identify the social rate of time preference that would satisfy all major ethical considerations.

The issue of intergenerational equity clearly is difficult to handle in the benefit-cost analytical framework. Perhaps the best that can be said is that sensitivity analyses using social discount rates between the selected social rate of time preference and zero could be performed, and, in cases involving potentially large health impacts on future generations, a social decision

process outside of the benefit-cost context is the appropriate way to evaluate alternative government actions.

5.0 DISCOUNT RATE PRACTICES OF OTHER FEDERAL AGENCIES

A survey of the choice and application of discount rates by other federal agencies was made in conjunction with preparing this report. All agencies surveyed, except the Environmental Protection Agency, are Executive Branch agencies. The survey revealed a wide variation in approaches. As noted in Section 2, Executive Branch agencies must follow OMB's RIA Guidance and its recent "Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs." The "Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs" are too recent (November 10, 1992) to have had any significant implementation and, consequently, are not reflected in the discussion of agency practices.

In conducting the survey, particular attention was devoted to the practices of agencies involved in programs affecting human safety and health. The discount rate approach of each surveyed agency is summarized below.

5.1 ENVIRONMENTAL PROTECTION AGENCY

Application of discount rates in benefit-cost analyses has varied considerably at different times and across different divisions in the agency. In its 1986 analysis of drinking water lead risks, EPA used a 5% discount rate to determine the present value of benefits and a 10% discount rate to determine the present value of costs (Gillette and Hopkins 1988, p. 64). In its economic analyses, EPA has generally assumed that there is no latency period between the time of exposure and the onset of a disease (Kolb and Scheraga 1990, p. 388). In a 1991 regulatory analysis of health-related asbestos effects, EPA applied a 10% discount rate to costs of abatement and a 0% discount rate to health-related benefits, with no latency period. This regulation was vacated, in part because of this approach to the application of discount rates, as discussed in Section 2.4.

Recently, the EPA applied the two-stage shadow price of capital method to evaluate the discounted benefits and costs in its wood stove regulatory improvement analysis, the domestic policy study on acid rain, and various

ambient air quality measures. A rate of 3% to represent the real rate of social time preference in the two-stage SPC approach was usually chosen for these impact analyses.⁽¹⁵⁾

The EPA has developed a computer software package to facilitate use of the two-stage SPC approach. The software allows consideration of different values for lengths of economic life of equipment purchased to implement regulations, latency periods and time spans of health benefits accruing from regulations (including the option of different values of benefits per year), social rates of time preference, and shadow prices of capital.⁽¹⁶⁾

5.2 OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION

The Occupational Safety and Health Administration (OSHA) has typically applied a 10% discount rate to costs, but has not discounted benefits, implying a 0% discount rate on benefits. Recently, OSHA has moved toward annualizing costs of a proposed regulation over the economic life of the investment required to implement the regulation. This approach is similar to the procedure used in the two-stage SPC approach for estimating investment costs. OSHA feels this approach to the cost side of its regulatory analyses is appropriate because the costs of compliance will be recouped by regulated firms over the life of the displaced private investment.⁽¹⁷⁾ A 0% discount rate continues to be applied to benefits of proposed regulatory actions. Thus, the OSHA approach is a hybrid of the two-stage SPC method; under the two-stage SPC approach, benefits would be discounted at a proxy value for the social rate of time preference.

(15) Information on these impact analysis approaches was obtained from personal communication with Joel D. Scheraga, Chief, Adaption Branch, Climate Change Division, EPA, on December 21 and 22, 1992.

(16) Personal communication with Joel D. Scheraga, Chief, Adaption Branch, Climate Change Division, EPA, on December 21 and 22, 1992.

(17) The description of OSHA procedures was obtained through personal communication with Hugh Conway, Economist, Office of Policy Evaluation, OSHA, on December 18, 1992.

5.3 DEPARTMENT OF TRANSPORTATION

The general guidelines for Department of Transportation (DOT) use of discount rates in regulatory analyses are given in the DOT handbook for benefit-cost analysis (U.S. Department of Transportation 1984, p. 17):

OMB Circular A-94 prescribes the use of a 10 percent discount rate for analyses submitted to the Office of Management and Budget in support of legislative and budget programs. Discounting should also be used in regulatory evaluations.

Thus, DOT prescribes adherence to the OMB guidelines for the appropriate discount rate to use in regulatory analyses. However, the National Highway Traffic Safety Administration (NHTSA) within DOT now uses discount rates of 2%, 4%, and 10% on costs, and discount rates of 2% and 4% on benefits, resulting in a series of sensitivity analyses comparing different present value measures of benefits and cost under different discount rate applications.⁽¹⁸⁾

5.4 FOOD AND DRUG ADMINISTRATION

In its impact analysis of nutritional labelling requirements, the Food and Drug Administration (FDA) recently applied a 5% real discount rate to benefits and to costs.⁽¹⁹⁾ The OMB recommended two modifications of the discounting approach. First, it asked that a sensitivity analysis of the impacts be undertaken, using the OMB Circular A-94 guideline of 10% for the real discount rate. Second, it suggested an additional sensitivity analysis with benefits measured in potential life-years saved rather than number of lives saved. Both OMB recommendations tend to reduce the present value of benefits from the proposed regulatory action.

(18) Description of NHTSA discounting procedures is based on personal communication with James Simmons, Chief Economist, Economic and Technical Support Division, NHTSA, on December 8, 1992.

(19) Information on this regulatory analysis was obtained from personal communication with Larry Braslow, Economics Staff, Office of Planning and Evaluation, FDA, December 2, 1992.

5.5 SUMMARY

As Gillette and Hopkins (1988, p. 65) note, actual discounting practices are indeed diverse among federal agencies. At some agencies, e.g., EPA, discounting practices are sometimes even different within various branches of the agency. The discounting practices of other federal agencies is potentially of some help to the NRC in choosing and applying discount rates, but these practices should be supplemented by the theoretical developments discussed in Sections 3 and 4 of this report and the OMB guidance.

6.0 RECOMMENDATIONS

On the basis of the discussion and analysis of the preceding sections, the authors offer the following recommendations for consideration by the NRC:

- The present OMB guideline for the social discount rate is a real (i.e., inflation adjusted) rate of 7% (57 FR 53523), which approximates the marginal pre-tax rate of return on an average investment in the private sector in recent years. The NRC should consider using this OMB-established rate in regulatory analyses when applying a conventional (opportunity cost of capital) benefit-cost approach. This rate should be modified if the recommended rate in OMB Circular A-94 is modified.
- The sensitivity of the results of the regulatory analysis to the choice of discount rate should be tested using real discount rates lower than 7%. Lower rates are appropriate for such testing because theoretical results derived with the shadow price of capital (SPC) approach clearly show that the correct social discount rate is below the opportunity cost of capital. For example, Kolb and Scheraga (1990, p. 386) found that the effective discount rate using the two-stage SPC approach was less than half the OMB rate for projects where benefits did not begin to accrue until 20 years after a regulatory action was implemented. In addition, if future benefits and costs involve intergenerational effects, as NRC's regulatory actions frequently do, theoretical results indicate even lower real social discount rates are appropriate and should also be used in sensitivity analyses. As noted in Section 5.3, the National Highway Traffic Safety Administration, for example, uses real discount rates of 2% and 4% as well as the designated OMB rate.
- For proposed regulatory actions where the costs to licensees and the regulated community are particularly large or where projected benefits and costs are close in value, the SPC or the two-stage SPC approaches should be considered for use in the regulatory analysis. This recommendation follows recent OMB guidance (see Sections 2.1 and 2.2 of the report) and is currently viewed as the correct theoretical approach

to benefit-cost analysis. The SPC approach is more difficult to apply than the conventional approach, and, accordingly, should only be considered for use by the NRC in special cases.

- Future health-related benefits should be discounted at the same rate used for discounting costs. The objective of benefit-cost analysis is efficient allocation of society's resources. The correct rate of discount for effects of a public project or regulatory action is the social rate of time preference, which is the same for weighing future welfare gains (benefits) and future welfare losses (costs) to society. This approach is consistent with the OMB RIA Guidance (see Section 2.1).
- While there are clear arguments to support use of social discount rates lower than the OMB-designated rate for valuing future benefits, selected rates should be nonzero. If a nonzero discount rate for future health benefits is considered inappropriate, an approach where the timing and value of costs and benefits are displayed without application of a discount rate should be considered. In this case, the resulting benefit-cost ratio or net benefits should not be calculated.

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