GUIDELINES FOR PERFORMING REGULATORY IMPACT ANALYSIS

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Office of Policy, Planning and Evaluation
Office of Policy Analysis
Economic Analysis and Innovations Division
Economic Analysis and Research Branch
Phone: 202-260-3354, Mail Code: (PM-221)

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I. INTRODUCTION

On February 17, 1981, the President issued Executive Order 12291. According to this order, regulatory agencies must prepare regulatory impact analyses (RIAs) on all major regulations. In addition, before taking action, they must send all RIAs and proposed regulations to the Office of Management and Budget (OMB) for review.

An RIA assesses the analytical results of studies conducted during a regulation's development.[1] Each RIA should calculate the benefits and costs of a proposed regulation's full range of effects and should compare them with those of other regulatory and nonregulatory approaches. For environmental regulations, this range extends from the release of pollutants to their ultimate harmful effects on humans and the environment.

Benefits and costs should be quantified and monetized in the RIA to the extent possible. The RIA should discuss fully benefits and costs that cannot be quantified and should assess their importance relative to those that are quantified or monetized. When many benefits cannot easily be monetized, or when law requires a specific regulatory objective, cost-effectiveness analysis may be used to evaluate regulatory alternatives.

These guidelines are designed to help analysts at the U.S. Environmental Protection Agency (EPA) prepare RIAs that satisfy OMB's requirements. They generally follow the outline of OMB's guidance document, Interim Regulatory Impact Analysis Guidance, and provide information on the types of analytical procedures that can be used to satisfy the Executive Order's requirements. Specifically, they discuss the analytical techniques that may be used and the information to be developed when (l) stating the need for the proposed regulatory action; (2) examining alternative approaches to the problem; (3) quantifying benefits and costs and valuing them in dollar terms (where feasible); and (4) evaluating the findings on benefits, costs, and distributional effects.

More detailed information on benefit analysis, cost analysis, choice of discount rate, and analysis of distributional effects is provided in appendices. The appendices elaborate on many of the conceptual issues raised in the Guidelines and suggest how to proceed with the analysis.

The goal of regulatory impact analysis is to develop and organize information on benefits, costs, and economic impacts so as to clarify trade-offs among alternative regulatory options.[2] RIAs may vary in terms of level of detail; quantification of benefits, costs, and economic impacts; and precision of information. These differences may result because of variations in the nature and quantity of underlying data or in the adequacy of the available analytical techniques, because of resource or time constraints, or because some environmental problems or regulatory approaches are less amenable to formal analysis. However, by developing and organizing information, quantifying and monetizing benefits and costs to

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[1] It should incorporate all analyses required by the Regulatory Flexibility Act and the Paperwork Reduction Act (the requirements under the Paperwork Reduction Act replace EPA's requirement for a "reports impact analysis"). However, OMB no longer requires a "urban impact analysis."

[2] When the Agency is legally precluded from using the information provided in the RIA for regulatory decision making, the RIA should set forth the legal basis for that determination.

the extent possible, and determining distributional effects and economic impacts, the RIA should provide decision makers with a comprehensive assessment of the implications of alternative regulatory actions.

These Guidelines have been designed for evaluating specific regulations controlling individual pollutants or particular waste streams. They are not readily applicable to regulations for generic information gathering, testing, and procedural rules. In these situations, program offices should contact EPA's Office of Policy, Planning and Evaluation and OMB in the early stages about the procedures, extent of detail, and degree of quantification appropriate for the RIA.

II. SCHEDULES FOR OMB REVIEW

The Executive Order specifies when RIAs are required and establishes a schedule for rule making.[3]

- For every major rule[4] with a notice of proposed rulemaking, the Agency must submit:

  - a preliminary RIA to OMB at least sixty days before publishing the notice of proposed rule making and

  - a final RIA and a final rule to OMB at least thirty days before publishing the rule as final.

- For every major nonemergency rule with no notice of proposed rule making, the Agency must submit a final RIA to OMB at least sixty days before publishing the rule as final.

- For all rules other than major rules, the Agency must submit every notice of proposed rule making and every final rule to OMB at least ten days before publication. Although a full-scale RIA will not be required, sufficient analysis must be performed to demonstrate that the rule meets the objectives of the Executive Order. At a minimum, this should include cost and economic impact (distributional effects) analyses.

III. STATING THE NEED FOR AND CONSEQUENCES OF THE PROPOSAL

An RIA should describe concisely the nature of the environmental problem as perceived by the Agency, industry, labor, and public interest groups.[5] It should explain that the proposed regulatory

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[3] OMB has no firm guidelines on deregulatory proposals. It examines each proposal separately to decide whether to waive the RIA requirement.

[4] "'Major rule' means any regulation that is likely to result in:
(l) An annual effect on the economy of $l00 million or more;
(2) A major increase in costs or prices for consumers, individual industries, Federal, State, or local government agencies, or geographic regions; or
(3) Significant adverse effects on competition, employment, investment, productivity, innovation, or on the ability of the United States-based enterprises to compete with foreign-based enterprises in domestic or export markets." [Executive Order 12291]

[5] The Agency's public participation policy for the regulatory process also applies to RIAs.

action is within the Agency's statutory authority and should indicate whether specific action by the Agency is required by statute. The RIA also should provide information on the following points:[6]

- the market imperfections that necessitate regulatory action;
- the pollutant creating the problem, its annual discharge mass, and its principal sources, both now and, where feasible, over the time horizon of the analysis;
- the degree of the pollutant's current or projected impact on the environment, health and safety, and the economy;
- current control techniques and their effectiveness; and
- the amount or proportion (or both) of the pollutant that the proposed regulatory action would control and the resulting beneficial effects.

In stating the consequences of the proposed regulation, an RIA should discuss how, if promulgated, the regulatory proposal would:

- improve the way the market functions (primarily through internalizing the damages from pollution) or otherwise meet the regulatory objectives, and
- produce better results than no regulatory change, taking into account the possibility that regulation fails to achieve its stated goals (this may result from poorly designed rules, as well as from weakness in enforcement and lack of compliance).

IV. CONSIDERING ALTERNATIVE APPROACHES

The Executive Order requires that RIAs thoroughly examine the most important regulatory alternatives. It also requires RIAs to explain why the proposed approach has been selected.

In developing this part of the RIA, the analyst should first define the baseline, which will be the standard against which the incremental benefits and costs of all alternative actions will be compared. The baseline is what is likely to occur in the absence of regulation. Certain analyses, such as those dealing with new sources of pollution, may require more than one baseline because of uncertainties about what might happen without the proposed regulation.

The next step is to develop an initial set of regulatory alternatives that would mitigate or eliminate the environmental problem.[7] An RIA should consider four major types of alternatives.

- Alternatives to federal regulation. These include negotiated voluntary actions and market, judicial, or state or local regulatory mechanisms that could address the environmental problem.

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[6] Consult the Guidelines for Evaluation Planning, developed by EPA's Office of Standards and Regulations.

[7] Consult the Checklist of Regulatory Alternatives developed by EPA's Office of Standards and Regulations.

- Alternatives within the legislative provision's scope. These include three broad categories of alternatives: the degree of control, effective compliance dates, and methods of ensuring compliance. The second category, for instance, could involve issuing related regulations jointly to allow the affected industries to modify their products or operations to comply simultaneously with all the regulations. Alternative methods of ensuring compliance could involve employing various enforcement options (e.g., on-site inspections versus periodic reporting and sharing implementation responsibilities among the different levels of government); using various compliance methods for different segments of industry or types of economic activity where costs of compliance vary sharply (e.g., different treatment for small and large firms); or allowing variances under certain conditions.

- Market-oriented regulatory alternatives (whether or not they are explicitly authorized in the Agency's legislative mandate). These methods include using information or labeling to enable consumers or workers to evaluate hazards themselves and using economic incentives, such as fees or charges, marketable permits or offsets, changes in insurance provisions, or changes in property rights.

- Major alternatives beyond the scope of the legislative provision under which the proposed regulation is being promulgated. These would include regulatory alternatives that controlled other routes of exposure and that possibly would be authorized under other legislation.

Often there may be a trade-off between considering more alternatives and developing more detailed, quantified, and reliable benefit and cost estimates for fewer alternatives. In each case, the choice will be subjective, taking into account the nature of the environmental problem, current government regulations and status of compliance, the amount of flexibility permitted by the law governing the regulation under consideration, the schedule of required action, and resource constraints.

V. ASSESSING BENEFITS

The benefits of decreased pollution are the resulting improvements in health and aesthetics and reductions in damages to plants, animals, and materials. To measure benefits, one must ordinarily follow a chain of events from (l) the release of pollutants by industry, households, agriculture, and municipal sources to (2) the impact of these releases on ambient quality to (3) exposures of people, plants, animals, and materials through various media (air, water, etc.) to (4) the adverse effects to (5), when feasible, what people would pay to avoid these effects. Finally, the analysis of benefits should cover the entire spectrum of benefits, from those that can be assigned a dollar value to those that can only be described qualitatively, and from those that are direct and immediate to those that are remote in distance or time.

The direct chain of events is, in itself, complex to model. Beyond that, one should take into account alternative behavior that could mitigate the effects of pollution, such as using substitute materials and obtaining medical care. Thus, because of the complexity of assessing benefits, the analysis should report not only most likely estimates but also upper- and lower-confidence limits.

Benefits should be measured relative to an assumed baseline. All underlying assumptions should be consistent, and all related information should be documented in detail and a form enabling reproduction of the analysis.

A. Quantifying Health Effects

To assess the health risks posed by a pollutant, one must have information on the nature and extent of human exposure and on the toxicity of the pollutant.[8] Such information may be used to estimate the likely number and type of harmful effects, as well as to characterize the uncertainty underlying the estimates. Often, however, the information available may be insufficient to quantitatively assess health effects.

A comprehensive analysis of health effects would include:

- evaluation of substances on a case-by-case basis;
- a discussion of the likelihood that the substance may be harmful to humans and a description of the nature and duration of the harmful effects (this should be based on a weight-of-evidence evaluation of scientific information, including the results of both positive and negative studies);
- estimation of dose-response relationships to extrapolate risk[9] at low doses or, if the information available for noncarcinogens do not permit developing dose-response relationships, determination of a no-observed-effect-level or a related parameter (these should include a discussion of the mechanism of action and the procedures used to convert evidence from other organisms to predictions of potential human effects);
- information on the exposure of people to the substance (this should include the number of people in and the composition of the exposed populations; the level, frequency, and duration of their exposures; and the routes of exposure);
- an estimate of the distribution of risk to individuals or, if information available for noncarcinogens do not permit risks to be quantified, a margin of safety or recommended limit of exposure (the population and age groups with greater sensitivities should be identified where possible);
- an estimate of the expected number of adverse health effects; and
- a discussion of the science policy judgments and uncertainties present in all the analyses.

The Agency's ability to provide this information may vary, depending on the quality and types of data available, the nature of the harm, and the capability to predict exposures.

To the extent possible, an RIA should include information on the types of adverse effects the suspect substance causes, whether or not these effects are reversible, and whether they follow single or repeated exposures. It should predict the magnitude, pattern, and length of human exposure, along with the nature and composition of the exposed groups (including sensitive subgroups). Finally, it should combine the information on the substance's toxicity with exposure estimates to predict the effect each regulatory alternative has on improving human health.

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[8] Health effects need not be quantified for some regulatory activities, such as information gathering, testing, and procedural rules.

[9] Risk is defined as the probability of experiencing an adverse health effect from the pollutant under consideration.

More specific guidance on evaluating the health effects of carcinogens and noncarcinogens is provided below. It should be recognized that risk assessment policies are updated from time to time, and as changes are made these Guidelines will be modified appropriately.

1. Carcinogens

- Carcinogenic risk assessment should be on a case-by-case basis.

- A determination of the likelihood that a substance is a human carcinogen should be based on a weight-of-evidence judgment. All available information from human epidemiological studies and from animal studies should be evaluated, along with evidence from short-term tests, studies of comparative metabolism, structure-activity analysis and other relevant toxicological and biological analysis. The evaluation should consider the number and kind of tumorigenic responses and their statistical significance, as well as the quality of the available studies. Properly evaluated animal data may be used to predict human responses.

- A variety of models may be used to estimate the risk of cancer at low doses, based on what is known about possible mechanisms of action and the quality of data available. Where possible, most likely estimates, as well as upper- and lower-confidence limits, should be provided. When lack of data or of scientific understanding prevent the Agency from providing a "most likely" estimate, it may use plausible upper-limit estimates of risk, so long as they are identified as such.

- Where epidemiological data permit, the expected types of cancer should be described in terms of the disabilities they produce and their duration.

Some risk assessments will be more consistent with this guidance than others due to differences in the amount and quality of information available for specific substances, as well as uncertainties in understanding of the disease.

2. Noncarcinogens

- Noncarcinogenic health effects, which include target organ toxicity, neurotoxicity, adverse reproductive effects, and other health effects, should be evaluated on a case-by-case basis. (These effects traditionally have been evaluated similarly to each other, but as a group in a different way from carcinogenicity.)

- An assessment of the likelihood that the substance causes noncarcinogenic health effects should be based on a thorough evaluation of human epidemiological studies and animal studies. It should discuss the type of health effects, their severity and potential reversibility, and whether they may occur from single, repeated, or continuous exposure.

- A judgment of the extent of potential health hazards posed by a substance (at ambient concentrations or at estimated dosages) should be based on an evaluation of human or, more commonly, experimental animal studies in which preselected uncertainty factors are applied to no observed effect levels (NOEL) or other parameters to determine the level below which human exposure should fall. Alternatively, margins of safety can be computed that express the ratio between the NOEL (or other parameters) and estimated human exposure. Judgments about the adequacy of protection of public health can be based on such ratios. Occasionally, more complete data may be available and it may be possible to construct dose-response functions for predicting health effects at alternative exposure levels.

B. Quantifying Environmental Effects

Pollution may also result in a number of environmental effects. They include adverse effects on plants and animals, including ecological disruptions and effects on endangered species; increased soiling and materials damage; and adverse effects on recreational activities and aesthetics. The objective of a benefits assessment is to quantify these impacts in physical terms, provide measures of the uncertainty inherent in the estimates, and trace the links to human activities and values.

Where data permit, the analysis should consider the likely actions individuals may take to mitigate the effects of pollution. For instance, ozone may adversely affect agricultural productivity, but farmers may lessen the impacts by planting different crops.

The Agency's ability to provide this information will depend on the quality and types of data available, the nature of the environmental effects, and the ability to estimate the fate and transport of substances in the environment.

C. Valuing Health and Environmental Effects

The major objective of economic valuation is to transform estimates of changes in physical or biological effects into monetary estimates of benefits. This is done by using the amount individuals would pay for such changes as a measure of their value, i.e., benefits should be measured in terms of willingness to pay.

When markets exist, such as for consumer goods and services, estimating benefits in terms of willingness to pay is essentially a problem of estimating a demand curve from observed prices and quantities. But organized markets for environmental quality typically do not exist, even though people are willing to pay for environmental improvements. Thus, other techniques for valuing the health and environmental effects associated with regulatory programs must be used.

1. Health Effects

Morbidity (illness) should be valued by estimating its direct cost, unless it is feasible to use willingness to pay measures. This estimate provides a lower bound on the value of morbidity. It includes medical costs, loss of work and earnings, and impacts on future productivity. Since this procedure does not consider pain and suffering, as well as the value of time for sick people who are not in the labor force, it is likely to underestimate the benefits of reduced morbidity. It is also likely to ignore the value of reducing the incidence of very subtle health effects attributable to pollution, e.g. discomfort and impairments in cognitive development.

Mortality may be valued either directly or indirectly through the implicit valuation technique. In either approach, however, a value is not placed on saving a particular individual's life. Environmental regulations generally provide health benefits by reducing the risk that people experience adverse health effects, e.g., a regulation may reduce the probability that individuals contract cancer over their lifetimes from 1 in 1,000 to 1 in 10,000. The extent of likely improvements in health to the total population may be estimated by aggregating the expected reductions in health risks to individuals. When assessing potential life-threatening illnesses, such as cancer, the resulting measure is termed "statistical lives saved." Thus, "statistical lives saved" refers not to particular lives, but to the sum of small reductions in risk to large numbers of people. This measure is useful for comparing the aggregate health effects likely to result from regulatory alternatives and for determining the relative cost of attaining health benefits.

If mortality is to be valued directly, a range of values can be used to determine the sensitivity of the results to alternative values. Recent studies that measure how much people need to be compensated to incur small risks provide a means for selecting such values. For example, many of these studies examine the relationship between risks in the workplace, which typically range between 1 in 100,000 and 1 in 1,000 on an annual basis, and wages. They have found that annual wages are between about $4 and $70 higher for jobs with 1 in 100,000 greater risk. This translates into a value for a statistical life of roughly $400,000 to $7,000,000 (in 1982 dollars).

Alternatively, mortality may be valued indirectly by calculating the implicit cost per statistical life saved. This is done by subtracting the monetized benefits of a regulatory alternative from its costs and dividing the result by the estimated number of statistical lives saved. When possible, the implicit cost per statistical life saved should be calculated on an incremental basis, i.e., dividing the change in costs (less benefits) between regulatory alternatives by the change in statistical lives saved. The resulting implicit value may be evaluated in light of the compensation people have been observed to require to incur small risks or the costs of other government regulations. However, when there are other important nonmonetized benefits, the implicit valuation technique will overestimate a regulation's cost per statistical life saved.

2. Environmental Effects

There are four basic methods for valuing environmental effects: direct cost, travel cost, property value, and contingent valuation. All lead to estimates of what groups are willing to pay to avoid the damages of the pollutant(s) to be regulated. (These techniques sometimes may measure both nonhealth and health effects.) However, each technique is best suited for estimating only certain types of environmental benefits.

- The direct cost method is best suited for estimating the value of the commercial effects of reduced pollution, such as reduced damage to fisheries, forests, and agriculture and increased lifetimes of building or machinery. The monetary value of these effects is estimated as the savings in costs to industry and to consumers.

- The travel cost method may be used to estimate the value of the recreational effects of reduced pollution. monetary values are estimated by developing a demand curve for recreational activities and determining how it would change because of improvements to the environment.

- The property value method may be used to estimate the value of the health, aesthetic, and recreational effects of reduced pollution. This method relates differences in property values to housing characteristics, location, and environmental characteristics to infer the values placed on environmental improvements.

- The contingent valuation method primarily has been used to estimate the value of nonmarket goods and services, such as improvements in aesthetics (gains in visibility or water clarity and reductions in odor) and the preservation of wildlife and wilderness areas. In this method people are asked what they would be willing to pay to enjoy alternative levels of environmental quality.

A more detailed discussion of techniques for valuing environmental effects is provided in the appendix on benefits analysis.

VI. ANALYZING COSTS

EPA generates cost estimates for a number of purposes during the rule-making process. These estimates typically have been used to help determine the economic effects of regulations on the regulated community.

Performing cost analysis appropriate to the benefit-cost assessment required in RIAs should involve more than predicting the compliance costs of parties directly affected by regulation. It requires estimating total costs to society, defined as the value of goods and services lost by society resulting from the use of resources to comply with and implement a regulation, and from reductions in output. Thus, a comprehensive analysis adds up all costs society incurs. These fall into four general categories: private-sector real-resource costs, government regulatory costs, dead-weight welfare losses, and adjustment costs (these costs are described below). For most regulations, firms' real-resource costs will account for nearly all the costs to society. Thus, adapting Agency cost analyses to incorporate the total social cost concept needed for RIAs usually will require only minor adjustments.

As in benefit analyses all assumptions underlying cost analyses must be consistent and all related information should be documented in a form enabling reproduction of the analysis. To account for uncertainty, most-likely estimates of costs should be presented, along with cost ranges and statements about their likelihood.

A. Selecting a Cost Framework

The use of a static, partial-equilibrium analytical framework is the most practical means for estimating total social costs. This framework, in its most sophisticated form, is based on an analysis of supply-and-demand relationships in the directly affected markets.

When an industry is regulated, compliance requirements generally result in increased unit costs of production. This, in turn, leads to an upward shift in the industry's supply curve, which normally results in higher prices and a lower production level. Compliance costs, and net welfare losses incurred by producers and consumers because of decreased output, are measurable within this framework; other costs, described below, are not.

Each of the unconventional regulatory alternatives (such as user charges, offsets/bubbles, pollution indemnity) involves its own particular set of cost considerations. These are discussed in the appendix on cost analysis.

B. Defining the Components of Cost Analysis

1. Baseline

The first step in estimating the costs of a regulation is to determine the baseline -- what is likely to happen in the absence of the regulation. The population of the regulated community must be estimated, as well as the degree of pollution control that may occur without the regulation.

2. Principal Cost

An estimate of the total costs that regulations impose on society should begin with private real-resource costs. These are pretax compliance costs, net of any transfer payments (e.g., emission fees, licensing fees, or subsidies). Compliance costs should include costs imposed on both existing and new sources.

Calculating the net present value of compliance costs requires adding the discounted stream of operating and maintenance costs to the initial investment costs. In many cases compliance is not required immediately, and the initial investment must be discounted.

Estimates of private real-resource costs usually rely on engineering cost estimates. They should be based on a realistic appraisal of the equipment or process changes needed to meet the requirements of each regulatory alternative. A most likely, as well as an upper- and lower-bound estimate of cost should be provided. For alternatives that do not involve engineering controls, the cost analysis components will have to be modified accordingly.

For most regulations requiring the use of pollution control technology, private real-resource costs will account for nearly all of the total cost to society, and little further effort to estimate costs is necessary. In some cases, however, other costs to society may be significant.

3. Other Costs

Although some of the following costs are difficult to predict and quantify, they should be considered when estimating total costs to society. The amount of resources devoted to such analyses should depend on the expected contribution of these costs to total costs. If certain components are likely to be small, less analytical effort should be used to measure them than when they are likely to substantially change estimated total cost.

- Government Regulatory Costs -- Federal, state, and local governments may incur costs to issue permits for affected plants, to monitor performance, and to enforce compliance.

- Dead-Weight Welfare Loss -- Net losses in consumers' and producers' surplus may occur from the decrease in output of goods and services resulting from a regulatory action. Generally these losses are a relatively small part of the total costs to society, except when there are no readily available substitutes for a product that is banned or that has its use severely restricted. Dead-weight welfare loss should be estimated within the conceptual framework discussed in the appendix on cost analysis.

- Adjustment Costs for Displaced Resources -- Regulatory action often results in dislocation of labor and other productive resources. Three types of costs may occur. First, if an industry's production decreases, some of the resources that had been required to produce the lost output fail to be used elsewhere in the economy. The value of resources that are reallocated to other markets is netted out. Second, there is a resource reallocation cost, typified by a person's spending time and money looking for a job and moving to a new location. Finally, society expends resources to operate programs to help the unemployed (this does not include transfer payments to individuals).

- Adverse Effects on Product Quality, Productivity, Innovation, and Market Structure -- These effects should be quantified to the extent possible or, at a minimum, discussed qualitatively.

The analysis conducted to conform with the requirements of the Paperwork Reduction Act should be incorporated into this section of the RIA. The reporting requirements imposed on industry are a part of principal costs, while those incurred by the Agency will be in the "other costs" category.

VII. EVALUATING BENEFITS AND COSTS

The final section of an RIA should be a comprehensive evaluation having the following elements:

- estimates of the net benefits of each major alternative, based on the benefits and costs for which a dollar value can be assigned, and a discussion of nonmonetizable or unquantifiable benefits and costs;

- a schedule of all benefits and costs for each major alternative, including economic impacts and intergenerational effects; and

- the results of cost-effectiveness analysis of major alternatives, when many benefits are not easily monetized or when the law sets forth specific regulatory objectives.

A. Estimating Net Benefits

The net benefits of each major alternative may be estimated by subtracting the present value of monetary social costs (as defined in section V) from the present value of monetary social benefits (as defined in section IV). For this calculation the same baseline must be used in both the benefit and cost analyses. Plausible upper- and lower-bound estimates of net benefits should be provided, and the sensitivity of the net benefits estimate to variations in uncertain parameters (including the rate of compliance) should be examined.

The choice of discount rate is critical in calculating the present value of estimates of net benefits. OMB's Guidance requires using an annual real discount rate of l0 percent. It also states that "where it appears desirable, other discount rates also may be used to test the sensitivity of the results."

In many instances, the present value of net benefits should be calculated using an additional discount rate because a l0 percent rate may not reflect the opportunity costs associated with (I) each of the many ways of financing public investments, (2) differences in their riskiness, (3) differences in the form of the benefits and costs, and (4) differences in their distribution. Four alternative approaches are available for selecting discount rates for benefit-cost analyses of government programs and projects: shadow price of capital, opportunity cost, weighted average, and social rate of time preference. One or more of these approaches may best fit the particular economic circumstances of the regulation being considered. The appendix on discount rates provides more detail on these approaches.

The net benefit estimate should be carefully evaluated in light of all the effects that have been excluded because they could not be assigned a dollar value. Thus, immediately following a net benefit calculation, all benefits and costs that can only be quantified, as well as all benefits and costs that can only be qualitatively described, should be presented and evaluated.

The incremental benefits, costs, and net benefits of moving from one regulatory alternative to the next also should be presented. This should include a discussion of incremental changes in quantified and qualitatively described benefits and costs.

Finally, this section should discuss other potential costs and benefits that may be by-products of the proposed action. These include transfers of the pollutant problem from one exposure medium or program office jurisdiction to another, or possible exacerbation of exposures for specific groups (e.g., very sensitive populations, maximum exposure groups, or specific types of workers).

B. Developing Schedules of All Benefits and Costs

The criterion of economic efficiency used in benefit-cost analysis is not designed to assess whether the distribution of the benefits and costs of a particular regulatory action is equitable, either among different groups at a point in time or among different generations. Both E.D. 12291 and the Agency recognize that regulatory decisions should address distributional issues.

Thus, OMB's Guidance calls for schedules showing the distribution of benefits and costs. The benefit schedule should show the type of benefit, to whom it will accrue, and when it will accrue. The cost schedule should identify the type of cost (e.g., capital, recurring), who will bear it, and when and where it will be incurred. Important benefits or costs should be highlighted and their relative importance to the dollar estimate of net benefits should be assessed.

The part of the schedule showing the distribution of benefits should be based on an analysis of the distribution of health risks to the current population (developed in the section of the RIA that assesses health effects), along with an analysis of intergenerational equity. The part of the schedule showing the incidence of costs should rely on the 'type of economic impact analysis the Agency historically has performed.

C. Analysis of Intergenerational Equity

Considering intergenerational equity is particularly important for EPA because of the uneven distribution over time of the benefits and costs of many environmental regulations. For regulatory actions with intergenerational impacts -- time horizons exceeding the 25- to 30-year range -- the economic efficiency criterion used in benefit-cost analysis is less suitable as a guide for decision making. For example, many people consider the major issue in disposing of long-lived hazardous wastes as how to equitably distribute benefits and costs across generations.

No entirely satisfactory method exists for evaluating intergenerational effects. For analytical purposes, several alternative procedures may be helpful in portraying trade-offs in benefits and costs between generations. These would include:

- discounting benefits and costs at a lower social rate of discount, rather than at the rate of return on capital;
- indicating the number of years until net undiscounted benefits become positive and the number of years and amounts by which they remain positive; and
- directly comparing benefits to future generations with costs to the current generation.

D. Economic Impact Analysis

The economic effects to be examined can be divided into two general categories: (1) primary effects, which should be examined in every case, and (2) secondary effects, which should be examined if primary effects appear substantial or if there is reason to believe that any of the categories of impacts are likely to be important to the decision process. The primary effects consist of changes in prices (for both producers and consumers), production, industry profitability and capital availability (including plant closures), and employment. The secondary effects are influences on related markets, secondary employment, the community, the balance of trade, and energy consumption.

Although many of the secondary effects may be negative, some may be positive (such as expansions for producers of pollution control equipment or substitutes for the pollution-related product). The appendix on economic impact analysis discusses techniques for analyzing each of these effects.

Quantifiable economic effects can be estimated from a combination of financial and market analyses. For program offices that do not have such sophisticated methods as simulation techniques, the analysis should begin by segmenting the industry into categories of plants that will be similarly affected -- e.g., according to size distribution, age, and pollution control process. Whenever possible, industrial analysis should be performed at a plant level of detail for the affected segments. Long- and short-run effects should be analyzed. Financial analysis, whether performed on an actual plant-by-plant basis or for "model plants" that represent significant industry segments, should normally be employed to address economic impact issues. Real-resource effects should be separated from transfers, so that efficiency considerations are distinct from distributional concerns.

A discounted cash flow analysis should be used to determine whether the value of projected future cash flows minus the costs of pollution control (as indicated by engineering estimates of compliance costs) is sufficient to continue operating the plant at current levels. Where data are unavailable to perform this type of analysis, a return-on-investment analysis should be performed.

Each of these analyses should assess how much of the cost increases plants will be able to pass through. They should consider both supply and demand factors. Financial analyses generally should use both a most-likely estimate of cost pass-throughs for (model) plants and a worst-case assumption of no cost pass-throughs. They also should discuss the likelihood of there being no cost pass-throughs.

E. Analyzing Cost-Effectiveness

When many benefits cannot easily be monetized, or when the law sets forth a specific regulatory objective, the RIA should present the results of a cost-effectiveness (CE) analysis. This will provide useful information to decision makers and conforms with the Executive Order's requirement to minimize the cost of achieving regulatory goals.

The cost-effectiveness of a regulatory alternative is calculated by dividing the annualized cost of the regulatory alternative by a measure of its effectiveness. That measure may range from the amount of the reduction in pollution to the ultimate improvements in human health or the environment. Each measure has advantages and disadvantages: "pounds of pollution removed" is the easiest to calculate across a broad range of regulations but ignores wide differences in pollutant toxicities and dilutions, "units of exposure avoided" may require sophisticated dispersion models, and "statistical lives saved" requires a detailed understanding of population exposure and dose-response relationships. In general, the measure of effectiveness used should be as close as possible to the final effects thought to result from the regulation.

CE analysis can be used to identify:

- the most efficient (least-cost) way of achieving a predetermined objective, such as avoiding a given level of pollutant emissions or related health effects;[10]

- policies that maximize the level of a stated type of benefit (e.g., reductions in exposure to a certain carcinogenic pollutant) for a given compliance cost; and

- incremental trade-offs between successively more stringent levels of control when there are no firm benchmarks that must be attained.

CE analysis does not necessarily reveal what level of control is reasonable. However, it can indicate which control measures or policies are inferior options and, thus, usually should be an integral part of benefit-cost analysis.

CE analysis also can be used to make comparisons across industries when the effects of emissions or discharges of pollutants are similar. Regulations for controlling the same pollutant in other industries can provide a general "range of reasonableness" against which the cost-effectiveness of a proposed regulation can be assessed. When properly conducted, comparative CE analysis can take a stated goal for reductions in aggregate pollution and determine which distribution of reductions in pollution across industries is least costly.

Regulations established by different program offices within the same medium should also be compared if possible. This requires using comparable measures of effectiveness. Thus, either a pound of a pollutant removed at one place must be similar to one reduced at another, or more sophisticated measures of effectiveness must be used. These would include dollars per exposure avoided or dollars per health effect prevented. When feasible, this gives a comparison of "payoffs" relative to costs across program offices.

F. Using the RIA in Decision Making

One of the purposes of E.O. 12291 is to improve the economic efficiency of government regulations. In theory, this is achieved by selecting regulatory options that maximize net social benefits. Unfortunately, determining which regulatory options are best in terms of economic efficiency often is made difficult by uncertainties in data, by inadequacies in analytical techniques, and by the presence of benefits and costs that can be quantified but not monetized or that can only be qualitatively assessed. Thus, even if the criterion of economic efficiency were the sole guide to policy decisions, the analytical results of the RIA may not always point unambiguously to a specific regulatory option as being superior.

Additionally, as recognized by E.O. 12291 and the Agency, regulatory decisions should address distributional issues. Analysis can reveal the likely distribution of benefits and costs among groups or between generations. But it cannot determine whether the distribution is equitable or how distributional issues are to be weighted relative to concerns about economic efficiency.

In view of the limitations of current analytical techniques and the range of factors that may enter into decision making, the RIA is best viewed as a document that organizes information and comprehensively assesses the effects of alternative actions and the trade-offs among them. The results

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[10] Other criteria, such as legislative requirements, enforcement problems, technological feasibility, or quantity and location of total emissions abated, may preclude selecting the least-cost solution in a regulatory decision.

should identify which regulatory alternatives are reasonable, while leaving considerable latitude to decision makers in selecting the preferred regulatory approach.

GUIDELINES FOR PREPARING REGULATORY IMPACT ANALYSIS

APPENDIX A

ANALYSIS OF BENEFITS

MARCH, 1988

GUIDELINES FOR PREPARING REGULATORY IMPACT ANALYSIS

APPENDICES A, B, C, 'SUPPLEMENT TO C' AND D

GUIDELINES FOR PREPARING REGULATORY IMPACT ANALYSIS

APPENDIX A

ANALYSIS OF BENEFITS

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APPENDIX A

ANALYSIS OF BENEFITS

I. INTRODUCTION

This Appendix provides further guidance on how to evaluate benefits as part of a Regulatory Impact Analysis (E.O. 12291). It supplements the Agency's Guidelines for Performing Regulatory Impact Analysis (December 1983). This Appendix is not intended as a comprehensive "cookbook" for benefits estimation. It is a guide to basic economic principles for assessing environmental program benefits and the applicability of alternative methods in specific program areas. It also provides references to recent benefits studies.

The Appendix is organized as follows. Section I provides an overview of a conceptual approach for estimating the benefits of improvements in environmental quality. Section II describes the analytical methods that can be used to estimate benefits and discusses their advantages and disadvantages. Section III reviews a few recent applications of these methods for measuring benefits.

II. A CONCEPTUAL APPROACH FOR ENVIRONMENTAL BENEFITS

A. Introduction - The Benefits Principle

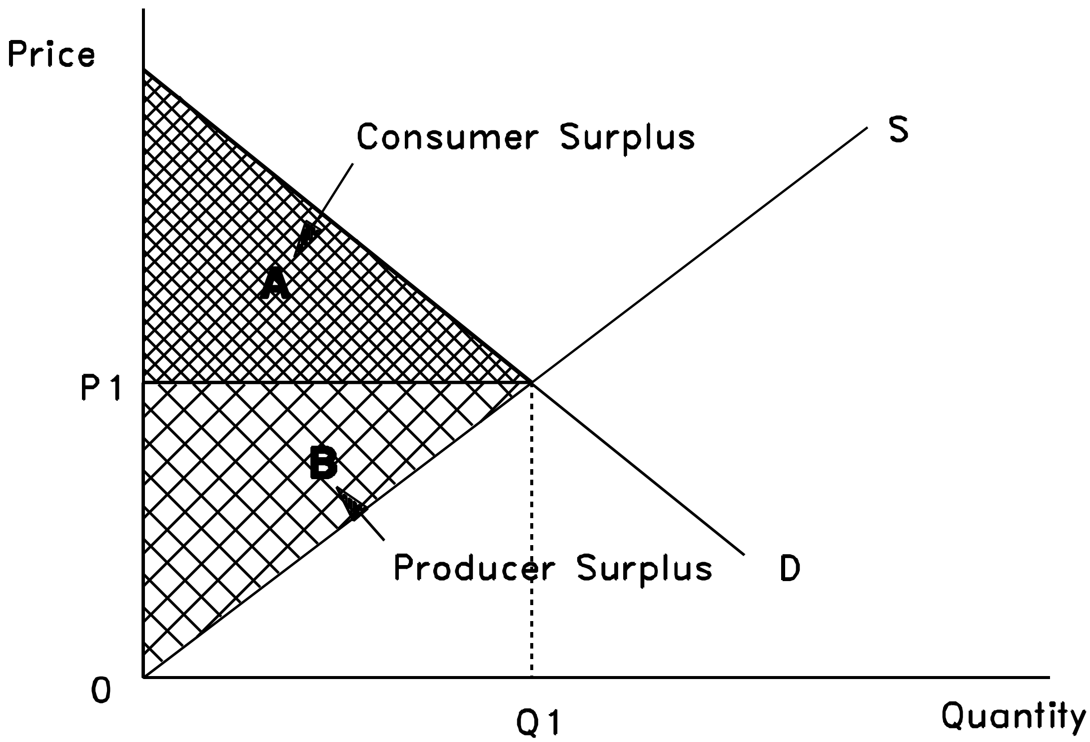
Environmental pollutants can affect people in many ways. For example, pollutants can impair health directly or they can limit outdoor recreation by degrading rivers and lakes. Environmental regulations reduce the magnitude of these effects. The satisfaction that individuals experience because of the environmental improvement is a measure of the benefits of the regulation. Assuming that individuals are aware of the effects of pollution, these benefits can be expressed in monetary terms by identifying individuals' willingness to pay for an environmental improvement.

An alternative way to measure benefits is to identify the decrease in the cost of producing a good or service that results from an environmental improvement. These effects of environmental regulations will be reflected in the demand and supply of goods and services. Benefit estimation, in its simplest form, is the process of identifying the relevant changes in consumer demand and producer supply due to environmental improvements.

The concept of economic benefits can be illustrated with a simple graph of demand and supply. Figure 1 shows a demand and supply curve for a hypothetical good x. The net economic benefits derived from production and consumption of this good are composed of two parts -- consumers' surplus and producers' surplus. The area, A, above the price line and below the demand curve measures the consumer's surplus. It is defined as the excess consumers are willing to pay over the actual expenditures at the price p_1. The consumers' surplus is a measure of the net consumer benefits at the existing price. The producers' surplus is defined as the excess of price over suppliers' production costs (all opportunity cost included) and is shown in Figure 1 as the area, B, below the price line and above the supply curve. The areas A plus B represent the net benefits to society from the production and consumption of this hypothetical good.

Improvements in environmental quality can shift either of these curves from some initial position to a new position that reflects a reallocation of resources in the economy. For example, improved water quality at a lake would tend to increase recreation visits to the lake. This can be represented as a rightward shift of the demand curve for lake visits from D1 to D2 as shown in Figure 2.

FIGURE 1

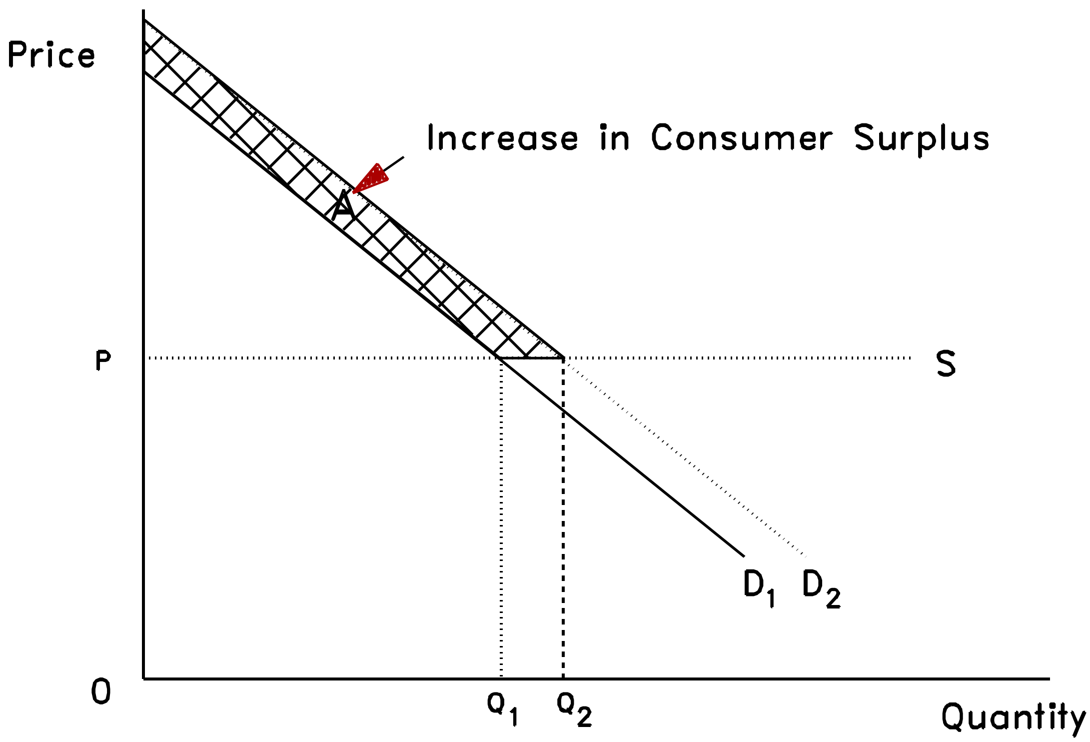


In this case, the horizontal supply curve reflects the assumption that additional visitors can be accommodated at constant cost per visitor. The gross benefits of improved water quality are measured by the increase in consumers' surplus given by the area A, while net benefits are found by subtracting out any costs of improving water quality.

Similarly, improved water quality can shift the supply curve. For example, industrial firms may benefit from water quality improvements through reduced water intake treatment costs. These benefits would be measured by the new producers' surplus created by shifts in the firms' supply curves.

The actual distribution of benefits between consumers and producers depends on the relative slopes of the demand and supply curves. In practice, however, it is common to assume that the supply curve is horizontal in order to simplify the measurement of benefits for environmental improvements affecting consumers. Alternatively, it can be assumed that the demand curve is vertical in order to measure the benefits of environmental improvements for producers. In most cases these assumptions will not significantly alter the benefit measures.

FIGURE 2



B. Some Qualifications

While this graphical illustration conveys the basic principles of benefit estimation, several qualifications should be considered. First, in order for changes in environmental quality to be reflected in consumer demand and producer supply decisions, these buyers and sellers must be aware of the effects on their activities. This suggests that it is necessary to include some dimension of environmental quality as an explicit argument when estimating consumers' demand or producers' supply. This process of identifying the linkage between environmental quality and economic decisions can yield many insights about the complex effects of environmental quality of economic activities.

Second, describing the linkage between environmental quality and consumers'/producers' decisions leads to a recognition of the institutional setting in which changes can be evaluated. Some aspects of environmental quality (e.g. surface water used for irrigating agricultural crops) are directly related to goods traded in competitive markets and therefore can be evaluated by estimating actual or expected changes in market demand and supply. Environmental quality also may be indirectly related to economic decisions in competitive markets or to consumers' decisions about their use of such resources as public waterways and parklands. In this setting the revealed behavior of consumers can be examined to estimate the actual or expected changes in the indirect demand for environmental quality. In other cases, improvements in environmental quality may be important to consumers, but their preferences are not expressed in markets either directly or indirectly. This type of benefit requires methods which elicit preferences using surveys. Finally, some changes in environmental quality may not be relevant for consumer or producer decisions and cannot be quantified in monetary terms using either market or survey information. In these cases the best the analyst can do is to describe the expected environmental consequences and allow the policy-maker to weigh this information along with other relevant factors.

A third qualification to the simple consumers' and producers' surplus analysis is the distinction between use and intrinsic benefits of environmental improvements. Use benefits are associated with consumption and production activities affected by changes in environmental quality and can be measured using market and survey information. Use benefits may accrue through indirect activities such as aesthetic perceptions but they are related to some current or future use. Intrinsic benefits can occur when there is some uncertainty about future use or availability of an environmental resource (option value) or when an individual benefits from the knowledge that a resource will exist in the future (existence value). These intrinsic benefits can be identified only through survey methods.

Finally, it should be recognized that the simple consumers' and producers' surplus will not provide reliable measures of benefits if the improvement in environmental quality affects several goods and services and / or the change in consumer welfare is a relatively large part of total income. In these situations it is necessary to take account of income and multiple price changes that can have a significant effect on benefit computations. More detail on these compensating and equivalent benefit measures is available in Freeman (1979, pp. 33-61).

II. SPECIFIC METHODS FOR ASSESSING ENVIRONMENTAL BENEFITS

Improvements in environmental quality may produce benefits for several different sectors of the national economy. While the analytical methods described in this section are flexible enough to evaluate many of those benefits, estimating various kinds of benefits usually requires more than one method. Thus the analyst should consider the range of environmental effects expected from a regulation and select those methods that are most appropriate for the affected sectors.

Five methods have been developed to estimate environmental benefits. A brief description of each is provided below:

- Cost savings method - This method measures benefits by estimating the reductions in production costs or household expenditures because of an environmental improvement.

- Damage function method - This method is based on a dose response function. It relates changes in a pollutant to physical changes in receptor organisms or materials. The value of the physical changes is then estimated by an appropriate method.

- Hedonic pricing method - This method measures benefits by identifying the indirect effects of changes in environmental quality on the market price of economic resources. It usually relies on real estate prices or labor wages.

- Travel cost method - This method identifies the relationship between visits to recreation sites with different levels of environmental quality and the travel costs of those visits.

- Contingent valuation method - This method uses survey methods to elicit individuals' preferences for environmental improvements. Several survey formats have been developed.

Table 1 provides an overview of how these benefit estimation methods can be applied for Agency programs. Columns 1 and 2 list Agency programs and the primary pollutant indicators for each program. Columns 3 and 4 list alternative measures of effects on human or environmental receptors due to changes in the primary pollutant indicators. These receptor effects provide the essential links between environmental quality and economic activities that are necessary to measure economic benefits. Column 5 lists alternative benefit estimation methods that can be used to measure the economic impact of these receptor effects. This list is not intended as a comprehensive description of benefit estimation methods for all Agency programs.

The rest of this section describes each method and assesses its general advantages and disadvantages. A review of recent benefit studies in the next section illustrates how these methods have been applied to specific receptor effects.

A. Cost Savings

Changes in environmental quality can affect the production costs of firms and reduce the maintenance and health care costs of households. In some cases, they can alter the market prices of output. Since several factors determine the appropriate measure of cost savings, it is necessary to distinguish two possible settings.

In the first setting, the affected firm's production costs would decrease (e.g., less water treatment), but output levels and market prices for inputs and products would remain the same. In this case, the relevant benefit measure is the producers' surplus. It is measured by the expected difference in production costs before and after the change in environmental quality. Alternatively, from the consumers' side, the consumers' surplus from improved environmental quality could be measured by expected reduction in household maintenance, health care, or other relevant costs. In evaluating both producers' and consumers' surpluses in this setting, the most important assumption is that the cost savings measure captures the full effect of the change in environmental quality on the affected economic agent.

In the second setting, the affected firms experience a decrease in costs, but other input prices, output levels, and output prices would also change. In this setting, the simple difference in costs before and after the change in environmental quality would not be an adequate measure of the benefit. The damage function method, discussed below, is more appropriate.

Production cost savings usually are estimated from engineering cost studies since the benefits may be location-specific or data may be insufficient to estimate actual cost relationships. On the consumer side, it is commonly assumed that all consumers affected by a change in environmental quality would enjoy the same cost savings. The cost savings method is most useful when environmental improvements lead to one-time 'lumpy' changes in economic activity. For example, improved water quality in a river may lead to a one-time reduction in industrial water treatment capital costs. When these cost savings are incremental and vary with the actual level of the pollutant, the change in variable production costs over a facility's useful life should be estimated.

Advantages of Cost Savings Methods

- The cost savings approach is generally easier to apply than other benefit estimation methods since it uses primarily engineering or market data.

- This method is based on general income accounting principles and may be more readily understood by persons with limited economic training.

TABLE 1

SUMMARY OF LINKAGES BETWEEN REGULATORY PROGRAMS, POLLUTANT INDICATORS RECEPTOR EFFECT TYPES, AND ECONOMIC BENEFIT MEASUREMENT CATEGORIES

Program Area	Primary Pollutant Indicator	Type of Environmental Receptor Effects	Linkage to Economic Benefit	Possible Measurement Methods
AIR	Ambient Pollutant (TSP, SO_2, etc.) Concentrations (ug/m^2, ppm, etc.)	Respiratory discomfort or illness	Restricted activity days, work loss days, health care expenditures, pain and suffering	Damage Function, Cost Savings, Contingent Valuation
		Respiratory-related mortality	Deaths per 100,000 persons	Damage Function, Cost Savings, Hedonic Wage
		Respiratory cancer risk	Probability of cancer death, statistical lives saved	Damage Function, Cost Savings, Hedonic Wage, Contingent Valuation
		Recreation	Site visitation, activity participation	Travel Cost, Contingent Valuation
		Aesthetics	Visual range, odor, color	Hedonic Property, Contingent Valuation
		Materials	Maintenance and repair expenditures	Damage Function, Cost Savings
		Agriculture, Fisheries, and Silviculture	Crop or stock loss	Damage Function, Cost Savings

TABLE 1 (continued)

SUMMARY OF LINKAGES BETWEEN REGULATORY PROGRAMS, POLLUTANT INDICATORS RECEPTOR EFFECT TYPES, AND ECONOMIC BENEFIT MEASUREMENT CATEGORIES

Program Area	Primary Pollutant Indicator	Type of Environmental Receptor Effects	Linkage to Economic Benefit	Possible Measurement Methods
WATER	Ambient Priority Pollutant Concentrations (ppm, ppb)	Drinking water morbidity or mortality risk	Probability of consumption related illness or death, statistical lives saved	Damage Function, Cost Savings, Hedonic Property, Contingent Valuation
	Conventional Pollutant (BOD, TSS, etc.) or Concentrations (mg/l, etc)	Recreation (fishing, swimming, etc.)	Site visitation, activity participation	Travel Cost, Contingent Valuation
		Fisheries	Stock loss	Damage Function, Cost Savings
		Aesthetics	Turbidity, color	Hedonic Property, Travel Cost, Contingent Valuation
		Ecosystem	Habitat loss, diversity loss	Damage Function, Cost Savings, Contingent Valuation
TOXIC SUBSTANCES, PESTICIDES, AND HAZARDOUS WASTES	Concentration and exposure risks	Non-lethal poisonings or illness	Restricted activity days, work loss days, health care expenditures, pain and suffering	Damage Function, Cost Savings, Contingent Valuation
		Non-lethal and lethal cancer risks	Statistical life-years saved, statistical lives saved	Damage Function, Cost Savings, Hedonic Wage, Contingent Valuation
		Aesthetics	Proximity to exposure	Hedonic Property
		Ecosystem	Habitat loss, diversity loss, stock loss	Damage Function, Cost Savings, Contingent Valuation

Disadvantages of Cost Savings Method

- Cost savings may not measure all the benefits of an environmental improvement and may only be a lower bound on the total benefits.

- The cost savings method is very difficult to apply for common property and open access resources since data are often limited or unavailable.

B. <u>Damage Function</u>

The damage function method is a two-step procedure. First, a dose-response relationship between exposures to a pollutant and receptors is estimated from field or laboratory data. The expected changes are then converted into monetary units by assigning a dollar value to expected incremental reductions in the level of the pollutant.

Ideally, the dollar values should be based on the observed market prices of goods and services. However, while it is possible in some cases to define the technical (dose-response) relationship between environmental change and economic activities, there may be no clear dollar value that can be assigned to the expected damage prevention. Most often this problem involves common property or open-access natural resources that are not priced in competitive markets. It also occurs for health benefits when the avoided costs, such as reduced hospitalization or foregone earnings, are not considered an appropriate measure of social benefits because they do not account for all the benefits of improved health. In some cases the methods described later in this section can be used to identify appropriate dollar values. However, when these methods are not practical, it may be necessary to use market prices of closely related goods as proxies.

The damage function method assumes that only the quantity of the good changes with a change in environmental quality. In some cases it may be necessary to also consider changes in the input levels and market price of a good. A different form of the damage function method, sometimes called the cost function method, can be used in these cases. This method requires the simultaneous estimation of supply and demand functions to determine the net benefits of an environmental improvement.

Advantages of Damage Function Method

- The damage function method explicitly distinguishes the scientific (dose-response) and economic valuation components of benefit estimation.

- This method can be used for a wide variety of environmental changes including health and ecological risks where only animal or clinical epidemiological information is available.

- The cost function method can capture several interrelated effects of changes in environmental quality on input and output markets. This may be useful for analyses of regulatory impacts on closely related industries.

Disadvantages of Damage Function Method

- This method may be sensitive to the specification of the dose-response function. The dose-response function may be based on limited scientific evidence.

- Monetary values for goods and activities may be difficult to define especially in situations where the market price may not reflect all productive uses of the resource.

- The cost function method requires extensive data about production processes and consumer demand. It may be difficult to identify specific pollution effects when several pollutants are present.

C. Hedonic Pricing

The hedonic pricing method is based on the premise that consumers adjust their purchases of goods and services in response to differences in environmental quality. These goods and services can be viewed as bundles of characteristics such as size, shape, and less obvious attributes that may be related to environmental quality.

The hedonic pricing method seeks to identify the indirect linkage between environmental quality and the market price of a good by estimating the implicit price of a characteristic of environmental quality. Under appropriate conditions, changes in this implicit price can be interpreted as individuals' willingness to pay for environmental quality. In other situations, it is necessary to estimate a demand function for environmental quality to obtain correct benefit (consumers' surplus) estimates. Most hedonic pricing applications have been to housing prices and labor wages.

Housing Prices

The hedonic method can be used to estimate the implicit prices of environmental quality characteristics related to residential location. It can identify consumers' implicit willingness to pay for differences in neighborhood environmental characteristics such as air and water quality. Since these environmental factors are not separately exchanged in markets, the hedonic pricing method has been developed to identify consumers' preferences for environmental quality from related market transactions.

Houses are differentiated by such characteristics as lot size, number of rooms, and location. With sufficient variation in the housing characteristics available on the market, the implicit price function relating housing prices to the quantities of various characteristics can be estimated. A hedonic price function takes the general form:

$$p = p\ (b, n, q),$$

which expresses housing price as a function of building structure, b, neighborhood, n, and environmental quality, q. The implicit price of any characteristic is the partial derivative of this function with respect to the characteristic. An implicit price function can be constructed relating changes in q to changes in the implicit price.

Under the special condition that all households have identical incomes and preferences, the area under the implicit price function can be used as a measure of the benefits (consumers' surplus) of a change in environmental quality. This condition is quite restrictive, however, and can be misleading when estimates from a single housing market are extrapolated to regional or national benefits.

A more general procedure is to use the implicit price function in a two-stage analysis that relates a household's implicit prices for characteristics to the household's income, socioeconomic traits, and other factors that influence preferences. The resulting (inverse) demand function(s) can then be used to estimate the benefits of a change in q.

Wages

The hedonic pricing method can also be applied to labor wages to identify the benefits of changes in such job characteristics as health risks. The basic assumption is that wages determined in competitive labor markets reflect a premium that is necessary to induce workers to locate in areas with reduced environmental quality and / or to enter risky occupations. This wage premium is the implicit price of job-related environmental quality or of occupational risk.

The hedonic wage model differs from the hedonic housing price model in that the hedonic wage function is a single equation reflecting the demand and supply for both job characteristics and worker characteristics. Consider the general hedonic wage relationship:

$$w = w\ (v, q^*, q^{**}),$$

where w is a worker's annual earnings, v is a vita profile of the worker including age, education, union status, etc., q^* is a variable reflecting ambient environmental quality associated with the job site, and q^{**} is a job safety variable relating occupation (industry) to morbidity and mortality risk. The partial derivative of this function with respect to q^* is the implicit price of a change in job-related environmental quality.

Assuming that labor markets are in equilibrium with full mobility between regions and occupations and that workers have full knowledge of job-related environmental quality, the area under the implicit price function can be interpreted as a measure of the benefits from changes in environmental quality. While this condition is quite restrictive, a more general procedure is complicated by the simultaneity of labor demand and supply.

It is also useful to recognize that environmental quality and job-related health risk preferences may not be uniform across occupational groups. Therefore, hedonic wage studies should include all occupational groups if the purpose of the analysis is to obtain a representative benefit estimate.

Finally, it should be noted that, in theory, both hedonic property and wage equations should be estimated simultaneously since choice of employment and residence are interdependent. In addition, health-related effects may not be unique to neighborhood or work-related factors alone. At present a more comprehensive technique to consider these interactions has not been developed.

Advantages of Hedonic Pricing Methods

- The hedonic technique uses market data on property sales prices and labor wages; these data are usually available through several sources and can be related to other secondary data sources to obtain appropriate descriptive variables for the analysis.

- The technique is versatile and can be adapted to consider several possible interactions between market goods and environmental quality.

- The hedonic pricing method provides estimates of individuals' preferences for changes in environmental quality which, under special conditions, can be interpreted as benefit measures.

Disadvantages of Hedonic Pricing Methods

- The assumptions necessary to interpret the results of the hedonic pricing technique as benefit measures are restrictive and, in many real world settings, implausible. Market equilibrium conditions require full knowledge of environmental effects that may be imperceptible to the physical senses. Benefit estimates from a single product class will likely only capture a part of an individual's preferences for environmental quality.

- The estimating equations used for the hedonic technique may be sensitive to specification and estimation decisions. Appropriate tests for unbiasedness in housing and wage studies are still being developed.

- Complete data on property or job characteristics may be difficult and expensive to gather, especially environment related characteristics. The omission of relevant characteristics and/or interactive environmental effects may reduce the validity of benefit estimates.

D. Travel Cost

The travel cost model was developed as a technique to value public recreation sites. Because people visiting recreation sites usually pay nothing or a nominal fee, the primary costs of a visit are the time and expense of travel. These costs include transportation expenses, direct expenses related to the site, and the opportunity cost of time. Environmental quality will influence demand for a site because users generally will prefer sites with higher levels of environmental quality. Changes in visitation rates for sites with different levels of environmental quality, holding travel costs constant, provide an estimate of the benefits of changes in environmental quality.

Consider the following general site visitation expression:

$$v_i = v\,(c_i, c_j, q_i, q_j, y)$$

where v is the number of visits per time period to site i, c is the cost of travel (vehicle, time, etc.) to site i or to some alternative site j, q is the environmental quality at site i or site j, and y represents several socioeconomic variables (income, family size, education, etc.) that may influence the choice of observations of recreation site. Using individual (household) on site visits, a site demand function can be estimated that relates the number of visits to these independent variables. Alternatively, when data on individual visitation rates are unavailable, users can be grouped into travel zones around a site. Variations in visitation rates across zones then can be used to estimate the site demand function.

Assuming that visitors react to increases in entrance fees in the same way as to increases in travel costs, estimated parameters can be used to trace out a demand curve for a site. The area under the site demand curve is a measure of consumers' surplus. In addition, the benefits of changes in environmental quality at a site can be estimated from the site demand equation by simulating the effect of changes in q_i and v_i. The resulting indirect demand equation also provides a measure of benefits in terms of consumers' surplus.

Several aspects of the travel cost method are not clearly defined. Although vehicle related travel costs are a relatively straight forward concept, the value of time to an individual can have several interpretations and can lead to different benefit estimates. Similarly, environmental quality is a multidimensional variable and can be represented in a site demand function in several different ways. Objective measures of environmental quality (e.g. BOD, TSS levels) may not be consistent with recreationists' subjective assessments and may be poor predictors of site choice. Some trips may involve stops at additional destinations as part of travel to the site; their full travel costs are not a proper estimate of the opportunity costs for the site. In addition, the effects of site congestion and the exclusion of nonuse preferences complicate the problem of estimating the site demand function.

Advantages of the Travel Cost Method

- The travel cost method can provide benefit measures for changes in environmental quality from the observed behavior of recreation site users.

- The method can be adapted to many environmental quality issues where changes in quality affect the desirability of a recreation site.

- The method can be implemented using mail, phone or interview surveys or site registration data. In some cases, data are available from state and federal resource management agencies.

Disadvantages of the Travel Cost Method

- The method can provide benefits information only on changes in environmental quality that have a direct effect on the site preferences of recreationists. Quality characteristics that users are indifferent to or unaware of cannot be evaluated.

- Exclusion of alternative recreation sites and their characteristics (environmental quality and other site features) from the travel cost model may bias the benefit estimates. Environmental quality and other site characteristics may be difficult to describe in quantitative terms.

- Specification and estimation procedures can have a significant impact on benefit estimates. A lack of satisfactory estimates for the value of time is particularly troublesome. The method usually does not consider the preferences of individuals who do not use affected recreation sites.

E. Contingent Valuation

The contingent valuation (CV) method uses direct surveys (interview, phone and mail) to elicit individual preferences for changes in environmental quality. In contrast to the previously discussed methods which use behavioral information from actual choices, the CV method reveals individuals' preferences in conditional choice, or contingent, situations that are depicted by the researchers. Since these methods do not depend on market data, they can be applied to a variety of environmental quality issues where no market-based information is available for benefit estimation.

The basic objective of CV is to estimate an individual's willingness to pay for a given change in environmental quality. The CV technique uses a hypothetical market that exists only as it is described in the survey. Participants respond to specified changes in environmental quality by expressing their willingness to pay and/or willingness to accept compensation for these hypothetical changes. The market analogy typically is reinforced by linking payment (compensation) directly to some related market good or to taxes. Benefit estimates can be derived from a direct question, a bidding procedure, acceptance or rejection of a single specified value, or a process in which the individual ranks alternative combinations of environmental quality and money (contingent ranking). The summation of these individual preferences using appropriate aggregation methods provides a measure of the total social benefits.

The conditional setting for the CV method can cause both strategic and structural problems that may bias benefit estimates. Strategic bias can result if participants exaggerate their preferences to influence the valuation process. This problem may be serious when the conditional setting describes major controversies of local interest, but recent studies suggest it is generally not a problem. Structural bias can result from the design of the conditional choice situation. Survey procedures may influence participants' decisions through issue and question framing, payment formats, and / or subject-interviewer interactions. Properly constructed surveys can usually minimize these potential shortcomings, and statistical tests can be used to determine the existence of some biases.

One distinct difference between this method and the market-based methods is that the conditional setting can be used to elicit option and existence values. The validity of these nonuse benefit measures is limited by the same strategic and structural problems discussed above.

Advantages of Contingent Valuation Methods

- The CV method can be used to estimate the benefits of a variety of environmental effects for which market or secondary data are not available.

- Comparisons of benefit measures from CV studies with benefit estimates from other direct and indirect market techniques suggest that respondents can generally provide reasonable and consistent values for changes in environmental quality.

- Nonuse benefits can be measured; benefit estimates are not limited to current and past market data.

Disadvantages of Contingent Valuation Methods

- The contingent valuation method is based on hypothetical situations in which it is difficult to verify whether expressed preferences are consistent with actual or planned behavior. Attempts to minimize the hypothetical nature of the process may only be partly successful.

- Survey participants learn about their preferences for environmental quality during the valuation exercise. Survey design features may have a significant effect on this learning process and lead to responses that may not represent participants' true preferences. Conditional choice settings that are not at least partly familiar to the respondent may lead to uncertain responses.

- Survey research is costly and time-consuming. National benefit estimates require properly designed sampling and enumeration procedures. Respondent refusals to consider environmental tradeoffs discussed in the choice exercise raise questions of validity about benefit estimates.

F. Summary

The Economic Analysis Branch is supporting a continuing series of research projects designed to improve the methods described above and to develop new techniques for benefit measurement. Analysts should be aware that the EARB publications can provide current information about benefits analysis.

In addition, the Department of the Interior has published a series of documents describing methods for assessing the damage to natural resources from discharges of oil or hazardous substances.

That research was undertaken for use in assessing liability for damages under CERCLA or the CWA; but the methods are appropriate for use in measuring the benefits of pollution control. These methods are described in the Federal Register, Vol. 51 No. 148, August 1, 1986.

IV. APPLICATIONS OF METHODS FOR MEASURING BENEFITS

This section discusses some applications of these methods for measuring the benefits of changes in environmental quality. Primary emphasis is given to human health, recreation and ecosystems. A reference list of benefits studies organized by type of environmental effect is provided.

A. Health--Morbidity and Mortality

Changes in environmental quality can have significant effects on human health in the form of temporary or chronic illness and premature death. Estimates of the expected change in human health from an environmental regulation can be combined with estimates of health care expenditures, foregone earnings, psychic dis-utility, and/or the value of a statistical life to measure the economic benefits of the regulation.

Most previous health benefits research has relied on the damage function method. The damage function translates environmental quality changes into estimates of risks to human health using macro- and micro-epidemiological information or clinical and animal experimental results. In some cases, the estimates of human health risks can be monetized by assigning a value to the risk of mortality or morbidity. However, explicit monetization of human health risk is controversial.

In one recent study, the health effects of changes in air quality were estimated by Ostro (1983). A dose-response function was estimated from microepidemiological data relating TSP and $S0_2$ ambient air concentrations to individual days of work lost and days of reduced activity. Mathtech (1983) combined this damage function with an estimate of the average wage rate and average direct medical expenditures for acute respiratory illness to estimate the benefits of reduced morbidity due to a reduction in particulate matter emissions. These measures, however, do not capture the full value of reduced discomfort or other non-work related changes that may be expected from reduced respiratory illness. Therefore, they may result in an underestimate of the benefits. One method that could be used to estimate these additional benefits is a contingent valuation survey. Chestnut and Violette (1985) evaluate the merits of this method for estimating the benefit of reduced morbidity.

The damage function method also has been used to measure the benefits of reduced mortality due to improvements in air quality. Lipfert (1984) and Chappie and Lave (1982), among others, have used macro-epidemiological data to estimate damage functions linking ambient air pollution concentrations to mortality rates. Mortality rates are expressed as some fraction of the population (e.g. 1/100,000). Regulations that reduce air pollutant concentrations lead to small decreases in the mortality rate. When these are aggregated for the whole population they can be expressed as "statistical lives saved."

Cancer risks from exposure to oncogenic substances also can be evaluated using the damage function method. In this application laboratory animal information on exposure levels, duration, latency periods, and incidence are combined in a risk analysis to develop estimates of the expected human cancers (both number and type) for an exposed population. The benefits from regulating an oncogenic substance result from the reduction or prevention of cancers.

There is no general agreement about the appropriate monetary value for the benefits of mortality reduction. It is important to note that the purpose of monetizing mortality effects is not to determine the value of any single individual's life but rather to estimate the value of small reductions in the <u>probability</u>

of death for a given population. One approach to determine the benefit of a statistical life saved uses the cost savings method and is sometimes called the "human capital" approach. Ridker (1967) and Cooper and Rice (1976), for example, use the present value of future earnings over an average person's lifetime to estimate the value of a statistical life. The reduction in foregone earnings due to a reduction in pollution-induced mortality risk can then be used as a lower bound benefit measure.

One criticism of the human capital approach to value mortality risk is that it fails to reflect the correct measure of benefits: individuals' total willingness to pay to reduce health risks. An alternative approach is to examine situations where individuals explicitly consider the tradeoff between income and expected longevity. Thaler and Rosen (1976) use the hedonic wage technique to obtain an implicit monetary value for the risk of death associated with specific high-risk occupations. Similar applications of the hedonic wage technique have been made by Olson (1981) and Viscusi (1983).

In addition to these indirect techniques for estimating the value of a statistical life, some researchers have used the contingent valuation technique to directly elicit individual preferences for changes in mortality risk. A complete review and critique of these efforts and other studies to estimate the value of a statistical life is provided in Violette and Chestnut (1983), and updated in their 1986 report. Schulze and Kneese (1981) provide some perceptive insights to ethical issues that complicate the benefit estimation procedure for human health risks.

B. Agriculture, Fisheries and Silviculture

Changes in environmental quality can affect commercial production activities including the harvesting of renewable resources. Regulations that reduce pollutant concentrations may increase yields and total production. Conversely, yields and total production may decrease when regulations permit an increase in pollutant concentrations. In either case producers will be affected by changes in production costs. Producers and consumers may be affected by output price changes. In the special case where output prices do not change, the relevant measure is the change in producers' surplus due to production cost changes.

The most straightforward method to measure the benefits of a regulation which affects agriculture, fisheries or silviculture is the damage function method. As in the case of health effects, a dose response function that links ambient pollutant concentrations (i.e. ug/m^3 of $S0_2$ mg/l of BOD, etc.) to output (i.e. bushels per acre, catch per unit effort, etc.) can be constructed using field or laboratory data. Adams et al. (1979) demonstrate this process for air pollution effects on agricultural production.

The appropriate price used to value the expected output change depends on market demand and supply. In the special case of output changes that do not affect market prices, the appropriate measure of producers' surplus is simply the expected change in output multiplied by market price per unit. This is typically the case for a product that is affected by pollutants in a small, localized area when the product also is produced in several other areas.

The more general case of pollutants which affect the total supply of a product and hence the market price requires a more complex procedure. Since pollutant reductions usually will increase output of a renewable resource, the market price of a product will decrease, all other things held constant. Therefore, it is necessary to consider supply and demand to estimate the decrease in market price. One method that accounts for these interactive effects is the cost function. An application for ozone effects on U.S. agriculture is provided in Kopp et al. (1983). The cost function technique will yield estimates of both producers' and consumers' surplus.

C. Materials

Pollutants that cause materials to deteriorate more rapidly than normal result in higher repair and maintenance expenses and / or more rapid replacement expenditures. The direct cost savings (either consumer- or producer related) that would result from reduced pollutant concentrations is one measure of the benefits of a regulation. In some cases these costs savings can be estimated directly from repair and maintenance expenses for specific industries (see Waddell (1974) and National Academy of Sciences (1974)), but most often it is necessary to use the damage function method to estimate the extent of materials damage at different levels of pollution. As with other applications of the damage function method, the dose-response function is determined from technical or engineering data for the applicable pollutant and material class. The value of reduced materials damage would be the costs of foregone repairs and maintenance or replacement. In most cases, the market price of repair or replacement units can be used and is analogous to the use of market prices for agricultural and fishery products. This assumes that changes in the level of pollution damages have no impact on total output or market prices.

When this assumption is not appropriate, it is necessary to use the cost function method. This method allows the full range of averting behavior and material substitutions to enter the analysis through the cost function of economic agents in regions with different levels of pollution. An example of this method is the study by Mathtech (1982) in which cost functions were estimated for industry groups using regional pollution levels as an independent variable. The estimated decrease in production costs across the industries due to a reduction in air pollutants was then used as a measure of the expected benefits from reduced damages to industrial materials.

A related application is the use of the cost function method to identify changes in households' cleaning and repair expenditures due to air pollutant soiling. Watson and Jaksch (1983) use household survey data to estimate the change in household cleaning costs which would result from reduced suspended particulate (TSP) levels in urban areas. A similar, but more general, approach is Mathtech's (1982) use of household survey data on expenditures for shelter, cleanliness, furnishings, and transportation to determine the effect of air pollutants. The estimated change in consumer expenditures for these goods, given a change in air pollutants (TSP and $S0_2$), is used as a measure of the benefits of reduced materials damage.

D. Recreation

Recreation-related benefits of environmental regulations have been attributed primarily to water quality improvements and sometimes to visibility improvements. Outdoor recreation such as fishing, swimming and boating typically occur at specific sites on rivers and lakes that are accessible to the general public. To the extent that individuals are affected by changes in water quality at these sites, the benefits of water quality improvements can be measured by individuals' willingness to pay (consumers' surplus). Since recreation sites typically are not priced like other market goods (although sometimes a minimal entrance fee is required), this willingness to pay must be inferred from individuals' travel expenditures for recreation at different sites (the travel cost technique) and / or from individuals' expressed preferences for water quality improvements (contingent valuation).

The travel cost method can be used to measure the benefits of water quality changes by estimating the change in visitation rates and travel expenditures at a recreation site(s) with varying levels of water quality. Several indicators of water quality have been used to link recreationists' behavior and perceptions to technical measures of water quality. But the results to date suggest that individuals respond principally to sensory changes such as odor, clarity, debris, etc. or to changes in fish, shellfish and wildlife populations. The relationship between these perceived effects and technical measures of pollutants may be quite strong in the case of conventional pollutants such as BOD and fecal coliform, but it may be insignificant for many priority pollutants.

The simplest version of the travel cost method is the single recreation site model. For example, Bouwes and Schneider (1979) estimate a travel cost demand function for a freshwater lake. Users' perceptions of water quality in the lake are included as an explanatory variable in the demand equation. The visitation rates and site demand equation are then recomputed for a hypothetical deterioration in water quality at the lake. The area between the existing demand curve and the projected demand curve yields a consumers' surplus measure for the existing level of water quality.

A major shortcoming of the single site travel cost approach is that, in general, it will incorrectly estimate the benefits of water quality changes because substitute sites are excluded from the analysis. A complete model would include the visitation rates at several alternative sites, the travel cost expenditures to each site, the amenities available at each site, and an indicator of water quality at each site. In principle, this model should distinguish between groups of recreationists (swimmers, boaters, anglers, etc.) since changes in water quality may have differential effects on their participation.

One version of a more complete model is Vaughan and Russell's (1982) varying parameter demand model for freshwater fishing. Their model uses the availability of sites (acreage) to support different types of fishing (cold water, warm water, and rough) as an indicator of substitution possibilities and the effect of water quality on site visitation.

An alternative approach is Desvousges et al's. (1983) two-stage technique which estimates demand equations for individual sites and then uses site attributes (including water quality indicators) to explain the variation in demand equation parameters. Measures of dissolved oxygen were the principal water quality indicators.

Other approaches to a more complete model have focused on the issues raised when individuals visit only one or a few sites from among many alternatives. Feenburg and Mills (1980) and Bockstael, Hanemann and Strand (1984) discuss these issues in the context of benefit estimation for water quality improvements and demonstrate alternative methods for estimating travel cost equations.

Contingent valuation methods also have been used to measure the recreation benefits of environmental improvements. This method has been used to estimate both use and nonuse benefits. For example, Brookshire et al. (1976) used a contingent valuation interview survey of both recreationists and residents in a study of air pollutant effects on scenic and aesthetic attributes of a recreational lake. Gramlich (1977) also used a contingent valuation survey for swimming related benefits of water quality improvements in an urban river. Desvousges et al. (1983) used contingent valuation and contingent ranking techniques in a household interview survey of users and nonusers of a river. Both option and existence values were elicited. Desvousges et al. also provide a comparison of benefit measures for water quality improvements using the travel cost, contingent valuation, and contingent ranking techniques. A complete discussion of contingent valuation techniques for recreation-related benefit estimation is available in Cummings et al. (1984).

E. Aesthetics

Changes in environmental quality may also influence individuals' sensory enjoyment of the physical environment. Air pollutants may reduce visibility at scenic vistas, degraded water bodies may produce offensive odors, and various air emissions may cause personal discomfort even without serious health effects. These intangible effects are one of the most difficult types of benefit estimation. Since these effects are not directly related to market goods, researchers have used the hedonic and contingent valuation methods.

The most common application of the hedonic method to estimate aesthetic benefits has been the hedonic property value analysis. In theory the hedonic pricing model suggests that perceived changes in aesthetics will be reflected in property values. With all other factors the same, decreases in aesthetic quality would reduce property values whereas improvements would increase property values. The major difficulty in this logic, however, is that it is not clear how to separate aesthetic factors from other environmental effects.

For example, air pollutants may cause a reduction in visual range or have a noxious odor. Property prices may reflect these aesthetic effects but they may also reflect property owners' perceptions of the health effects from these pollutants, the perceived damages to building surfaces and materials, and the perceived soiling from particulate deposition. Thus it is not clear whether aesthetic benefits can be simply added to health and materials benefit estimates from other methods. If property values actually reflect these combined effects, then simple addition of the benefit components will lead to double counting. Brookshire et al. (1979) provide an example of the hedonic property method to estimate the benefits of reduced air pollutants ($S0_2$ and TSP).

One way to circumvent the problem of separating environmental effects with the hedonic method is to use a contingent valuation analysis in which aesthetic factors can be uniquely described and evaluated. For example, personal interviews can be used to describe potential aesthetic changes and preferences elicited through the contingent valuation method. Brookshire et al. (1979) used this method to evaluate the aesthetic benefits of air quality improvements. Respondents were presented with photographs of urban vistas depicting alternative pollutant concentrations. Individual preferences were elicited using bidding games in which the respondents bid incremental dollar amounts for explicit air quality improvements. The total bids were then separated into aesthetic and health effect components based on individuals' assessments of the relative importance of each.

Contingent ranking also has been used for aesthetic changes in environmental quality. Rae (1983) asked respondents to rank alternative combinations of visual range in a national park and money payments. The individual rankings of these combinations were then used to infer the benefits of air pollution regulation. Lareau and Rae (1985) provide a comparison of contingent ranking and contingent valuation techniques for estimating the aesthetic impact of diesel odors.

F. Ecosystems

Estimating the benefits (or damages averted) of environmental regulations that affect ecosystems is perhaps the most complex problem in benefits analysis. Two major sources of uncertainty exist. The first is the lack of understanding about the direct effects of pollutant concentrations on flora and fauna and the subsequent trophic level interactions. This uncertainty makes it very difficult to model and/or monitor ecosystem responses to pollutants. Dose-response functions cannot be described with precision because the "receptor" is not easily portrayed as a single species or as a collection of interrelated species.

The second source of uncertainty is the actual unit to be measured. Most benefits analyses focus on well defined measurement units such as individuals, units of output, etc. Ecosystems consist of component parts, such as the number of species and the total land (water) area, but the total is not merely the sum of the parts. This fact complicates benefits analysis because most of the available methods can be used only to value components of the total ecosystem.

In some regulatory analyses, benefit estimates for ecosystem components may be acceptable as "lower bound" measures of regulatory impact. For example, an aquatic ecosystem (i.e., wetlands, coastal bays, etc.) may be affected by water quality control regulations. Biological data may be useful in constructing a dose-response function for major wildlife species such as game birds which use the habitat.

Numerical estimates of the change in population for a given species can then be combined with appropriate dollar values for the species, when available. As long as neither the primary productivity of the ecosystem nor the total population of the affected species is jeopardized by the change in water quality, component pricing can be used to measure the changes in service flows from the resource.

As with other applications of the damage function method, the selection of component prices is problematic. For some cases such as a change in commercial fishery stocks, the component prices can be determined using the same methods discussed previously for agriculture and fisheries. Where primarily recreational fish and wildlife stocks are affected, the method discussed for recreation benefits would be applicable. Fish and wildlife that are not harvested or used for recreational purposes are generally considered to have no exchange value to society. This does not mean that these species have no intrinsic value, but that their value is difficult to measure with conventional economic methods.

Changes in environmental quality that alter the basic biological processes of the ecosystem or eliminate the ecosystem cause unique problems for benefit estimation. In principle, the ecosystem's usefulness to society is determined by service flows from the resource. Usually these service flows are not apparent or well understood. Aquatic ecosystems, for example, may provide water purification and retention, flood control, and primary biomass productivity, yet these service flows are not reflected in market prices for property encompassing the ecosystem. Property owners are not likely to benefit directly from these service flows, hence there is little or no reason to capitalize the value of such services into property prices. Therefore benefit (avoided damages) estimates which use market prices of ecosystem property will generally understate the true impact. Some attempts have been made to construct ecosystem prices (e.g. for aquatic ecosystems see Gosselink et al. (1974), Shabman and Batie (1978), and Lynne (1981)), but these estimates have not been widely accepted.

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GUIDELINES FOR PREPARING REGULATORY IMPACT ANALYSIS

APPENDIX B

ANALYSIS OF COSTS

JULY, 1984

GUIDELINES FOR PREPARING REGULATORY IMPACT ANALYSIS

APPENDIX B

ANALYSIS OF COSTS

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APPENDIX B

ANALYSIS OF COSTS

I. INTRODUCTION

This Appendix provides a further discussion of how to estimate the total social costs imposed by regulations. Efforts made to estimate such costs should take into consideration limitations of time and resources, availability of data, and the significance of the regulatory action.

Past cost analyses usually focused only on the compliance cost of private parties directly affected by regulation. Total social cost, however, is a broader concept that includes all the opportunity costs of regulation, such as compliance costs, governmental regulatory costs, "deadweight" welfare losses, and adjustment costs for displaced resources. Though the distribution of these costs, in terms of the segments of the economy, regions of the country, or members of society that incur the costs, is not explicitly included in the measure of total social cost, it may be of importance when evaluating regulatory alternatives. Appendix D discusses how to analyze distributional issues and integrate them with the results of benefit-cost analyses.

In practice, cost analyses conducted by the Agency should not be substantially affected by the requirement to estimate total social costs. The major portion of total social costs usually will be pre-tax compliance costs (investment costs and the present value of variable costs, which include operating, maintenance, and other regulation-related annual costs), except in the case of product bans and restrictions on product use. These costs already are estimated by the Agency using well-established methods that rely on engineering cost estimates. Moreover, many program offices now include monitoring, enforcement, and other governmental regulatory costs in their analyses. The remaining components of total social costs will vary in importance depending on the specific regulation, and efforts to estimate these cost components should vary commensurately.

This Appendix describes the conceptual framework for performing cost analysis, defines relevant cost concepts and discusses how to estimate such costs, and examines the kinds of costs imposed by unconventional regulatory alternatives.

II. CONCEPTUAL FRAMEWORK FOR COST ANALYSIS

This section discusses two conceptual frameworks for estimating total social costs -- a dynamic, general-equilibrium approach and a more practical static, partial-equilibrium approach.

A. A Dynamic, General-Equilibrium Approach

Regulations may impose both direct and indirect social costs. Some of these costs may occur during short time periods, whereas others may occur only over the long run. In theory, firms directly affected by regulations will react to regulatory requirements by choosing methods of compliance that minimize the expected present value of after-tax compliance costs plus noncompliance fees (or fines and liability claims). Other parties may be indirectly affected through induced changes in supply and demand conditions in secondary product or labor markets.

The responses to regulation, such as installation of equipment, changes in product mix, relocation of displaced resources, changes in productive capacity, and technical innovation, will occur gradually over time. For example, in the short run, a regulated facility may be able only to install required pollution control equipment or shut down. But over time, older plant capacity may be replaced by newer and cleaner plants, new processes using less polluting raw materials may be developed, and displaced workers may find new employment. Other things being equal, the social costs imposed by regulations are highest initially, when options for responses are more limited, and decline over time as more flexible responses are possible.

To measure all of these costs would require the use of a dynamic, general-equilibrium framework of analysis. This type of approach would attempt to consider the price and output adjustments that occur over time in each affected market. Although it would be expensive and complicated to apply, this approach provides a useful benchmark for evaluating more practical approaches.

B. A Static, Partial-Equilibrium Approach

A static, partial equilibrium approach is substantially easier to apply than a dynamic, general-equilibrium approach, and is generally satisfactory for regulatory analysis.

Partial-equilibrium analyses consider effects only in the directly regulated market. The supply-demand framework in this market generally will indicate most of the social costs of regulation, as secondary demand shifts or price changes in substitute and complementary good markets usually will be small. Given this premise, the error created because a partial, rather than a general, equilibrium analysis is used should be insignificant.

Static analyses ignore the timing or path of adjustments from one equilibrium to the other. The type and extent of the bias (a consistent under- or overestimate of costs) introduced into the analysis because a static, rather than a dynamic, approach is used depends on the types of adjustments that are expected to occur between equilibrium points. Social costs are likely to be overestimated if only short-term adjustments to regulations are considered. Similarly, social costs would be underestimated if equilibrium points were chosen so as to allow all long-run adjustments to take place.[1]

Regulatory costs should be estimated using one of the following equilibrium points:

- a point in time (year) between the short- and long-term that is expected to provide relatively unbiased results, in the sense that this point strikes a balance between the types of adjustments thought likely to occur in the short and long term; or
- a short-term point, with an explanation of its likely biases.

Alternatively, a dynamic model may be approximated by using static models to analyze several equilibrium points. This approach is appropriate when the short-term response to regulation is thought to be substantially different from, and more costly than, the long-term response.

III. ESTIMATING TOTAL SOCIAL COSTS

This section defines in more detail, and discusses how to estimate, the costs that should be included in total social costs.

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[1] Long-run adjustments, such as developments of and improvements in technologies, and changes in consumer preferences, are difficult to predict. Thus, in practice, "long-run adjustments" usually refers to the application of existing least-cost technologies to new facilities.

A. Definitions

The total social costs of pollution control are the opportunity costs incurred by society because of regulation. They are the value of goods and services lost by society resulting from the use of resources to comply with and implement a regulation, and from reductions in output.

The principal component of total social costs is private real-resource costs. These are pre-tax compliance costs net of any transfers, such as emission fees, licensing fees, or subsidies. (These costs should also include unpriced resources that, nonetheless, have opportunity costs associated with them, such as land diverted from other uses.)

Other components of total social costs include the following:

- governmental regulatory costs -- permitting, monitoring, enforcement, and other related costs expected to be incurred by government after promulgation of a regulation;

- deadweight welfare loss -- the net losses in consumers' and producers' surplus associated with decreases in the output of goods and services resulting from a regulatory action or other program;

- adjustment costs -- the value of resources that are displaced because of regulation-induced reductions in production and the cost of reallocating those resources. Off-setting these costs, in theory, are regulation-induced increases in resource use in both primary and related markets; and

- adverse effects on product quality, productivity, innovation, and market structure.

B. Baseline Costs

Total social costs (and benefits) should be measured relative to baseline costs -- the likely costs without the regulation. The baseline usually should be determined by making one of the following assumptions: (l) the status quo will continue if the regulation is not enacted; (2) present industry trends in pollution control will persist without the regulation in question; or (3) the baseline will differ from the status quo or past trends because of changes in the relative prices of inputs used in production, other regulations, or technological change.[2]

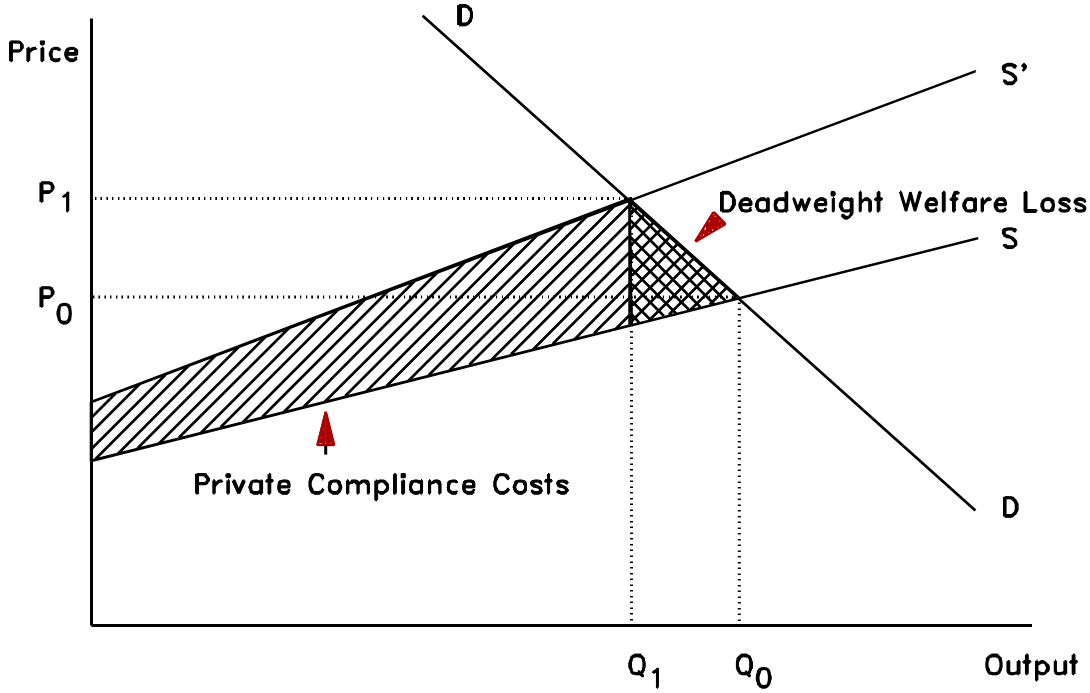
C. Analytical Framework

1. Private Real-Resource Costs

The framework of static, partial-equilibrium analysis is useful for assessing both a regulation's real-resources costs and its effects on an industry or market. Figure l illustrates the application of this approach to a single market. Here, a regulation imposes costs on firms that results in a shift of the industry supply curve from S to S' by the amount required to recover all compliance costs. In the long run this includes a required return on investment at each level of output -- the curve shifts upward by the additional revenue requirement for each level of output.

[2] For additional information, see Baseline Concepts for Regulatory Impact Analysis (Economic Analysis Division, August l982).

FIGURE 1



The pre-regulation supply curve shown in Figure 1 is upwardly sloped, but in practice it may be quite difficult to determine its precise slope. If so, it should be assumed to be horizontal. However, the post-regulation supply curve may be upwardly sloped if the cost of compliance, as derived from engineering estimates, differs among plants in the industry.

The demand curve should be based on estimates of the price elasticity of demand. Information on the elasticity of demand is available for the aggregate output of most industries. When such information is unavailable, as is often the case for intermediate goods, or is of poor quality, the elasticity of demand should be quantitatively or qualitatively assessed. Econometric techniques can be used to estimate a demand curve when sufficient data are available. An alternative technique, especially useful when dealing with intermediate products, is to use engineering cost data to develop both supply and demand curves. Information on the availability of product or service substitutes, the impact of price increases on final goods (where the product or service is an intermediate good), and the necessity of the final product or service can be used to qualitatively assess demand elasticities. The estimate selected for the point elasticity should be consistent with the equilibrium point (the time allowed for adjustments to occur) used in the analysis.

Once the shift in supply has been projected and the demand curve estimated, the new regulation-induced price and output levels can be determined. Figure l indicates that the new price and output levels are at P_1 and Q_1, respectively. The shaded area represents the compliance costs to private firms. Private real-resource costs are calculated by netting out transfer payments, which include some types of taxes and certain insurance payments (for already-existing liabilities). Generally these transfer costs will be negligible, except for those arising from unconventional regulatory approaches.

The private real-resource costs, when discounted over time, correspond to the sum of investment costs and discounted annual costs (operating and maintenance and other annual regulatory costs) that will be incurred by firms to comply with the regulation. Thus, the real-resource costs of regulation can be approximated, in most instances by methodologies already used by program offices to evaluate compliance costs. Furthermore, the supply and demand curves that implicitly lie behind such calculations need not be formally estimated unless the effects of the regulation on price and output are expected to be significant.

Although Figure l assumes competitive market conditions, it can be adapted to analyze varying market conditions that may more closely reflect real-world conditions. Sometimes it may be necessary to indicate that benefits or costs have been overestimated or underestimated because of biases caused by market distortions. However, the principles underlying the conceptual framework can still be used to evaluate the real-resource costs of the regulation in question.

2. Governmental Regulatory Costs

The costs expected to be incurred by the government to implement and enforce regulations often are not included in regulatory analyses. However, any analysis that attempts to measure all costs of a given regulatory action should include them.

Government regulatory costs include: litigation; enforcement; permitting; monitoring / reporting (if they are not included in compliance costs); and any other costs expected to be incurred by federal, state, or local agencies because of EPA's regulatory actions. Enforcement and monitoring costs usually will constitute the major portion of government regulatory costs. Only costs incurred after the specified regulation is promulgated are relevant to benefit-cost or cost-effectiveness analysis, as all costs incurred before that point are sunk costs.

3. Deadweight Welfare Loss

Deadweight welfare loss is a dollar measure of the difference between the value consumers place on output that is lost because of regulation and the pre-regulation cost of producing such output. Thus, it is a measure of society's welfare loss resulting from reductions in output.

Graphically, the deadweight welfare loss corresponds to the solid triangle in Figure 1. It generally is a small part of the total social costs of regulation. Therefore, minimal effort should be expended measuring it.[3]

Conceptually, the steps for calculating deadweight welfare loss are as follows:

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[3] Programs, such as TSCA and FIFRA, that give EPA the power to ban substances and prohibit or limit specific uses may be exceptions to this general rule. In these cases, more resources should be allocated to calculating deadweight welfare losses.

- estimate the supply curve;

- estimate the demand curve in its relevant range;

- estimate the post-regulation supply curve shift;

- calculate the changes in price and output; and

- calculate the deadweight welfare loss.

The first four steps underlie the estimation of private real- resource costs. Deadweight welfare loss may be approximated, in most instances, using the simple formula:

deadweight welfare loss = ("change in P" x "change in Q")/2.

4. Adjustment Costs for Displaced Resources

Regulations often cause short-term and sometimes long-term displacement of resources in markets directly affected by regulation, as evidenced by job losses and plant closures.[4] In the partial-equilibrium approach, the value of these displaced resources and the costs of reallocating them are adjustment costs. From a more general-equilibrium perspective, some or all of these costs could be offset by increases in the use of resources in markets that are directly or indirectly affected by regulations.

For example, employment may be stimulated because of an increased demand for alternative products or for pollution control equipment, or because of maintenance and operating requirements for installed equipment. Offsetting effects should be assessed, where possible, so as not to overestimate the social costs of regulatory actions. Thus, adjustment costs should include the following elements:

- the value of wages temporarily or permanently foregone because of reductions in production levels in directly affected markets less, where it is possible to assess, related gains in wages in both directly or indirectly affected markets;[5] and

- the cost of reemploying displaced workers (including the administrative cost for transfer payment programs, but excluding the payment itself).

Regulations also may substantially affect secondary or linked markets. Where a local economy depends on just a few plants (or industries), and government regulations significantly affect those plants, severe "ripple" effects may appear throughout that economy. The direct economic impacts, along with the potential local multiplier effects of regulations will be assessed where appropriate in the regulatory impact analysis as discussed in Appendix D.

5. Additional Market Costs

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[4] These impacts should be fully evaluated using the analytical framework discussed in Appendix D.

[5] Lost wages, rather than lost production, is suggested as a proxy for the value of displaced resources because it is likely that inputs other than labor may be reallocated to other sectors of the economy fairly quickly and at little cost.

Costs may also arise from effects on product quality, productivity, innovation, and market structure that cannot be considered within the framework of a static, partial-equilibrium analysis. They may be quite significant in certain instances, such as when regulatory requirements delay industrial projects or affect new product development. These costs are difficult to measure and often can only be qualitatively assessed. However, an effort should be made to quantify them where data permit, especially if they are thought to be a significant cost of regulation.

D. Discounting Regulatory Costs

OMB guidance has indicated that all costs and benefits should be stated in terms of net present value. This guidance can be followed easily within this analytical framework. The relevant cost components will be identified and (where possible) monetized. Relevant time frames for each component must then be set. Finally, all of the costs will be discounted at (presumably) a predetermined social rate. (Further discussion on this issue is found in Appendix C.)

IV. COSTING UNCONVENTIONAL REGULATORY ALTERNATIVES

This Section discusses methods of estimating the costs of regulatory approaches that are alternatives to the direct controls (design and performance standards and production bans) usually imposed by EPA.[6]

A. Trading of Pollution Entitlement

1. Bubbles and Offsets

Bubbles and offsets allow emissions to be traded among sources. Bubbles allow trades to take place within a plant, whereas offsets allow trades to take place between plants. The resulting level of emission control must be equivalent to or better than that required by existing regulations. If "banking" is allowed, pollution credits can be traded across time -- with potential offsets created in one period to be used in later periods.

Bubbles and offsets create incentives to reduce emissions where the costs of control are relatively low and to increase emissions where the costs of control are high. Therefore, no additional compliance costs are associated with using bubbles and offsets. On the contrary, bubbles and offsets will result in a reduction in compliance costs, compared with existing regulations (equal to the savings in capital and operating costs at sources where emission controls are relaxed, less the costs of additional controls at low-cost sources).

Initial administrative costs associated with establishing a market for offsets may be significant, and some additional enforcement costs for monitoring emission levels also may be incurred. The cost of the offsets traded in a formal market are transfers between the creator and the user of the offset and are not social costs. However, the costs incurred to arrange the trade, both private and public, are part of total social costs.

2. Marketable Permits

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[6] For further information see, Checklist of Regulatory Alternatives (Office of Planning and Management, July 1980).

Marketable permits are also mechanisms for trading entitlement to pollute. Permits are denominated in the amount of emissions allowed, and the number and denomination of permits issued determines the aggregate amount of emissions. While emission charges set the price for pollution entitlement and allow the quantity of pollution to vary, marketable permits establish the aggregate quantity of pollution allowed and allow the price of those entitlement to vary.

The costs of pollution control under a marketable permits system are estimated by calculating demand functions for permits. Polluters will be willing to pay prices for permits up to the unit cost of reducing emissions. Different polluters incur different costs to control emissions and, hence, will be willing to pay different amounts for permits. The price of permits, in theory, will be established by the unit cost of control of the marginal polluter.

Once the equilibrium price for permits is calculated, the sources that will install pollution control measures and will pay for permits can be identified. The real-resource cost of the regulation is the sum of investment costs and the present value of operating and maintenance costs incurred to reduce emissions. The amount firms pay for entitlement to pollute are private costs of the regulation, but are not social costs.

Marketable permits may be sold at auction initially, in which case the prices bid for the newly issued permits again represent private (though not social) costs. Alternatively, permits may be allocated to sources by some rule, in which case no private costs are imposed at the outset (later trades of permits will result in private costs).

Like offsets and bubbles, marketable permit systems require enforcement efforts to ensure that emissions do not exceed the levels for which permits are held. In addition, creation of a market for permits results in administrative costs.

B. Pollution Charges

1. Charges on Emissions

Charges on emissions or effluents are designed to induce firms to reduce pollution. The charges establish a price for releasing pollutants into the environment. By leaving decisions in the hands of those most knowledgeable about the potential for pollution control, effluent or emission fees are thought to induce more extensive control at the points where the private costs of control are lowest. Cost-minimizing polluters, in theory, will reduce emissions up to the point where the marginal cost of control equals the fee. Therefore, the costs of alternative compliance methods for each source of emissions must be estimated to predict how the market will respond to the fee.

Private real-resource costs, the principal component of total social costs, may be estimated as the sum of investment costs and the present value of all annual costs incurred as a response to the charge system. Where charge approaches require polluters to pay fees on the uncontrolled level of emissions, the fees are private costs of doing business. However, because such fees accrue to the government, they are income transfers and should not be included in total social costs.

The other cost components may be estimated as just discussed in Section II. Government regulatory costs may be fairly high for charge systems. Administrative costs could be substantial because of the need to monitor emissions and collect fees. In addition, to avoid frequent adjustments in charge rates, the government might have to gather extensive information on control costs to set charges that will achieve the desired level of control.

2. User Charges

Charges may be imposed directly on users of publicly operated environmental control systems. Such charges have been imposed on industrial discharges into municipal water-treatment facilities and on nonhazardous solid wastes disposed of in public systems. User charges are usually set to recover the costs of operating the public system, rather than to create incentives for reducing pollution. Measuring the total social cost imposed by user charges is similar in concept to measuring the costs of emission charges.

3. Product Charges

Charges may be imposed on products (as raw materials or otherwise) whose use or disposal pollutes the environment. The costs imposed by product charges depend on the extent to which users switch to substitutes, reduce the rate at which the product is used by recycling or other process charges, or continue to use the regulated products. Predicting responses and estimating compliance costs requires analysis of the costs and effectiveness of substitute products and the costs of recycling and reuse. Any charges paid on continuing use represent private, but not social, costs.

C. Recycling, Reuse, and Disposal Incentives

1. Subsidies for Pollution Reduction

Subsidies paid to polluters based on their reductions in pollution have the same general effect on behavior as charges on pollution. Sources will reduce pollution up to the point where the costs of control equal the subsidy.

Measuring the social costs resulting from a system of pollution subsidies is similar in concept to measuring the social costs resulting from pollution charges, except that private costs are reduced by the amount of the subsidy, rather than being increased by the amount of the fee. Again, the subsidies themselves are income transfers and are not a net-resource cost, i.e., private real-resource costs should be computed excluding the subsidies.

Using subsidies instead of charges shifts private costs to the government. This may result in more sources continuing to operate than if a charge system were used. Thus, subsidies and charges may not have the same aggregate social costs or the same degree of pollution control.

2. Refundable Deposits

Refundable deposits create economic incentives to return a product for reuse or for proper disposal. Products will be returned if the deposit exceeds the cost of returning the product to the prescribed location. Therefore, the cost of returning products must be measured to predict the rates of return.

Compliance costs consist of the resources (labor, equipment, transportation) required to return the regulated product, plus the cost of preparing products for reuse (if required), less the cost of new products replaced in use by recycled products. The private administrative costs of a deposit system vary, depending on where in the production-consumption cycle and from whom deposits are collected. Also, they may include substantial record-keeping requirements. Enforcement costs should be minimal because economic incentives are created to induce compliance. The deposits themselves represent transfers from one point in the production-consumption cycle to another, and hence are not social costs. The transfers are temporary or permanent, depending on whether deposits are ultimately reclaimed.

With government "buy-back" systems, the government either directly pays a fee for returned products or subsidizes firms that purchase recycled materials. They are equivalent to product deposits, except that the government, rather than the purchaser, provides the deposit. The government subsidy represents a transfer from the government to the private sector, which offsets the private costs of recycling products.

D. Pollution Indemnity

Instead of mandating or inducing changes in private polluters' behavior directly, regulations may impose stricter liability on polluters to reimburse persons suffering damages from pollution, may reduce the costs incurred by injured parties to obtain such compensation, or may require that polluters guarantee their ability to reimburse damages from pollution such regulations do not themselves directly impose costs, but instead shift more of the risk of exposure to polluters. This may induce polluters to alter their behavior and to expend real resources to reduce their probability of being required to reimburse other parties for pollution damages.

Other regulations may require firms to demonstrate financial ability to compensate damaged parties by posting performance bonds that are forfeited in the event of damages, by obtaining liability insurance, or by contributing to a pool of funds to compensate victims. The administrative and enforcement costs imposed by such requirements represent the use of economic resources. The funds set aside to pay damages do not represent a use of resources but instead are transfers among private parties (between polluters and insurers and, ultimately, to the victims of pollution). Again, however, these requirements are likely to alter private behavior and lead to increased outlays of real resources to reduce the probability of accidents.

E. Information and Labeling Rules

Information or labeling rules may be applied to specific substances or to certain contaminated locations. For example, warning labels may be required for hazardous substances that describe safe-handling procedures or describe the risks posed by the product. Purchasers may then switch to less damaging substitutes for some or all uses, or handlers of hazardous substances may be better able to prevent damages. Posting contaminated locations gives potentially exposed parties the opportunity to avoid hazards -- for example, contaminated dump sites or drinking water aquifers.

Calculating the costs of complying with information and labelling requirements for particular cases is straightforward. Compliance costs include the cost of developing the required information (analyzing the composition of substances, monitoring and testing of sites, testing for health damages, etc.) and the cost of disseminating information (printing and applying labels, and maintaining and publishing information on sites).

Similarly, the direct costs of enforcing and administering the requirements (including government review and approval of labels) can be calculated directly. Calculating aggregate costs may be more difficult, however, if the number of containers requiring labels or the number of facilities affected is unknown. In addition, it is difficult to predict responses by the recipients of the information and, hence, the degree of environmental protection afforded by information and labeling regulations.

F. Government Cost-Sharing

In addition to issuing the regulations described above, the government may take actions to lower the private costs of specific actions -- most notably, by subsidizing investments in pollution control equipment. Subsidies may take the form of reduced interest rates, accelerated depreciation, direct capital grants, and loan assistance or guarantees for pollution control investments. Such policies will not by themselves induce changes in private behavior. However, in conjunction with direct controls, pollution fees, or other regulatory mechanisms, they may influence the nature of private responses and the distribution of the cost burden. In particular, such subsidies will encourage investment in pollution control equipment, rather than other responses that do not require capital investments (changes in operating practices or recycling and reuse).

Subsidies reduce the private costs associated with the resulting private investments. However, social costs will arise if cost-sharing programs lead to resource misallocations. They also will result from administration of the subsidy program. These costs are likely to be minor if incentives are provided through the existing tax system, but may be significant if new administrative structures are required.

GUIDELINES FOR PREPARING REGULATORY IMPACT ANALYSIS

APPENDIX C

ANALYSIS OF THE CHOICE OF DISCOUNT RATES

JULY, 1984

GUIDELINES FOR PREPARING REGULATORY IMPACT ANALYSIS

APPENDIX C

ANALYSIS OF THE CHOICE OF DISCOUNT RATES

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APPENDIX C

ANALYSIS OF THE CHOICE OF DISCOUNT RATES

I. INTRODUCTION

The costs and benefits that result from environmental regulations usually are paid and received at different times. Capital investments required by regulations tend to be concentrated at the outset, whereas other costs and benefits occur at later dates. Similarly, private investment projects often are characterized by large initial capital outlays followed by a stream of operating costs and revenues extending over a considerable length of time.

In both situations, some method must be used to permit comparisons between costs and benefits (revenues) that have different time profiles. The analytical technique used for this purpose, discounting, transforms future costs and benefits into their "present values," that is, into what they are worth today. Direct comparisons between costs and benefits then can be made to determine whether a particular regulation appears to be justified.

OMB requires federal agencies to use an annual real discount rate of 10 percent to calculate the present values of costs and benefits of proposed regulations.[1] However, if there is an adequate rationale, OMB's guidance allows other discount rates to be used.

The problem of selecting a discount rate for use in benefit- cost analyses of federal regulatory programs is complex and continues to be a subject of controversy among economists. Yet, benefit-cost analysis is not a precise tool that yields firm numerical results; rather, it is a general framework for more carefully accounting for the potential and varied effects of government programs. Some of these effects can be quantified, whereas others can only be assessed qualitatively. Some may be relatively certain, whereas others may be quite speculative.

The imprecision connected with assessing benefits and costs suggests that the controversy surrounding the discount rate, in many circumstances, may have more theoretical than practical significance, since decisions about the assumptions to make for measuring and valuing uncertain regulatory effects may overwhelm the effects of changes in the discount rate. Additionally, for some government projects, benefits and costs may have similar time profiles, or benefits may so outweigh costs (or vice versa), that changes in the discount rate will not influence the policy implications of the analysis.

Nonetheless, the discount rate can significantly affect the assessment of some environmental regulations, especially those which feature short term costs and long term benefits. The following general guidelines should be used in selecting discounting techniques for evaluating environmental regulations.

- Discounting by the marginal rate of return on investment -- approximated by OMB's suggested 10 percent discount rate -- is most appropriate for environmental regulations that have fairly short time horizons.

- Several discount rates should be used when there is uncertainty about what discount rate is appropriate. If the results of the analysis are insensitive to changes in the discount

[1] When a "real", rather than a "nominal", rate of discount is used, all costs and benefits must also be in real terms, i.e., expressed in the same base year's dollars.

rate, there is no need to determine which one is most appropriate. If the analytical results change substantially, the economic effects of the regulation should be examined more closely to determine whether it is justifiable to use a discount rate lower than OMB's suggested 10 percent rate.

- A variety of approaches may be used to evaluate environmental problems spanning several generations. These include discounting at the opportunity cost of capital; discounting at lower rates, such as the social rate of time preference; or comparing benefits and costs to different generations outside the discounting framework. (The difficulties introduced by the issue of intergenerational equity are discussed more fully in appendix D.)

- Under most circumstances, discounting costs by one rate and benefits by another should be avoided.

- The benefits and costs of environmental regulations should be evaluated either by computing their net present value or by annualizing costs and comparing them to undiscounted, annual benefits. In either case, unquantified benefits and costs should also be described.

The rest of this Appendix provides a summary of issues involved in discounting. It discusses general concepts underlying discounting, reviews several alternative procedures for discounting, and discusses the relationship between discounting and risk.

II. THE DISCOUNTING CONCEPT

A. Calculating Net Present Values

In many government programs, costs are incurred and benefits are realized at different points in time. To evaluate such programs it is helpful to put their costs and benefits on a common basis. The analytical technique for doing so is discounting. It is based on the economic concept that there is a cost involved in having to wait to receive money or benefits. That is, a dollar received in the future is worth less than if received now. Similarly, a dollar paid in the future is worth less than if paid now. Discounting converts future dollars into their present value (what they are worth today) through the use of a discount rate that reflects the relative value of having a dollar now rather than later.

In formal terms, the net present value of a projected stream of future benefits and costs is found by multiplying the benefits and costs in each year by a time-dependent weight, d_t, and adding all of the weighted values according to the formula below:

$$PV = d_o V_o + d_1 V_1 + d_2 V_2 + \ldots + d_N V_N.$$

V_t is the net difference between benefits and costs (B_t - C_t) that accrues in year t and the weights are given by

$$d_t = 1 / (1+r)^t,$$

where r is the discount rate.

The usual decision rule for evaluating both public and private projects (including government regulations) is that an action is justified if its net present value is positive, i.e., the present value of the stream of benefits exceeds that of the costs. If there are several mutually exclusive projects, the one with the highest net present value is justified under the criterion of economic efficiency.

B. Annualizing Costs

An alternative to calculating the present values of both costs and benefits is to annualize costs. If the stream of benefits is constant over the lifetime of a project, comparing annualized costs to annual benefits is analytically equivalent to comparing the present values of costs and benefits.

Costs may be annualized by using a two step procedure. The present value of costs is calculated using the above formula. This present value is then annualized (as in calculating mortgage payments) according to the following formula:

$$AC = PVC*r*(l+r)^n / ((l+r)^n - 1);$$

where,
- AC = annualized cost;
- PVC = present value of costs;
- r = the discount rate; and
- n = the length of the project.

This approach is particularly useful when analyzing non- monetized benefits, such as reductions in emissions or reductions in health risks. The cost-effectiveness of a regulation can be calculated by dividing the annualized cost by the annual benefit. The resulting number can be evaluated in light of the implicit costs of other government programs, the results of recent studies examining tradeoffs between risk and wages, and the lag between when costs are incurred and benefits are likely to be realized.

C. Sensitivity of Present Value Calculations

Although the present values of costs or benefits that occur during the first few years after a project is initiated are not very sensitive to changes in the discount rate, the present values of costs and benefits that occur in later years will vary considerably. High discount rates greatly reduce the present values of future costs and benefits relative to those calculated using low rates.

For example, the present value of a steady stream of returns of $100 a year for twenty years is about $850 if a discount rate of 10 percent is used, whereas it is about $1,490 (almost twice as large) if a discount rate of 3 percent is used. The present values of returns that are not realized until long after a project is initiated are even more sensitive to the discount rate. For example, the present value of $100 received thirty years from now is only about $6 if a discount rate of 10 percent is used, whereas it is about $41 (about seven times larger) if a discount rate of 3 percent is used.

For many government projects or regulations that require large initial outlays or that have long gestation periods before benefits are realized, the selection of the discount rate can be a major factor in determining whether the net present value is positive. Many of EPA's regulations are of this form. Large investments by public or private parties are usually required early on, whereas the benefits of those investments either accrue for many years thereafter (e.g., improvements in health and environmental quality) or will not begin for many years (e.g., reductions in the contamination of environmental systems from hazardous waste, landfill facilities, and the protection of the earth's atmosphere and climate).

D. Discounting in an Idealized Economy

Some of the problems besetting the discounting issue in our actual economy can be illustrated by discussing the procedures that should be adopted for discounting in an idealized market economy in which there is complete certainty.

In both an idealized economy and in ours, individuals -- acting for themselves or collectively -- exchange present consumption for future consumption through decisions to save and borrow. A decision to save means postponing a portion of current consumption in order to increase or to stabilize consumption opportunities in the future. A decision to borrow means the opposite. It means reducing consumption in the future in order to increase it today. For the saver, interest received is the amount by which future consumption opportunities are increased; for the borrower, interest paid is the amount by which those opportunities are reduced.

Market rates of interest reflect saving and borrowing decisions; rates rise and fall depending on the supply (savings) and demand (borrowing) for funds. Market rates of interest, therefore, are measures of individuals' willingness to exchange present consumption for future consumption.

In an idealized economy, the market rate of interest on securities would be equal to both:

- the marginal rate of return on investment in the private sector (this is the rate of return earned on incremental investment in the private sector); and

- the consumption rate of interest -- this is the rate at which individual consumers are willing to exchange consumption today for consumption in the future.

The first equality would occur because firms would find it optimal to invest up to the point where the marginal benefits of additional investment were just equal to their marginal costs, i.e., the point at which the marginal rate of return on investment equals the market rate of interest. The second would occur because consumers would adjust their consumption over time to best meet their needs by borrowing or lending at the market rate of interest; consumers would make these adjustments until they were indifferent between exchanging consumption now for consumption in the future at the market rate of interest. It also can be assumed that the consumption rate of interest would be a good proxy for the social rate of time preference -- this is the rate at which society (individuals acting collectively through government) is willing to exchange consumption today for consumption in the future. Since the marginal rate of return on private investment, the consumption rate of interest, and the social rate of time preference would all be equal to the market rate of interest in the idealized economy, it is clear that it would be appropriate to use the market rate of interest as the discount rate when evaluating investments in public projects or government regulations. But in our economy the consumption rate of interest and the marginal rate of return on private investment diverge, primarily because of corporate and personal income taxes.[2] This divergence of rates in our economy poses problems for selecting discount rates and has led to essentially two different schools of thought on the matter.

- The first views the discount rate as a measure of the opportunity cost of a government action, i.e., the rate of return on the investment and consumption in the private sector that is foregone by virtue of using private sector resources for public purposes.

- The second regards the discount rate as a planning parameter that reflects society's willingness to exchange consumption of private goods today for the future benefits of public investments or regulation. (This view can include the claim that in certain situations the appropriate discount rate is zero.) The remaining sections discuss the arguments in support of and the implications of using alternative discounting approaches.

III. ALTERNATIVE APPROACHES TO SELECTING THE DISCOUNT RATE

Economists have developed a number of different procedures for selecting an appropriate discount rate for public projects. They include:

- opportunity cost of displaced resources:
  - marginal rate of return on private investment,
  - consumption rate of interest, or
  - weighted average of the marginal rate of return on private investment and the consumption rate of interest;
- social rate of time preference; and
- shadow price of capital plus a discount rate equal to the social rate of time preference.

A. Opportunity Cost of Displaced Resources

This general approach to selecting a discount rate is based on the principle that a public investment or government regulation should yield outputs or benefits with value no less than that of the resources it displaces from the private sector. Accordingly, the discount rate used to evaluate public projects or government regulations should correspond to the rate of return yielded by the private

[2] The corporate income tax and the personal income tax create a large divergence between the pre-tax rate of return that would be earned on a marginal investment in the economy and the after-tax rate of return that individuals would receive at the margin on invested funds. It is this after-tax marginal rate on which individuals base their marginal saving decisions. At the margin it would equal the rate at which they are willing to postpone present for future consumption. For example, a corporate income tax rate of 46 percent requires that a company make a 10 percent return on a marginal investment in order to be able to pay the stockholders a 5.4 percent return. This creates a difference between the pre-tax marginal rate of return on investment in the private sector and the after-tax rate of return that individuals can earn on their marginal savings (which equals their consumption rate of interest). This difference becomes even larger when there is inflation.

resources that are displaced, i.e., their opportunity cost. Thus, in this approach the manner in which public investment or government regulation is thought to affect the allocation of resources throughout the economy largely determines the value used for the discount rate.

l. The Marginal Rate of Return on Private Investment

Many economists have reasoned that when resources for a public investment are withdrawn entirely from funds that are available for private investment the pre-tax marginal rate of return on private investment should be used as the discount rate in evaluating proposed public projects.[3] Most of EPA's regulatory actions are of this form, as they require firms to use private capital to finance pollution controls. However, there are different views regarding where private investment eventually is displaced.

In one view, the availability of capital throughout the entire economy is restricted by the use of capital for pollution controls. For example, if firms must purchase equipment to comply with a pollution control regulation, such purchases will increase the overall demand for capital in the economy. That, in turn, either creates scarcity of capital or raises interest rates sufficiently to reduce other demands for capital to the point where supply and demand for capital are equal overall. In either case, investment plans throughout the economy must be cut back -- the "crowding out" effect of public investments. Since the capital displacement effects are dispersed throughout the economy, it follows that the pre-tax marginal rate of return on all private investment, both corporate and non-corporate, is the appropriate measure of the opportunity cost of the public investment.

Unfortunately, it is quite difficult, in practice, to measure the marginal rate of return on private investment. An approach for developing a proxy for this rate of return is to use aggregate accounting data to compute the ratio of before-tax earnings to the value of private capital. When adjusted for inflation, this provides an estimate of the average real rate of return on private investment.[4] Such estimates made for the period before the 1970's (after which inflation increased substantially) generally range between 10 and 15 percent. Estimates made for the early and mid-seventies average around 10 percent.[5] These estimates are in general agreement with OMB's recommended 10 percent discount rate.

Another view, which presumes that there are significant imperfections in the capital market, is that the pre-tax marginal rate of return of the industry directly affected by government regulation should be used as the measure of opportunity cost. For example, a requirement to purchase pollution control equipment may reduce a firm's budget for investing in other fixed assets. The marginal rate of return to the firm's investment then becomes the opportunity cost of committing resources to pollution control activities. Since different corporations face different borrowing and lending rates, and different industries have different growth potentials, actual marginal rates of return on investment may vary substantially from one industry to another. According to this view, when evaluating the benefits and costs of an environmental regulation that affects a specific industry, the industry's pre-tax marginal rate of return

[3] More precisely, it is the pattern of actual resource diversion of private investment and consumption that determines the opportunity cost of the public investment. However, it is generally assumed that the source of funding for a public project determines whether primarily private investment or private consumption is displaced.

[4] The extent to which the average rate of return may exceed the marginal rate of return in a competitive economy with relatively minor limits on capital flows is unclear.

[5] See Stockfish (l969) and (l982), Gorman (l972), Nordhaus (l974), and Holland and Meyers (l979).

on investment, in most instances, will provide a good estimate of the opportunity cost of capital and should be used as the discount rate.[6]

2. Consumption Rate of Interest

Many economists have argued that if resources withdrawn from the private sector for public investment displace only private consumption, the consumption rate of interest (the rate at which individual consumers are willing to exchange consumption today for consumption in the future) should be used as the discount rate. The line of reasoning is that when private consumption is displaced by public investment, the preferences of consumers for present versus future consumption should be reflected in the decision making framework.

Estimates of the consumption rate of interest are based on rates of return on savings.[7] These range from 2.5 percent, the average nominal rate of return on essentially riskless Treasury bills over the period 1926 to 1978, to 8.9 percent, the average nominal rate of return on the relatively risky market portfolio of common stocks over the same period.[8] If it is conservatively assumed that the average taxpayer pays a marginal income tax rate of 20 percent, the after-tax nominal rate of return is 2.0 percent on Treasury bills and 7.l percent on the market portfolio. When adjusted for inflation (which averaged 2.5 percent during this period) real, after-tax rates of return on these assets are -0.5 and 4.6 percent, respectively.[9] Therefore, a range in rates of return from zero to 5.0 percent is likely to bracket the real, after-tax rate of return that individual consumers receive on their savings.[10]

It may seem curious that the marginal rate of return on investment is calculated before taxes, whereas the consumption rate of interest is calculated after taxes. Yet, this procedure is entirely

[6] The flow of capital resources in a free market, in theory, tends to make all sectors' effective returns equal at the margin. One sector may appear to yield a higher return then another in the long run. Yet, this probably results because it is riskier or because of some other disadvantage in that sector. In such cases, the higher apparent return is needed to compensate investors for holding less attractive assets, so on balance a dollar of investment should not be expected to be more beneficial in one sector than in another.

[7] Estimates of the consumption rate of interest (an individual's marginal rate of time preference) could be based on either after-tax lending or borrowing rates. Because individuals may be in different marginal tax brackets, have different levels of assets, and have different opportunities to borrow and invest, the type of interest rate that best reflects marginal time preference will differ among individuals. Additionally, individuals routinely are observed to have several different types of savings, each possibly yielding different returns, while simultaneously borrowing at different rates of interest. Thus, discerning an average marginal rate of time preference from observed interest rates is very difficult. However, the fact that, on net, individuals generally accumulate assets over their working lives suggests that the after-tax returns on savings instruments generally available to the public will provide a reasonable estimate of the consumption rate of interest.

[8] See Ibbotson and Sinquefield (l979).

[9] See Lind (l982) p.73.

[10] Zero or even negative rates of return are consistent with rational consumer behavior. Some individuals are willing to forego some real income for the certainty of assuring consumption at a future time, such as after retirement.

appropriate. The opportunity cost of displaced private investment is its social rate of return, which is its pre-tax, not after-tax, return. Conversely, when people decide to consume now, rather than a year from now, they are giving up additional future consumption equal to the interest they receive after taxes on the foregone saving. Hence, the consumption rate of interest should be measured on an after-tax basis.

3. The Weighted Average of Opportunity Costs

Some environmental regulations may require a diversion of resources resulting in the displacement of both private consumption and investment. In these cases, some economists have advocated using a discount rate that is a weighted average of the consumption rate of interest and the marginal rate of return on investment, with the weights proportioned to the (?) and from private investment, respectively. This is thought to better reflect the opportunity cost of the private resources diverted by government actions than would the use of either the marginal rate of return on private investment or the consumption rate of interest.

The weighted average approach may also be used for regulatory activities that are financed entirely out of federal tax revenues, because the incidence of federal taxes falls on consumers and business, thereby displacing both consumption and investment spending. Estimating the discount rate requires that the relevant contribution to federal tax revenues be traced to its source in the household and business sectors. The observed opportunity rates of return (the consumption rate of interest and the marginal rate of return on investment) must then be weighted by the relative amounts of spending that are displaced from each subsector.[11]

B. Social Rate of Time Preference Approach

Some economists view the discount rate as a planning parameter that should reflect society's willingness to trade private consumption today for either private consumption or benefits from public projects in the future.[12] This is based on the notion that most individuals would prefer to place more weight on consumption by future generations than is indicated by the marginal rate of return to private investment. Since this preference can not be dictated in the market place, mostly because the structure of taxes, it must be expressed through the political process.[13]

In the absence of direct empirical evidence, economists have offered a number of alternative propositions as to how the social rate of time preference ought to be determined. One view holds that because individuals are insensitive to interest rates, the social rate of time preference should be computed by the government. A second view holds that individuals do respond to interest rates and their social rate of time preference is likely to be closely related to the consumption rate of interest. A third view

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[11] Some economists have disagreed with both the weighted average approach and the consumption rate of interest approach arguing that the marginal rate of return on private investment should be used as the discount rate regardless of the source in the private sector from which resources are withdrawn for public investment. The argument is that, in order to maximize the returns to its citizens, the government should invest only in those activities that yield rates of return similar to those yielded in the private sector. However, this argument does not appear to be valid, since private consumption (of goods and services or the benefits of government programs) is not maximized under such a criterion.

[12] See Marglin (l963).

[13] This approach makes no effort to evaluate the opportunity cost of resources displaced by government action.

holds that the social rate of time preference can be determined from an analysis of optimal growth rates of the economy.[14] This divergence in views has more theoretical than empirical significance, since in each view the social rate of time preference is presumed to be substantially lower than the opportunity cost of capital. Thus, the social rate of time preference may be approximated by the consumption rate of interest.

C. Shadow Price of Capital Plus a Discount Rate Equal to the Social Rate of Time Preference

This is a relatively new approach with which few readers may be familiar.[15] Yet, there is a growing body of economists that hold that it is the most theoretically defensible technique for evaluating public projects or government regulations.

The approach begins with the presumption that a public project should be evaluated in terms of its net effect on future consumption, i.e., by a comparison of the stream of consumption to be yielded by the project with the stream of consumption that would have resulted from the private employment of the resources that are diverted to the public project.[16] When a dollar's worth of private consumption is diverted to a public project, the opportunity cost (the foregone private consumption) is one dollar, but when a dollar's worth of private investment is diverted to a public project, the opportunity cost is the stream of private consumption that would have resulted from such investment. The present value of this foregone consumption stream may be computed by discounting it using the consumption rate of interest (a proxy for the social rate of time preference). The resulting number is called the shadow price of capital. It represents the present value of the future stream of consumption foregone when one dollar of investment is diverted from the private to the public sector.[17]

Assuming for the present that the shadow price of capital is known, or can be estimated reasonably, the remainder of this discounting procedure is carried out as follows. The projected costs of a public project in each year are separated into those which are thought to divert private sector consumption and those which divert private sector investment. Those which divert private sector investment are multiplied by the shadow price of capital to compute their real opportunity cost (in terms of foregone consumption) to society. If the benefits of the public project are thought to cause more future private investment to be undertaken than would otherwise occur (or if benefits enhance disposable income and cause more savings), they also should be adjusted upward by the shadow price of capital. (This increases the amount of benefits yielded by a project because of the increase in future consumption that results from the additional investment). The annual stream of net benefits (benefits minus costs) is then computed and discounted, as in the standard discounting formula, using the social rate of time preference as the discount rate. This is the appropriate discount rate to use in this approach because both

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[14] See Gramlich (1981).

[15] Much of the discussion on the shadow price of capital approach and on risk (in a later section) is based on the chapter entitled "A Primer on the Major Issues Relating to the Discount Rate for Evaluating National Energy Options," by Robert C. Lind in Discounting for Time and Risk in Energy Policy, Resources for the Future, (l982).

[16] Consumption here means the dollar value of net benefits (or of goods and services) produced by the public and private use of the resource in question.

[17] The shadow price of capital is greater than one dollar only because the marginal before-tax rate of return on investment is greater than the consumption rate of interest.

the cost and benefit streams are transformed into equivalent streams of consumption foregone and received.[18]

In summary, to carry out this procedure one must be able to:

- compute the shadow price of capital,
- estimate the share of each dollar of project costs that comes from displaced private investment and consumption, respectively,
- estimate the effect of future benefits produced by the project on private investment,
- discount by the social rate of time preference.

Unfortunately, it is quite difficult to accurately quantify each of these elements. Additionally, use of this approach may make it difficult to evaluate the consistency of discounting practice across the Agency and potentially may be time consuming. Nonetheless, the shadow price of capital approach can be implemented if one is willing to make assumptions that appear to be reasonable, but which have yet to be verified empirically or thoroughly reviewed in the literature. A brief discussion of the factors that should be considered in each of the elements of this approach is presented below.

l. Compute the shadow price of capital. To calculate the shadow price of capital one needs to know (I) the marginal before tax rate of return on investments in the private sector, (ii) the marginal propensity to save, (iii) the economic life of private capital investment either displaced or stimulated, and (iv) the social rate of time preference.[19] Using a multi-period model in which the return to capital is spread out evenly over the life of an investment, depreciation is fully reinvested, and 20 percent of income is reinvested, Lind estimates that the shadow price of capital is in the range of from $3 to $5, with a best estimate of $3.80, i.e., one dollar of private investment creates a consumption stream with a present value of $3.80. This is the most recent estimate of the shadow price of capital appearing in the literature. However, it should be noted that Lind's computational approach has not been thoroughly reviewed.

2. Estimate the private investment and consumption displaced. The amount of private investment and consumption displaced by a public project depends on how it is funded, the types of costs it imposes, the condition of the economy, and government spending and tax policy. Although it is quite difficult to make a precise determination of how a public project or government regulation displaces private resources, it may be possible to make rough estimates along the following lines. Regulations or projects may be divided for convenience into two categories: those financed by the Federal (or state) government, and those financed by private parties. For those financed by the Federal government, the portion funded by issuing bonds may be assumed to displace mostly private capital, whereas the portion funded through tax revenues

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[18] In other discounting approaches, the discount rate is changed to reflect the pattern of private resource displacement and hence, opportunity costs, whereas in the shadow price of capital approach the benefits and costs are adjusted.

[19] The shadow price of capital need not be re-estimated for each regulation considered, unless there is good reason to believe that the pattern of capital displacement is unusual. In most cases, the marginal investment opportunity in the private sector that is displaced may be assumed to be independent of the regulation under consideration.

may be assumed to displace mostly private consumption.[20] For example, if the marginal propensity to save is 10 percent, then 90 percent of the cost of a project financed through tax increases could be assumed to displace consumption. For those projects financed by private parties (firms), the capital costs of the projects may be assumed to displace mostly private capital, whereas annual operating and maintenance costs (presuming cost pass-through) may be assumed to displace mostly consumption, again with the 90-10 split mentioned above.[21]

3. Estimate the effect of future benefits on private investment. Environmental benefits usually are not in a form that leads to further savings. If better health leads to reduced medical expenditures, future savings may be increased, but the value of increased health and longevity (in terms of willingness to pay) typically is much greater than real expenditures saved. Thus, unless the benefits from environment regulation give rise to tangible benefits (or release conventional resources), it should be assumed that they have no effect on future investment.

4. Discount by the social rate of time preference. A good proxy for the social rate of discount is the consumption rate of interest, which ranges between about zero and 5 percent. The specific discount rate used should depend on the risk embodied in the public project, as is discussed in more detail in section III, below. Rates of one or two percent generally should be used for environmental projects.

To illustrate the application of this approach, consider a regulation requiring an existing facility to purchase pollution control equipment that will reduce emissions of a pollutant for twenty years. For simplicity, assume that annual operating and maintenance costs are $50,000 in each year, that the benefits from reductions in emissions are $170,000 per year, and that capital costs of $400,000 are incurred to purchase and install the equipment. The capital costs must be multiplied by the shadow price of capital to compute their consumption equivalent: $400,000 x 3.8 = $1,520,000. The annual costs and benefits (assuming they do not affect future private investment) are discounted at the social rate of time preference (assumed to be 2 percent for this example) to yield a present value of about $1,960,000. The consumption equivalent ($1,520,000) of the initial capital cost is then subtracted to yield a net present value of about $440,000. Since net benefits are greater than zero, the regulation would be justified on economic grounds.

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[20] There is debate as to whether marginal increases in public outlays are funded through increased taxes or through additions to general public debt. Many economists have argued that in the short run it is likely to occur through increases in debt, but in the long run taxes will be adjusted upwards. Yet, it is quite difficult to predict the manner in which taxes may be raised and the timing of tax increases relative to increases in expenditures.

[21] There is controversy over the extent to which "productive" capital is displaced by investment on environmental controls. The problem is made more difficult because the private capital displaced does not necessarily occur in the industry affected by the regulation. Further, the amount of private capital displaced is influenced by the degree to which there are unemployed resources in the economy at large. Since potential regulations usually are evaluated several years before capital expenditures are required, adjusting capital displacement effects to reflect the degree of unemployed resources would require projecting future macroeconomic activity. A simplifying assumption is that resources will be fully employed in the future end that private capital is displaced on a one-to-one basis.

IV. RISK AND THE SOCIAL DISCOUNT RATE

A. The Concept of Risk

The relationship between risk and the rate of return on assets has been an important subject in modern finance. The issue of risk has also entered into the controversy over selecting an appropriate discount rate in benefit-cost analyses.

Some economists have argued that the government should use a risk-free rate in evaluating benefits and costs. Others have argued that for public projects with expected cost or benefit streams that are risky or uncertain, a higher rate of return should be required, just as it is in the private sector. Some advocates of the latter proposition have argued that the rate of return on public investments should be the same as the marginal rate of return on private investments of comparable risk.

The concept of risk is often interpreted in a narrow sense. As the variability or range in possible outcomes of a project increases, the risk of investing in the project is thought to increase commensurately. The notion of risk can also be conceptualized more broadly. The risk of a project is then assessed in terms of its effect on the variability in outcomes of the entire portfolio of assets to which it is added. This actually is a common sense approach. The risk faced by an individual does not depend on the variability of return (or uncertainty of return) of each asset held. Rather, it depends on the variability of the returns of the entire portfolio of assets the individual holds.

A simple example is useful in clarifying this point. Suppose the decision of whether to buy fire insurance for a home is being evaluated. Looking only at the variability in the return of the asset being purchased, the insurance policy, one would conclude that it is quite risky. The payoffs range from a small negative return with high probability (the insurance payment) to a large positive return with low probability (the value of the house). But if this asset is evaluated in terms of its effect on the portfolio of assets to which it will be added, it is clear that this asset reduces risk -- it eliminates the chance that the individual will suffer a very large financial loss and thereby reduces the variability of returns of the entire portfolio of assets held.

The degree of risk associated with an asset generally is measured in terms of the covariance of its returns with those of the portfolio of assets to which it is added.[22] A positive covariance means that adding the asset to the portfolio increases the variability in returns to the entire portfolio; the asset is therefore considered risky. A zero covariance implies that adding the asset to the portfolio creates no additional risk, i.e., it is riskless. A negative covariance implies that risk is diminished, i.e., the asset has negative risk.[23] This is the same as the theory behind the use of the "beta" coefficient as a measure of risk in modern financial theory. (The beta coefficient indicates the degree to which an asset's returns are correlated with the returns of the stock market.)

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[22] If the returns of an asset are positively correlated with those of the portfolio (high returns on the asset are associated with high returns on the portfolio and low returns are associated with low returns on the portfolio), the covariance is positive. If the returns are uncorrelated, covariance is zero and if there is a negative correlation between the returns, the covariance is negative.

[23] An assumption underlying this analysis is that the asset being acquired is a very small fraction of the portfolio of assets already held. If this assumption is violated, the variability in returns of the asset can directly affect the variability of returns to the entire portfolio. The potential costs and benefits of environmental regulations generally are spread among large numbers of people, which satisfies the condition that the asset acquired be a small portion of the portfolio of assets already held.

In the context of the national economy, the riskiness of a public investment that absorbs a small fraction of national income depends on the covariance of the investment's returns with the national income, provided the risk is broadly distributed.[24] Whether the risk of an investment that is required by a specific regulatory action will be broadly distributed depends on whether the benefits and costs of that investment are widely distributed over large segments of the population. If so, and if the returns of the public investment have a positive covariance with national income, there will be some risk associated with the project. If the covariance between the returns to a public investment and national income is zero, from the standpoint of the nation as a whole, risk is minimal; if the covariance is negative, the investment has the characteristic of insurance.

In the aggregate, investors appear to be risk averse. This means that most investors would be willing to trade higher, but uncertain, returns for lower and more certain returns. Thus, riskier assets are generally required to yield higher expected rates of return. This is dealt with in the discounting formula by adding a risk premium to the discount rate when evaluating the returns to risky projects.

B. Analyzing Risk in Benefit-Cost Analysis

Various procedures have been used to account for risk in benefit-cost analyses. One approach that has been used is to base the assessment of risk on the degree of variability in potential returns from a project. A common technique for dealing with projects with uncertain returns is to estimate the expected value of returns in each year. This is usually based on a qualitative assessment of the probability distribution of future returns from the project. The expected value of returns is then used in the discounting formula and the risk of the project is evaluated from the shape of the probability distribution of future returns, with narrow distributions indicating less risk and wide distributions indicating greater risk. If the project is risky, relative to the level of risk embodied in the discount rate already selected, a risk premium is added.

Another approach that has sometimes been followed for treating risk is to separate the expected values of benefits and costs (as opposed to using net benefits) and to discount each according to their own degree of risk. Since future benefits of an investment project are typically more uncertain (more risky) than are the costs, a higher rate is used to discount expected benefits and a lower rate is used to discount expected costs.

Both of these approaches narrowly focus only on the returns to the particular project, or the components of those returns. In this way they neglect the effects of the project on the larger portfolio of society's investments of which this asset is a part. These two commonly used approaches toward assessing risk should be avoided when evaluating most environmental projects.[25] Instead, the broader

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[24] For environmental regulations, the comparison should be made to an expanded version of national income. It would include both future measured income and changes in other aspects of economic well-being not measured in the national accounts that would result from environmental improvements.

[25] For some government programs, costs and benefits may be incurred and received by different individuals. Such costs and benefits also may be large relative to the returns on other assets held by such individuals and may affect the overall risk to each individual differently. For example, if the costs imposed by a regulation are relatively certain (and are uncorrelated with returns on other assets), the expected cost of the regulation is a good measure of the cost to the individual. However, if the benefits are uncertain their expected value may overstate their value to individuals who are risk averse, as most persons may be assumed to be. Such individuals would be willing to exchange lower, more certain, expected benefits for higher, but more uncertain, benefits. This is the rationale for adjusting expected

concept of risk should be employed when determining how to discount the benefits and costs of environmental projects.

When viewed from the perspective of how an investment affects the variability of returns of the portfolio of assets to which it is added, most environmental projects are either riskless or reduce risk. This is because most environmental projects have benefits and costs that are widely dispersed and that are uncorrelated or negatively correlated with future measured income and other aspects of economic well-being.

benefits downward by discounting by a higher rate. Alternatively, uncertain benefits can be adjusted downward to their "certainty equivalent" value before discounting both benefits and costs by the same rate, but it is not clear how this adjustment should be made.

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<u>SUPPLEMENTAL</u> GUIDELINES FOR PREPARING REGULATORY IMPACT ANALYSIS

APPENDIX C

ANALYSIS OF THE CHOICE OF DISCOUNT RATES

1989

SUPPLEMENTAL GUIDELINES FOR PREPARING REGULATORY IMPACT ANALYSIS

APPENDIX C

ANALYSIS OF THE CHOICE OF DISCOUNT RATES

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SUPPLEMENTAL APPENDIX C

ANALYSIS OF THE CHOICE OF DISCOUNT RATES

I. THE IMPORTANCE OF DISCOUNTING IN ENVIRONMENTAL POLICY

Executive Order 12291 of 1981 requires all federal agencies to prepare Regulatory Impact Analyses (RIAs) for most major regulations. The order directs all federal agencies to choose regulatory alternatives that maximize the "net benefits to society." In the words of the executive order, "Regulatory action shall not be undertaken unless the potential benefits to society for the regulation outweigh the potential costs to society ... to the extent permitted by law."

To satisfy the executive order, government decision makers must compare the costs of a regulation with the benefits. But the benefits and costs of environmental regulations often do not occur at the same time. The costs are often borne immediately by society, but the benefits are not realized until some future point in time. This complicates the comparison of benefits and costs because a dollar spent today does not have the same value as a dollar earned as a benefit tomorrow. The dollar spent today could be invested in some alternative activity (e.g., corporate AAA bonds) that could earn a positive rate of return.[1]

The dollar values of benefits and costs cannot be compared unless the time differential is accounted for. A translation factor must be used to convert all costs and benefits into their "present values." Discounting is the process of adjusting all future benefits and costs to their present values. The discount rate is the rate by which the present value of money (benefits or costs) received in the future can be computed.[2]

II. CHOOSING AN APPROPRIATE DISCOUNT RATE

EPA regulations displace resources from the private sector to public uses. (For example, when EPA requires that a scrubber be installed in an electric utility's smokestack, the firm must pay for the scrubber with funds that could have been directed to alternative uses.) A basic principle underlying economic analyses at EPA is that the benefits of regulations should be compared with the opportunity costs of the resources they displace from the private sector. These opportunity costs include the investment and consumption foregone in the private sector by virtue of using private sector resources for public purposes.

Discounting procedures must account for these opportunity costs. The two conventional approaches to discounting use a single discount rate to capture these opportunity costs and to evaluate environmental programs and regulations. The first approach accounts for the rate of return that could have been earned by <u>investments</u> in the private sector, and the second approach accounts for

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[1] It is also true that a dollar of future costs is not valued as highly as a dollar of costs incurred today.

[2] The process of discounting is equivalent to the annualization of costs and benefits. A project can be evaluated by comparing streams of annual costs and benefits and seeing what net benefits (i.e., benefits minus costs) are in each year. Alternatively, the project can be evaluated by first discounting the cost and benefit streams to obtain their present values, and then comparing them to ascertain the present value of net benefits. The two approaches are equivalent and will yield the same evaluation of the project.

consumption opportunities foregone by society.

Consider the first approach. Many environmental regulations require firms to purchase and install pollution control equipment (e.g., scrubbers, liners and leachate collection systems, and aqueous treatment systems). Firms must finance these expenditures with funds that might otherwise have been directed to alternative investments. In such cases, the marginal rate of return on private investment (pre-tax) is the appropriate discount rate.[3] We estimate this rate to be around 10 percent.

Consider the second approach. Some regulations increase the annual operating costs of firms. These cost increases are often passed through to consumers in the long run in the form of higher prices. Price increases have the effect of reducing the consumption of goods and services, generally by the amount of the increase in cost. Consumption is displaced. In such cases, the social rate of time preference is the appropriate discount rate. This is defined as the rate at which society is willing to trade off future for current consumption.[4] We estimate this after-tax rate to be at most 3 percent. (Recall that the corporate income tax and the personal income tax create a significant differential between the pretax rate of return that can be earned on the marginal investment in the economy and the after-tax rate of return that individuals can earn on their savings, which equals their consumption rate of interest.)

The choice between the consumption rate of interest and the marginal rate of return on private investment is important, since a higher discount rate reduces the present value of future costs and benefits. That is, a higher discount rate signifies that society is more heavily discounting the value of future costs and benefits. Some economists have advocated using a discount rate that is a weighted average of the consumption rate of interest and the marginal rate of return on private investment. It is not clear, however, how the weights would be developed to reflect the relative amounts of the resources displaced. An alternative solution must therefore be found.

III. THE SHADOW PRICE OF CAPITAL APPROACH TO DISCOUNTING

To solve the dilemma of which single discount rate to choose, an alternative approach called the shadow price of capital method was developed in the economic literature. The logic underlying this approach is that a public project should be evaluated in terms of its net effect on future consumption. That is, the stream of consumption yielded by the public project should be compared with the stream of consumption that would have resulted from the private employment of the resources. For this comparison, all benefits and costs must be converted into streams of consumption. Once this is done, the social rate of time preference is unambiguously the appropriate discount rate, because it is the rate at which society is willing to trade off current consumption for future consumption.

Three streams must be expressed in consumption units: benefits, O&M costs, and capital costs. Benefits usually are also expressed in terms of consumption gained (e.g., the value of improved recreational opportunities, damages avoided, and risk reductions). O&M costs also are usually expressed in units of consumption. Recall that cost increases due to O&M are passed through to consumers in the form of higher prices, which directly reduces the consumption of goods and services.

The problem is that capital costs are not expressed in consumption terms. This is significant because when a dollar is diverted away from private investment to pay for a public project, the

[3] This most likely was the rationale used by OMB in 1981 when it issued its guidance on discounting.

[4] Since this rate is never directly observed, the consumption rate of interest is used as a proxy. This is defined as the rate at which individual consumers are observed in the market to trade off future consumption for current consumption.

opportunity cost of that move is the entire stream of consumption that would have resulted from the private investment. The opportunity cost is greater than one dollar.

The approach suggested in the literature for converting capital costs into a "foregone" stream of consumption is to multiply the capital costs by a number called the shadow price of capital (SPC). The SPC is defined as the present value of the consumption stream yielded by a dollar's worth of investment today in productive capital. Current estimates are that the SPC equals 2.5. This implies that a permanent reduction in the stock of private capital by $1 should be valued at $2.5 of lost future consumption by society. Once capital costs have been converted into consumption units, benefits and costs can be discounted by the social rate of time preference.

In summary, the shadow price of capital procedure is a two-step approach:

Step 1: Multiply capital costs incurred in any year by a number called the "shadow price of capital."

Step 2: Discount both benefits and costs by the appropriate discount rate. This rate is the social rate of time preference, since both benefits and costs are in terms of consumption.

IV. THE KOLB-SCHERAGA TWO-STAGE PROCEDURE

Although the shadow price of capital approach to discounting appears to solve the dilemma of which single discount rate to choose, it still is not appropriate for the evaluation of many environmental regulations. The SPC approach substantially increases the cost stream, thus distorting the present value of net benefits.

The explanation for this can be found in the way the SPC number is estimated. Existing estimates of the SPC assume that environmental regulations permanently lower the capital stock once investment is displaced from the private sector to public uses. In reality, however, the capital costs for many environmental regulations can be passed through to consumers in the long run as higher prices. The capital stock is not permanently lowered. Using existing estimates of the SPC therefore overestimates the amount of resources displaced from the private sector. The SPC procedure effectively uses higher discount rates.

In addition to this deficiency with the SPC approach, the problem of choosing a single discount rate is further exacerbated by the fact that the rate should vary as the burdens of regulations on investment and consumption vary, as the length of the benefits stream increases relative to the cost stream, and with any lags that may exist between the time costs are incurred and benefits are realized. The intuition behind this is straightforward. The existence of corporate and personal income taxes causes the marginal rate of return on private investment to diverge from the social rate of time preference. It is this divergence that can lead to underinvestment and bias investment decisions against long-term projects and regulations with long-term benefits streams. Investment in public projects becomes less attractive the higher the discount rate; that is, specification of a single discount rate that is always equivalent to the marginal rate of return on private investment will lead to underinvestment. Further, since the marginal rate of return on private investment is greater than the social rate of time preference, private investment decisions are biased against long-term investments when judged from a social perspective.

In order to solve these problems, an alternative two-stage procedure has been developed. This procedure attempts to account for the way environmental regulations are likely to divert private resources. It may be implemented as follows:

Step 1: Annualize capital costs over the expected lifetime of the pollution controls, using the marginal rate of return on private investment. Add O&M costs to this stream to yield total annualized costs.

The annualization procedure calculates the stream of annual revenues necessary to retire the initial capital expenditure on pollution controls. Adding annual operating costs yields the stream of additional revenues that must be collected through price increases to pay for all costs imposed by the regulations.

Step 2: Discount both the benefit and cost streams, using the consumption rate of interest (as a proxy for the social rate of time preference). Since the benefit and cost streams are in terms of consumption gained and foregone, this is the appropriate discount rate.

There are several outcomes from, and advantages to, this two-stage procedure has several advantages:

(1) It is preferable to the conventional approach of using a single discount rate because it accounts for both displaced private investment (in the annualization process) and foregone consumption (by discounting both costs and benefits by the social rate of time preference).

(2) It is preferable to the SPC approach because it recognizes that the capital costs of environmental controls are eventually returned to the economy. Therefore, it does not underestimate net benefits.

(3) It implicitly uses different discount rates for different EPA regulations. The implicit rate varies with the time profiles of the streams of benefits and costs. (The implicit rates are constrained by the a priori choice of the marginal rate of return on private investment and the social rate of time preference that are used in the two-stage procedure.)

The calculation of the two-stage procedure has been made easy by OPPE (Economic Studies Branch) through the development of a menu- driven computer program that can be run on any DOS-based personal computer. The analyst provides the program with the regulation's capital costs, the stream of O&M costs (which can vary over time), the benefit stream (which can vary over time), any lag that may exist before benefits are realized, the marginal rate of return on private investment, the social rate of time preference, and the number of years over which capital costs should be annualized. The output from the program consists of the capital recovery factor (used to annualize the capital costs), the present value of benefits, the present value of costs, the net benefits of the regulation, the ratio of benefits to costs, and the single discount rate that is implicitly being used in the two-stage procedure.[5]

It is important to understand when it is appropriate to use the two-stage approach and when it is not. The approach can be used in situations where the capital costs imposed by regulations are likely to be passed directly through to consumers. In competitive markets, the costs of environmental controls can be fully passed through to consumers (in the long run), just as are other capital and operating costs. Product prices would increase by an amount reflecting the marginal rate of return on investment, the expected lifetime of the pollution controls, and any operating costs. The capital that was initially displaced would be returned to the economy and the capital stock would not remain permanently lower as assumed when calculating the shadow price of capital. If consumers' savings rates out of disposable

[5] A sample computer session is appended to this package.

income are not be affected by the regulation, the increased amount paid for the good purchased with environmental controls would come from reductions in other consumption, not from reductions in savings.

There are, however, regulatory situations where consumption is not likely to be displaced. For example, the cost of the air and water regulations for the iron and steel industry most likely could not be passed forward. Likewise, the costs of RCRA regulations for existing facilities in non-expanding markets or markets with strong foreign competition could not be passed forward. The costs of remedial actions, Superfund, and RCRA Corrective Action programs are not likely to be passed forward. The alternative SPC approach is applicable in such situations.

V. CHOOSING RATES FOR ANNUALIZING COSTS AND DISCOUNTING BENEFITS AND COSTS

Recommending specific rates for annualizing capital costs and discounting benefits and costs can be quite controversial. A number of issues must be considered. First, a marginal, risk-free rate of return should be used to annualize costs. A marginal, rather than an average, rate of return should be used because investments that would be displaced elsewhere in the economy yield marginal rates of return that generally would be lower than observed average rates of return. Second, a risk-free rate should be used to discount benefits and costs for most environmental regulations. Whether risk-free rates or rates embodying some degree of risk should be used depends on the degree to which costs and benefits are spread widely and are small relative to income and other measures of well being. It also depends on the degree of correlation between environmental returns and national income. There is reasonable consensus that, to the extent that a particular government project is risky, the discount rate used to evaluate it should be the expected market interest rate on private investments that present comparable risk. According to Lind (1982), the riskiness of the project should be measured by the amount of variance that the project adds to society's overall portfolio of investments. If the project's costs and benefits are independent of the rest of the economy, then it adds no additional risk, and the appropriate discount rate is the rate of return to consumers from riskless investments. The returns to most environmental regulations are relatively uncorrelated with returns to private-sector investments. They add no additional risk (or variance to society's overall portfolio of investments), which suggests that risk-free rates should be used in most instances.

The marginal rate of return on private investment may be inferred from observed rates of return on corporate bonds, from the real returns on corporate equities, or from studies of average rates of return in the nonfinancial sector of the economy. Based on data from 1946-1986, the marginal risk-free rate of return lies within the range of 5 to 10 percent. From 1946 to 1980, real rates of return on 10-year Treasury bills and Corporate Aaa bonds averaged under 2 percent. In the 1980s, 10- year Treasury bills and Corporate Aaa bonds averaged about 7 or 8 percent.[6] Real rates of return (pre-corporate tax) on equities averaged between 10 and 12.9 percent over the last 60 years.[7] Various studies have placed the average rate of return on investment in the nonfinancial sector in the range of 8 to 13 percent.[8] Given these data, the 10 percent rate is suggested for use in the two-stage procedure in order to maintain consistency with

[6] The higher yield for long-term securities in the 1980s probably reflects inflationary expectations based on observed inflation in the late 1970s and early 1980s.

[7] See Ibbotsen and Sinquefield (1984).

[8] See Gorman (1972), Holland and Meyers (1979), Nordhaus (1974), and Stockfisch (1982).

current OMB guidelines. However, the use of an alternative estimate for this rate might be supportable by the available data.

The consumption rate of interest may be inferred from after-tax rates of return on savings instruments that are widely available to the public (e.g., 3-month Treasury bills) or from returns on stock portfolios. Based on data from 1946-1986, the consumption rate of interest lies within the range of 1 to 5 percent, and the risk-free rate probably lies at the lower end of the range. Real after-tax rates of return on 3-month Treasury bills were actually negative (-1.1 percent), on average, over the period 1946 to 1980. More recently, they have ranged from about 2 percent to 4 percent. Returns to stocks averaged about 5 percent over the past 60 years. Based on these data, the 3 percent rate is suggested for use in the two-stage procedure.

VI. A COMPARISON OF THE DIFFERENT DISCOUNTING PROCEDURES: FURTHER JUSTIFICATION FOR THE KOLB-SCHERAGA TWO-STAGE PROCEDURE

We have summarized three alternative approaches to discounting: (I) the conventional approach of using a single discount rate; (ii) the shadow price of capital approach; and (iii) the Kolb-Scheraga two-stage procedure. The three discounting procedures can yield similar or very different results, depending on the type of benefit and cost streams associated with a regulation. Table 1 compares the results of the three discounting procedures applied to regulations with five different time profiles for benefits and costs.

The first two scenarios consist of short-term benefit streams (i.e., 20-year duration), and the other three consist of long-term benefit streams (50-year duration). Some of the scenarios also contain lags between the time when costs are incurred and benefits are realized. In all cases, capital costs are annualized over a 20-year period.[9]

Table 1 is designed, however, to show how each of the discounting procedures performs relative to one another. This is done by calculating the ratio of benefits to costs derived using a particular procedure and then dividing it by the benefit-cost ratio derived using the conventional discounting approach. That is, the conventional discounting procedure (using a 10 percent discount rate) is used as the base for comparison (i.e., the numeraire). These are the numbers reported in the first three columns of the table. A value greater than one indicates the approach yields a higher benefit-cost ratio than does conventional discounting, whereas a value less than one indicates a lower benefit-cost ratio. The numbers in the first column are all ones because the conventional approach is being compared to itself.

The results indicate that the two-stage procedure generally yields higher benefit-cost ratios than the conventional single-rate discounting procedure. Further, the disparity in results increases as the period over which the benefits occur lengthens and as the lag between the time when costs are incurred and benefits are received widens.[10] The two-stage procedure yields the same results as the conventional discounting approach only when the time profile of benefits and the time profile of costs exactly coincide.

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[9] Because the table is designed to show the relative effects of the different discounting procedures, the absolute values of the benefit and cost streams are unimportant.

[10] The numbers in Table 1 were calculated using 10 percent to annualize costs and 3 percent to discount benefits and costs. The differences between the results of conventional discounting and the two-stage procedure would be even greater if a discount rate lower than 10 percent were used to annualize capital costs.

TABLE 1

RELATIVE BENEFIT-COST RATIOS USING ALTERNATIVE DISCOUNTING PROCEDURES FOR REPRESENTATIVE BENEFIT AND COST STREAMS

	Type of Discounting Approach		
Type of Benefits	Conventional 10%	SPC[a] of 2.5	Two[b] Stage
Short Term (20 years)	1	0.7	1.0
Short Term With 10-Year Lag	1	1.3	1.9
Long Term (50 years)	1	1.1	1.5
Long Term With 10-Year Lag	1	2.0	2.9
Long Term With 20-Year Lag	1	3.8	5.5

NOTE: The above numbers are calculated as the benefit-cost ratio yielded by a specific discounting procedure divided by the benefit-cost ratio yielded by conventional discounting.

[a] Uses 3 percent to discount benefits and costs.

[b] Uses 10 percent to annualize costs and 3 percent to discount benefits and costs.

The shadow price of capital approach yields lower benefit-cost ratios than the conventional discounting procedure when benefits are short term. It is only in situations were there are long-term benefits with a lag that the benefit-cost ratios are significantly higher than those yielded by conventional discounting. In all cases, the shadow price of capital approach yields lower benefit-cost ratios than does the two-stage procedure. This result supports the claim that if displaced capital is indeed returned to the economy, use of the shadow price of capital approach will distort benefit-cost comparisons.

VII. CALCULATION OF EQUIVALENT DISCOUNT RATES

The two-stage procedure does not make use of a single discount rate in the same way as does the conventional discounting approach. Rather, it is constrained by the choice made for two rates: the marginal rate of return to private investment and the consumption rate of interest. Once these are specified, it is possible to calculate net benefits using the two-stage approach.

It is possible, however, to calculate the single discount rate that, if used with the conventional discounting procedure, would yield the same benefit-cost ratio as the two-stage approach. We term this single rate the **equivalent discount rate**. This rate is implicitly determined in the two-stage process and varies with the choice of the marginal rate of return on private investment, the consumption rate of interest, and the time profiles of benefits and costs.[11]

Table 2 lists the equivalent discount rates for the five scenarios previously depicted in Table 1.[12] The results presented in Table 2 illustrate that if conventional discounting is to be used, one discount rate is not appropriate in all

circumstances. As the period of analysis increases or as the lag between costs and benefits increases, lower discount rates are more appropriate. (If O&M costs are substantial relative to capital costs, equivalent discount rates would be higher than those shown in the table.)

VIII. CONCLUSIONS

The development of the two-stage procedure was motivated by several observations about existing techniques for discounting and about the types of regulations being evaluated:

(1) Environmental regulations must be evaluated in terms of both displaced private-sector investment and displaced private consumption. Neither the marginal rate of return on private investment nor the social rate of time preference is alone adequate for the evaluation of all environmental regulations.

(2) A single discount rate is not appropriate for the evaluation of all environmental regulations. The discount rate should vary with the varying burden on private sector investment and consumption, the length of the benefit stream, and the lag between the time costs are incurred and benefits are realized.

(3) The shadow price of capital approach to discounting is not a viable alternative to the

[11] This concept of an "equivalent discount rate" should not be misinterpreted. It is not the rate at which discounted net benefits are positive. It is simply the single rate that, when used with the conventional discounting approach, yields results equivalent to the two-stage procedure.

[12] These calculations assume that the social rate of time preference is 3 percent and the marginal rate of return on private investment is 10 percent. The implicit discount rate therefore varies from 3 to 10 percent. The implicit rate could, however, vary over a wider ranger if the Agency proposed to use rates higher than 10 percent for the marginal rate of return on private investment or lower than 3 percent for the social rate of time preference. Changing economic conditions in the future might eventually justify the use of different estimates for these rates.

TABLE 2

EQUIVALENT DISCOUNT RATES FOR REPRESENTATIVE BENEFIT AND COST STREAMS AS DETERMINED BY THE TWO-STAGE PROCEDURE

Type of Benefits	Equivalent Discount Rate (percent)
Short Term (20 years)	10.0
Short Term With 10-Year Lag	6.1
Long Term (50 years)	6.6
Long Term With 10-Year Lag	5.1
Long Term With 20-Year Lag	4.6

conventional discounting procedure for evaluating most environmental regulations. The shadow price of capital approach in many instances is equivalent to using higher discount rates than is appropriate.

The two-stage procedure resolves these problems. It resolves the dilemma of how to account for both displaced private investment and foregone consumption, it recognizes that environmental controls do not permanently reduce the nation's capital stock, and it implicitly uses different discount rates for different environmental regulations. This procedure yields significantly different results than the alternative discounting procedures when there is a substantial lag before benefits start, or when benefits occur over a long period of time.

The two-stage procedure is more appropriate than either the conventional discounting procedure or the shadow price of capital approach for the evaluation of environmental regulations. Its implementation will foster a consistent approach to discounting and to choosing discount rates within the EPA.

IX. APPENDIX - ILLUSTRATION

SAMPLE COMPUTER SESSION FOR SOFTWARE PACKAGE DEVELOPED TO FACILITATE THE IMPLEMENTATION OF THE TWO-STAGE PROCEDURE

TWO-STAGE DISCOUNTING PROCEDURE

Software developed by: Joel D. Scheraga (U.S. EPA) and Albert McGartland (OMB)

Please turn the CAPS LOCK key on. Hit the ENTER key when you are ready to proceed.

Please input all rates of return as decimals.

What is the initial capital cost?
10
Over how many years should capital costs be amortized?
20
What is the marginal rate of return on private investment?
.1
What is the social rate of time preference?
.03

Are there any O&M costs?
(Please answer YES or NO.)
YES

Are O&M costs constant across all years?
YES

Input the constant O&M costs that accrue each year:
1

Over how many years will there be benefits?
20

How long of a lag is there before benefits are realized?
10

Are annual benefits constant and the same in every year?
(Please answer YES or NO.)
NO

(continued on next page)

Input the benefits for each year:
Year 11:
5
Year 12:
5
Year 13:
5
Year 14:
5
Year 15:
5
Year 16:
2
Year 17:
2
Year 18:
2
Year 19:
2
Year 20:
2
Year 21:
2
Year 22:
2
Year 23:
2
Year 24:
2
Year 25:
2
Year 26:
2
Year 27:
2
Year 28:
2
Year 29:
2
Year 30:
2

(continued on next page)

REPORT OF DISCOUNTING RESULTS
USING TWO-STAGE PROCEDURE

The Capital Recovery Factor = .1174596

The present value of benefits is: 32.36368

The present value of costs is: 32.3525

The benefit / cost ratio is: 1.000345

Net benefits as determined by the two-stage procedure = 1.117384E-02

PLEASE STAND BY. DISCOUNTING PROCEDURE IN PROGRESS.

The single equivalent discount rate = 5.399996E-02

(end of illustration)

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GUIDELINES FOR PREPARING REGULATORY IMPACT ANALYSIS

APPENDIX D

ANALYSIS OF ECONOMIC IMPACTS

JULY, 1984

GUIDELINES FOR PREPARING REGULATORY IMPACT ANALYSIS

APPENDIX D

ANALYSIS OF ECONOMIC IMPACTS

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APPENDIX D

ANALYSIS OF ECONOMIC IMPACTS

I. INTRODUCTION

This Appendix provides further guidance on how to evaluate the economic impacts of environmental regulations. For the most part, the economic impact analyses that the Agency has been performing for some time are consistent with this guidance. Efforts to estimate economic impacts should take into consideration limitations of time and resources, the availability of data, and the significance of the regulatory action.

Economic impact analysis is designed to determine to what extent specific groups, such as income classes, geographic units, or industry groups, bear the costs (or receive a greater share of the benefits) of environmental regulation. This information is important in evaluating the fairness of the distribution of benefits and costs, in determining whether it is important to mitigate such effects, and in assessing the social costs of regulations.[1]

The following sections discuss how to evaluate the primary economic effects of proposed regulations, the potential secondary economic effects (i.e., community, energy, balance of trade, and secondary employment effects) associated with proposed regulations, and the environmental effects that span several generations.

II. MEASURING PRIMARY ECONOMIC IMPACTS

The primary economic impacts of an environmental regulation are the direct effects on firms, markets, and populations. Of most interest are effects on prices, production, profitability, capital availability, growth, and employment.

A. General Analytical Approach

l. Establishing the Baseline

The analysis should establish a baseline for comparing the primary economic impacts of regulatory alternatives. It should reflect the likely situation in the industry in the absence of the applicable pollution control requirements.[2] The baseline usually should be determined by making one of the following assumptions: (l) the status quo will continue if the regulation is not enacted; (2) present industry trends in pollution control will persist without the regulation in question; or (3) the baseline will differ from the status quo or past trends because of changes in the relative prices of inputs used in

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[1] The Regulatory Flexibility Act requires EPA to review proposed regulations to ensure that, while accomplishing their intended purposes, they do not unduly inhibit small businesses from competing. The Small Business Ombudsman is now developing guidelines that may be useful for improving our analysis of the economic impacts on small businesses. For more information, contact the Ombudsman at room 1003 CM-2, mail code A-149, or call 557-7777.

[2] For additional information see, Baseline Concepts for Regulatory Impact Analysis, (Economic Analysis Division, August 1982).

production, other regulations, or technological change. Baseline costs should account for levels of control already in place and, in the case of water pollution control, how extensively industrial dischargers are using municipal systems.

2. Segmenting Industries

Plants within an industry should be segmented into similar categories. For example, plants may be grouped by size, type of production process, type of pollution control, or age. Industrial analysis should be performed at a plant level whenever possible.

3. Using DCF and ROI Analysis

Financial analyses, whether performed on an actual plant-by- plant basis or for "model plants" that represent significant industry segments, should normally be employed to assess economic impacts. A discounted cash flow (DCF) analysis can aid in deter- mining whether a plant is likely to close or curtail operations. Such an analysis attempts to determine whether the value of a plant's projected future cash flows is sufficient to cover the cost of pollution controls (as estimated through engineering analysis) at current or reduced operating levels.

Where data are unavailable for a DCF analysis, a return on investment (ROI) analysis should be performed. One method of doing ROI analysis is to compare projected profit levels (after pollution control costs have been accounted for) with the value of invested capital. The presumption is that a firm will remain open as long as it generates an acceptable rate of return on invested capital.

4. Estimating Cost Pass-Throughs

Common to each of these financial analyses is the need to perform a "market" analysis to assess the extent to which particular plants can pass through cost increases.[3] Both supply and demand factors should be considered when making this evaluation. The major factors on the demand side that affect an industry's ability to increase prices and vary production are the elasticity of demand and growth in demand.

- The elasticity of demand should be either quantitatively or qualitatively assessed. Econometric techniques can be used to estimate a demand curve when sufficient data are available. An alternative technique, especially useful when dealing with intermediate products, is to use engineering cost data to develop both supply and demand curves. Information on the availability of product or service substitutes, the impact of price increases on final goods (where the product or service is an intermediate good), and the necessity of the final product or service can be used to qualitatively assess demand elasticities.

- Growth in demand may be estimated by examining historic trends or by relating product demand to certain components of GNP for which growth trends are projected. These factors also may provide some indication of the time span over which the economy might adjust to changes in relative prices.

A number of factors on the supply side influence the ability of particular plants to pass cost increases forward. Such factors include:

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[3] For mobile sources, a firm (rather than plant) level of analysis is appropriate.

- the amount of excess production capacity,
- projected growth in demand,
- the speed with which entry or expansion is likely to occur, and
- the volume of production capacity projected to be retired.

In addition to making "best estimates" of cost pass-throughs for (model) plants, financial analyses should be performed using a worst-case assumption -- namely, no pass-throughs of pollution control costs. The likelihood of this worst case occurring also should be presented.

In general, in the short run firms will be able to pass forward only the variable costs associated with pollution controls. However, more of the increase in costs may be passed through than is suggested by the paradigm of pure competition if specialized products or services exist, competition is insulated geographically (due to transportation costs or service requirements), or there are noncompetitive market structures. And certain industries may be able to pass cost increases backward to raw material suppliers. In the longer run, price increases will be limited by the prices of substitutes, by the unit costs of new entrants or new capacity, or possibly by foreign competition.

B. Specific Economic Effects

The important factors that should be considered when assessing specific economic effects are summarized below.[4]

l. Price effects

Both supply and demand factors should be considered when evaluating price effects in markets for intermediate and final goods.

- Current and projected changes in the supply and demand situation in the industry, including the effect, if any, of imports and exports, should be evaluated.
- Primary demand elasticities and cross elasticities of demand should be assessed to determine likely reductions in demand.
- Differences in the unit costs of pollution control for existing and new plants should be assessed to determine whether newer, more efficient plants may set an upper limit on passing through costs.

2. Production Effects

Estimates of the effects of various regulatory alternatives on production can be based on the results of the financial analysis of model plants and the market analysis. The pollution control costs used in such analyses will depend on the time frame of the analysis.

[4] Wherever possible, positive as well as negative economic effects should be taken into account, e.g., the entry of new firms, price decreases, increases in employment (in the pollution control equipment industry or in operating/maintaining pollution control equipment in the regulated industry). Such positive effects may (at least) partially offset negative impacts.

- In the short-run, the average variable cost of pollution controls per unit of output generally should be used as a proxy for a plant's incremental cost (this may not be realistic if a plant is operating at maximum capacity, i.e., the short-run supply curve may be inelastic).

- In the long-run, the average total cost of pollution controls per unit of output should be used as a proxy for incremental cost.

3. Effects on Profitability, Capital Availability, and Industry Growth

The financial analysis should focus on two interrelated factors: profitability and capital availability.

- Profitability. A discounted cash flow (DCF) analysis should be performed to determine whether future profit, after deduction of pollution control costs, are sufficient to continue operating a plant.[5] The assumption underlying the analysis is that the plant will remain open only if the net present value of its projected cash flow exceeds the combination of the plants current salvage value and the additional capital required for pollution control. If possible, closures caused by pollution control requirements should be distinguished from closures merely hastened by pollution control requirements. (The "survivor technique," which examines the share of industry output emanating from various plant sizes over time, may be helpful in identifying plants that are likely to close even in the absence of pollution controls.)

- Capital availability. The effects of the regulation on capital availability should be addressed if a firm is likely to have difficulty in raising capital from external sources. Each model plant's total capital requirements (pollution control plus other investments) are compared with the ability of the firm to generate capital internally or to raise it externally. Projections of cash flows or internally generated capital should be adjusted for pollution control costs that cannot be recovered through price increases. Relevant financial parameters that affect a firm's credit rating, such as debt/equity ratios, projected debt service coverage, cash-flow-to-total-debt-ratio, and the salvage value of assets should be evaluated to assess the ability of the firm to attract capital from external sources. These financial ratios should be adjusted to take into account the firm's ability to pass through price increases.

- Growth. The likely growth in demand may be estimated by analyzing historic trends or by relating product demand to certain components of GNP for which growth trends are projected. The unit costs of pollution control for new and existing sources should be compared to determine if existing plants are likely to have a cost advantage over new plants, since this may affect the structure of the industry. A DCF analysis comparing the net present value of future cash proceeds with the total investment required for a new plant may be performed for this purpose.

4. Employment Effects

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[5] Some regulations, such as new source performance standards, may increase the profitability of existing plants if they impose costs on new plants greater than those incurred by existing plants. Some of the unconventional regulatory techniques, such as offsets and marketable permits, may create a "right" that has substantial value. For example, analysis of a proposed marketable permits system for controlling CFCs revealed that income transfers (the value of the permits) would dwarf the direct costs incurred to reduce emissions or the use of CFCs.

Estimates of direct, short-run effects on employment should be based on the estimates of plant closures and reductions in output developed in the DCF or supply and demand analysis. The longer-run employment effects depend on prospects for industrial growth. Estimates of the regulation's impact on employment should also account for any increases in employment that result from the operation and maintenance of pollution control equipment in the regulated industry.

- Where a proposed regulation's effects on employment appear to be serious, it may be necessary to determine the nature of transitional problems workers may have in finding other jobs.[6] Many economic analyses ignore these transitional problems, implicitly assuming ready transferability of labor skills and capital, perfect information, and costless relocation. Some of the factors that will influence the extent of transitional problems are as follows:

  - The regulation is projected to result in short-run unemployment that is a significant portion of the total employment base of particular communities (under this circumstance, the local community will have problems absorbing these workers until other local industries expand production or new industries locate in the area).

  - The economy is in a recession (this directly affects the local economy's ability to expand and absorb workers).

  - The skills of the unemployed workers are not compatible with the job categories that are expanding in the local economy (workers from basic manufacturing industries may have to undergo retraining or leave the area in order to find jobs).

  - Geographic areas are losing manufacturing jobs to other regions (a contribution by environmental regulations to the closure of otherwise threatened plants would compound transitional problems).

- Once the likelihood of business closures and their probable locations are predicted, the significance of any resulting unemployment relative to the employment base in the area can be determined. If the unemployment is fairly minor, unemployed workers are likely to be absorbed fairly quickly. However, if it is fairly substantial, further analysis is warranted.

- The potential for reemployment in an area should be qualitatively assessed by determining the growth prospects of the local economy and the types of job openings that may become available. The area's growth potential may be evaluated by examining past trends in economic activity and by determining whether firms are projected to expand output or to enter the area. The job categories in which additional employment is likely to occur should then be compared with the skills workers in the affected industries possess. This type of analysis may not precisely identify possibilities for reemployment, but it should indicate the general size of transitional unemployment problems. If reemployment prospects in the local economy are poor, the possibility of out-migration should be considered and assessed to the extent possible.

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[6] If a plant is predicted to close, the analysis should assess the employment effects but should assign a value of zero to the future control costs for that plant. Otherwise there would be double-counting of economic effects.

5. Income Distribution Effects

For very high cost regulations, effects on income distribution possibly could be significant. When this is expected, the following general procedure may be used to evaluate the effects.

- The estimated costs of the regulation should be allocated among the sectors of the public responsible for meeting the requirements.
- Assumptions must be made about how each sector will finance its share (e.g., tax increases, expenditure cuts, or some combination).
- An analysis is required to explain how the shares of income will be distributed among families in the population depending on their sources and uses of funds. The analysis must distinguish among taxes on personal income, general sales taxes, taxes on capital (corporate profits or real property), and user charges.
- The burden must be apportioned among families in different income classes.

III. SECONDARY EFFECTS ON EMPLOYMENT, COMMUNITIES ENERGY, AND TRADE

Secondary effects on employment, communities, energy, and balance of trade should be addressed if the primary effects appear substantial, or if any of the secondary effects are likely to influence the regulatory decision.

A. Secondary Employment Impacts

Secondary employment impacts can be estimated by applying input/output multipliers to the estimates of direct unemployment or lost earnings. The theory behind this approach is that a reduction in output and employment in the regulated industry creates a "ripple effect" in the economy as the reduction in demand for goods and services is transmitted from industry to industry.

However, a multiplier approach may not be able to identify impacts on specific suppliers or customers of a plant or group of plants or on small regional areas. Hence, an examination of key relationships that would amplify the direct impacts of price increases or plant closures should be considered. For example, changes in costs of smelting operations could affect mining, and higher costs for tin or aluminum could affect manufacturers of metal containers. Economic base multipliers may be used to assess the gross effects on regional employment.

B. Community Effects

Individual communities may be directly affected by EPA regulations because of business closures or reductions in plant output. These effects may be exacerbated if unemployed workers and the plant reduce their purchases of goods and services from the surrounding community.

Much of the analysis of community effects can be taken from the estimates of transitional unemployment already described above. The analysis should be sensitive to such factors as the size and composition of the population, the distribution of income, and the fiscal condition of affected state and local governments.

C. Energy and Balance of Trade Effects

l. Energy Impacts

Energy impacts include increased use of energy by the economic units under analysis and any induced demands placed on energy-supplying sectors. Energy impacts have presumably been incorporated in the cost analysis (in dollar terms), but are broken out as a separate category in the economic impact analysis. The extent of such impacts should be identified (and quantified where significant).

2. Trade Impacts

Where an input-output model approach has been used as an adjunct to the impact analysis, trade impacts can be calculated as one component of final demand. If it is assumed that there are no large changes in relative prices between foreign and domestic goods, the distribution of goods to the foreign trade sector will maintain their proportional share in the base year. On the other hand, large changes in relative prices (e.g., domestic prices of goods manufactured with a particular pollution abatement technology might rise disproportionately in relation to foreign prices) would increase imports or reduce exports for the affected industry. Impacts of this nature are outside the scope of an input-output model and require a separate analysis.

Estimates of balance of trade effects should rely on results of the financial and market analyses, but, in most cases, should be done apart from the rest of the analysis. They should include:

- the impact on the competitive position of U.S. producers in foreign and U.S. markets,
- the effects on capital accounts, and
- the impact on decisions about whether to build plants at domestic sites.

IV. INTERGENERATIONAL EQUITY AND ENVIRONMENTAL REGULATIONS

A. Economic Efficiency and Equity

Under the criterion of economic efficiency, regulations are justified if discounted benefits exceed discounted costs. However, this criterion is not designed to address whether the distribution of the benefits and costs, either among different groups at a point in time (intratemporally) or between different generations (intertemporally) is fair or equitable.

For many short-term government projects, distributional effects (equity impacts) may be small and transitory. Where distributional effects are significant, the government may have means -- such as transfer payment or tax or regulatory changes-- to partially mitigate adverse effects to the distribution of income or wealth. In these situations, the criterion of economic efficiency is suitable as a basis for evaluating governmental actions.

For government actions that have intergenerational impacts (i.e., time horizons exceeding 25 to 30 years) the economic efficiency criterion is less suitable as the sole guide for decision making. As an example of how weighing future values less than current economic values becomes and equity issue, imagine that 50 years from now a person is forced to evacuate a coastal area as a result of CO_2 emissions from burning coal today.[7] Further, assume that persons would accept a payment of $100,000 as "fair" compensation for property losses and any risks imposed.

If we, the current generation, wish to compensate that person. do we need to set aside $100,000? Is the damage now the same as the damage 50 years hence? The usual economic answer is "no." If we were to invest $850 today in productive asses yielding a 10% real rate of return (over inflation), in 50 years we would have $100,000 of real value in accumulated interest and principal to compensate that person. Thus, the argument goes, a 10 percent discount rate would be appropriate for evaluating the damage done to future generations. In our example. if scrubbing CO^2 from stack emissions of finding a non-CO^2-emitting energy substitute for coal (such as solar or nuclear energy) were to have an excess cost of more than $850 today, benefit-cost analysis would indicate that these technologies should not be adopted.

Many would view such a decision, which is based entirely on the efficiency criterion, as unacceptable:

- Compensation is likely to be only hypothetical and not real, making the discounting procedure meaningless on ethical grounds, since actual compensation is not likely to be paid.[8]

- The amount of money that most be invested to provide future compensation can be estimated only of the extent of future environmental damages can be accurately predicted, which is difficult to do in actual regulatory situations.

Thus, standard present value analysis is questionable as the sole basis for a decision when the public investments being evaluated involve intergenerational distributions of benefits and costs. This is not surprising, as it is not designed to evaluate the equitableness of different distributions of income. The same problem also may surface when evaluating short-term projects having significant distributional effects.

B. Evaluating Intergenerational Effects

No entirely satisfactory method exists for evaluating intergenerational effects. However, for analytical purposes, several alternative procedures may be helpful in portraying trade-offs in benefits and costs between generations. These include:

- Discounting benefits and costs at a lower social rate of discount, rather than at the rate of return on capital:

- Indicating the number of years until net undiscounted benefits become positive and the number of years and amounts by which they remain positive; and

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[7] Intergenerational equity consideration are most important (and thus should be analyzed most carefully) where irreversible environmental impacts appear likely.

[8] Future generations would, to some extent, benefit from a larger capital stock if the investment were made in productive assets rather than in environmental projects, Additionally, future generations are likely to be substantially better off than the current generations, if past trends in productivity growth continue.

- Directly comparing the benefits to future generations with the costs to the current generation.

These procedures do not themselves provide a means for determining how much weight should be attached to future environmental effects versus current compliance costs. However, they can more clearly indicate to decisions makers the trade-offs of benefits and costs between generations.