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BENEFIT-COST ANALYSIS OF ENVIRONMENTAL REGULATIONS

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I. Introduction

Benefit-cost analysis is an important perspective for evaluating proposed public expenditures. Its cornerstone, the principle of economic efficiency, states that projects should be undertaken only if benefits exceed costs. Morever, proposed projects or programs should be scaled such that incremental costs and incremental benefits are approximately in balance in order that net benefits are maximized. In benefit-cost analysis all consequences, both favorable and unfavorable, are converted to a common unit of measurement, most often dollars (although other measures such as lives saved or environmental quality could be used as well), so that the benefits and costs may be readily compared.

This paper provides an overview on the use of benefit-cost analysis in the design, implementation, and evaluation of environmental policies. Historically, the Environmental Protection Agency has devoted considerable time and resources to the measurement of costs, particularly industrial compliance costs. Recently, the EPA has begun to investigate seriously the benefits associated with individual regulatory actions. These efforts to improve benefit assessment represent an important step in determining the extent to which it is feasible to apply full benefit-cost analysis to a broad range of environmental programs.

As this paper demonstrates, assessment of the benefits and costs of environmental regulations is often a difficult task, complicated as it is by tremendous scientific uncertainty, problems in the allocation of benefits arising from groups of regulations covering the same medium (such as air or water), lack of proper units of observation, and overriding issues of equity. Because of these difficulties, benefit-cost analysis should not be an absolute requirement for evaluating environmental regulations. Indeed, when scientific uncertainty and related problems arise, the best strategy may be to use other complementary approaches in addition to or in place of benefit-cost analysis. In particular, the test of comparative cost-effectiveness can assure that environmental goals, even if selected in the absence of quantified benefit information, are achieved at something approaching least cost.

In sum, benefit-cost analysis is, in theory, the best single evaluation device for regulatory analysis. However, in the area of environmental policy, scientific uncertainties and other practical considerations make accurate benefit assessment a very difficult problem. Despite these difficulties, benefit-cost analysis will be useful in identifying issues that are of relevance to decision makers. And where benefit assessment is reasonably tractable, the results of such analyses will identify optimal targets (such as aggregate pollution levels) as well as those policy options which may most efficiently attain them. Thus, benefit-cost analysis should be viewed as a helpful tool but not the final rule by which decisions are made regarding environmental quality.

II. Benefits of Environmental Regulation

The principal efforts to evaluate environmental benefits to date have focused on program-wide analysis of air and water pollution. This section summarizes some of the findings.

A. Air Pollution Control Benefits

Over the last two decades, economists have attempted to quantify different categories of benefits, or costs reduced or avoided, as a result of air pollution. These benefits include improvements to human health, reduced soiling and cleaning costs, reduced materials damage, improved agricultural productivity, and increased aesthetics. In addition, the effects of air pollution on property values, which may overlap with some of these other benefits, has been analyzed. This section will provide a broad overview of the methodology and results of some of this research.

Human Health

Most of the economic research on the health benefits from reducing air pollution uses cross-sectional analysis to quantify the relationship between various air pollutants and different measures of human health (e.g., total mortality rates). As initially developed by Lave and Seskin, the procedure involves three steps. First, a "dose-response" relationship that relates different levels of air quality to human health is determined. Second, this relationship is used to predict how changes in air pollution will affect changes in health status. Third, the economic value of health benefits is estimated. Economic values have been based on one of these measures: (1) the value of changes in worker productivity; (2) the direct expenditures on medical care and services; or (3) the "willingness to pay" by people to reduce the risk of death or disease. Because the first two measures exclude pain and suffering to the individual and his family, they provide a lower bound estimate of true economic benefits. Using the first two measures of monetary value, Lave and Seskin estimated the national health benefits of reduced mortality and morbidity from air pollution (primary sulfates and particulates) to be about $16 billion in 1973 dollars.

Freeman (1979) attempted to adjust the $16 billion estimate to produce a more accurate measure of the actual benefits derived from air pollution control. He assumes: (i) a 20% reduction in air pollution levels has occurred since 1970; (ii) 1978 prices, income and population are applicable; and (iii) the benefits of air pollution control are received primarily by the urban U. S. population. With these adjustments, the benefits derived from the methodology of Lave and Seskin amount to \$4.7 billion. Using these assumptions, Freeman adjusted the results of two other similar studies, finding health benefits ranging from \$5.9 billion (Waddell, 1974) to \$6.4 billion (Heintz, Hershaft, and Horak, 1976).

Two additional studies have added significantly to the knowledge of health effects and the advancement of alternative methodologies. Liu and Yu (1976) and Crocker et. al. (1979) each estimated morbidity and mortality benefits separately. Liu and Yu found smaller morbidity benefits relative to Lave and Seskin, while Crocker found much larger morbidity effects. The Crocker study yielded a health benefits estimate very close to the \$16 billion of Lave and Seskin. This was due, however, to two offsetting effects: a lower estimated impact of pollution on mortality and a higher imputed value of life (i.e., willingness to pay for reducing risk to life). Thus, many questions remain about the level and value of the health benefits of reductions in air pollution. Better data and more careful model specification may answer some of these questions and reduce uncertainty.

<u>Soiling and Cleaning</u>

Liu and Yu (1976) provide estimates of the national benefits to households due to decreased soiling and resultant cleaning costs associated with the abatement of suspensed particulates. The dollar estimates were obtained by first testing the extent to which variations in total suspensed particulates (TSP) explain the variation in cleaning frequency. The additional cleaning tasks were then valued by an average unit cost and summed across the 168 Standard Metropolitan Statistical Areas with TSP readings in excess of 45 ug/m^3. Their estimated national benefit amounts to \$5.0 billion per year (1975 dollars). A study by Watson and Jaksch (1978) used a conceptually preferred method in which households react to different "prices" of cleanliness associated with varying TSP levels. They estimate that the primary TSP standards would yield a reduced soiling benefit of approximately \$2.6 billion.

<u>Vegetation</u>

Among the best attempts to estimate the effects of air pollution (in this case, photochemical oxidants) on vegetation, is the work of Heintz, Hershaft, and Horak (1976). They applied the results of a number of controlled field experiments on crop damage to those counties which were expected to have high oxidant readings. Their best estimate suggested a loss in crop production of roughly \$2.9 billion in 1973 dollars. Although there is some evidence that other forms of pollution, including acid rain, can affect vegetation, the scientific evidence at this point is too inconclusive for sound benefit estimation.

Aesthetics and Visibility

Some of the benefits of visibility and aesthetics may be measured through their impact on residential property values. This market data approach will be discussed later. Survey techniques may also be used to determine household willingness to pay for, and hence the value of, aesthetic improvements. This approach has most frequently been utilized for unique sites such as national parks and wilderness areas. A recent study by Brookshire, et al. (1979), however, was conducted in Los Angeles. Estimates obtained of the willingness to pay for improvements in urban air quality reveal that households would bid $29 per month in 1978 dollars for a 30% improvement in air quality.

Materials Damage

Research by Liu and Yu (1976), Heintz, Hershaft, and Horak (1976), and Waddell (1974) provide estimates of the effect of air pollution on the values of various materials. Liu and Yu, for example, apply evidence of physical dose-response relationships for metals, paints, rubber and textiles to estimates of national materials damage in order to determine the benefits of air pollution control. These benefits, adjusted by Freeman(1979), are approximately $2.9 billion 1978 dollars.

Property Values

Much research has been conducted to determine the extent to which residential property values may capture the values which households place on characteristics such as ambient air quality or proximity to parkland. By controlling for many differences in housing characteristics through multiple regression techniques, the premium placed on an additional unit of air quality (i.e., the marginal willingness to pay for that improvement in air quality) may be obtained.

However, there are two general problems with using this information to estimate national benefits. First, there is some disagreement on the theoretical validity of applying the marginal willingness to pay concept to estimates of the benefits of discrete changes in air quality. Second, there is concern that the property value measure of benefits may actually be double counting some of the benefits recorded in the studies mentioned above. For example, aesthetics, soiling and material damages, and short term health effects may be partially valued within residential property values. Thus, of the best point estimate of $2.7 billion in 1978 dollars, Freeman (1979) suggests that perhaps $.8 billion in property value benefits do not overlap with the other benefit estimates suggested above.

B. Water Pollution Benefits

For a variety of reasons, estimates of the various benefits of water pollution control are much more difficult to obtain than those arising from reductions in air pollution. For example, many indicators of water quality vary dramatically by location and time of year. In addition, there is still much scientific uncertainty about the actual effects of many water pollutants. Finally, the contribution of nonpoint sources of pollution to environmental damages are not well documented. Despite these problems, a number of studies have attempted to estimate the benefits of meeting water quality standards. These benefits can be classified in the following manner: (i) recreation, (ii) non-user benefits (amenity, aesthetic and ecological), (iii) diversionary uses (drinking water, treatment by municipalities and industries), and (iv) commercial fisheries.

Recreation

Research by Gramlich (1977) used a willingness to pay survey of households in the Charles River Basin in Massachusetts to estimate the benefits of obtaining swimmable water. After using the survey results in a multiple regression analysis, an average benefit of $32 per family was obtained. Assuming a similar willingness to pay for families across the U.S., national benefits amount to $2.2 billion per year in 1978 dollars. Walsh (1978) surveyed residents of the South Platte River Basin of Colorado where heavy metals are the major source of pollution. Recreational uses indicated a willingness to pay of $62 per year for water quality improvement. Finally, Bouwes and Schneider (1979) estimated a demand relationship for visits to a small lake in Wisconsin. This relationship depicts how a given group of people will change their usage of the site in response to changes in monetary travel costs. This function then approximates a "willingness to pay" for visits to the lake. The relationship also included a variable which reflected water quality. This approach, representing the most theoretically appropriate technique, was then used to estimate the impact on demand and the willingness to pay to prevent storm sewer pollution. The value of good water quality was estimated to be $.23 per visitor day. This relatively low value probably reflects the availability of close substitutes.

Non-User Benefits

As suggested above, non-user benefits are difficult to define and measure, and only very general estimations have been attempted. Both the property value and survey technique have been used. Heintz, Hershaft, and Horak (1976) and Walsh (1978) found a similar proportional relationship between non-user and recreational benefits, and the former applied a simple ratio to generate a non-user benefits estimate of $2.2 billion in 1978 dollars.

Diversionary Uses

Heintz, Hershaft, and Horak used sources that suggest that 40% of the "drinking water" pollutants were controlled at the source. Therefore, the best point estimate of the value of controlling waterborne contagious disease was $.9 billion per year in 1978 dollars. This figure may increase dramatically as new drinking water standards come into effect. The authors also use data from other EPA studies to estimate the level of disease and death caused by poor drinking water quality. The best estimate of the benefits of preventing waterborne contagious disease is about $1.0 billion per year in 1978 dollars. Unfortunately, few estimates of the benefits of improved health from reduced chemical contamination have been attempted. A study by Harris, Page, and Reiches (1977) found a statistical relationship between cancer mortality and polluted drinking water.

Commercial Fisheries

Bell and Canterbery (1975) developed a model which first estimated the impact of water quality on biological productivity. The changes in productivity were then used to predict the change in prices and quantities of marine fisheries. The estimated benefit to commercial fisheries of achieving the 1985 water quality objectives was approximately $.7 billion in 1978 dollars.

In sum, a number of benefit studies have been completed on air and water pollution. Many have some conceptual and/or empirical difficulty and few are tied directly to regulations.

III. The Limitations of Benefit-Cost Analysis of Environmental Regulating

Some critics of environmental regulation argue that cost-benefit analysis should be required as a prerequisite to environmental regulation. It is important to consider some of the difficulties and limitations of this conceptually attractive approach before adopting it wholeheartedly. In reviewing these problem areas it is important to recognize that decision mechanisms other than benefit-cost analysis are also plagued with serious methodological problems.

The area that has been singled out by the EPA Science Advisory Board as most damaging to the benefit-cost mode of analysis for health, safety, and environmental regulations is the paucity of hard scientific evidence on most of the substances EPA is regulating. Inadequate evidence arises from uncertainty and difficulties in measuring the probable benefits. Cause and effect, for example, is very hard to demonstrate due to time lag problems, confounding causal factors and imperfect or nonexistent data. For example, cancer has a ten to forty year latency period, complicating determinations of adverse effects before widespread harm occurs.

Pollutant diffusion and transport represents another area of inadequate information. Typically, EPA must act while uncertainty exists regarding the magnititude and location of various pollutants that are introduced into the environment and the physical and chemical mixing of these pollutants. Modeling is complicated by weather patterns, by mountains, bodies of water, and other natural features that affect pollutant dispersion. Uncertainties about the contribution of various sources to overall pollutant loadings lead to controversy over which emissions should be controlled and how much control is necessary.

The limited knowledge of dose-response relationships also hinders benefit estimation. Since testing on humans is unacceptable, animals with metabolic processes similar to humans are used to assess carcinogenicity. To make sample sizes manageable for animal experimentation, doses orders of magnitudes greater than those humans face are normally used. Thus, it is not clear what relevance carcinogenicity at such high levels would have to low doses, much less whether the extrapolation to humans can be made. However, while a substance may be carcinogenic at high doses but not at low doses, the reverse seems unlikely. Therefore, this method minimizes the chances of falsely classifying a substance as non-carcinogenic. Such a safe and conservative approach may not be of much relevance, though, if the aim of regulation is to protect sensitive subpopulations.

The response of individuals to pollution is another area of uncertainty, when people take action to mitigate the effects of pollution, such as sleeping more during severe smog incidents or drinking bottled water; the actual effects may not be as bad as presumed in scientific studies of doses and responses.

Even when the scientific data base does not permit accurate estimation of the human health effects from a substance being considered for regulatory action, there exist a number of methods for making informed guesses as to effects. One of the more appealing is the use of subjective probability assessments provided by experts on the issue. In such a procedure, the several steps from release and exposure to ultimate health effects are carefully described. A panel of experts is convened to evaluate the parameters for each step. The resulting range of opinion can be used both as a measure of the central tendency of expert opinion and as an index of the dispersion of uncertainty inherent in that body of opinion.

When scientific data are better, a number of other approaches may be used. When data permit it, multiple regression analysis can be used to assess the possible long-run human effects from exposure to a suspect substance, using exposures to suspect substances to explain possible adverse health effects. In such an assessment, it is critical to control for other variables that may also affect health -- such as income, occupation, age, smoking, eating, and drinking habits of the population. Most criticisms of the epidemiological approach, especially from the scientific community, center around the inadequacy of these control variables and the lack of well-formulated scientific hypotheses on causes of illness, making consistent evaluation of the data difficult. These criticisms can be overcome in long-term studies that compare exposed and non-exposed control groups, but doses of harmful substances ordinarily are limited to normal background or environmental levels. While definite limitations exist for epidemiological studies, there remains the fact that epidemiological approaches can provide useful if imprecise information on the linkages between past exposure and current health effects.

A related approach termed an episodic study can be used to measure short-run health impacts from current exposures to a substance. In episodic studies multiple regression analysis may be used to explain hospital admissions, for example, with data on current or recent population exposures to various air pollutants. Such approaches reveal little or nothing about long-run impacts, but they do reveal a wealth of information on short-run morbidity impacts. These latter impacts may be just as interesting to the regulatory agencies as are chronic morbidity and mortality.

Just as significant uncertainty may be associated with benefit estimates, the costs associated with a regulation may be difficult to quantify accurately. The difficulties are due to the variations in the analytical assumptions concerning the effectiveness of regulations. The baseline chosen from which to make a comparison will have an effect on the magnitude of the estimate. Generally, the baseline chosen is "no action", ignoring the fact that changes may occur in the absence of regulation through other mechanisms such as liability suits or union bargaining for protection from hazards. In addition, 100 percent compliance is usually assumed though it may take time for firms to take action. Perhaps more importantly, though, is the difficulty of predicting the actual costs that will be incurred by an industry given shifts in the utilization of resources and technologies within a firm that occur after a regulation is in place. These difficulties are compounded by the fact that agencies are dependent upon the firms for information.

Benefit-cost analysis also suffers from inadequate economic models and techniques. A controversial issue is the assignment of values to non-priced outcomes, especially morbidity and mortality. This issue is skirted in cost-effectiveness and risk-benefit analysis, but benefit-cost analysis must value everything in dollar terms or some other common unit of measurement. The two accepted approaches are "willingness to pay" and "revealed preference." "Willingness to pay" attempts to determine what people think the avoidance of an outcome is worth by asking them to choose from a set of options. Aside from the obvious problem of getting people to respond truthfully, people tend to underestimate the amount of risk involved. Thus, the indicated willingness to pay is usually an underestimate.

"Revealed preference" tries to avoid these problems and looks instead at choices people have already made. Prices can be extrapolated from these choices by measuring, for example, the variation in real estate prices according to air quality or wage premimums commanded by workers in risky jobs. However, again, people underestimating the risk they face is a problem. There are questions of how much free choice people actually have in choosing where to live or work as well as their knowledge of exposure and effects. Thus, these studies cannot give an exact answer to the values placed on items protected by regulations, but they are still useful for giving an idea of the ranges into which these values might fall.

Economic models and techniques are also inadequate for comparing benefits and costs accruing at different times, particularly where health and mortality are involved. A dollar to be spent in the future is generally agreed to be worth less than one spent today, but no consensus exists on the appropriate discount rate to apply to outcomes such as human fatalities. In theory, income transfers can always be arranged to compensate for adverse distributional impacts. But when the potential adverse outcomes in the future are large, as may be the case for irreversible environmental effects, it is impossible for current beneficiaries to compensate future losers. These issues, then, are best left as value judgments to be made by the decision maker.

Limitations to the general applicability of benefit-cost analysis to environmental regulations certainly exist. In some carefully selected instances, the state of the art is such that a benefit-cost assessment will provide clear guidance to decision makers. As the next section points out, however, there will always be many other cases where it is still premature or inappropriate to rely on benefit-cost analysis as the definitive decision criterion.

IV. What Can and Cannot Be Done with Benefit-Cost Analysis

In order to perform a complete benefit-cost analysis of a proposed public expenditure or regulatory action, all favorable and unfavorable outcomes must be (i) identified, (ii) quantified, and (iii) converted to a common measure. These steps represent formidable barriers to the early and successful application of benefit-cost analysis to many areas of environmental policy. The previous sections reviewed many of these obstacles in some detail. Our goal here is to clarify what use can now be made of benefit-cost analysis in light of these difficulties.

Proposed environmental actions are always accompanied by some evidence from the health or environmental sciences that substances may cause harm to humans and the environment. Many of the criticisms of benefit-cost approaches utimately can be traced to weak scientific evidence on exposures and subsequent health and ecological impacts. Of course, the same scientific research that would strengthen the case for regulating an activity will also go a long way to support better benefit and cost estimates from the economist.

Any form of regulatory analysis is only as sound as the scientific evidence regarding the types and levels of impacts which the policy is expected to generate. When these outcomes are not predicted with a reasonable amount of confidence, then benefit-cost studies can be invalid and potentially misleading. But where all the outcomes of an environmental program may be identified and quantified with some degree of scientific rigor, then benefit-cost analysis should be superior to other forms of regulatory analysis in determining (i) whether or not the policy is economically justified and (ii) how stringent the regulations should be.

When overriding issues of equity are present, or when it is impossible to attribute benefits to a single regulation where several regulations affect environmental quality of a medium, benefit-cost analysis may be less useful as a decision tool than other techniques of evaluation. Ordinarily, though, benefit and cost information should be a highly useful input to decision makers. Better decisions are unlikely to be made by ignoring benefits and costs; at the same time rigid adherence to its calculus can produce poor decisions if the benefit and cost information is incomplete or inaccurate. Thus, benefit-cost analysis should be viewed as a tool but not the final rule by which decisions are made regarding environmental quality. The ultimate use of that tool should be carefully evaluated in each case based on the completeness and accuracy of the available information.

V. Use of Benefit-Cost Analysis at EPA

EPA's use of benefit-cost approaches to analyze existing programs and proposed regulatory actions historically has followed closely its mandate from Congress. Relatively few of the EPA governing statutes specify that careful comparisons be made of regulatory costs and benefits. Rather, EPA is typically told either to implement best available technologies, or to reduce pollution to the maximum extent feasible or to prevent adverse health impacts. In the instances where comparisons of of costs and benefits are required, notably under legislation governing toxic substances and pesticides, EPA is asked to compare health and environmental risks with the costs of reducing pollution. This is not a true benefit-cost comparison but it comes closer than other forms of analysis. Because most other governing statutes do not require such comparisons, other program offices of EPA normally have not attempted to measure their benefits of their individual regulations.

The Office of Research and Development (ORD) for some time has had a program to improve methods for benefit assessment and has supported research on the economic benefits of existing regulations since 1971. Typically, these assessments have covered all regulations on one of two media: air and water. Many of the environmental benefit studies noted earlier in this paper were funded through ORD. Its current research concentrates on improving the estimates of what are believed to be major benefits of air and water pollution control, i.e., health and visibility benefits in the case of air and recreation benefits for water.

Recently several EPA program offices have evinced a new interest in assessing the benefits of proposed regulatory action. The Office of Air Quality Planning and Standards, in Durham, North Carolina, has made the most progress to date. It has initiated studies on the benefits and costs of a number of proposed regulatory actions, including visibility protection, as well as some proposed secondary ambient air quality standards, and new source performance standards.

In 1979, the Office of Planning and Management established the Benefits Staff in the Economics Analysis Division to accelerate EPA's development and use of benefits information. The Benefits Staff coordinates activities on benefit and benefit-cost analysis within the Agency and is conducting on an experimental basis a series of protype benefit analyses of proposed regulations side by side with cost and impact studies done during rule making. The Benefits Staff recently completed a benefit-cost study of a proposed regulation on corrosive water. Studies in progress include an assessment of the state of the art of benefit analysis, an analysis of pesticide testing rules, a review of stream use criteria, an analysis of a proposed regulation on volatile organic chemicals in drinking water, an investigation of human morbidity from air pollution, and assessments of the benefits of reducing acid rain and protecting groundwater. This pilot project will help to delineate further the value to environmental managers of benefit and cost information on specific regulatory initiatives.

VI. Pragmatic Alternatives to Full Benefit-Cost Analysis

Ethical, political, and methodological considerations have often made quantitative benefit assessment problematic, especially with regard to environmental policies. Subsequently, alternate means have been sought with which to design and evaluate regulatory programs in order to insure that they yield economically efficient solutions. The two prominent alternatives to full benefit-cost analysis are (1) implicit benefit valuation, and (2) cost-effectiveness studies. Both of these approaches require full analysis of the costs of relevant policy options, but they avoid the quantification problem with regard to those benefits which are generally regarded as intangible.

A. Implicit Valuation of Benefits

Full benefit-cost analysis requires that dollar values be placed on items such as the lives expected to be saved by a regulation so that the total dollar benefits may be compared to the costs imposed. Rather than explicitly assigning dollar values to human lives and other non-market commodities, one may instead assign such values implicitly through policy decisions.

Implicit valuation is accomplished by calculating the amount by which a given program's costs exceed its market-valued benefits, and then comparing the remaining "excess costs" to the intangible benefits. If policy makers ultimately decide that the project at hand is warranted, then they have implicitly placed a value on the intangible benefits equal to at least the excess costs. Alternatively, if the project is rejected, then those benefits will have an implicitly assigned value of less than the stated excess costs. For example, consider a program expected to cost $10,000,000 while yielding $9,000,000 in measured benefits and, in addition, also eliminating five cancer deaths. Such a program would cost $200,000 per life saved, and if the policy were enacted, this would indicate an implicit value of life of at least that amount. This approach avoids the methodological problems of valuing life in dollar terms but gives the decision maker a useful perspective on the implications of a decision. Many decision makers who are reluctant to assign any particular value to a life will not hesitate to make a choice if told that it implies a valuation of $100 a life or $5 billion a life.

Implicit valuation can be applied to any type of program benefit for which monetary quantification is infeasible or undesirable. The resulting implicit values, or cost per unit of intangible benefit, may then be used to rank projects according to their relative efficiency (providing these benefits are of the same type). A policy which costs less per life saved than do all others would be considered cost-effective, meaning that if a given total expenditure were to be devoted to saving lives, spending it all on that program would maximize the total number of lives saved.

A major disadvantage to the implicit valuation approach is that it is not readily applicable to programs yielding more than one type of intangible benefit, nor does it provide a means with which to compare and rank projects which yield different types of intangible benefits. For example, consider a hypothetical program with one million dollars in costs in excess of quantified benefits, but which is also expected to save five lives plus prevent twenty cases of total sight loss. What is the cost per life saved in this program? What is the cost per case of visual impairment avoided? Is this project more efficient (cost-effective) than one costing one million dollars, yielding only four lives saved, but which would prevent thirty cases of sight loss? In order to answer these questions, one would require a means of converting the benefits of sight preservation into units compatible with life saving. If the common denominator selected were dollars, then one would have reverted to standard cost-benefit analysis.

In sum, the major advantage of the implicit valuation approach is that it obscures the sensitive issue of placing explicit dollar values on saving human lives, preserving endangered species, and other such events. It also permits cost-effectiveness comparisons across similar programs. Nonetheless, all intangibles utimately are assigned dollar values, albeit implicitly, when projects are rejected or selected for implementation. And, implicit valuation is incapable of providing a clear ranking of alternate projects where multiple types of non-market valued benefits are generated.

B. Comparative Cost-Effectiveness

The value of a full cost-benefit analysis is that it not only generates an efficiency ranking of projects, but it also reveals which of these projects are and are not efficient. A cost-effectivess analysis begins with the assumption that various options for attaining a stated objective are absolutely efficient, and the approach concentrates on the problem of determining the relative efficiency of those options.

- Banking is an attempt to facilitate the search for offsets by new firms while providing incentives for existing polluters to increase abatement now rather than waiting for potential entrants to stimulate the demand for offsets. Bankers or brokers centralize offset trades across firms, and also across time. The addition of such intermediaries assists in the creation of a uniform and visible market for trading pollution rights, and as such helps to establish a clear price signal which polluters will use as the basis for their abatement decisions. An existing firm will sell to a broker that portion of its emission privileges for which abatement costs are less than the established price. The bank can then sell this pollution privilege to anyone for whom the value of increased emissions exceeds the selling price. Thereby, the total amount of permitted emissions may be allocated efficiently between both existing and potential polluters.

VII. Conclusions and Recommendations

Environmental regulations should be imposed on society only if the benefits of these requirements exceed the costs of meeting them. The review and synthesis by Freeman suggested that the most likely value of annual air pollution control benefits achieved by regulations in effect in 1978 was about $21.4 billion. EPA estimated that annual costs of compliance with these regulations was approximately $16.6 billion that year. Efforts to compare the benefits and costs of existing water pollution control regulations are complicated by the fact that significant benefits will not accrue until stricter standards come into effect in the mid-1980s. With this in mind, one can compare Freeman's 1985 estimate of $12.3 billion for water pollution benefits (for all regulations except those covering toxics and heavy metals) with the EPA cost estimate for the mid-1980s of $20.4 billion. The research used to generate these estimates is of varying quality and acceptability; thus the results should be interpreted with caution. Moreover, balancing total costs and benefits would still not assure that incremental costs and benefits are balanced, a necessary condition for maximizing net social benefits.

The benefit and cost figures provided above are not derived from analyses of single regulations, rather they are estimates of the aggregate impact of all air and water pollution abatement requirements combined. To date, little attention has been focused on assessing the benefits of individual regulations in order to compare them to the costs they impose. Such analyses, if properly conducted, would be invaluable in designing standards that would maximize social welfare. EPA currently performs risk-benefit studies, as mandated, for pesticides and toxic substances. However, these efforts do not provide actual benefit-cost comparisons. The Agency also performs extensive analyses of the costs of its individual regulations. Benefit assessment has been more problematic and has thus received less attention. However, EPA has recently undertaken to review and improve methods of benefit estimation and started an experimental program to see if the approach can be applied to specific regulatory decisions.

In order to perform a complete benefit-cost analysis of a regulatory action, all of its outcomes must be (i) identified, (ii) quantified, and (iii) converted to a common measure - usually dollars. These steps represent formidable barriers to the successful application of benefit-cost analysis to many areas of environmental policy. Scientific and methodological uncertainties make benefit assessment especially difficult. For example, the type and level of human health effects to be avoided through a proposed regulation must be predicted, and then valued in dollar terms. Such analyses must often be based upon tenuous scientific risk assessments, extrapolated from animal experiments. Further, the explicit valuation of events such as illnesses and deaths avoided is a politically and morally sensitive issue, not to mention methodologically difficult.

Requiring a benefit-cost analysis of every environmental regulation, though conceptually attractive, would effectively block future regulations in many areas unjustifiably due to limitations in the state-of-the-art in benefits assessment. To conduct such analyses properly would require, for many programs, scientific and economic knowledge that is not currently available. Until such uncertainties can be resolved, benefit-cost calculations will often be unreliable and erroneous, potentially leading to undesirable policy choices. Thus benefit-cost analysis should be viewed as a useful tool, but not a required final rule, by which decisions are made concerning environmental quality. And comparative cost-effectiveness and similar methods should be viewed as essential, complementary tools for the design and evaluation of regulatory policy options.

References

1. Bell, Frederick W., and E. Ray Canterbery, An Assessment of The Economic Benefits Which Will Accrue to Commercial and Recreational Fisheries from Incremental Improvements in the Quality of Coastal Waters, Florida State Univ, 1975.

2. Brookshire, David S., Ralph C. d'Arge, William Schulze, and Mark Thayer, Methods Development for Assessing Tradeoffs in Environmental Management, Volume II, Experiments in Valuing Nonmarket Goods, Environmental Protection Agency, Washington, 1979.

3. Bouwes, Nicolaas W., and Robert Schneider, "Procedures in Estimating Benefits of Water Quality Change," American Journal of Agricultural Economics, 61, No. 3, (August 1979), 535-39.

4. Crocker, Thomas D., William Schulze, Shaul Ben-David, and Allen V. Kneese, Methods Development for Assessing Air Pollution Control Benefits, Environmental Protection Agency, Washington, 1979.

5. Freeman, A. Myrick, The Benefits of Air and Water Pollution Control: A Review and Synthesis of Recent Estimates, prepared for the Council on Environmental Quality, 1979.

6. Gramlich, Frederick W., "The Demand for Clean Water: The Case of the Charles River," National Tax Journal, 30, No. 2 (June 1977), 188-94.

7. Heintz, H. T., A. Hershaft, and G. C. Horak, National Damages of Air and Water Pollution, a report submitted to the Environmental Protection Agency, 1976.

8. Lave, Lester B., and Eugene P. Seskin, Air Pollution and Human Health, Johns Hopkins University Press, Baltimore, 1977.

9. Liu, Ben-Chieh, and Eden S. Yu, Physical and Economic Damage Functions for Air Pollutants by Receptor, Environmental Protection Agency, Corvallis, 1976.

10. Waddell, Thomas G., The Economic Damages of Air Pollution, Environmental Protection Agency, 1974.

11. Walsh, Richard G., et al., Option Values, Preservation Values, and Recreational Benefits of Improved Water Quality: A Case Study of the South Platte River Basin, Colorado, Environmental Protection Agency, Research Triangle Park, 1978.

12. Watson, William and John Jaksch, "Household Cleaning Cost and Air Pollution Control," 1979.