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The fundamental principles of cost-benefit analysis

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Abstract. Cost-benefit analysis is reducible to several major principles that collectively describe the assumption base, objectives, analytical tasks, and merits of this important project assessment methodology. Here, these principles are identified and described using basic economic terms and concepts. The deficiencies of cost-benefit analysis also emerge from these principles, and these issues are also observed in this article. Further discussion investigates high-profile issues in the economic assessment of environmental affects and the economic effects on sectors linked to water-project-impacted sectors.

1. Introduction

Opposition among the stakeholders of proposed public projects can lead to confusion about what counts in the economic appraisal of such projects and how counted things are to be economically weighted. This confusion expands the latitude available to juxtaposed stakeholders and widens the breaches over which they contest. The result may be wasted resources and expensive delays for project decisions. Sometimes this problem seems to be confounded by economic analysts who, perhaps in their eagerness to assuage clients, quantify net benefits of dubious origin. Nonspecialists are undoubtedly perplexed by the array of benefits and costs that are claimed; yet better understanding can be obtained only by consulting sizable texts containing considerable notation and theory.

The primary objective of this paper is to clarify these debates by synthesizing modern economic wisdom into the sharpest possible perspective on the proper conduct of cost-benefit analysis (CBA). The presentation strives to rely on basic economic concepts (such as supply and demand functions).

In terms of project analysis, no method other than CBA enjoys as widespread application or analytical power. Cost-benefit analysis has long served as an institutionalized component of federal decision making for water projects. In addition, the application of cost-benefit analysis to federal policy has been expanded in recent years to include regulatory rule making of many types, providing additional evidence of CBA's usefulness and power. Indeed, the notion that public policy, like public projects, should offer benefits in excess of costs has been embraced by recent Presidential administrations. Executive Orders 12291 (*Federal Register*, *46*, pp. 13,193–13,198, February 19, 1981) and 12866 (*Federal Register*, *58*(190), pp. 51,735–51,744, October 4, 1993) require a formal consideration of benefits and costs for proposed regulations by federal agencies. This is not to say that the methodology is without shortcomings, and the second objective of this paper is to identify where important problems may lie. A third objective is to indicate CBA's unresolved and evolving issues, matters for which ongoing investigations may lead to further refinements in the technique.

To accomplish these three tasks expeditiously, we begin by reviewing the cost-benefit methodology, proceeding to identify and highlight its central principle. Some additional principles are then enumerated and identified. A thesis of this paper is that the practice of cost-benefit analysis condenses to these eight guiding principles and that close attention to these directives resolves many issues that might arise in the performance of project evaluations. Moreover, it is argued that any flaws of cost-benefit analysis are necessarily rooted in these principles as well. Any other deficiencies are to be regarded as the result of incomplete or misguided analysis rather than the result of a faulty methodology.

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2. Foundations of Cost-Benefit Analysis

Cost-benefit analysis is founded on a branch of economics known as welfare economics. As differentiated from the economic theory of decision making by individual consumers and enterprise owners, welfare economics emphasizes public decisions that impact the economic interests of more than one person [*Boadway and Bruce*, 1984; *Graaff*, 1957]. That is, what social choices are "best" when the available choices will affect the welfare of different people differently, or even oppositely? Welfare economics is a relatively young social science, having made most of its advances during the past century. These accomplishments have established progressively greater rigor for understanding the implications of social choice. Moreover, welfare economists have devoted significant effort to formulating and examining public decision criteria, such as CBA.

In the United States during the 1900s, the relevance of welfare economics has been intimately tied to the desire for formal rules for deciding among alternative federal water projects. CBA was arguably pioneered in the pursuit of a better framework for resolving decisions about federal water projects. Questions like "Which projects should be built?" and "How large should a particular project be?" have dominated debate and have captured the attentions of economic analysts and theorists, agency personnel, and decision makers. The current state of CBA, obtained primarily during the past 50 years, is built upon the contributions of these people.

As a subdiscipline within the growing science of economics, CBA continues to evolve. Difficult questions remain unanswered, and the methodological work continues. As a contemporary example, the valuation of environmental gains and losses represents a major thrust by economists to contribute more refined information to public decision-making processes. As this work matures and becomes proven, the practice of CBA is being reformed to accommodate new procedures.

3. CBA on Paper: "Principles and Guidelines"

For the past few decades, interest in the consistent and uniform application of CBA for water projects has resulted in rules for conducting CBA's for proposed federal water projects [*Hanley and Spash*, 1993]. The current regulations, commonly called the "Principles and Guidelines" (P&G) were published in 1983 in the *Federal Register* [*U.S. Water Resources Council*, 1983]. These regulations specify what project impacts are to be evaluated, and in most cases, they suggest assessment methodologies. The primary audience for these mandates are planning personnel of the water project agencies, chiefly the U.S. Army Corps of Engineers and the U.S. Bureau of Reclamation, but they also apply to water development efforts of the Natural Resources Conservation Service and the Tennessee Valley Authority. While the P&G should not be equated to CBA, pivotal portions of the P&G relating to the national economic development account constitute a noteworthy, institutionalized example of CBA.

The P&G rules are revised from time to time. In addition to updating previous rules to take advantage of new methodological advances, motivation for a revision can sometimes come from changes in political preferences, which can emphasize different priorities. For example, the 1983 P&G, established by the Reagan Administration, supplanted the rules set in place 3 years earlier by the Carter Administration. Relative to the Carter rules, the 1983 P&G acted to deemphasize the standing of environmental costs and benefits that might be associated with a water project.

Today, the 1983 P&G are supported by a host of technical manuals which set forth agency interpretations of the P&G. The U.S. Army Corps of Engineers maintains comprehensive documentation of methods and data sources for conducting CBA according to the precepts established by the P&G. Much of this information is either contained in a publication entitled *Guidance for Conducting Civil Works Planning Studies* or in the many reports of the Corps of Engineers's Institute for Water Resources [*U.S. Army Corps of Engineers*, 1990; *Yoe*, 1995].

4. Central Objective

The P&G, together with supporting documents, specifies the federal practice of CBA in considerable detail. Careful inspection of the economic analysis sections of the P&G finds that these regulations represent good CBA methodology in most, but not all, areas. While the particulars of the P&G and its predecessors have changed over time, at the heart of each set of these regulations lies a very stable concept. Here, it is referred to both as "Principle 1" and as the "central objective." The national economic development account of the P&G share this concept with CBA. It is as follows:

Principle 1

Projects are deemed economically acceptable "... if the benefits to whomsoever they accrue are in excess of the estimated costs ...."

This language first appeared in the Flood Control Act of 1936, but it has since been used many times because it captures well the spirit of a crucial CBA doctrine. Taken literally, it implies that all benefits are to be reduced to monetary units and summed, and all costs are similarly reduced and summed. No attention to the distribution of these benefits and costs across different socioeconomic classes, regions, commercial or manufacturing classifications, or any other groupings of people or industry is given. If the total benefits exceed the total costs, then the proposed project is regarded as acceptable. This does not imply, however, that the project will be constructed. Financial resources for construction must still be found for the project in the political process, and there may be other acceptable projects which are politically preferred.

In the jargon of economics, the comparison of summed benefits to summed costs is referred to as a "compensation test." This nomenclature derives from the following query: Could the beneficiaries of a project hypothetically compensate those people harmed by the project and still have some remaining benefits? A "yes" answer is regarded as necessary for project approval [*Gittinger*, 1982; *Hanley and Spash*, 1993; *Harberger*, 1971; *Mishan*, 1976; *Sassone and Schaffer*, 1978; *Schmid*, 1989]. There are many theoretically conceivable compensation tests, which differ in terms of the starting positions from which gains and losses are evaluated [*Griffin*, 1995]. However, it has become standard in CBA to measure benefits and costs using the preproject conditions of all people as the starting position. Thus benefits are regularly measured as the accumulated "willingness to pay" of beneficiaries for the project, and costs are measured as the accumulated "willingness to accept" compensation by losing parties in the project.

Compensation tests are not equivalent to the mainstream economic efficiency concept of Pareto optimality [*Griffin*, 1995], and they consequently pose ethical worries for welfare economists due to the hypothetical nature of the tests. Some groups of people will inevitably experience losses as a result of a project's construction. For a single project this consequence may not be very troublesome for society as a whole. On the other hand, it may be contentious if losses are incurred by people who are already disadvantaged in some manner (e.g., by poverty). Alternatively, if there is a systematic bias across all water projects toward imposing losses on specific social groups, then the ethical palatability of CBA is also weakened. Furthermore, compensation tests can be technically troubling in two ways. First, a compensation test criterion may yield circular advice: following the adoption of a public policy passing the test, the complete reversal of the policy may also pass the test [*Boadway and Bruce*, 1984]. Second, the economic measures calculated to perform the test may be logically necessary, yet not sufficient, for guaranteeing passage of a compensation test [*Blackorby and Donaldson*, 1990].

In its present state, CBA sets aside these concerns and focuses heavily on the total willingness to pay of beneficiaries vis-à-vis the losers' total willingness to accept compensation. This emphasis is not without support, however. J. Hicks, one of welfare economics' major contributors, has argued that repeated use of the central objective to decide all policy and project proposals tends to benefit everybody over time [*Griffin*, 1995]. This perspective has been implicitly embraced by the P&G's designers and its practitioners. On the other hand, it represents a possible deficiency of general CBA practices in selected circumstances. To the extent that a particular water project may harm a disadvantaged group (such as poor tenants occupying land to be inundated by a water project) or to the extent that all water projects may systematically harm a group of people (such as dryland farmers or typical taxpayers), Principle 1 opens CBA to criticism.

Another criticism sometimes leveled by noneconomists against CBA's central principle is actually attributable to economics generally. The economic perspective is that the only welfare changes that count are those experienced by humans and that all projects impacts felt by humans are welfare changes. In other words, economics and CBA are decidedly anthropocentric: nonhuman life forms are valued only to the extent that humans experience gains or losses. However, critics should be mindful that all humanly endured environmental impacts on other life forms do constitute welfare changes and are not ignored in CBA. For example, when a public project enhances the survivability of a threatened species, the added satisfaction of caring people counts as a project benefit.

5. Additional Principles of CBA

Welfare economics lays down certain principles, in addition to the central objective noted above, which are paramount in the conduct of CBA. Like the central objective, these principles may be accompanied by problems. All of the principles discussed below are fundamental to recommended practices for CBA. This does not imply that they have been completely built into the P&G, but the remainder of this paper departs from the P&G to focus upon CBA generally. For each tenet, a statement of meaning is provided, and the underlying rationalization of the tenet is discussed. As appropriate, additional details and examples are provided, and shortcomings are observed.

Principle 2

Welfare changes pertain to differences between with- and without-project scenarios.

Project-associated welfare changes are benchmarked against the conditions that are expected in the absence of the project. That is, all welfare impacts are obtained by contrasting with-project conditions to without-project conditions. Both benefit and cost measures are computed in this way. In the discussion that follows, change notation such as Δx will refer to a calculated difference between the x that occurs with the project and the x that occurs without it. That is, $\Delta x = x_{\text{with}} - x_{\text{without}}$.

Because individual and social conditions are not constant during the time span during which a project would operate, before-project and after-project conditions do not suffice as substitutes for without-project and with-project conditions [*Young*, 1996]. Consequently, projections are required for establishing without-project conditions just as they are for with-project conditions.

The necessity of conducting projections in CBA introduces possible errors of many kinds. However, the inevitability of mistakes does not dislodge society's need for a reasoned inquiry of proposed projects. Analytical approaches are available for considering the influence of potentially faulty projections on CBA results, and it is advisable for analysts to employ these techniques. The primary methods in current use involve various types of sensitivity analysis [*Hanley and Spash*, 1993; *Sassone and Schaffer*, 1978]. The common element of these methods is that expected project outcomes are varied across reasonable ranges to explore the implications upon the results of the CBA.

Principle 3

Cost measurement is founded on social opportunity costs.

In one sense, cost assessment is methodologically equivalent to benefit assessment except that goods are being used rather than produced. Hence the procedures that will be highlighted for principles 4 and 5 are also applicable to cost evaluations. In another sense, cost evaluation is often simplified. Whereas public water projects may include the production of public goods (such as flood control, recreation, and navigation) that are only weakly provided by private enterprises, the inputs to these public projects are commonly offered in markets and used in a much broader array of economic activities. That is, the concrete, labor, energy, steel, etc., that go into the construction and operation of a public project can often be purchased in the marketplace from suppliers at the suppliers' willingness to accept compensation. In many of these instances, market price serves as a good indicator of the value society places on these resources, so $P\Delta I$, where P is the price of any input and ΔI is the amount of the input used by a project, can estimate project costs.

While using price as the measure of a commodity's social value is practical in many instances, analysts must always be mindful that CBA requires social values because the essence of CBA is to gauge the attractiveness of a project to society. The operational requirement is that goods must be valued at their "social opportunity cost." Price does not always coincide with social opportunity cost [*Pearce and Warford*, 1993]. For example, in a region of high unemployment, the social opportunity cost of hiring certain workers may be small because they would be unemployed in the absence of the project. Here the wages to be received by such workers overstate their opportunity cost. As an opposite example, the price of fuel used during project construction excludes the environmental costs associated with energy production (acid deposition, carbon emissions). In this example, price may be too low for use in a social evaluation tool such as CBA.

Principle 4

Producer benefits are to be measured as producer surplus changes.

In general, water projects enhance the availability of water-dependent goods such as drinking water, transportation, and hydropower. In cases where these additional goods are used by firms in production activities, the net income of these firms can be increased. In these situations the added net income of businesses is attributable to the project and is therefore a benefit of the project. To employ a navigation project example, a deeper canal can increase the profits of a tug operator who is a direct user of the canal. This increase in profits might be the result of lowered operation costs and/or an increase in the quantity of transported materials. In either case, we have a project benefit experienced by tug operators, who would be willing to pay as much as their profit increase to acquire this canal improvement.

Figure 1 contains a common depiction of direct benefit assessment in a situation where the availability of a production input or service, such as canal depth, has been enhanced by a project. Prior to the project, Q_1 units of the input are available. After the project, Q_2 units are available. The curve D is total demand for the good, and this demand is illustrated as a function of the good's price, which is measured on the vertical axis. The fact that this good may not be actually exchanged in the marketplace is irrelevant, theorywise, but market trading does assist application of this theory. This is true because market data can enable the statistical estimation of D, which is pivotal in performing welfare analysis.

In valuing ΔQ, the increase in Q, it is noteworthy that demand for Q is derived from the demand entrepreneurs face

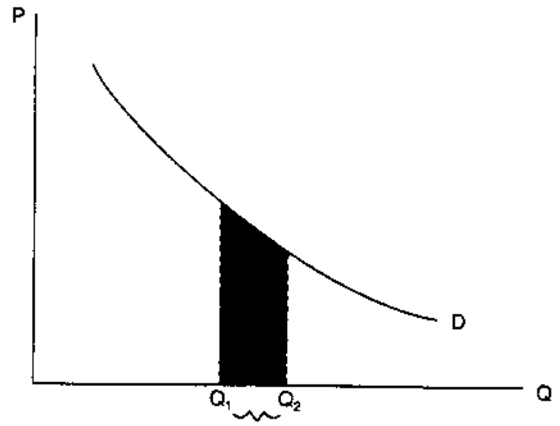

Figure 1. Willingness to pay for a quantity increase.

for the goods they produce. The curve D is the mathematical product of two variables: the value of the goods produced with Q and the marginal product of Q in the production of these goods. D is negatively sloped primarily because of the declining marginal productivity of Q in production. Owing to the construction of D, which is predicated on the economically optimal use of Q, any single point on the demand curve tells us the incremental value of that level of Q. Using integral calculus, the shaded area of Figure 1 constitutes the total value of ΔQ to its immediate users. This shaded area is the willingness to pay [*Pearce*, 1983], and it is also the change in producer surplus if the good Q is unpriced (free). More generally, producer surplus is equal to willingness to pay less actual payments made for Q. When quantity changes such as ΔQ occur for priced goods (as is typical), the change in producer surplus is the appropriate measure of benefits experienced by Q users.

The trapezoidal change in producer surplus area depicted in Figure 1 can be approximated by the rectangular area $P\Delta Q$ where P is given by the height of the demand curve evaluated between Q_1 and Q_2, inclusively. The approximation is particularly good when ΔQ is small relative to the total production of Q.

If a water project enhances the profitability of linked industries (such as industries using tug services or industries providing inputs to the tug industry), then a similar approach can be used to compute the change in producer surplus measuring those benefits. In general, beneficiary industries may lie either forward or backward of the transportation industry in our example [*Just et al.*, 1982]. Forward industries use inputs provided or enhanced in some way by water-project-assisted industry. Backward industries help to provide inputs for use by the water-project-assisted industry. If a water project introduces a strong enough influence that prices are altered in forward or backward industries, then there may be secondary welfare benefits attributable to the project. On the other hand, tax revenues used to fund project costs may cause secondary welfare costs of a more or less offsetting magnitude. These matters will be considered more closely later.

Production-side benefits of a water project are obtained by summing all such changes in producer surplus. As was noted above, actual computation of these benefits is greatly assisted by knowledge of specific supply and demand relationships. For market-exchanged goods and services, this information is often obtainable by collecting price and quantity data from actual market activity and applying suitable regression methods to estimate supply and/or demand functions. However, this is not practical for the many unmarketed goods and services provided by water projects. In such cases, sound economic theory and ingenuity are necessary to achieve a suitable "work-around." Much of the science and art of CBA has been engaged with the need to surmount the informational gaps caused by missing markets or missing data. Nevertheless, the above overview of producer surplus changes identifies the measures being ultimately sought. The suitability of all work-arounds rests on their ability to approximate producer surplus changes.

The noteworthy shortcoming of this principle arises in situations where producers have, in addition to profit objectives, risk preferences that are better served by the presence or absence of the proposed project. Depending on the extent of project impact on risky outcomes, this shortcoming may cause welfare changes to be incompletely stated by the change in producer surplus.

Principle 5

Consumer benefits are to be measured as consumer surplus changes.

In addition to the heightened profitability of economic production activities, which has been considered above, final consumers of water-project-enhanced goods may experience benefits that are not part of some industry's profit. That is, consumers may gain additional satisfaction or "utility" from the additional services and goods made available by a water project. These commodities may include those project products directly usable by consumers (e.g., household water, recreation) or derived final consumer products (transported goods, goods manufactured using hydropower or water). For example, a new reservoir may contribute to water recreation and thereby improve consumer welfare, or a water project may increase the supply of some final commodity (e.g., a food item) and thereby lower its price or alleviate a shortage, either of which is a benefit to consumers.

Assessment of such benefits requires that consumers' enhanced utility be monetarized into money units. A great aid to this requirement is the consumers' total demand curve for the good being increased by the water project. Referring again to Figure 1, if D represents consumer demand for an unpriced output of a water project, then the shaded area is the consumer's willingness to pay and it is also the change in consumer surplus. If this project output is priced at some level F (presumed to be low enough not to limit demand), then consumer surplus is the shaded area minus $F\Delta Q$, in which case altered income of the project owner is an additional project benefit. This depiction is enabled because the demand curve possesses the useful feature of indicating the marginal value of the commodity Q to consumers. Consequently, the shaded area is an appropriate measure of consumer benefits for ΔQ. In situations where ΔQ is small, this area can be approximated using $P\Delta Q$.

In the case of a water project's forward linkages to final consumers, the change in consumer surplus can be illustrated using Figure 2. Here the project is presumed to have a favorable impact on the supply of a produced and marketed good. Price is reduced, and production and consumption are increased. Integration is sufficient to obtain net consumer value after consumers pay for the good. Area A_1 is consumer surplus prior to the project, and area $A_1 + A_2 + A_3 + A_4$ is consumer surplus following the project. The difference, A_2 +

$A_3 + A_4$, is the correct measure of this aspect of the water project.

As in the case of producer-side benefits, all consumer benefits are to be summed, and market-derived information greatly aids application of these methods. Where market exchange of the relevant goods or services is not the norm (such as for flood control or recreation), other procedures can be employed with the following caveat. Any such procedures require theoretical rationales for why they estimate the consumer surplus changes discussed here.

One shortcoming of this principle is a technical issue in economics concerning how well consumer surplus changes estimate exact (Hicksian) consumer welfare measures. In most circumstances the approximation is quite good, but economists should be attentive to this matter so that they can recognize and correct this problem when it is sizable [*Alston and Larson*, 1993; *Hausman*, 1981; *Randall and Stoll*, 1980; *Willig*, 1976]. A second shortcoming concerns situations where the proposed project affects a matter over which consumers have a risk preference. As with producer welfare changes, the change in consumer surplus may be an incomplete measure of welfare changes when a water project modifies risky outcomes [*Freeman*, 1984; *Graham*, 1981; *Graham-Tomasi and Myers*, 1990].

Principle 6

Zero-sum transfers of benefits or costs are to be ignored.

As a corollary of CBA's central objective of comparing summed benefits with summed costs, we must ignore any economic aspect of a project that results in the mere one-for-one transfer of a benefit or cost. As a basic example, if a project results in a $10 million profit for firms using project-enhanced port facilities, but firms at other ports consequently lose $10 million in profits (possibly because of a one-for-one relocation of traffic), then the two economic effects may cancel each other. If the accounting stance of the decision-making authority spans both gaining and losing ports, then the economic effects do cancel and there is no net benefit in this particular example. If the decision-making authority is concerned only for the gaining port, then there is a $10 million benefit to be counted because the accounting stance does not extend to the losing ports. However, most water projects constructed in the United States are largely developed and funded by federal agencies, thereby establishing a national accounting stance. In these circumstances the $10 million benefit would be negated by the $10 million loss unless a portion of these losses occur at ports outside the United States. This perspective, though well founded, is a source of contention for regionally focused project participants, such as local governments and regional consumer or industry organizations, who have little understanding why area benefits (which are dear to them) do not count.

Because of this principle's close ties to CBA's central objective, there are no additional shortcomings consequent to principle 6.

Principle 7

Temporal aggregation employs discounting.

Most public projects involve long timescales in which the timing of benefits is unmatched by the timing of costs. This feature begets something of an apples and oranges problem for economic assessments. Individuals and communities of individuals are not indifferent between a unit of value today and a unit of value in some future period. Other things being the same and regardless of inflation levels, they prefer the unit of value today. In economic jargon, individuals and corporations have "private rates of time preference" indicating their trade-offs between $1 today and $1 "tomorrow."

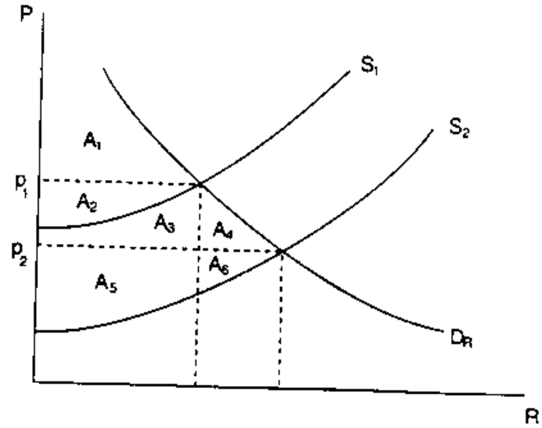

Figure 2. Willingness to pay in a linked industry.

Information about rates of time preference, also termed "discount rates," emerge in financial markets where borrowing and lending takes place, and this information can be used to address the apples and oranges problem of temporally separated costs and benefits. If the auction interest rate for relatively riskless treasury bonds is about 5% after inflation has been removed, then auction market participants are suggesting that they view equivalently $100 today and $105 a year from now.

The main remaining matter is the question of whether a private rate of time preference, such as 5% in the above example, is usable for the social rate of time preference needed for CBA. Hotly debated during CBA's evolution, the matter remains theoretically unsettled except for the general recognition that the social rate of time preference is "somewhat" less than private ones (e.g., if private rates are identified as 5%, then the social rate should be less than 5%). The crux of the matter is as follows: Financial markets are composed of present-day agents disclosing personal trade-offs regarding their todays and tomorrows. However, government, as care-keeper for today's people and people yet to be born, must exhibit concern for the welfare of future people, and it must make trade-offs regarding today's people and tomorrow's people.

Many theorists regard CBA decision criteria as harsh in accounting for the welfare of future people [*Ferejohn and Page*, 1978; *Howe*, 1990; *Lind*, 1982]. For example, if the rate of time preference is 5%, a $1,000 cost to be experienced in 100 years, is only costed at $7.60 today which is outweighed by a mere $10 in present-day benefits. Other theorists argue that 5% is the opportunity cost of project funds, and it is therefore the appropriate rate. Recent advances view the private/social discount rate debate as somewhat off target, for the market selection of discount rate is dependent on the presumed distribution of resources across people of different generations [*Howarth and Norgaard*, 1990; *Norgaard and Howarth*, 1991]. This perspective asks that we first settle a fair intergenerational distribution of resources and then let the private discount rate fall where it may. Any discount rate d is essentially a price indicating that $1 today can be purchased for $\$(1 + d)$ in the next period, so it is natural that the market determination of d

should be influenced by temporally defined resource endowments.

This may be a matter where ongoing advances in economic theory will eventually bring change to the conduct of CBA. For the present, federal policy has acted to extinguish debate over discount rate selection by legislating either a fixed rate or a process for the annual revision of the rate. The latter approach is used for federal water project studies.

It is noteworthy that standard practice is to to perform all benefit and cost assessments in current-day dollars, in which case the discount rate should also exclude inflation. However, it is equally correct if all aspects of a CBA are performed with inflation included, in which case the discount rate must also include inflation.

The selected discount rate can be used to calculate either a benefit-cost ratio (BCR) or a net present value (NPV) for a proposed project. Formulae are as follows:

$$\mathrm{BCR} = \left(\sum_{t=0}^{T} \frac{B_t}{(1+d)^t} \right) \left(\sum_{t=0}^{T} \frac{C_t}{(1+d)^t} \right)^{-1} \qquad \mathrm{NPV} = \sum_{t=0}^{T} \frac{B_t - C_t}{(1+d)^t}$$

where the planning period begins in the current year, $t = 0$, and extends to some future planning horizon T. B_t and C_t are total benefits and costs in the subscripted year, estimated using the methods of cost and benefit estimation consistent with principles 2–6 above, and d is the discount rate expressed in decimal form. Once one of these summary economic indices has been computed, the decision criterion is as follows. If the benefit-cost ratio exceeds 1.0, then the project is judged to be beneficial. If the net present value exceeds 0, then the project is beneficial. While there are clear circumstances in which one of these criteria may be preferred to the other, here they can be regarded as equivalent insofar as they provide the same recommendations regarding project acceptability. They do not rank alternative projects identically, however, and neither of these criteria tells us whether a project is scaled (sized) most efficiently [*Sassone and Schaffer*, 1978].

Thus the prime shortcoming of using discounting in CBA is that private discount rates have been resolved under market conditions that are not attentive to the fair distribution of resources to future generations. To the extent that the chosen social discount rate resembles a private discount rate, the welfare of future people is underweighted, and long-term, multigenerational projects or policies would appear to be ill suited for analysis by CBA.

Principle 8

Unmonetarized welfare changes are to be disclosed.

The general procedures outlined above seek to condense all the consequences of a project into a single index, either a benefit-cost ratio or a net present value. Ideally, this index would then be used to resolve a recommendation: either the project is deemed to have benefits in excess of costs or it is not. This procedure works very well as long as all project consequences are commensurable. A "commensurable" impact is an effect upon human welfare that can be valued using reasonable economic techniques. However, in the present state of economic science, not all project impacts may be commensurable.

It is informative to distinguish between two types of goods that are not commensurable: incommensurables and intangibles. An "incommensurable" is a project result that cannot be valued using reasonable techniques but can be physically measured. For example, additional barge traffic on an inland waterway might be expected to stir more silt and reduce water clarity in a predictable amount with estimatable implications for a loss in aquatic vegetation, but how might this impact be valued? Similarly, a dredging operation's off-channel deposit of silt might create x hectares of predator-free nesting area resulting in y new hatchlings each breeding season, but, again, what might be the value of this impact?

An "intangible" is a project impact that can be neither counted nor economically valued. For example, a large hydroelectric project may improve national security through enhanced self-sufficiency in energy production and decreased exposure to political influence exerted by energy-exporting countries, but how can we measure or value the increment to national security? Either task represents a considerable challenge. Similarly, this same hydroelectric project might interfere with an indigenous people's traditional activity, such as harvesting fish during migratory spawning runs, with some consequential loss of cultural integrity for the group. Again, obtaining either physical or economic measurements of this impact is problematic.

The existence of both incommensurables and intangibles means that some project impacts will not be monetarized. Such impacts cannot then be included in any CBA economic metrics such as the BCR or NPV. However, at a conceptual level this does not infer that such impacts are irrelevant. They are project consequences distinguished only in our ability to monetarize them.

In these circumstances, benefit-cost ratios and net present values are incomplete metrics. The advice for CBA analysts in these situations is to abandon full reliance on a benefit-cost or net present value criterion. Regardless of which economic measure is computed and reported in the decision-making process, it should be accompanied by the reasonable disclosure of unmonetarized project impacts. This task can be achieved only by describing unmonetarized impacts using available information and data. In the case of incommensurables, physical measures of impacts should be reported. Intangible impacts should also be described even though physical measurement is infeasible. This body of impact information is often very extensive, and it may be advisable to present impacts using a large, many-page tableau whose cells contain descriptive text and physical impact measures [*Sassone and Schaffer*, 1978; *Yoe*, 1995].

6. Current Issues in CBA

Having overviewed the governing principles for CBA, we further consider two areas commonly separating water project stakeholders. These two matters stand out as the source of most debate involving project analysis. They are the computation of environmental net benefits and the standing of secondary economic effects. The following sections take up each of these issues individually, drawing upon contemporary economic knowledge as well as the structure provided by the CBA tenets.

6.1. Environmental Benefits and Costs

We can begin to answer the question of how to evaluate environmental impacts accompanying water projects by reviewing CBA principles 5 and 8. These tenets apply to both positive and negative effects. Because most environmental impacts tend to be experienced by households rather than by producers, it is generally appropriate to economically assess environmental impacts for their influence on consumer surplus (principle 5). The fundamental element for conducting such an evaluation is consumer demand for the good being affected (e.g., concentration of a given water contaminant, number of a specific species). However, because environmental goods tend to be allocated by nonmarket institutions (especially government policies), consumer demand estimation can be problematic.

Nonmarket valuation methodologies for "working around" the absence of direct market data for estimating demand include hedonics, the travel cost method and contingent valuation [*Feenberg and Mills*, 1980; *Freeman*, 1979, 1993; *Johansson*, 1987, 1993; *Moss et al.*, 1994; *Smith*, 1993]. Depending on actual circumstances for the specific environmental impacts under consideration, one or more of these methods may be applicable. However, application of these methods can also be both expensive and contentious [*Diamond and Hausman*, 1994; *Eberle and Hayden*, 1991; *Hanemann*, 1994; *Portney*, 1994]. If economic evaluation of environmental impacts is infeasible owing to a lack of data, impracticality of nonmarket valuation techniques, or the high cost of performing nonmarket valuation, then principle 8 applies directly. That is, some impacts will have unmonetarized welfare changes to be disclosed apart from net present value or a benefit-cost ratio.

Because of occasional misuse, it bears mentioning that consumer expenditures on items complementary to environmental goods do not indicate the social worth of these goods. For example, sport fishing expenses for equipment, bait, lodging, and charters do not indicate the welfare changes of a prospective change in the quality and quantity of sport fishing. Such information may, however, be usable by an indirect estimation procedure such as the travel cost method.

To continue with this example, nor is expenditure information indicative of the net benefit of the sport fishery prior to any changes. Expenditures are presumably a lower bound for gross benefits because rational people would not engage in such expenditures otherwise. However, such expenditures are both a private and a social cost and are necessarily excluded from net benefits. Net benefits may be less than, the same as, or more than expenditures; there is no way to tell on the basis of mere expenditure information. The net benefit of a sport fishery is its gross value to consumers minus expenditures. That is, it is the consumer surplus. In CBA the welfare change of an action that will improve or degrade an environmental good is its change in consumer surplus.

6.2. Economically Linked Industry and Employment

Public discussion of projects often emphasizes the "economic development" enabled by water projects as a consequence of economic dependencies with project-influenced industry. Both job creation and income opportunity are commonly touted by project supporters. It is well acknowledged that economically linked industries and households encounter secondary or, synonymously, indirect economic effects when any industry changes its production level as a result of a public project. But do any of these impacts translate into welfare changes that should be incorporated in cost benefit analyses? That is, can secondary economic effects be equated to secondary welfare changes? This question is at the heart of considerable confusion and misinterpretation in economic analysis.

An example illustrates this issue. If a public project causes a local employment increase of 1000 worker-months averaging an income of $2000 per month, then this component of secondary economic effects is $2 million. However, if these workers would be otherwise employed at the same wages, there is no secondary welfare change; they are merely employed differently. On the other hand, if in the absence of the project these workers are to earn $1900 per month under similar working conditions, then the welfare of these workers is increased by $100,000.

As suggested within the discussion accompanying principle 4, attention to the secondary welfare benefits of a project requires similar attention to any secondary welfare costs associated with sources of project funds. Although project-supporting tax collections are dispersed across a government's many citizens, this is not a reason to doubt the existence of secondary welfare costs. They exist in diffuse form. The key matter is the size of secondary welfare benefits relative to secondary welfare costs. However, either is difficult to calculate. The present practice of cost-benefit analysis is to set aside the matter by presuming that secondary welfare measures are offsetting: the benefits are assumed to be cancelled by the costs. While this assumption is unlikely to be correct, it is an expedient alternative to intricate economic analyses.

Because of the method's prevalence, it is noteworthy that it has become common to approach the analysis of secondary economic effects by applying input-output (I-O) analysis to develop economic multipliers which convert direct economic changes into the sum of direct plus indirect economic impacts. Obtained multipliers are commonly of the order of 2.0 to 3.5, indicating that secondary effects easily surmount and dominate direct impacts. Hence the issue of whether or not secondary impacts count is of some consequence in decision making for public projects.

To enhance political support for proposed water projects, input-output studies are sometimes commissioned by beneficiary groups or local governments. Interest in the results of such studies continues to increase as industries, firms, and public facilities strive to "prove their worth" in a political climate that is increasingly conscious of economic growth and employment. The media have become quick to report employment and economic impacts of these organizations when such information is made available, thus contributing to the general politicization of economic impact analysis, and other groups have begun to use similar approaches in railing against public support of particular activities. But is it truly proper to consider such impacts?

As it turns out, I-O-based multipliers are ill suited for illuminating direct and indirect welfare changes in most circumstances. In the case of direct welfare changes, I-O analysis is not applicable, as the methods discussed in previous subsections admit no role for I-O. In the case of indirect (secondary) welfare changes, the inappropriateness of multipliers does not mean that indirect welfare changes are nonexistent, only that I-O multipliers do not estimate secondary welfare changes. While there are general equilibrium methods that are conceptually capable of calculating secondary welfare changes, I-O multipliers are not among them. Because secondary welfare changes are brought about by induced price changes in forwardly or backwardly linked markets and because I-O analysis does not model price changes, I-O models are strongly limited.

Given that I-O multipliers do not indicate secondary welfare changes, does I-O analysis have the capability of contributing to the estimation of secondary welfare changes in some other way? Repeated debate and inquiry over this issue as it relates to water projects has generally forwarded a negative response [*Cooke*, 1991; *Hamilton et al.*, 1991, 1993; *Hughes and Holland*, 1993; *Young and Gray*, 1985]. However, even the most critical literature suggests that cautious and purposeful extensions of I-O models can be successful in estimating secondary welfare changes. Accomplishing this requires that opportunity costs be subtracted from the so-called value-added components of the I-O model so that remaining portions of value added correspond with true welfare changes [*Hamilton et al.*, 1991]. It is improper to include the entirety of value added because it is largely attributable to other inputs (such as labor, capital/depreciation, and land), which possess opportunity costs of their own [*Young and Gray*, 1985]. Literature on this matter consistently indicates the importance of not attributing all value added to a public project, because there are valuable inputs that are jointly responsible for increments in the value of produced goods.

7. Scope and Limits of CBA

The practice of CBA condenses to eight important principles, and these principles are sufficiently encompassing to indicate both the practice, accomplishments, and shortcomings of the CBA method. The eight are as follows:

1. Projects are deemed economically acceptable "... if the benefits to whomsoever they accrue are in excess of the estimated costs ...."
2. Welfare changes pertain to differences between with- and without-project scenarios.
3. Cost measurement is founded on social opportunity costs.
4. Producer benefits are to be measured as producer surplus changes.
5. Consumer benefits are to be measured as consumer surplus changes.
6. Zero-sum transfers of benefits or costs are to be ignored.
7. Temporal aggregation employs discounting.
8. Unmonetarized welfare changes are to be disclosed.

The collected power of these principles is that they permit a theoretically well founded and cohesive basis for weighing the many consequences of a public project. At the same time these principles raise issues for CBA, and these vary in severity depending on the nature of a project, the methods used by CBA analysts, and personal beliefs. The goal of CBA is to incorporate all humanly felt welfare changes, and this can be regarded as a deficiency by those believing that public decision making possesses broader responsibilities than advancing the welfare of humankind. Moreover, the central objective of CBA, principle 1, introduces the possibility of inequities in the distribution of project benefits or costs. These inequities may be localized and peculiar to specific water projects, and they can also be systematic, pertaining to water projects generally.

Principles 2–5 dictate objectives for benefit and cost quantification. Most of the problems associated with benefit and cost determination are the result of incomplete satisfaction of these principles. That is, CBA analysts commonly employ work-arounds to surmount informational gaps, and these work-arounds are sometimes deficient in emulating principles 3–5. There are, however, some minor issues inherent to these three quantification principles. Neither producer or consumer surplus measures usually account for welfare changes stemming from modifications to risk. Also, consumer surplus measures only approximate true welfare changes, but the approximation is customarily thought to be quite good.

Principle 7 is accompanied by an occasionally serious problem insofar as discounting has the purposeful impact of weighting near-term welfare changes more greatly than far-term welfare changes. When future welfare changes are experienced by the current generation rather than future generations, this is not an important matter, but long-range effects such as biodiversity losses, climate change, and resource depletion can make this a crucial issue. Again, personal views become important here. If we envision our society as a multigenerational one, then CBA becomes an assailable social decision rule in cases where welfare changes accrue to many generations and these effects are to be discounted within CBA.

In addition to isolating the prime principles of CBA and the consequential issues, two areas were addressed more deeply because they constitute persistent matters for project analysis. These concern opportunities to correctly monetarize environmental welfare changes and the ability to measure welfare changes occurring in economically linked households and industry.

Contemporary environmental evaluation techniques, such as contingent valuation, will not always be suitable or will be too expensive to employ in some circumstances. It is therefore unlikely that all environmental influences will be evaluated. In such situations, we must be mindful of principle 8. That is, environmental impacts are project consequences distinguished only in our ability to monetarize them. Their omission from net present value or benefit-cost ratio metrics does not demonstrate irrelevance, but any omissions do underscore the incompleteness of the economic metrics. Meritorious decision making must now contemplate more than a single economic index, because all welfare changes could not be reduced to this index.

Concerning secondary economic effects, welfare measurement also can apply to industries and consumers who may be economically linked to a water project, and valid welfare changes in these sectors are generally a consequence of commodity price changes originating from the project. Some form of general equilibrium welfare analysis is most appropriate for performing welfare change estimation for linked industries, but the information and analytical burden is high for such techniques. Input-output analysis stands as a ready alternative but, owing to its nontreatment of price repercussions, is in need of crucial adjustments if its results are to assist in welfare analysis. The input-output-derived multipliers, which estimate direct plus secondary economic effects, cannot be interpreted as welfare consequences unless the social opportunity costs of committed resources and production inputs are first debited. This adjustment is not commonly pursued in input-output work. Thus input-output results generally represent economic impacts rather than welfare changes, the distinction being crucial in policy/project study. Economic impact and welfare change will generally coincide only for local accounting stances in which all resource and input costs accrue externally. As the matter presently stands in CBA methodology, the standard operating practice is to presume that all secondary welfare benefits are cancelled by secondary welfare costs.

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