



## CHAPTER TWENTY-ONE

# COST-EFFECTIVENESS AND COST-BENEFIT ANALYSIS

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Both cost-benefit analysis (CBA) and cost-effectiveness analysis (CEA) are useful tools for program evaluation. Cost-effectiveness analysis is a technique that relates the costs of a program to its key outcomes or benefits. Cost-benefit analysis takes that process one step further, attempting to compare costs with the dollar value of all (or most) of a program's many benefits. These seemingly straightforward analyses can be applied anytime before, after, or during a program implementation, and they can greatly assist decision makers in assessing a program's efficiency. However, the process of conducting a CBA or CEA is much more complicated than it may sound from a summary description. In this chapter we provide an overview of both types of analyses, highlighting the inherent challenges in estimating and calculating program costs and benefits. We organize our discussion around practical steps that are common to both tools, highlighting differences as they arise. We begin with a simple description of each approach.

*Cost-effectiveness analysis* seeks to identify and place dollars on the costs of a program. It then relates these costs to specific measures of program effectiveness. Analysts can obtain a program's cost-effectiveness (CE) ratio by dividing costs by what we term *units of effectiveness*:

$$\text{Cost-Effectiveness Ratio} = \frac{\text{Total Cost}}{\text{Units of Effectiveness}}$$

Units of effectiveness are simply a measure of any quantifiable outcome central to the program's objectives. For example, a dropout prevention program in a high school would likely consider the number of dropouts prevented to be the most important outcome. For a policy mandating air bags in cars, the number of lives saved would be an obvious unit of effectiveness. Using the formula just given and dividing costs by the number of lives saved, you could calculate a cost-effectiveness ratio, interpreted as "dollars per life saved." You could then compare this CE ratio to the CE ratios of other transportation safety policies to determine which policy costs less per unit of outcome (in this case lives saved). Although it is typical to focus on one primary outcome in CEA, an analyst could compute cost-effectiveness ratios for other outcomes of interest as well.

Like cost-effectiveness analysis, *cost-benefit analysis* also identifies and places dollar values on the costs of programs, but it goes further, weighing those costs against the dollar value of program benefits. Typically, analysts subtract costs from benefits to obtain the *net benefits* of the policy (if the net benefits are negative, they are referred to as *net costs*):

$$\text{Net Benefits} = \text{Total Benefits} - \text{Total Cost}.$$

In this chapter we focus on social (or economic) cost-benefit and cost-effectiveness analyses, rather than financial analyses. A social CEA or CBA takes into account the costs and benefits—whether monetary or nonmonetary—that accrue to everyone in society. Any negative impacts of a program are treated as costs and added to actual budgetary outlays in assessing the overall costs of a program, whereas positive impacts are counted as benefits. To assess the value to society, the analyst would consider all the costs and benefits that accrue to taxpayers, neighbors, participants, competing organizations, or any number of other groups that are affected by the program under study. In contrast a financial CEA or CBA considers only the monetary costs and benefits accruing to a particular organization and simply ignores the rest. Although such an approach is sometimes useful for accounting and budgeting purposes, it is less useful in assessing a program's effectiveness. Nonetheless, the process we outline here can be easily applied to a financial CBA or CEA: the only difference is that a narrower set of costs and benefits is considered in the analysis.

The concepts and basic equations presented so far are seemingly simple, yet obtaining accurate estimates of costs and benefits can be extremely challenging. Every analysis requires a host of assumptions, sometimes complicated calculations, and ultimately, the careful judgment of the analyst. We address these challenges in the following pages as we discuss each step of a ten-step process (adapted from Boardman, Greenberg, Vining, and Weimer, 2006):

*Steps in Cost-Effectiveness and Cost-Benefit Analysis*

1. Set the framework for the analysis
2. Decide whose costs and benefits should be recognized
3. Identify and categorize costs and benefits
4. Project costs and benefits over the life of the program, if applicable
5. Monetize (place a dollar value on) costs
6. Quantify benefits in terms of units of effectiveness (for CEA), or monetize benefits (for CBA)
7. Discount costs and benefits to obtain present values
8. Compute a cost-effectiveness ratio (for CEA) or a net present value (for CBA)
9. Perform sensitivity analysis
10. Make a recommendation where appropriate

To illustrate the ten-step process, we discuss the evaluation of a program aimed at at-risk students and intended to reduce the incidence of early high school dropouts. This is an important national issue that was a target of President Obama's initial speech to Congress and is being addressed in various ways in school districts across the United States. Although our example is hypothetical, we draw on data from studies of similar programs (for example, Ramsey, Rexhausen, Dubey, and Yu, 2008). As a practical matter, we encourage the use of spreadsheet software, such as Microsoft Excel, to allow the analyst to consider multiple assumptions about the valuation of costs and benefits.

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## Step 1: Set the Framework for the Analysis

The first question is: Will you undertake a cost-benefit analysis or a cost-effectiveness analysis? This will depend on what you want to know. Are you evaluating one program or comparing two or more? Does the program have multiple objectives or just one major focus? Box 21.1 provides an overview of the choice.

### The Status Quo

No matter how many programs you are evaluating and whether you choose CEA or CBA, the step-by-step process outlined here is essentially the same. In considering each program or project, the analyst must always start by describing the status quo: that is, the state of the world in the absence of the program or policy. This scenario sets the baseline for the analysis. The only costs and benefits that should

### Box 21.1. Step 1 Key Issue: Deciding on Cost-Benefit or Cost-Effectiveness Analysis

#### Cost-Benefit Analysis

CBA is most useful when you are analyzing a single program or policy to determine whether the program's total benefits to society exceed the costs or when you are comparing alternative programs to see which one achieves the greatest benefit to society. The major difficulty with CBA is that it is often difficult to place dollar values on all (or most) costs and benefits.

#### Cost-Effectiveness Analysis

CEA is most useful when you know the outcome you desire and you are determining which of a set of alternative programs or projects achieves the greatest outcome for the costs. It is also useful in cases where major outcomes are either intangible or otherwise difficult to monetize. The major difficulty with CEA is that it provides no value for the output, leaving that to the subjective judgment of the policymaker.

#### Our Recommendation

Although some view CBA as a superior technique, it is difficult and time consuming. CEA may provide a good starting point by requiring the evaluator to identify the most important outcome and relate that outcome to the dollars spent on the project.

be considered in a CBA or CEA are those that would occur over and above those that would have occurred without any action (under the status quo). These additional costs and benefits are known as the *marginal* or *incremental* costs or benefits of a policy, and these are what you seek to capture in your measures of total costs, total benefits, and units of effectiveness.

### Timing

Both CBA and CEA can be performed at any point in the policymaking process. A CBA or CEA undertaken when a program is being considered is considered an *ex ante* (or *prospective*) analysis. This type of analysis is useful in considering whether a program should be undertaken or in comparing alternative prospective programs aimed at common policy objectives. If an analysis is done at some point during

implementation, it is considered an *in medias res* analysis (or *current year* or *snapshot* analysis). Such an analysis provides data on whether the program's current benefits are worth the costs. Finally, an *ex post* (or *retrospective*) analysis provides decision makers with total program costs and benefits upon the program's completion, to assist them in evaluating a program's overall success.

Each of these types of analyses has its usefulness, peculiarities, and issues. For example, in an *ex ante* analysis, the estimation of costs and benefits is most difficult because they have not yet occurred. In this case the analysis will require a significant number of assumptions and may yield less accurate results. In contrast, in an *ex post* analysis costs and outcomes are largely known and can often be estimated accurately. Nonetheless it can be difficult to determine which costs and benefits to attribute to the program because the observed outcomes may have been the result of programs or events other than the one being analyzed.<sup>1</sup>

### Step 1 Illustration: Dropout Prevention Program

In our illustration, we will examine a dropout prevention program that is currently implemented in just one high school. Assume that you have been tasked with evaluating the program's effectiveness for state policymakers interested in expanding it. The policymakers would like to know whether the costs of the program have been worth the results and they may be considering alternative programs to achieve the same objective. Because they will want to know both whether the program is better than nothing and how it compares to other programs, both CEA and CBA will be useful. For purposes of illustration, we will present both analyses.

The dropout prevention program has involved the creation of a special academy aimed at students at risk of dropping out. The academy has access to space, teachers, and equipment. In order to create the program, a consultant was hired to train the teachers and provide a curriculum for the academy. One full-time teacher was hired to manage the academy, and three other teachers were paid extra compensation to work after school in the program. As an analyst you may be asked whether the current program—now completing its fifth year—has been worth the costs and whether it should be continued or expanded to a larger group of high schools.

In this example the status quo would be described simply as all regular high school activities and programs that occurred before program implementation. Our analysis will thus count the incremental changes in costs, dropouts prevented, and other benefits that can reasonably be attributed to the program.

## Step 2: Decide Whose Costs and Benefits Should Be Recognized

Almost every policy or program involves a broad range of stakeholders and every cost or benefit ultimately affects a particular group of people. For public programs, taxpayers may bear a large portion of the costs of a program, while the benefits may be concentrated on a few select groups (for example, program participants). In light of this, determining whose costs and benefits should *count* (or who should have standing) is an important consideration in CEA and CBA.

In a social CEA or CBA the goal is to assess the impact of the policy on society as a whole, so the analyst must include all members of the relevant society in the analysis—one cannot simply pick and choose which stakeholders within society deserve standing. The key issue then becomes how to define *society*. To maintain objectivity, society must be defined on a geographical basis. Typically, analysts

### Box 21.2. Step 2 Key Issue: Whose Benefits and Costs Count?

#### Analysis Scope

A major issue for evaluators is determining the geographical scope of the analysis, for example, should benefits and costs be aggregated at the national or state level? The narrower the geographical scope, the fewer costs and benefits will need to be counted. However, narrower geographical boundaries will miss any costs and benefits that may spill over to neighboring jurisdictions. It is often useful to identify these missing costs and benefits, even if you do not quantify or place a dollar value on them. Sometimes spillovers, such as air and water pollution, have broad negative impacts; at other times projects such as mass transit have positive spillovers to neighboring jurisdictions and those benefits might be used to argue for a subsidy or other assistance from that jurisdiction.

#### Our Recommendation

The analyst should base her definition of society on the jurisdiction that will bear the brunt of the costs and receive the majority of the benefits. This will be the primary concern to the policymakers of that jurisdiction. However, major spillovers (both costs and benefits) should at least be recognized and explained in the analysis. Policymakers might want greater information on those that are the most significant or that have political implications. If spillovers are substantial, the most useful approach might be to start with a broader geographical scope (for example, statewide) then look at the subset of costs and benefits accruing to smaller areas (for example, cities).

choose to define society according to national, state, county, or city borders, but other geographical distinctions are also acceptable. Box 21.2 provides a summary of the factors to take into consideration when deciding on issues of standing.

### Step 2 Illustration: Dropout Prevention Program

In the dropout prevention program, the state policymakers will likely want to consider the costs and benefits from the state's perspective. The decision may also depend on who is paying for the policy. In this case, we assume that the school district and state taxpayers foot the bill, so a state-level perspective can again be justified. The analyst should therefore count all the costs and benefits of the program that accrue to state residents. Defining *society* as the state will naturally include almost all stakeholders, as few costs and benefits of one high school's program are likely to spillover to neighboring states. Note, however, that if the school is near a state border causing costs and benefits to spill over to other jurisdictions, or if the program is paid for by federal taxpayers, the analyst might want to consider taking a broader regional or national perspective, or at least to identify and discuss the nature of the spillovers.

### Step 3: Identify and Categorize Costs and Benefits

In conducting a cost-effectiveness or cost-benefit analysis as part of a program evaluation, the third step is to identify and categorize as many of the known benefits and costs of the program as possible. Even though all costs and benefits cannot be known for certain, the analyst should make a reasonable effort to identify those that will have the most significant implications on the policy. Not all of these effects will require an evaluation in dollars. Small or negligible costs and benefits—those that will have little impact on the bottom line—are often ignored or just briefly discussed in the final analysis. Nonetheless, in the early stages of analysis, we recommend thinking broadly about possible costs and benefits.

When discussing costs and benefits it is common to classify all negative impacts of a policy as costs and all positive impacts as benefits, whether these occur in implementation or as a consequence of a particular policy. However, one could instead frame the analysis as comparing inputs to outcomes. In this case both the inputs and outcomes could be either positive or negative, but the same process applies. In identifying and classifying these costs and benefits, we suggest using the framework displayed in Box 21.3 (and based on Musgrave and Musgrave, 1989), to divide them further into distinct categories: real versus transfers, direct and indirect, tangible and intangible, financial and social. Keep in mind that where to place a specific benefit or cost is sometimes debatable.

### Box 21.3. Step 3 Key Issue: Categorizing Costs and Benefits or Outputs and Outcomes

#### Real Benefits and Costs Versus Transfers

*Real* benefits and costs represent net gains or losses to society, whereas *transfers* merely alter the distribution of resources within the society (again, defined by geographical area). Real benefits include dollars saved and dollars earned, lives saved and lives enriched, increased earnings and decreased costs for the taxpayers, and time saved and increased quality of life. In contrast, some societal gains are directly offset by other losses and are considered transfers. For example, a local tax abatement program for the elderly will provide a tax-saving benefit to some but a cost (of an equal amount) to others (in terms of higher taxes or lower services). Many government programs involve the subsidizing of one group by another in the society, and this should be clearly identified where possible. But from an overall societal perspective, transfers do not increase total welfare; they merely redistribute welfare within society.

#### Direct and Indirect Benefits and Costs

*Direct* benefits and costs are those that are closely related to the primary objective of the project. Direct costs include costs for such things as personnel, facilities, equipment and material, and administration. *Indirect* or *secondary* benefits and costs are by-products, multipliers, spillovers, or investment effects of the project or program. An often-cited example of indirect benefits from space exploration is the numerous spin-off technologies benefiting other industries. Indirect costs are unintended costs that occur as a result of an action. For example, a dam built for agricultural purposes may flood an area used by hikers, who would lose the value of this recreation. This loss might be partially offset by indirect benefit gains to those using the lake created by the dam for recreation.

#### Tangible and Intangible Benefits and Costs

*Tangible* benefits and costs are those that the analyst can readily identify in unit terms for CEA and can convert to dollars for CBA. In contrast, *intangible* benefits and costs include such things as the value of wilderness or an increased sense of community. It is especially difficult to place a dollar value on many intangible benefits. This is perhaps the most problematic area of cost-benefit analysis, and why cost-effectiveness analysis is considered more appropriate for some types of programs.



### Financial and Social Benefits and Costs

We believe it is important to identify those costs that are *financial* (that is, are cash outlays of the organization considering the program or project) and those costs that are *social* (that is, they are not cash outlays, but represent real costs to society). For example, salaries and benefits paid by an agency for a government regulatory program are a fiscal cost; the effects of those regulations on business and the public are social benefits and costs.

### Step 3 Illustration: Dropout Prevention Program

**Costs.** Using the framework suggested in Box 21.3, we illustrate in Exhibit 21.1 various cost categories of the dropout prevention program.

**Benefits.** The benefits of the dropout prevention program accrue mainly to those attending the program. It is well known that high school graduates, on average, earn more than high school dropouts and there is less unemployment among

### EXHIBIT 21.1. DROPOUT PREVENTION PROGRAM COST BREAKDOWN

#### Costs to Program Participants

- Opportunity cost to students participating in the after-school program: for example, loss of wages from a part-time job (indirect, tangible, social)

#### Costs to Society (including the school)

One-Time or Up-Front Costs (the timing of costs is described in Step 4)

- Cost of the consultant who provided teacher training and information on how to set up the academy (direct, tangible, fiscal)
- Computer software purchased for use in the program (direct, tangible, fiscal)

#### Ongoing Investment Costs

- Use of existing classroom facilities (direct, tangible, social)
- Purchase of computers for use in the academy (direct, tangible, fiscal)
- Purchase of academic texts that are used for more than one year (direct, tangible, fiscal)

### Recurring Costs

- Full-time salaries and benefits of teachers dedicated to the academy (direct, tangible, fiscal)
  - Part-time salaries and benefits for teachers receiving extra compensation for after-class programs associated with the academy (direct, tangible, fiscal)
  - Extra maintenance costs associated with after-school use of the facilities (indirect, tangible, fiscal)
  - Materials and supplies, including workbooks and other materials used up during the program (direct, tangible, fiscal)
  - Travel expenditures for field trips (direct, tangible, fiscal)
  - Overhead costs, such as general supervision and finance (indirect, tangible, fiscal)
  - Increased insurance (indirect, tangible, fiscal)
  - Cost of volunteers (indirect, tangible or intangible, social)
  - Opportunity cost to parents; for example loss of time in transporting students (indirect, tangible, social)
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## EXHIBIT 21.2. BENEFITS OF A DROPOUT PREVENTION PROGRAM

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### Benefits to Program Participants

- Higher lifetime earnings (direct, tangible, social), reduced by the following:
  - (Will pay more taxes)
  - (Will receive fewer welfare payments)
- Greater self-esteem (indirect, intangible, social)

### Benefits to Society in General

- Decrease in government subsidies (for welfare, health care, and so forth) (indirect, tangible, fiscal)
  - Increase in taxes paid by program participants (indirect, tangible, fiscal)
  - Decrease in crime and other social problems (indirect, tangible and intangible, both fiscal and social)
- 

high school graduates. There would be some indirect fiscal benefits for taxpayers in that students who do not drop out are likely in the long term to have less dependency on government subsidies and to pay more in taxes. Though indirect (not the primary reason for the program), these outcomes provide fiscal benefits to government and society. Exhibit 21.2 summarizes the benefits.

## Step 4: Project Cost and Benefits Over the Life of the Program, If Applicable

After identifying and categorizing costs and benefits, the next step involves thinking about the time frame for your analysis and how the costs and benefits will change over time. CEAs and CBAs may be conducted over any length of time, and time is typically measured in years for these analyses, though the analyst may also use any other unit of time that seems reasonable. Most cost-benefit and cost-effectiveness analyses consider a time frame in the range of five to fifty years, but in some cases the analyst may decide that just one year is sufficient to assess costs and benefits. When this is the case the analyst can skip this step.

If you have settled on a time frame with more than one time period, you will typically start with the first year of the program and track down information on the costs and benefits that accrue in that year (we describe how to place dollar values on costs and benefits further in the next steps). For an ex ante analysis, you will then need to predict the impacts over the life of the project: will each cost or benefit remain the same each year or will it increase, decrease, or disappear in each subsequent year? If there are changes over time, will costs or benefits increase smoothly (for example, at 2 percent per year) or change at irregular intervals (for example, appear for five years during construction then disappear thereafter). For an ex post analysis, much of this information may be known, particularly if actual costs and outcomes have been reported annually. It may help to consider whether costs and benefits are one-time (or up-front), accruing only in the first year, or whether they are recurring costs or benefits that occur every year. A final category of costs is ongoing investment costs: one-time investments that are used continually. Box 21.4 summarizes the issue of an appropriate time frame. We provide details on how to place dollar values on these costs and benefits in the next sections.

### Step 4 Illustration: Dropout Prevention Program

One challenge to the analyst in the dropout prevention program is that the program's fiscal costs are mostly up-front, whereas the benefits (both fiscal and social) accrue over a long period of time; in the case of the participants, the major benefit is their increased earnings over a lifetime. Thus it is appropriate to examine the total costs of the program over its first five-year period of operations; but benefits will need to be analyzed over an extended period of time. We choose thirty years to capture most of the benefits from increased earnings, tax savings, and other long-term benefits.

### Box 21.4. Step 4 Key Issue: Considering Costs Over the Life of the Project

#### Determining Useful Life

You may decide to evaluate the costs and benefits accruing over one year, five years, fifty years, or even an infinite number of years. The key to deciding on a time frame is assessing the *useful life* of the program. This term comes from infrastructure projects, such as buildings or highways, that need replacement or substantial maintenance after some typical length of time (for example, twenty years). In the case of program evaluation, if a program that requires congressional reauthorization in five years that suggests that five-year analysis may be a logical time frame.

#### Our Recommendation

We suggest using a length of time that is sufficient to capture most costs and benefits of the program. It may be that the costs accrue over a shorter period of time than the benefits. Or the reverse could be true if, for example, state action creates negative outcomes (such as pollution) that might extend over many years.

## Step 5: Monetize (Place a Dollar Value on) Costs

After identifying all costs and benefits and considering how they change over the time period you study, the next step in both CEA and CBA is to assign each cost a dollar value. Critics of cost-benefit analysis and even cost-effectiveness analysis often ask why monetization is necessary—particularly for intangible costs or benefits. The idea is simply that you want to have all or most costs and (in the case of CBA) benefits expressed in the same units for easier addition and comparison. Because dollars are a common measure of value that people generally understand, they are preferred to other measures.

For each cost (or benefit) that you seek to place a dollar value on, it is important to clearly state its nature, how it is measured, and any assumptions made in the calculations. Those assumptions need to be made clear to decision makers and subjected to a sensitivity analysis (described in step 9) to determine to what extent the outcome of the analysis is controlled by the assumptions made.

## Budgetary or Accounting Costs

Accounting or budgetary information typically will provide data on salaries, capital costs and materials, and other expenditures, used in a program. Nevertheless, some costs will not be as easily identified from project documents but must be developed using best estimates. Economists focus on the concept of *opportunity cost*: if a resource is used for one thing, it cannot be used for something else.

**Cost of Capital.** The cost of capital assets should be spread out over their expected useful life. Normally the asset (less its final salvage value) is depreciated equally per year over the life of the asset (straight-line depreciation). In addition to having depreciation, the owner of the asset loses the opportunity to use the money that is tied up in the undepreciated asset. This opportunity cost is expressed as an interest rate (generally the cost of capital to the organization) times the undepreciated portion of the asset. Spreadsheets and numerical tables provide an amortization or annualized cost of depreciation plus interest (see Levin and McEwan, 2001). In Excel, the payment (PMT) function can compute this value for you once you add the interest rate ( $r$ ), time period or number of payments ( $nper$ ), and the initial capital cost ( $pv$ ).

**Sunk Costs.** *Sunk costs* are defined as investments previously made in a program or project, such as original research and development costs, as compared to ongoing costs. In an ex post evaluation of total benefits and costs of a program, the evaluator will consider all previous costs. However, when the evaluator is recommending future action on a program or project, sunk costs should be ignored, because they have no impact on the marginal costs and benefits of the continuation of the project or program.

**Indirect Costs.** In calculating overhead, many institutions employ a standard indirect cost allocation figure on top of their direct costs, often computed at 30 to 60 percent of the total direct costs or a subset of direct costs, such as personnel expenditures. The major controversy with indirect cost allocations is whether a specific program really adds marginal cost to the overhead agencies. Rather than estimating an overhead rate, an evaluator might use a method called *activity-based costing* (ABC). In this method, overhead costs are allocated based on certain cost drivers. For example, if a proposed program is going to use summer help and involve significant personnel actions, then the additional cost assigned to the project would be the additional costs to the personnel or human resource office,

perhaps as a function of program employees versus total employees. Box 21.5 discusses how to handle certain nonmonetary indirect costs that are sometimes controversial.

### **Box 21.5. Step 5 Key Issue: Dealing with Nonmonetary Costs**

#### **Cost Shifting Among Groups**

Government, for example, often shifts costs to the private sector, especially in regulatory activity. When the U.S. Environmental Protection Agency mandates the installation of scrubbers on electric utilities or the purchase of higher-cost low-sulfur coal in order to reduce acid rain (as legislated in the 1991 Clean Air Act), the costs of the program are not just the regulatory agencies' costs of enforcement of the new requirements. The costs to the electric utilities, which will likely be passed forward to the consumers of the utilities' power, must also be considered.

#### **Costs to Participants and Volunteers**

The cost to participants and volunteers should also be considered. Although these are not cash outlays, they are considered real social costs of a program. For example, in the dropout prevention program, the academy operates after school. For the students involved, this represents an opportunity cost for their time that might be used for part-time employment. This program, like many other public programs, uses the services of volunteers. Volunteers can provide a real benefit to a program and may relieve an organization from spending money for part-time staff. Levin and McEwan (2001) argue that the value can be determined by estimating the market value of the services that a volunteer provides. This approach seems correct where the volunteer has specific skills and the organization would otherwise have to employ someone of the same skills. Otherwise the cost might be viewed as the opportunity cost to the volunteer. However, volunteers also may gain something by volunteering—a sense of civic virtue or new knowledge, for example—that may outweigh or simply cancel out the opportunity cost.

#### **Our Recommendation**

Indirect costs to other economic sectors or social groups and to participants and volunteers are controversial and their valuation sometimes problematic. Because of this, it is useful to separate costs (and benefits) to various groups: for example, costs to participants, costs to government and other organizations, and costs to others in society. In this fashion, the decision maker can more readily determine the most important costs to consider.

### Step 5 Illustration: Dropout Prevention Program

For both cost-effectiveness analysis and cost-benefit analysis, the evaluator must estimate and monetize total costs of the dropout prevention program, including both fiscal and social costs. For example, if the academy uses dedicated classroom space, whether during the school day or after school, there is no cash outlay for the school, but the classroom use would represent an opportunity cost. That is, the use of this space for the academy means it cannot be used for other educational activities. Should the evaluator place a dollar value on that opportunity cost? If the school could rent the space for other after-school activities, then the opportunity cost would be measured by the rental income forgone. If the classrooms would otherwise be vacant, then the opportunity cost for the space would be zero. Some additional cost would have to be assigned to the program for the additional maintenance costs caused by the extra use of the facility. This incremental cost should be charged to the program by the analyst.

In addition, in the dropout prevention program the cost of computers and textbooks that have a useful life of more than one year should be amortized over the expected life of the asset. Computers typically would be amortized over a five-year period and textbooks over three years. Thus the purchase of ten computers in year 1 of the project at \$2,000 per computer would cost \$20,000; however, the actual costs per year assigned to the program would be the depreciation (over five years) plus the interest cost on the undepreciated portion. This number can be annualized by using Excel's payment function. In our example, the interest rate is assumed to be 5 percent (cost of capital for the school or state), the capital cost is \$20,000, and the time period is five years. This leads to an annual cost of \$4,619 for the computers. Similarly, the textbooks with a cost of \$1,000 and a useful life of three years would have an annual cost of \$367. Table 21.1 provides a typical breakdown and estimate of costs and Table 21.2 displays those costs over a five-year period.

Table 21.2 examines the costs of the program over its first five years with fifty participants in each year. Note that even where the analyst chooses to not include a dollar value of the cost, the cost should be indicated and considered.

Cost data are important; they can, for example, provide information on exactly how much money is spent annually. In the dropout prevention program, fifty students participate at an annual cost (in year 5) of \$127,887 to the school and \$220,037 when adding in the costs to participants. The total cost to society over all five years is \$1.1 million.

**TABLE 21.1. COSTING AN EXISTING DROPOUT PREVENTION PROGRAM.**

<b>Financial Costs (to the school)</b>	<b>Estimate and Method of Valuation</b>
Up-front costs: use of consultants and computer software.	Actual costs of program in its first year. Assume \$3,000 for consultants and \$500 for software.
Capital expenses: purchase of material with use longer than one year—computers and textbooks.	These costs are generally spread out over their useful life—for computers and texts, 3 to 5 years. Assume 10 computers at \$2,000 for 5 years (annual cost: \$4,619) and 20 texts at \$50 with a 3-year life. Annual cost: \$387.
Salaries: both full-time and part-time salaries include annual costs plus benefits.	Assume 1 full-time faculty at \$35,000 plus 30 percent benefits (\$10,500), plus 3 part-time faculty for 9 months at \$2,000 per month plus benefits (part-time benefits are lower, assume 10 percent). Annual cost: \$104,900.
Maintenance: extra costs of maintaining facilities after normal hours; may include energy cost, janitorial, and maintenance.	These would be the marginal costs incurred over what the costs would have been without the program. Assume \$1,000 a month for 9 months. Annual cost: \$9,000.
Materials and supplies: paper, pencils, chalk, and so forth.	Assume \$100 per participant per year, with 50 participants. Annual cost: \$5,000.
Travel: cost of buses for field trips, car mileage, and so forth.	Annual assumed costs: \$3,000.
Overhead: administrative, including any costs of supervision; insurance.	Appropriate measure is marginal cost; for example, if insurance went up because of the new program or if cost of auditing program increased cost of annual audit. Annual assumed costs: \$1,000.
<b>Social Costs</b>	<b>Estimate and Method of Valuation</b>
Facilities: use of classroom after school	Opportunity cost of classroom use. Assume there is no other use: \$0.
Participants' cost: opportunity cost of students' time.	Although this is a nonbudget cost, it represents a real cost to participants. Assume \$1,843 per participant.
Parents' cost: opportunity cost of parents' time.	Parents may take time off from work or may incur additional transportation costs. If this is the case, their average wage should be used to value this cost. This example assumes no cost: \$0.
Volunteers' cost: opportunity cost of volunteers' time.	This one is controversial. This example assumes benefits are equal to the cost: \$0.



**TABLE 21.2. DROPOUT PREVENTION PROGRAM LIFETIME COSTS,  
IN CONSTANT DOLLARS.**

	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Fiscal costs to the school						
Up-front cost						
Consultants	\$3,000	\$3,000				
Software	\$500	\$500				
Capital expenses						
Classroom	\$0	\$0	\$0	\$0	\$0	\$0
Computers	\$4,619	\$4,619	\$4,619	\$4,619	\$4,619	\$23,097
Texts	\$367	\$367	\$367	\$367	\$367	\$1,836
Salaries						
Full-time	\$45,500	\$45,500	\$45,500	\$45,500	\$45,500	\$227,500
Part-time	\$59,400	\$59,400	\$59,400	\$59,400	\$59,400	\$297,000
Maintenance	\$9,000	\$9,000	\$9,000	\$9,000	\$9,000	\$45,000
Materials and supplies	\$5,000	\$5,000	\$5,000	\$5,000	\$5,000	\$25,000
Travel	\$3,000	\$3,000	\$3,000	\$3,000	\$3,000	\$15,000
Overhead						
Administrative	\$500	\$500	\$500	\$500	\$500	\$2,500
Insurance	\$500	\$500	\$500	\$500	\$500	\$2,500
Total costs to school	\$131,387	\$127,887	\$127,887	\$127,887	\$127,887	\$642,934
Social costs to others						
Participants	\$92,150	\$92,150	\$92,150	\$92,150	\$92,150	\$460,750
Parents	\$0	\$0	\$0	\$0	\$0	\$0
Total costs to others	\$92,150	\$92,150	\$92,150	\$92,150	\$92,150	\$460,750
Total costs	\$223,527	\$220,037	\$220,037	\$220,037	\$220,037	\$1,103,684

### Step 6: Quantify Benefits (for CEA) and Monetize Benefits (for CBA)

Although the cost calculations described previously are identical for CEA and CBA, the benefit calculations diverge. In the case of CEA, the analyst typically quantifies only the most important benefit to get the units of effectiveness (used in

the first equation). If more than one benefit is deemed important, separate cost-effectiveness ratios for an additional outcome or two are sometimes calculated and discussed. In CBA, however, the analyst not only quantifies benefits but also ascribes dollar values to them. Further, she does this for all benefits (or as many as possible), not only the most important.

### Quantifying Benefits (for CEA)

For CEA the task is seemingly straightforward. You must first identify the most important benefit by which you wish to measure the success of the program. Measures of effectiveness are idiosyncratic to each program. In all cases they must be related to the objectives of the program. Levin and McEwan (2001) provide a number of examples of effectiveness measures from various studies. The measure for a program with the objective of improving the functioning of disabled infants and toddlers was estimated based on behavioral tests, and the measure for a Brazilian program to improve achievement in elementary schools was based on test scores for basic skills in Portuguese and mathematics. Because one of CEA's strengths is its ability to provide comparisons with other programs, the measure of effectiveness should be a benefit that has direct comparisons to other programs.

The next task is to quantify the benefit in terms of units of effectiveness. The idea is to count only the units of effectiveness that are attributable to the program: that is, the causal effects of the program over and above the status quo. In a safety program the analyst might need to estimate the number of lives saved. For educational programs the difference in test scores between participants and non-participants provides the relevant quantification of units of effectiveness, though experimental or quasi-experimental estimates of participants' test score gains would be preferable, if available.

### Step 6 Illustration: Dropout Prevention Program, CEA

Cost-effectiveness analysis of the dropout prevention program simplifies the task of relating costs to benefits because it does not require converting all benefits into dollars. The key is whether there is one measure of benefit or effectiveness that can serve as a surrogate for program success. In the case of the dropout prevention program, the program has several benefits—potential dropouts who now graduate will lead more productive lives, earn higher wages, have less reliance on government assistance (such as welfare programs), and perhaps exhibit fewer criminal and other negative behaviors. But since the program's goal is to prevent

dropouts, the obvious measure of effectiveness for a CEA is simply the number of dropouts prevented. This can be measured using either the actual decrease in the number of dropouts or the increase in number of students graduating. All other benefits are left out of the CEA, but we will return to them in considering the CBA.

In an ex post analysis to determine the number of dropouts prevented as a result of the program, an analyst would examine data on dropouts for at-risk high school students. In the example the analyst determines that of 50 at-risk high school students, 20 typically drop out before graduation. However, those enrolled in the dropout prevention program were more likely to stay in school. Data indicate that over the five years of the program, of 250 participants, 69 dropped out before graduation, compared to the expected 100 with no program. Thus the number of dropouts prevented by the program can be estimated at 31.<sup>2</sup>

The analyst can now compare the 31 dropouts prevented with the program cost. Those costs can be displayed (as in Table 21.3) on an annual basis and totaled over the five years. Over the five-year period, total costs per dropout prevented are approximately \$35,600, of which the school spent about \$20,000

**TABLE 21.3. DROPOUT PREVENTION PROGRAM  
COST-EFFECTIVENESS ANALYSIS.**

Year	1	2	3	4	5	Total
Dropouts per 50 at-risk students	20	20	20	20	20	100
Dropouts per 50 participants	17	15	13	12	12	69
Dropouts prevented	3	5	7	8	8	31
Fiscal cost to school	\$131,387	\$127,887	\$127,887	\$127,887	\$127,887	\$642,934
Fiscal cost per dropout prevented	\$43,796	\$25,577	\$18,270	\$15,986	\$15,986	\$20,740
Total cost to society (including participants costs)	\$223,527	\$220,037	\$220,037	\$220,037	\$220,037	\$1,103,684
Total cost per dropout prevented	\$75,509	\$44,007	\$31,434	\$27,505	\$27,505	\$35,603

per dropout prevented (or per additional student who graduated). First-year costs to the school were higher and they gradually declined to about \$16,000 per dropout prevented in year 5. This information provides important data for the principal, school board, and state policymakers; and the question is now whether the result (preventing a dropout) is worth \$16,000 to the taxpayers or \$35,600 to society. This figure also can be compared with costs for other programs that achieved the same student retention goal.

### Monetizing Benefits (for CBA)

For a CBA, your ideal goal is to calculate a dollar value for every major output or benefit. The more complex the program objectives (for example, urban renewal), typically the more difficult the benefit analysis is, because it often involves multiple objectives aimed at different beneficiary groups (business interests, the poor, the middle class, and many others). Further, although some outcomes may be monetized using the approaches described for costs in step 5, most benefits are more complicated to place a dollar value on and some of the methods used are controversial. We describe several of the most common challenges and techniques in the following discussion.

**Nonmarket Goods and Services.** Unlike the majority of costs, many social benefits are not reflected or easily estimated using market prices or budgets. Most economists argue that market prices are the best valuation of a benefit, as they reveal a person's true preference or *willingness to pay* for a product or service. However, in most public programs, the recipients are not fully paying for the benefits received; therefore the evaluator must make an alternative assessment of value. These valuations are often referred to as *shadow prices*, and they can be obtained using a variety of methods. One of the most straightforward is to use prices in a similar private market to assign a dollar value to a public good. For example, to monetize the benefit of a free public swimming pool, one might use the fees that people pay for a similar swimming experience in a private pool—multiplying these fees by the number of patrons at the public pool.

**Cost Avoidance.** *Cost avoidance* (or *cost savings*) is also a benefit. Thus an anticrime program analyst could measure dollars saved from avoided burglaries. A health program analyst could measure avoided costs of medical care and lost productivity. To estimate the amount of cost avoidance, the evaluator would likely rely on historical data and trends before and after implementation of the program and

estimate the effect of the program on other spending by the program funder and on the general public.

**Time Saved.** Time saved is a tangible benefit. However, measurement of its dollar value is more subjective. Each person may value his or her time differently. A common method of estimating the value of time is by using the economists' theory of labor-leisure trade-offs. When people have control over the hours they are working, they will work (including overtime) until their subjective value for one hour of leisure is equal to the income they would gain from one more hour of work—their after-tax wage rate. The idea, then, is that the wage rate reflects the value of an hour of time to the individual. Further, if labor markets operate efficiently, a person's wage also reflects the value to society of his time, as this is what his time is worth to an employer.

**Increased Productivity.** Increased productivity is a common objective of many government investment programs—both capital investments, such as roads, bridges, water projects, and other infrastructure developments, and human capital investments, such as education and job training. These benefits might be measured in increased profits or wages.

**Property Values.** Increased property values may or may not be a benefit, depending on the geographical scope of the analysis. The narrower the scope, the more likely it is that increased property values will be a real benefit of the project. If property values increase in a neighborhood because of a new community park, from the neighborhood's perspective, this would be considered a benefit. In a CBA from the city's perspective, however, this benefit might be offset by losses in property values in other areas of the city farther from the park that are now relatively less desirable. It is only if demand is fueled by new residents from outside the jurisdiction that the benefits should be counted.

**Taxes.** Taxes are sometimes thought of as a benefit, and from a fiscal or budgetary perspective they are important, especially if the program or project is designed to produce revenues equal to expenditures. But from a societal perspective, taxes are transfers: the gain to the government is a loss to the individual paying the taxes. The individual does gain from the services that the government provides with taxes but loses dollars that could have been spent on private purchases. Economists also believe that there is some *deadweight loss* associated with taxes, due to the market distortions that they create, but this is usually left out of CBAs.

**Value of the Environment.** Many projects—particularly those that affect the environment—provide recreational activities such as hiking, fishing, or swimming. In this case one must calculate recreational values. These values are typically based on the concept of willingness to pay. The evaluator first must determine the number of people who have visited a particular recreational area and then attempt to value each *user day* of recreation.

One approach is to ask recreational users what they would be willing to pay to use a particular recreational area (for example, a park or wilderness area). This survey technique, known as *contingent valuation*, has several problems. One of the most significant problems is that respondents may answer strategically. If they think they may have to pay to use a favorite park, they may give a lower value than the true value to them. If they think the response may influence the continued provision of the recreation, they may state a higher value than their true value. In many cases, statements of willingness to pay have differed from actual behavior.

A second technique is to estimate what it costs users to travel to the recreation area—plane fares, rentals, gasoline, travel time, and so forth. This works best for a recreational site that draws visitors from a wide area, such as a national park. Finally, evaluators of public programs sometimes look at similar recreational experiences in the private sector. As described earlier, the value of a public swimming pool might be assessed using rates similar to the costs of similar private facilities in the area, adjusting for any difference in quality of the experience.

In addition, individuals typically value facilities like parks and wilderness areas for more than just their direct recreational value. One indirect benefit of these areas is the option they provide for a future visit. This *option value* can be thought of as a person's willingness to pay in order to maintain the option of visiting the area at some time in the future. To calculate this value, analysts often use recreation values multiplied by the probability of a future visit. Even if a person does not intend to visit a wilderness area, she may simply value its existence. This *existence value* may derive from a concern for others who may want to use the area now or in the future (for example, people may value saving the polar bears so that their grandchildren can see them), but it may also derive simply from the idea that plants and animals have a right to exist. Of course, putting a price tag on existence value is difficult, and surveys are about the only hope for ascertaining it. Box 21.6 deals with perhaps the most difficult problem in CBA, putting a value on a human life.

**Chain Reaction Problem.** A common error often made in cost-benefit analysis is to make the project or program appear successful by counting indirect benefits that arise from it while ignoring indirect costs. For example, if a government builds a road, the direct benefits are the reduction in transportation costs (time

**Box 21.6. Step 6 Key Issue: Valuing Life****Using the VSL**

Lives saved is clearly a tangible benefit of a policy and the justification for many government health and safety programs. The value of a life may be of infinite value to the person whose life was saved and to his loved ones. However, if the value of life is infinite, any project that leads to even a single life being saved should be undertaken. This leaves no sensible way to determine the admissibility of projects. The most common approach is to depersonalize the valuation of life. Ideally, the analyst seeks to use an average value for *any* human life, whether old or young, rich or poor, in the CBA. This value is known as the *value of statistical life* (VSL).

To obtain the VSL, economists typically calculate how much an average individual would pay to reduce their risk of death, or conversely, how much an individual would have to be paid to take on a given risk. For example, economists often compare the wages of individuals in similar risky and non-risky jobs. The idea is that workers in riskier jobs trade some risk of death for a higher wage, all else equal. Other studies ask what consumers are willing to pay for safety products, such as smoke alarms, that reduce their risk of death. Using this type of information, economists calculate an implicit value of life. This value (or an average value from many different studies) is then used as the VSL in a CBA to monetize any and all lives saved.

**Our Recommendation**

Although different studies still find different values for the VSL and some federal agencies require analysts to use a specific VSL for all their CBAs, the generally accepted range is \$3 million to \$8 million (in 2009 dollars).

spent and fuel) for individuals and businesses. Profits of adjacent restaurants, motels, and gas stations may also increase due to the traffic. This may lead to increased profits in the local food, bed linen, and gasoline production businesses. Economist Harvey Rosen (2001) calls this the *chain reaction game*: if enough indirect effects are added to the benefit side, eventually a positive net present value can be obtained for practically any project. Rosen notes that this process ignores the fact that there are likely losses as well as gains from building the road. Profits of train operators may decrease as some of their customers turn to cars for transportation, businesses in and around train stations may suffer lost profits, and increased auto use may bid up the price of gasoline, increasing costs to many gasoline consumers. At the very least, indirect costs must be counted as well as indirect gains. In many cases these benefits and costs are often transfers, with the gains to some

equaling the losses to others. Although a detailed discussion of the complexities of such *secondary market effects* is beyond the scope of this chapter, we refer the reader to Boardman, Greenberg, Vining, and Weimer (2006) and recommend restricting the analysis to the most significant indirect effects.

### Step 6 Illustration: Dropout Prevention Program, CBA

In the analysis of the dropout prevention program, the analyst may want to undertake a CBA to assess the efficiency of the program or may want to compare the benefits of this program with the different benefits of different options, for example, expanding the advising and counseling program to assist high school students in gaining college admissions. Either way, the analyst will want to place dollar values on the benefits of the program and compare them to the costs. The major benefit of completing high school is to the participants themselves: an increase in lifetime earnings because of the diploma. To estimate this figure, an evaluator could compare the wages of individuals who have completed high school with those of similar individuals who have dropped out. These data are available from the U.S. Bureau of Labor Statistics. Alternatively, one could draw on a number of studies reported in the economics literature that have used quasi-experimental methods and other data sources to estimate the returns of schooling. For purposes of illustration, we use data from a University of Cincinnati study (Ramsey Rexhausen, Dubey, and Yu, 2008) of the economic benefits of education. In Ohio, the median earnings of a high school dropout are \$17,748 (with a 47.5 percent employment rate) compared to \$26,207 (and a 70.6 percent employment rate) for high school graduates. Thus the earnings differential per graduate (wages plus employment rate) was \$10,079 a year over a working lifetime.

There are also indirect benefits to the rest of society as a result of an individual's completing high school. Among these indirect benefits are less crime (and prison expenses), less government support (welfare and other transfers), and increased taxes paid to the government. Some of these benefits to the rest of society are costs to the participants. Thus taxes gained by government are a cost to the participants (in effect, a transfer that is netted out of the analysis). We include taxes as negative benefits to the participants in Table 21.4.

The cost-benefit analysis makes the assumption that lower costs related to crime are primarily a benefit to the rest of society, due to the reduction in detention and judicial system costs. This benefit includes the "gain" to potential victims (they avoid a loss of their property), which might be offset somewhat by the "loss" to the participants (they lose the value of goods stolen and fenced). However,



because criminals do not abide by the laws of society, the losses they suffer are typically not included in cost-benefit analyses.

It is clear that there are some benefits that are difficult to put a monetary value on. For example, the true cost of a crime might be not just the cost of stolen goods but also the cost of pain and suffering to the victims, but these costs (and the benefits of avoiding them) may be difficult to place a dollar value on. Similarly, graduating from high school may create a self-confidence in the students that enhances their lives beyond lifetime earnings. In addition, better-educated citizens may benefit society in other nonmonetary ways. Even when we do not place a value on these intangible benefits, a thorough cost-benefit analysis should acknowledge them.

Table 21.4 provides a breakdown of benefits to participants and others in society, as identified by Ramsey, Rexhausen, Dubey, and Yu (2008). Although costs begin in year 1 of the project, benefits do not occur until the students have actually graduated at the end of year 1 or beginning in year 2, though it is possible that some benefits (such as lower crime) might begin immediately. Furthermore, the benefits continue to occur over the graduates' lifetimes, beyond the thirty years we focus on here. Nonetheless, our calculations reveal a total of approximately \$9.6 million in benefits, though these benefits have not yet been discounted. We describe this important adjustment in the next step.

**TABLE 21.4. ESTIMATED BENEFITS OF DROPOUT PREVENTION PROGRAM.**

	Annual Benefit per Dropout Prevented	30-Year Projection for 31 Dropouts Prevented
Direct benefits to participants		
Increase in earnings	\$10,079	\$8,305,096
(Reduction in welfare received)	(\$564)	(\$1,845,760)
(Increase in taxes paid)	(\$2,240)	(\$464,736)
Total benefits to participants	\$7,275	\$5,994,600
Indirect benefits to others		
Increase in tax revenues	\$564	\$464,736
Reduction in welfare costs	\$2,240	\$1,845,760
Reduction in incarceration costs	\$1,586	\$1,306,864
Total benefits to others	\$4,390	\$3,617,360
Total benefits	\$23,330	\$9,611,960

## Step 7: Discount Costs and Benefits to Obtain Present Values

It is important to recognize that the high school, by spending \$642,934 on the dropout prevention program, did not have those dollars to spend for other programs, and thus there is an additional opportunity cost that should be recognized in the analysis. The idea is that even without inflation, \$100 today is worth more to a person or organization than the same \$100 promised to that person or organization one year from now, and much more than the same \$100 promised for ten years from now. The reason is that the money has an opportunity cost. You could take the \$100 today and invest it to receive more money in the future. Just how much will you will receive will depend on the interest rate you get. The same is true of all costs and benefits. People value costs and benefits incurred today more than those that they may incur in the future.

In order to incorporate this concept, both cost-benefit and cost-effectiveness analysis convert all monetary values to their present value—or their equivalent value at the beginning of the project, in year 1. Rather than an actual interest rate, in CEA and CBA analysts use what is known as a *social discount rate* ( $r$ ) (for example, .03, for 3%), to calculate the present value of costs and benefits. The social discount rate is meant to reflect society's impatience or preference for consumption today over consumption in the future. We discuss the choice of the social discount rate later in this section.

In cost-effectiveness analysis, you take the present value of the costs of the project to use as the numerator in your cost-effectiveness ratio. To do this, you first aggregate the costs in each year, noting each year's costs as  $C_t$  where  $t$  indicates the year from 1 to  $T$  (the last year of the analysis). The values in each year need to be converted to their year 1 equivalent, and this is done by dividing  $C_t$  by  $(1 + r)^{t-1}$ . For example, using a 3 percent social discount rate, \$1 million of costs accruing in year 3, would be converted to present value by dividing 1 million by  $(1.03)^2$ . The result is \$942,596. Summing the present value of the costs in each year, you would obtain the *present value of costs* (PVC) for the whole project:

$$PVC = C_1 + \frac{C_2}{(1+r)^1} + \frac{C_3}{(1+r)^2} + \dots + \frac{C_r}{(1+r)^{r-1}} = \sum_{t=1}^T \frac{C_t}{(1+r)^{t-1}}$$

The PVC is then used to calculate the CE ratio, as described later in step 8.

In cost-benefit analysis, the calculation is much the same. One simply takes the present value of the benefits and subtracts the present value of the costs. The final calculation is now referred to as the *net present value* (NPV), rather than net benefits. The formula becomes

$$NPV = \sum_{t=1}^T \frac{(B_t)}{(1+r)^{t-1}} - \sum_{t=1}^T \frac{(C_t)}{(1+r)^{t-1}}.$$

### Box 21.7. Step 7 Key Issue: Choosing a Social Discount Rate

#### The Debate

The choice of an appropriate discount rate is critical for the program evaluator using CEA or CBA; however, there is considerable debate as to the appropriate rate. Circular A-94 of the Office of Management and Budget (2009), provides the rate that federal agencies must use for different periods of time. The rate is based on current interest rates but varies depending on the time frame of the analysis. For example, in the 2009 low-rate environment, real discount rates ranged from 0.9 percent (for three-year projects) to 2.7 percent (for thirty-year projects). The *Canadian Cost-Benefit Analysis Guide* (Treasury Board of Canada Secretariat, 2008), recommends a range of 3 to 7 percent depending on the project and its length. A 2007 study by the Asian Development Bank found that developed nations tended to use real rates between 3 and 7 percent, whereas developing nations used a higher rate of 8 percent or more, reflecting the higher risk and uncertainty of public investments in those nations (Zhuang, Liang, Lin, and DeGuzman, 2007). However, a World Bank paper has argued for a real rate of 3 to 5 percent (Lopez, 2008). A controversial U.K. report by Stern (2006) argued for a rate near 0 percent for long-term projects involving the environment.

#### Our Recommendation

Unless your organization specifies a specific interest rate, we suggest using a base real discount rate of 2 to 3 percent, while testing for sensitivity of the project to higher rates of 5 to 7 percent.

Rather than calculate these formulas by hand, it is much easier to use Excel's NPV function. One simply inputs the interest rate ( $r$ ) (for example, .03) and the values to be discounted. Box 21.7 discusses the difficult question of which social discount rate to use.

### Step 7 Illustration: Dropout Prevention Program

In the dropout prevention program, the choice of an appropriate discount rate to obtain net present value is important because the costs are up-front and the benefits accrue over many years into the future. The higher the discount rate, the greater the adverse impact on long-term benefits. For this analysis, we have chosen a 3 percent discount rate for the baseline, and we later explain how a change in the discount rate would affect the analysis (part of the sensitivity analysis).

## Step 8: Compute a Cost-Effectiveness Ratio (for CEA) or a Net Present Value (for CBA)

### Compute Cost-Effectiveness Ratio (for CEA)

This step finally brings together the present value of costs and units of effectiveness to calculate a CE ratio, where you have a single measure of program effectiveness. Rather than using *total costs* (as in the first equation), this ratio substitutes the present value of these costs (note, however, that often the term *total costs* is still used even though the present value is assumed):

$$\text{Cost-Effectiveness Ratio} = \frac{\text{PVC}}{\text{Units of Effectiveness}}.$$

The result is expressed in “dollars per dropout prevented” or “dollars per life saved.” When comparing multiple projects, you would calculate the CE ratio for each project separately.

A common alternative is to use the reciprocal of the standard CE ratio in program evaluation. That is, you could divide units of effectiveness by PVC. The ratio would then be interpreted as “dropouts prevented per dollar” or “lives saved per dollar.” These numbers of course, would be quite small, so evaluators often scale the dollars up to interpret the results as “dropouts prevented per \$1,000 dollars” or “lives saved per million dollars.” The advantage of this approach is that it may be easier to evaluate programs within the context of a specific budget.

One caution when using CEA to compare projects is that ratios hide differences in scale. That is, if one project is ten times the cost of another with roughly ten times the units of effectiveness, the CE ratios of the two projects will look the same even though the actual costs and benefits differ tremendously. In light of this, CEA is most useful when comparing projects of similar sizes.

### Calculate Net Present Value (for CBA)

For CBA, the most important calculation is the NPV, shown in the second equation in step 7. The NPV can give the clearest answer to whether a project improves social welfare, and it should be reported in every CBA. There are, however, two alternative calculations that may be used to supplement the NPV calculation.

The first is the *benefit-cost ratio*, calculated by taking the NPV of the benefits and dividing it by the NPV of costs. Benefit-cost ratios are useful in two respects. First, they may make it easier to compare similar programs. Second, a decision maker can decide whether a specific benefit gained per dollar of cost is sufficient given other investment or budget alternatives. From an economic efficiency perspective, any program with benefits exceeding costs, or with a benefit-cost ratio

of better than 1, would be considered an efficient allocation of resources. We caution, however, that decision makers should use benefit-cost ratios only when they are examining two similar projects in size and scope. Otherwise CBA ratios can mask scale differences, just as CEA does, which may lead to a choice that does not provide the greatest net benefits to society.

The second alternative calculation is *return on investment*. Unlike the private sector, government evaluators in the United States do not usually conduct *economic rate of return* (ERR) analysis (sometimes referred to as IRR, or *internal rate of return*). However, international organizations use it more frequently, and it can easily be computed. The ERR is simply the discount rate that would yield total present value benefits equal to costs. An organization, government agency, or political decision maker can then assess the value of the project based on whether a certain percentage rate of return is satisfactory given other opportunities the organization or agency might have had in year 1.

### Step 8 Illustration: Dropout Prevention Program

Table 21.5 provides a summary of our cost-benefit and cost-effectiveness analyses for the dropout prevention program. It reports all benefits and costs in present value, using a 3 percent social discount rate. It also includes a breakdown of the benefits and costs for the participants and for the rest of society on an aggregate basis and on a per-dropout-prevented basis. Box 21.8 offers suggestions for displaying an analysis.

**TABLE 21.5. DROPOUT PREVENTION PROGRAM: COST-BENEFIT AND COST-EFFECTIVENESS SUMMARY.**

	Total	Per Dropout Prevented (31 total)
Costs (PV at $r = 3\%$ )		
Fiscal costs to school	\$606,754	\$19,573
Social cost to participants	\$434,681	\$14,022
Total costs	\$1,041,435	\$33,595
Benefits (PV at $r = 3\%$ )		
To others	\$2,301,360	\$74,237
To participants	\$3,813,757	\$123,024
Total benefits	\$6,115,117	\$197,262
Net present value (NPV)	\$5,073,682	\$163,667
Benefit-cost ratio	5.87	

### Box 21.8. Step 8 Key Issue: How to Display Your Analysis

#### Understand the Expectations

When providing a summary of your findings, it is most important to understand what it is that is expected of the evaluator. Are you comparing various programs based on their CEA or CBA or examining one program from various perspectives?

#### Our Recommendation

Even where the goal is to develop dollar values on all costs and benefits, it may be useful to develop an interim measure of cost effectiveness by relating costs to one or more measures of effectiveness. Although this does not provide a dollar value on the benefits, it provides policymakers with important information on what they are receiving (in benefits or outcomes) for the dollars they are spending. However, where dollar values can be calculated on the benefits, providing information on the net present value of a project is likely to provide the most useful information to decision makers.

Whether viewed from the traditional societal perspective (participants and all others) or simply by looking at the net benefits to each group separately, the dropout prevention program can be considered a success: benefits exceed the costs.

- The CEA ratio is the total cost to society (\$1,041,435) divided by the number of dropouts prevented (31), or about \$33,600 per dropout prevented (the fiscal costs are about \$19,600 per dropout prevented).
- The net present value is substantial, over \$5 million, with \$3.4 million accruing to the participants and \$1.7 million to the rest of society.
- The PV of benefits (\$6,115,117) divided by the PV of costs (\$1,1041,435) yields a benefit-cost ratio of 5.87 to 1.

## Step 9: Perform Sensitivity Analysis

As we have noted throughout the chapter, it is important for the program evaluator to test the sensitivity of the analysis to particular assumptions. The advantage of Excel and other spreadsheet programs is that they allow the evaluator to easily plug in a range of alternative assumptions and determine their impact on the analysis. There are two main types of sensitivity analysis—partial and extreme case. Although other, more sophisticated methods (such as Monte Carlo simulations)

**Box 21.9. Step 9 Key Issue: Conducting a Sensitivity Analysis**

Because CEAs and CBAs must rely on assumptions that are oftentimes best guesses, it is critical that they contain an explicit sensitivity analysis that discusses key assumptions in the standard base case analysis and varies those assumptions to see how a change affects the analysis.

**Partial Sensitivity Analysis**

This approach varies one assumption (or one parameter or number) at a time, holding all else constant. For example, if the value of life plays an important role in your analysis, you might use an average value of \$5 million for the value of statistical life (VSL) in your base case. Using partial sensitivity analysis you would then plug in a range of values for the VSL, from \$3 million to \$9 million, without changing any other assumptions and report the results. You would apply the same process for other uncertain parameters, returning each time to the base case figures for everything except the number in question.

**Extreme Case Sensitivity Analysis**

This approach varies all of the uncertain parameters simultaneously, picking the values for each parameter that yield either the best- or worst-case scenario. If a project looks good even under the worst-case assumption, it strengthens the case to go forward. Similarly, if the project looks questionable under a best-case scenario, it is unlikely to be successful.

**Our Recommendation**

Both approaches are useful. Partial sensitivity analysis is most useful when there are only a handful of critical assumptions, and extreme case is more useful in cases of greater uncertainty. The choice of which approach to use will depend upon the number and type of assumptions made as well as the expectations of policymakers.

are available, partial and extreme case sensitivity analyses remain the methods of choice for most analysts. Box 21.9 reviews these two main approaches to conducting a sensitivity analysis.

**Step 9 Illustration: Dropout Prevention Program**

In the dropout prevention program, there are several uncertain assumptions and parameters. Among the most important to the bottom line are the number of dropouts prevented, the annual earnings gain for those who graduate, the forgone earnings of participants, and the social discount rate. Exhibit 21.3 provides an

### EXHIBIT 21.3. PARTIAL SENSITIVITY ANALYSIS OF THE DROPOUT PREVENTION PROGRAM

Base case analysis: net present value = \$5 million

#### Key Assumptions and Base Case Parameters

- 31 dropouts prevented over 5 years of program
- Increased earnings of high school graduates at \$10,079 a year
- Opportunity cost to students in forgone earnings of \$1,843 per participant
- Social discount rate of 3 percent

#### Effect of Changes in Key Assumptions for NPV

- One fewer/additional dropout prevented per year: +/- \$0.7 million
- Earnings of high school graduates \$1,000 more/less than baseline: +/- \$0.5 million
- Eliminate opportunity cost to participants: + \$0.4 million
- Discount rate 1 percent higher/lower than baseline: +/- \$0.8 million

example of a partial sensitivity analysis for the dropout prevention program. From this information the decision maker can easily determine that the analysis is most sensitive to the discount rate; however, a small change in any of the assumptions would not have a dramatic impact on the analysis: none of the changes would bring the NPV of the program below zero.

Given the consistently positive net benefits of the partial sensitivity analysis, it may also be useful to undertake a worst-case sensitivity analysis. Such an analysis will reveal if the school can ever expect to see negative net benefits of the program. We now vary all of the uncertain parameters at the same time, pushing each to the most extreme (yet plausible) values that will yield the highest costs and lowest benefits. We recalculate net benefits with the following worst-case assumptions:

- Three fewer dropouts prevented per year (16 prevented over 5 years)
- Earnings of high school graduates \$1,000 less than baseline (\$9,079)
- Maximum opportunity cost to participants (\$1,843 per participant)
- Social discount rate of 7 percent

Even in this worst-case scenario, the net present value remains positive at \$710,834.



## Step 10: Make a Recommendation

The final step of cost-effectiveness and cost-benefit analysis, if appropriate, is making a policy recommendation. In cost-benefit analysis, if a program has a positive net present value (particularly after a worst-case sensitivity analysis), then one should (theoretically) implement the policy, as it would increase social welfare. If it has negative net present value, then the project should be rejected.

In cost-effectiveness analysis, there is no clear decision rule when evaluating one project. The policymaker must use his or her own judgment as to whether the cost per unit of effectiveness is sufficiently low to merit adoption. However, when two or more programs are evaluated against the same units of effectiveness, the policy with the lowest CE ratio should be implemented (assuming the projects are of roughly the same scale, as noted earlier).

These decision rules, while simple, should not be the only consideration in making a policy recommendation. There are several other important points to take into account.

### The Black Box

The biggest danger in any such analysis is the black box syndrome. Instead of laying out the relevant issues, assumptions, and concerns, the analyst may be tempted to hide the messiness of the analysis from the decision maker, presenting a concise answer as to net benefits or costs or cost effectiveness. However, two honest, careful analysts might arrive at opposite conclusions on the same set of facts if their assumptions about those data differ. A Scotsman once proclaimed that the “devil is in the detail,” and it is the detail—the assumptions and the sensitivity of the analysis to those assumptions—that may be of most use to the decision maker in judging the value and usefulness of the evaluator’s work.

### Equity Concerns

It is not just the total benefits and costs but also who benefits and who pays that are of concern to policymakers. It is not always easy to determine if there are strong distributional consequences to a program, but where there are, they should be noted. Concerns over rising income inequality in the United States have made it common to give special consideration to distributional consequences in cases where low-income populations stand to gain or lose substantially. One approach to dealing with distributional issues is to weight the benefits and costs. For example, the analyst could weight a benefit or cost to a low-income family as twice the value of a similar

benefit and cost to a middle-income family and three times as much as a similar benefit to an upper-income family. The issue is the appropriate weights—a subjective factor that is ultimately the judgment of policymakers. A less controversial alternative is simply to identify the costs and benefits to each significant group affected by the project. That approach is illustrated in the dropout prevention program case, where benefits are divided between participants and the rest of society.

## Unquantifiabes

No matter how creative the evaluator is, there will be some benefits and costs that defy quantification. Even if you can value the cost of an injury, that dollar figure will not fully capture the pain and suffering involved, and financial savings from burglaries prevented does not fully capture the sense of security that comes with crime prevention. In other cases the analyst may not have the time or resources to quantify every cost and benefit, even if these could be valued. Box 21.10 discusses one approach to handling unquantifiabes.

### Box 21.10. Step 10 Key Issue: Dealing with Intangibles and Unquantifiabes in Your Recommendation

Although it would be ideal if all benefits and costs could be measured and valued, the reality is that many program benefits and costs may be intangible or unquantifiable. If these effects are significant, they need to be highlighted by the evaluator.

#### Using Indirect Methods of Valuation

The best method for identifying issues surrounding unquantifiable benefits and costs is to relate them to the final dollar results. For example, if the analysis reveals net costs (or negative NPV) of \$2 million but also identifies certain environmental benefits that could not be converted to dollars, then the analyst might highlight the question of whether the environmental benefits over the period studied would be enough to offset the \$2 million in costs. With dollars and the unquantifiabes juxtaposed, both the analyst and decision maker must use their judgment in assessing the importance of these factors in the analysis.

#### Relating Costs to Intangible Outcomes

If the major benefit of a project or program is to achieve some intangible benefit (such as improving visibility over the national parks through stricter environmental regulation), it may be best to treat the problem more as a cost-effectiveness issue, asking, for example, What is the marginal cost to increase park visibility from the current 10 miles to 20 miles?

### Step 10 Illustration: Dropout Prevention Program

The high net benefits in the base case, the relative insensitivity of the results to changes in assumptions, and a worst-case analysis that remains positive, all suggest that the dropout prevention program was a success and should be expanded to other schools in the state. The benefits to society outweigh the costs under a range of assumptions, suggesting that the program improves efficiency or overall social welfare. Before making the recommendation, however, the analyst should consider any unquantified costs or benefits that might change the results. For example, the analysis did not include any negative psychological effects that participants might incur from stigma associated with the program. Still, unless these negative feelings cause students more than \$5 million of harm altogether (or \$100,000 per participant—which seems implausibly large), an analyst has no reason to believe that omitting these effects would change the recommendation. A final consideration is equity. As this program potentially helps low-income students, who are most at risk of dropping out, equity is likely enhanced, providing one more reason to recommend that the program be expanded.

The ex post CBA assesses the success of the program to date—or for the thirty years we analyze. But if policymakers are considering whether or not to continue the program after the first five years have elapsed, in an in medias res evaluation, other considerations might also need to be taken into account. By year 5, the program is costing \$127,887 a year and is preventing eight dropouts a year for a fiscal cost to society per dropout prevented of \$15,986 (see Table 21.3). At this point, certain costs incurred by the school (for example, the original cost of consultants) are now sunk costs: that is, funds have already been spent and resources used. They have no relevance for decisions about whether to continue the project. Thus the funds previously spent on start-up and on capital costs are not considered by the agency in deciding whether to continue the project. The state policymakers are concerned only with the program's current and future costs and expected continued benefits. The considerations might include whether more funding will be needed to modify the program in the future, whether new equipment will be needed, and whether there will still be a need or demand for this program in the future. Thus the program's continuation faces a different analysis from an ex post analysis of the project's net benefits. One of the challenges for the analyst is determining whether the projections of costs and benefits are realistic.

The cost-benefit illustration reinforces an important distinction for the analyst: the difference between total and marginal (or incremental) benefits and costs. In assessing the overall efficiency of a proposed or existing project, a policymaker should consider the total costs of getting the program or project started and

proceeding through its operational cycle. But at any point when an agency is deciding whether to continue or discontinue a project or program, it should consider only the marginal costs and benefits—those that will accrue over and above the status quo at that point in time

## Conclusion

Cost-benefit and cost-effectiveness analyses are not panaceas that will provide decision makers with the answer to a policy problem. Indeed both techniques may –be more art than science. With a host of considerations and sometimes controversial assumptions, the process is far more complicated and potentially more biased than many realize. However, much can be learned about a project in creating a framework to consider benefits and costs: simply attempting to identify them, measure them, and value them can provide important information for the decision maker. Adding a thorough sensitivity analysis and a clear explanation of each assumption and estimate, CEA and CBA can be extremely effective tools in program evaluation. Box 21.11 lists some recent CEAs and CBAs that provide additional illustrations of these two techniques.

### Box 21.11. Selected Applications and Critiques of CEA and CBA

Belfield, C. R., Nores, M., Barnett, S., and Schweinhart, L. "The High/Scope Perry Preschool Program: Cost-Benefit Analysis Using Data from the Age 40 Follow-up." *Journal of Human Resources*, 2006, 41(1), 162–190.

Chen, G., and Warburton, R. N. "Do Speed Cameras Produce Net Benefits? Evidence from British Columbia, Canada." *Journal of Policy Analysis and Management*, 2006, 25(3), 661–678.

KPMG Foundation. *The Long-Term Costs of Literacy Difficulties*. [www.kpmg.co.uk/pubs/beforepdf.cfm?PubID=1890], Dec. 2006.

Landau, S., and Weisbrod, G. *Effective Practices for Preparing Airport Improvement Program Benefit-Cost Analysis*. Transportation Research Board of the National Academies, Airport Cooperative Research Program, Synthesis 13. Washington, D.C.: The National Academies, Transportation Research Board, 2009.

Levin, H. M., Belfield, C., Muennig, P., and Rouse, C. "The Costs and Benefits of an Excellent Education for All of America's Children." New York: Columbia University, Teacher's College, Center for Benefit-Cost Studies on Education, 2007.

Mandelblatt, J., and others. "The Cost-Effectiveness of Screening Mammography Beyond Age 65." *Annals of Internal Medicine*, 2003, 139(10), 835–842.

Paltiel, D. A., and others. "Expanded Screening for HIV in the United States—An Analysis of Cost-Effectiveness." *New England Journal of Medicine*, 2005, 352, 586–595.

Russell, L. B., and others. "The Role of Cost-Effectiveness Analysis in Health and Medicine." *JAMA*, 1996, 276(14), 1172–1177.

Salt Lake City Million Solar Roofs Partnership. "Memorandum of Support...Re: Rocky Mountain Power's Proposed Pilot Solar Initiative." [http://www.psc.state.ut.us/utilities/electric/07docs/07035T14/53519-5-29-07CorresSLC.doc], 2007.

Schwindt, R., Vining, A., and Globerman, S. "Net Loss: A Cost-Benefit Analysis of the Canadian Pacific Salmon Fishery." *Journal of Policy Analysis and Management*, 2000, 19(1), 23–45.

Siegfried, J., and Zimbalist, A. "The Economics of Sports Facilities and Their Communities." *Journal of Economic Perspectives*, 2000, 14(3), 95–114.

U.S. Government Accountability Office. *Clean Air Act: Observations on EPA's Cost-Benefit Analysis of Its Mercury Control Options*. GAO-05-252. Washington, D.C.: U.S. Government Accountability Office.

Weimer, D. (ed.). *Cost-Benefit Analysis and Public Policy*. Hoboken, N.J.: Wiley-Blackwell, 2008.

Wiseman, V., Kim, M., Mutabingwa, T. K., Whitty, C.J.M. "Cost-Effectiveness Study of Three Antimalarial Drug Combinations in Tanzania." *Public Library of Science Medicine*, 2006, 3(10). [http://www.plosmedicine.org/article/info:doi/10.1371/journal.pmed.0030373].

## Notes

1. Note that in CBA and CEA, the term *outcome* is typically used to refer to the causal impacts of a policy or program, rather than to the broader *program outcomes* described in other chapters of this volume. As discussed previously, the analyst should seek to ascertain the causal impacts of a policy—those over and above the status quo that would not have occurred in the absence of the policy. Experimental and quasi-experimental methods are best suited to obtaining causal effects, though they are difficult to implement in the context of a CBA or CEA. However, if experimental or quasi-experimental estimates are available on a particular cost or benefit, they should certainly be used.
2. Again, we point out that experimental or quasi-experimental estimates that control for differences between participating and nonparticipating students would yield more accurate estimates. However, in most CBAs and CEAs, these types of estimates are well beyond the scope of the study.

## References

Boardman, A. A., Greenberg, D. H., Vining, A. R., and Weimer, D. L. *Cost-Benefit Analysis: Concepts and Practice*. (3rd ed.) Upper Saddle River, N.J.: Prentice Hall, 2006.

Levin, H. M., and McEwan, P. J. *Cost-Effectiveness Analysis*. (2nd ed.) Thousand Oaks, Calif.: Sage, 2001.

Lopez, H. "The Social Discount Rate: Estimates for Nine Latin American Countries." The World Bank, Latin American and Caribbean Region, Office of the Chief Economist. June 2008.

- Musgrave, R., and Musgrave, P. *Public Finance in Theory and Practice*. New York: McGraw-Hill, 1989.
- Ramsey, B. B., Rexhausen, J., Dubey, A., and Yu, L. *An Evaluation of the Economic Benefits of High School Education*. Cincinnati, Ohio: University of Cincinnati, Economics Center for Education & Research, 2008.
- Rosen, H. S. *Public Finance*. (6th ed.) Homewood, Ill.: Irwin, 2001.
- Stern, N. *The Stern Review Report on the Economics of Climate Change*. London: HM Treasury, 2006.
- Treasury Board of Canada Secretariat. *Canadian Cost-Benefit Analysis Guide*. Ottawa: Treasury Board of Canada Secretariat, 2008.
- Zhuang, J., Liang, Z., Lin, T., and DeGuzman, F. "Theory and Practice in the Choice of Social Discount Rates for Cost-Benefit Analysis: A Survey." Economics and Research Department Working Paper Series No. 94. Manila: Asian Development Bank, 2007.