

Chapter-4

Introduction to Cost-Benefit Analysis

4.1. Introduction

4.2. History of Cost-Benefit Analysis

4.3. What Is a Cost Benefit Analysis?

4.4. Principles of Cost Benefit Analysis

4.5. The Steps of a Cost-Benefit Analysis

4.6. Common Unit of Measurement of CBA

4.1. Introduction

"Of all the techniques of investment appraisal which in recent years have come to be applied to the public sector, none has attracted more attention than cost-benefit analysis" (Blaug, 1970).

Cost-Benefit Analysis (CBA) estimates and totals up the equivalent money value of the benefits and costs to the community of projects to establish whether they are worthwhile. These projects may be dams and highways or can be training programs and health care systems.

The idea of this economic accounting originated with Jules Dupuit, a French engineer whose 1848 article is still worth reading. The British economist, Alfred Marshall, formulated some of the formal concepts that are at the foundation of CBA. But the practical development of CBA came as a result of the impetus provided by the Federal Navigation Act of 1936. This act required that the U.S. Corps of Engineers carry out projects for the improvement of the waterway system when the total benefits of a project to whomsoever they accrue exceed the costs of that project. Thus, the Corps of Engineers had created systematic methods for measuring such benefits and costs. The engineers of the Corps did this without much, if any, assistance from the economics profession. It wasn't until about twenty years later in the 1950's that economists tried to provide a rigorous, consistent set of methods for measuring benefits and costs and deciding whether a project is worthwhile. Some technical issues of CBA have not been wholly resolved even now but the fundamental presented in the following are well established.

4.2. History of Cost-Benefit Analysis

A general definition of cost-benefit analysis states that it is: "A practical way of assessing the desirability of projects, where it is important to take a long view (in the sense of looking at repercussions in the further, as well as in the nearer, future) and a wide view (in the sense of allowing for side-effects of many kinds on many persons, industries, regions, etc.), i.e. it implies the enumeration and evaluation of all the relevant costs and benefits" (Press and Turvey, 1965).

CBA has its origins in the water development projects of the U.S. Army Corps of Engineers. The Corps of Engineers had its origins in the French engineers hired by George Washington in the American Revolution. For years, the only school of engineering in the United States was the Military Academy at West Point, New York. In 1879, and Congress created the Mississippi River Commission to "prevent destructive floods." The Commission included civilians but the president had to be an Army engineer and the Corps of Engineers always had veto power over any decision by the Commission. In 1936, Congress passed the Flood Control Act which contained the wording, *"the Federal Government should improve or participate in the improvement of navigable waters or their tributaries, including watersheds thereof, for flood-control purposes if the benefits to whomsoever they may accrue are in excess of the estimated costs."* The phrase if the benefits to whomsoever they may accrue are in excess of the estimated costs established cost-benefit analysis. Initially the Corps of Engineers developed ad hoc methods for estimating benefits and costs. It wasn't until the 1950s that academic economists discovered that the Corps had developed a system for the economic analysis of public investments. Economists have

influenced and improved the Corps' methods since then and cost-benefit analysis has been adapted to most areas of public decision-making.

4.3. What Is a Cost Benefit Analysis?



A cost benefit analysis is used to evaluate the total anticipated cost of a project compared to the total expected benefits in order to determine whether the proposed implementation is worthwhile for a company or project team.

If the results of this comparative evaluation method suggest that the overall benefits associated with a proposed action outweigh the incurred costs, then a business or project manager will most likely choose to follow through with the implementation.

Generally speaking, a cost-benefit analysis has three parts. First, all potential costs that will be incurred by implementing a proposed action must be identified. Second, one must record all anticipated benefits associated with the potential action. And finally, subtract all identified costs from the expected benefits to determine whether the positive benefits outweigh the negative costs.

4.3.1. What is Cost?

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:

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

Evaluation 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):

Net Benefits = Total Benefits - Total Cost

4.3.1.1. Identifying Costs

The first step is to identify and quantify all costs associated with a proposed action. In order to successfully identify all potential costs of a project, one must follow the subsequent steps.

1. Make a list of all monetary costs that will be incurred upon implementation and throughout the life of the project. These include start-up fees, licenses, production materials, payroll expenses, user acceptance processes, training, and travel expenses, among others.
2. Make a list of all non-monetary costs that are likely to be absorbed. These include time, lost production on other tasks, imperfect processes, potential risks, market saturation or penetration uncertainties, and influences on one's reputation.
3. Assign monetary values to the costs identified in steps one and two. To ensure equality across time, monetary values are stated in present value terms. If realistic cost values cannot be readily evaluated, consult with market trends and industry surveys for comparable implementation costs in similar businesses.
4. Add all anticipated costs together to get a total costs value.

4.3.1.2. Identifying Benefits

The next step is to identify and quantify all benefits anticipated as a result of successful implementation of the proposed action. To do so, complete the following steps.

1. Make a list of all monetary benefits that will be experienced upon implementation and thereafter. These benefits include direct profits from products and/or services, increased contributions from investors, decreased production costs due to improved and standardized processes, and increased production capabilities, among others.
2. Make a list of all non-monetary benefits that one is likely to experience. These include decreased production times, increased reliability and durability, greater customer base, greater market saturation, greater customer satisfaction, and improved company or project reputation, among others.
3. Assign monetary values to the benefits identified in steps one and two. Be sure to state these monetary values in present value terms as well.
4. Add all anticipated benefits together to get a total benefits value.

4.3.1.3. Evaluate Costs and Benefits

The final step when creating a cost benefit analysis is to weigh the costs and benefits to determine if the proposed action is worthwhile. To properly do so, follow the subsequent steps.

1. Compare the total costs and total benefits values. If the total costs are much greater than the total benefits, one can conclude that the project is not a worthwhile investment of company time and resources.

2. If total costs and total benefits are roughly equal to one another, it is best to reevaluate the costs and benefits identified and revise the cost benefit analysis. Often times, items are missed or incorrectly quantified, which are common errors in a cost benefit analysis.
3. If the total benefits are much greater than the total costs, one can conclude that the proposed action is potentially a worthwhile investment and should be further evaluated as a realistic opportunity.

4.4. Principles of Cost Benefit Analysis

One of the problems of CBA is that the computation of many components of benefits and costs is intuitively obvious but that there are others for which intuition fails to suggest methods of measurement. Therefore some basic principles are needed as a guide.

4.5. The Steps of a Cost-Benefit Analysis

CBA can be thought of as progressing through four steps:

1. Choose the population.
2. Select potential impacts.
3. Consider how the program might change well-being.
4. Determine how society values these changes.

It is important to keep in mind that the final goal of a CBA is to estimate the social benefit (or cost) of a program. In the following paragraphs, we describe the conceptual steps and then offer an applied framework. Finally, we show how these steps work in practice through NIJ's MADCE.

4.5.1 Choose the Population

The first step of a CBA is to determine the population you are interested in (called the “standing” of the study). In brief, the study’s standing is the group whose well-being is changed by a new policy or practice. Stated another way, the standing is the population whose costs and benefits are counted. A study’s standing might be all of society, all of society excluding the program participants, or all taxpaying citizens. Choosing which group has standing is a value-based decision that depends on the nature of the program, the analysis, and the decision-makers or stakeholders. For example, a CBA of a mandatory job training program for recipients of government assistance generally includes program participants in its standing, whereas a CBA of sentencing policy generally does not include prisoners in its standing (although it could). In practice, the selection of the standing in the aforementioned examples

National Institute of Justice | NIJ.gov RESEARCH IN BRIEF 9 means that one cost of the job training program would be the value of the time that clients give up to participate in training (economists call this the “opportunity cost” of participants’ time), whereas a sentencing CBA would not include the opportunity cost of the prisoners’ time.

4.5.2. Select Potential Impacts

Select the potential impacts to include in the analysis. First, consider what might have changed as a result of the program. In a criminal justice context, potential impacts often mean changes in behavior (e.g., employment, criminal offenses) or resources used (e.g., police time, jail beds, court hearings). Think about what effects the program may have had, identify the impacts you can plausibly measure, and estimate the size of the changes that the program caused (if any). This step is the reason that a

CBA relies on a strong impact evaluation. Without an impact evaluation, estimating the program's effects is impossible, and, thus, there are no effects to value. Economists sometimes say that an evaluation is "well identified" if it convincingly isolates the causal impacts of the program.

4.5.3. Consider How The Program Might Change Well-Being

Consider how the program's effects might have changed the well-being (either positively or negatively) of someone in the standing. For instance, a program that increases meetings with a probation officer might decrease the time that the officer has to work with other clients. A program that improves participants' educational outcomes might lead participants to make greater contributions to society through employment. Regardless, this step translates the program's impacts into social well-being i.e. Economists usually call this "social welfare" or just "welfare." To avoid confusion with the unrelated government assistance programs, we often say "well-being" instead, even though researchers more commonly use the term "welfare."

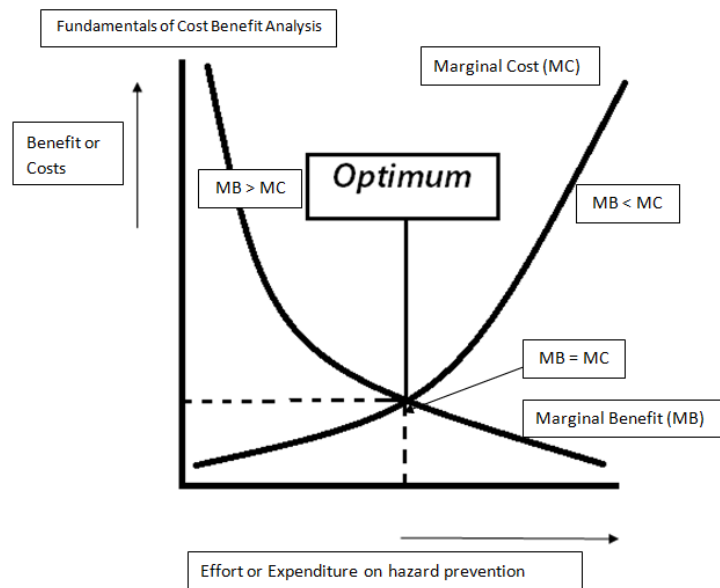
4.5.4. Determine How Society Values These Changes

Find information either from within or outside of the evaluation to determine how society values these changes. For instance, ask, "How much does society value a probation officer's time?" Or, "How much does society value more and better education?" Keep in mind that the answers to these questions have nothing to do with the analysts' beliefs about how much these issues National Institute of Justice | NIJ.gov 10 Cost-Benefit Analysis: A Guide for Drug Courts and Other Criminal Justice Programs should be valued; rather, the analyst must use existing data to estimate, based on observed behavior, how society does in fact value these changes.

4.6. Common Unit of Measurement of CBA

4.6.1. Background

In order to reach a conclusion as to the desirability of a project all aspects of the project, positive and negative, must be expressed in terms of a common unit; i.e., there must be a "bottom line." The



most convenient common unit is money. This means that all benefits and costs of a project should be measured in terms of their equivalent money value. A program may provide benefits which are not directly expressed in terms of dollars but there is some amount of money the recipients of the benefits would consider just as good as the project's benefits.

For example, a project may provide for the elderly in an area a free monthly visit to a doctor. The value of that benefit to an elderly recipient is the minimum amount of money that that recipient would take instead of the medical care. This could be less than the market value of the medical care provided. It is assumed that more esoteric benefits such as from preserving open space or historic sites have a finite equivalent money value to the public. Not only do the benefits and costs of a project have to be expressed in terms of equivalent money value, but they have to be expressed in terms of dollars of a particular time. This is not just due to the differences in the value of dollars at different times because of inflation. A dollar available five years from now

is not as good as a dollar available now. This is because a dollar available now can be invested and earn interest for five years and would be worth more than a dollar in five years. If the interest rate is r then a dollar invested for t years will grow to be $(1+r)^t$. Therefore the amount of money that would have to be deposited now so that it would grow to be one dollar t years in the future is $(1+r)^{-t}$. This called the discounted value or present value of a dollar available t years in the future. When the dollar value of benefits at some time in the future is multiplied by the discounted value of one dollar at that time in the future the result is discounted present value of that benefit of the project. The same thing applies to costs. The net benefit of the projects is just the sum of the present value of the benefits less the present value of the costs.

The choice of the appropriate interest rate to use for the discounting is a separate issue that will be treated later in this paper.

4.6.2. CBA is tool of Representation of Consumers or Producers

Valuations

The valuation of benefits and costs should reflect preferences revealed by choices which have been made. For example, improvements in transportation frequently involve saving time. The question is how to measure the money value of that time saved. The value should not be merely what transportation planners think time should be worth or even what people say their time is worth. The value of time should be that which the public reveals their time is worth through choices involving tradeoffs between time and money. If people have a choice of parking close to their destination for a fee of 50 cents or parking farther away and spending 5 minutes more walking and they always choose to spend the money and save the time and effort then they have revealed that their time is more valuable to them than 10 cents per minute. If

they were indifferent between the two choices they would have revealed that the value of their time to them was exactly 10 cents per minute.

The most challenging part of CBA is finding past choices which reveal the tradeoffs and equivalencies in preferences. For example, the valuation of the benefit of cleaner air could be established by finding how much less people paid for housing in more polluted areas which otherwise was identical in characteristics and location to housing in less polluted areas. Generally the value of cleaner air to people as revealed by the hard market choices seems to be less than their rhetorical valuation of clean air.

4.6.3. CBA- Measurement of Benefits

When consumers make purchases at market prices they reveal that the things they buy are at least as beneficial to them as the money they relinquish. Consumers will increase their consumption of any commodity up to the point where the benefit of an additional unit (marginal benefit) is equal to the marginal cost to them of that unit, the market price. Therefore for any consumer buying some of a commodity, the marginal benefit is equal to the market price. The marginal benefit will decline with the amount consumed just as the market price has to decline to get consumers to consume a

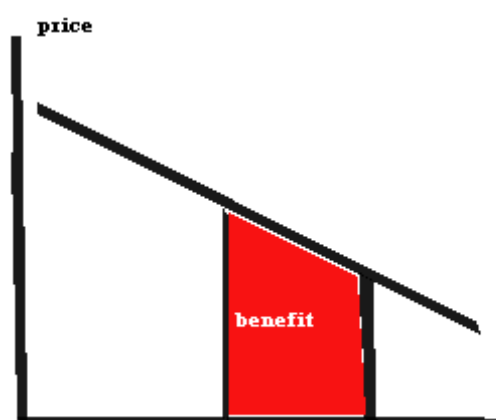


Fig. 1. General Cost benefit Analysis curve.

greater quantity of the commodity. The relationship between the market price and the quantity consumed is called the demand schedule. Thus the demand schedule provides the information about marginal benefit that is needed to place a

money value on an increase in consumption.

The increase in benefits resulting from an increase in consumption is the sum of the marginal benefit times each incremental increase in consumption. As the incremental increases considered are taken as smaller and smaller the sum goes to the area under the marginal benefit curve. But the marginal benefit curve is the same as the demand curve so the increase in benefits is the area under the demand curve. As shown in Figure 1 the area is over the range from the lower limit of consumption before the increase to consumption after the increase.

When the increase in consumption is small compared to the total consumption the gross benefit is adequately approximated, as is shown in a welfare analysis, by the market value of the increased consumption; i.e., market price times the increase in consumption.

4.6.4. Measurements of Benefits Require the Valuation of Human Life

It is sometimes necessary in CBA to evaluate the benefit of saving human lives. There is considerable antipathy in the general public to the idea of placing a dollar value on human life. Economists recognize that it is impossible to fund every project which promises to save a human life and that some rational basis is needed to select which projects are approved and which are turned down. The controversy is defused when it is recognized that the benefit of such projects is in reducing the risk of death. There are many cases in which people voluntarily accept increased risks in return for higher pay, such as in the oil fields or mining, or for time savings in higher speed in automobile travel. These choices can be used to estimate the personal cost people

place on increased risk and thus the value to them of reduced risk. This computation is equivalent to placing an economic value on the expected number of lives saved.

4.6.5. CBA Analysis-With or Without Comparison

The *impact* of a project is the difference between what the situation in the study area would be with and without the project. This that when a project is being evaluated the analysis must estimate not only what the situation would be with the project but also what it would be without the project. For example, in determining the impact of a fixed guide way rapid transit system such as the Bay Area Rapid Transit (BART) in the San Francisco Bay Area the number of rides that would have been taken on an expansion of the bus system should be deducted from the rides provided by BART and likewise the additional costs of such an expanded bus system would be deducted from the costs of BART. In other words, the alternative to the project must be explicitly specified and considered in the evaluation of the project. Note that the with-and-without comparison is not the same as a before-and-after comparison.

Another example shows the importance of considering the impacts of a project and a with-and-without comparison. Suppose an irrigation project proposes to increase cotton production in Arizona. If the United States Department of Agriculture limits the cotton production in the U.S. by a system of quotas then expanded cotton production in Arizona might be offset by a reduction in the cotton production quota for Mississippi. Thus the impact of the project on cotton production in the U.S. might be zero rather than being the amount of cotton produced by the project.

4.6.6. Cost Benefit Analysis Involves a Particular Study Area

The impacts of a project are defined for a particular study area, be it a city, region, state, nation or the world. In the above example concerning cotton the impact of the project might be zero for the nation but still be a positive amount for Arizona.

The nature of the study area is usually specified by the organization sponsoring the analysis. Many effects of a project may "net out" over one study area but not over a smaller one. The specification of the study area may be arbitrary but it may significantly affect the conclusions of the analysis.

4.6.7. Double Counting of Benefits or Costs Must be Avoided

Sometimes an impact of a project can be measured in two or more ways. For example, when an improved highway reduces travel time and the risk of injury the value of property in areas served by the highway will be enhanced. The increase in property values due to the project is a very good way, at least in principle, to measure the benefits of a project. But if the increased property values are included then it is unnecessary to include the value of the time and lives saved by the improvement in the highway. The property value went up because of the benefits of the time saving and the reduced risks. To include both the increase in property values and the time saving and risk reduction would involve double counting.

4.6.8. Decision Criteria for Projects

If the discounted present value of the benefits exceeds the discounted present value of the costs then the project is worthwhile. This is equivalent to the condition that the net benefit must be positive. Another equivalent condition is that the ratio of the present value of the benefits to the present value of the costs must be greater than one.

If there are more than one mutually exclusive project that have positive net present value then there has to be further analysis. From the set of mutually exclusive projects the one that should be selected is the one with the highest net present value.

If the funds required for carrying out all of the projects with positive net present value are less than the funds available this means the discount rate used in computing the present values is too low and does not reflect the true cost of capital. The present values must be recomputed using a higher discount rate. It may take some trial and error to find a discount rate such that the funds required for the projects with a positive net present value is no more than the funds available. Sometimes as an alternative to this procedure people try to select the best projects on the basis of some measure of goodness such as the internal rate of return or the benefit/cost ratio. This is not valid for several reasons.

The magnitude of the ratio of benefits to costs is to a degree arbitrary because some costs such as operating costs may be deducted from benefits and thus not be included in the cost figure. This is called *netting out* of operating costs. This netting out may be done for some projects and not for others. This manipulation of the benefits and costs will not affect the net benefits but it may change the benefit/cost ratio. However it will not raise the benefit cost ratio which is less than one to above one.

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