

FIFTH EDITION

# COST-BENEFIT ANALYSIS

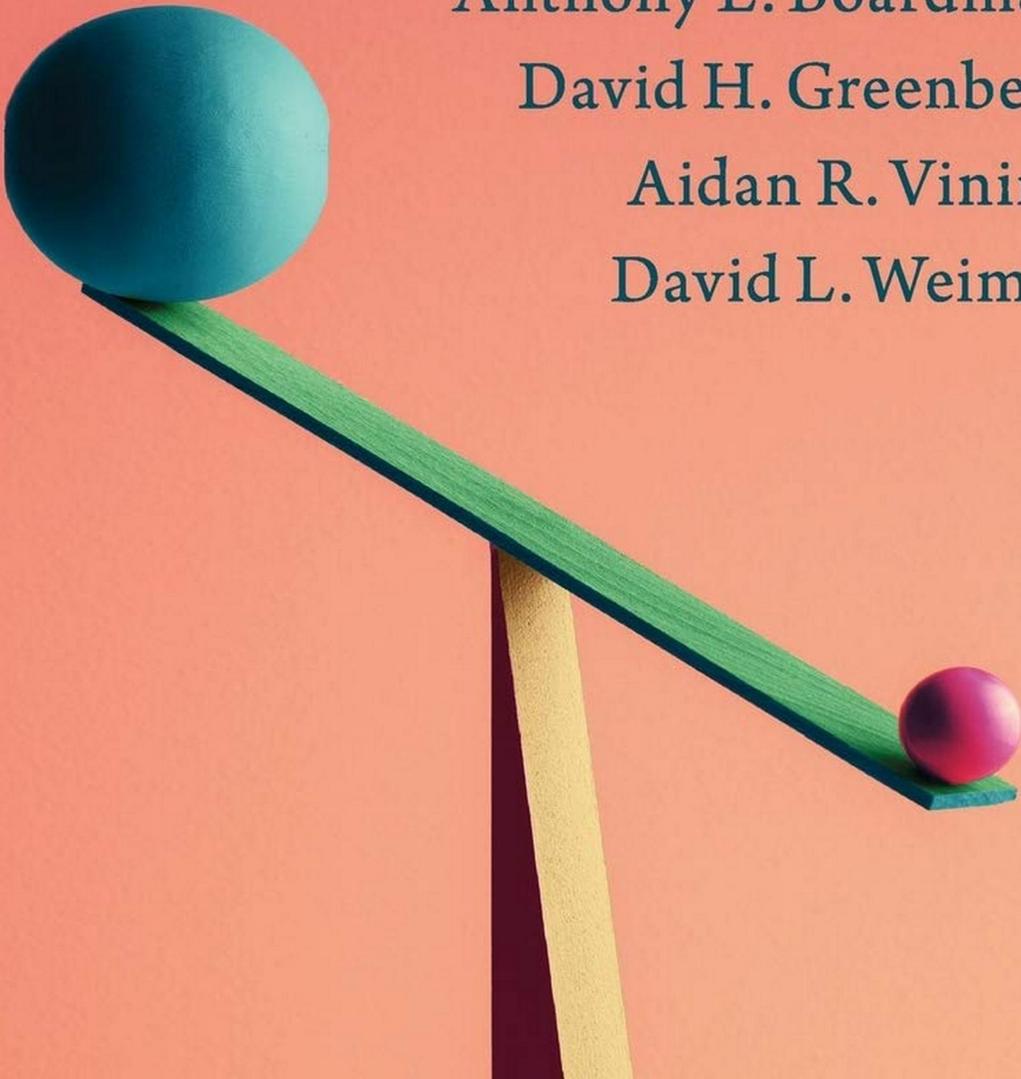
Concepts and Practice

Anthony E. Boardman

David H. Greenberg

Aidan R. Vining

David L. Weimer



## **Cost–Benefit Analysis**

### *Concepts and Practice*

Fifth edition

*Cost–Benefit Analysis* provides accessible, comprehensive, authoritative, and practical treatments of the protocols for assessing the relative efficiency of public policies. Its review of essential concepts from microeconomics and its sophisticated treatment of important topics with minimal use of mathematics helps students from a variety of backgrounds to build solid conceptual foundations. It provides thorough treatments of time discounting; dealing with contingent uncertainty using expected surpluses and option prices; taking account of parameter uncertainties using Monte Carlo simulation and other types of sensitivity analyses; revealed preference approaches; stated preference methods including contingent valuation; and other related methods.

Updated to cover contemporary research, this edition is considerably reorganized to aid in student and practitioner understanding, and includes eight new cases to demonstrate the actual practice of cost–benefit analysis. Widely cited, it is recognized as an authoritative source on cost–benefit analysis. Illustrations, exhibits, chapter exercises, and case studies help students to master concepts and develop craft skills.

**Anthony E. Boardman** is a Professor Emeritus at the University of British Columbia. With colleagues, he has won the Peter Larkin Award, the Alan Blizzard Award, the John Vanderkamp prize, and the J.E. Hodgetts Award. He has also been a consultant to many leading public-sector and private-sector organizations, including the Government of Canada and the Inter-American Development Bank. He served two terms on the Patented Medicine Prices Review Board and is currently on the Board of the Institute for Health System Transformation and Sustainability.

**David H. Greenberg** is Professor Emeritus of economics at the University of Maryland, Baltimore County (UMBC). He is a labor economist and cost–benefit analyst who received his PhD at MIT. Before coming to UMBC, he worked for the Rand Corporation, SRI International, and the US Department of Health and Human Services. He has taught courses in cost–benefit analysis at the University of Wisconsin–Madison, George Washington University, Budapest University of Economic Science, and Central European University. He is a long-time consultant to MDRC, Abt Associates and other research organizations.

**Aidan R. Vining** is the CNABS Professor of Business and Government Relations at Simon Fraser University in Vancouver. With co-authors, he is a winner of the John Vanderkamp prize (Canadian Economics Association) and the J.E. Hodgetts Award (Institute of Public Administration of Canada). With David Weimer, he is the co-author of *Policy Analysis; Concepts and Practice*.

**David L. Weimer** is the Edwin E. Witte Professor of Political Economy at the University of Wisconsin-Madison. He was president of the Association for Public Policy Analysis and Management in 2006 and president of the Society for Benefit–Cost Analysis in 2013. He is a past editor of the *Journal of Policy Analysis and Management* and currently serves on many editorial boards. He is also a Fellow of the National Academy of Public Administration.

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**Anthony E. Boardman**

University of British Columbia, Vancouver

**David H. Greenberg**

University of Maryland, Baltimore County

**Aidan R. Vining**

Simon Fraser University, British Columbia

**David L. Weimer**

University of Wisconsin–Madison



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# Preface

Collaborative academic projects often take longer than originally anticipated, not just because of the normal delays of coordinating the efforts of busy people, but also because initially modest goals can become more ambitious as participants delve into their subject. We confess to both these sins with respect to preparing the first edition of this text. Our goal was to produce a book that would be conceptually sound, practically oriented, and easily accessible to both students and practitioners. Although our final product was far different in form and content than we initially planned, we believe that our first edition was such a book.

Our plans evolved for a number of reasons. Perhaps most importantly, through our teaching of undergraduate and graduate students in different countries, as well as our experiences training government employees in different jurisdictions, we realized that many topics demanded extended treatment if the essential basics were to be conveyed effectively and if solid foundations were to be laid for further learning of advanced topics. We also decided that integrating illustrations and examples with concepts and methods is useful in addition to presenting independent cases. The result is a series of chapters that develop conceptual foundations, methods of application, and extensions of cost–benefit analysis (CBA) through numerous practical examples and illustrations.

Our own use of the book in teaching, as well as comments from other teachers and students, have helped us identify several areas for incremental improvement in subsequent editions. With this current edition, however, we decided to take a fresh look at both organization and content. With respect to organization, we interlace the chapters providing the theoretical foundations with those showing how to implement them. For example, the chapter introducing the basics of measuring social surplus changes in markets is followed immediately with the chapter on estimating demand schedules. With respect to content, we added a number of cases that show the application of concepts in policy analyses. For example, following the chapter on estimating demand schedules, we provide cases presenting the use, and misuse, of social surplus as a benefit measure in regulatory impact analyses. Other cases illustrate using evidence from multiple sources to arrive at net benefits, conducting Monte Carlo simulation to assess uncertainty in net benefits, estimating costs and benefits from social experiments, using contingent valuation methods to assess the benefits of non-market goods, developing a shadow price from multiple data sources, and weighting costs and benefits to incorporate distributional values.

In overview, this new fifth edition provides the following:

- Updated content and references
- Rearrangement of chapters to facilitate better integration of theory and craft
- Addition of six cases providing extended illustrations of CBA craft

As with the earlier editions, answers to chapter problems, including spreadsheets that can be provided to students, are available for instructors.

# Acknowledgments

Our project over the years has been made more productive and enjoyable by our many colleagues and students who gave us advice, comments, encouragement, or information. We thank here just a few people who were particularly helpful: Marcus Berliant, Edward Bird, James Brander, Stanley Engerman, Eric Hanushek, Robert Havemen, Doug Landin, Walter Oi, William G. Waters II, and Michael Wolkoff. We thank Roy I. Gobin, George T. Fuller, Ruth Shen, and Larry Karp, who wrote thoughtful reviews of the first edition for the publisher; Ian Davis, John DeWald, Tim Gindling, and Laurie T. Johnson, who offered valuable comments during preparation of the second edition; Terri Sexton and Nachum Sicherman, who offered valuable comments during preparation of the third edition; Thomas Hopkins and M. Leslie Shiell, who offered valuable comments during preparation of the fourth edition; and John Janmaat, Farhad Sabetan, and Gideon Yaniv, who offered valuable comments during preparation of the fifth edition. Haynes Goddard kindly provided helpful suggestions for both the second and third editions. We especially thank Mark Moore, whose joint work with us helped us substantially improve our discussion of the social discount rate, and Roger Noll, who made extremely valuable suggestions that prompted many other substantial revisions. Of course, they are not responsible for any errors that remain.

We also thank Robert Dreesen and the editorial team at Cambridge University Press for encouraging us to take the time to do a substantial revision. We hope that teachers and students find the new edition to be both authoritative and pedagogically effective.

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# 1 Introduction to Cost–Benefit Analysis

In the Affair of so much Importance to you, wherein you ask my Advice, I cannot for want of sufficient Premises, advise you what to determine, but if you please I will tell you how. When those difficult Cases occur, they are difficult, chiefly because while we have them under Consideration, all the Reasons pro and con are not present to the Mind at the same time; but sometimes one Set present themselves, and at other times another, the first being out of Sight. Hence the various Purposes or Inclinations that alternately prevail, and the Uncertainty that perplexes us.

To get over this, my Way is, to divide half a Sheet of Paper by a Line into two Columns; writing over the one Pro, and over the other Con. Then during three or four Days Consideration, I put down under the different Heads short Hints of the different Motives, that at different Times occur to me, for or against the Measure. When I have thus got them all together in one View, I endeavor to estimate their respective Weights; and where I find two, one on each side, that seem equal, I strike them both out. If I find a Reason pro equal to some two Reasons con, I strike out the three. If I judge some two Reasons con, equal to some three Reasons pro, I strike out the five; and thus proceeding I find at length where the Balance lies; and if after a Day or two of farther consideration, nothing new that is of Importance occurs on either side, I come to a Determination accordingly. And, tho' the Weight of Reasons cannot be taken with the Precision of Algebraic Quantities, yet, when each is thus considered, separately and comparatively, and the whole lies before me, I think I can judge better, and am less liable to make a rash Step; and in fact I have found great Advantage from this kind of Equation, in what may be called Moral or Prudential Algebra.

B. Franklin, London, September 19, 1772<sup>1</sup>

## 1.1 Individual Versus Social Costs and Benefits

Benjamin Franklin's advice about how to make decisions illustrates many of the important features of cost–benefit analysis (CBA). These include a systematic cataloguing of impacts as benefits (pros) and costs (cons), valuing the impacts in dollars (assigning weights), and then determining the *net benefit* of the proposal relative to the current policy (net benefit equal incremental benefits minus incremental costs).

When we as individuals talk of costs and benefits, we naturally tend to consider our *own* costs and benefits, generally choosing among alternative courses of action according to whichever has the largest net benefit from our perspective. Similarly, in evaluating various investment alternatives, a firm tends to consider only those costs (expenditures) and benefits (revenues) that accrue to it. In CBA we try to consider *all of the costs and benefits to society as a whole*, that is, the *social costs* and the *social benefits*. For this reason, some analysts refer to CBA as *social cost–benefit analysis*.

*CBA is a policy assessment method that quantifies in monetary terms the value of all consequences of a policy to all members of society.* Throughout this book we use the terms *policy* and *project* interchangeably. More generally, CBA applies to policies, programs, projects, regulations, demonstrations, and other government interventions. *The broad purpose of CBA is to help social decision-making and to increase social value or, more technically, to improve allocative efficiency.*

CBA analysts focus on social costs and social benefits, and conduct social cost–benefit analysis. However, it is tedious to keep including the word “social”. We usually drop it and simply refer to costs, benefits, and cost–benefit analysis. Thus,  $B$  denotes the social benefits (the aggregate benefits to all members of society) of a policy, and  $C$  denotes the social costs (the aggregate costs to all members of society) of the policy. The aggregate value of a policy is measured by its *net social benefit*, sometimes simply referred to as the net benefit, and usually denoted  $NSB$ :

$$NSB = B - C \tag{1.1}$$

The term social is usually retained in the expression net social benefit to emphasize that CBA does concern the impacts on society as a whole.

Implicitly, the benefits, costs, and net social benefit of a policy are relative to some “benchmark.” Usually, the “benchmark” is the status quo policy, that is, no change in the current policy. Generally, the benefits, costs, and net social benefit of a policy measure incremental changes relative to the status quo policy.

Stated at this level of abstraction, it is unlikely that many people would disagree with doing CBA from an ethical perspective. In practice, however, there are two types of disagreements. First, social critics, including some political economists, philosophers, libertarians, and socialists, have disputed the fundamental utilitarian assumptions of CBA that the sum of individual utilities should be maximized and that it is possible to trade off utility gains for some people against utility losses for others. These critics are not prepared to make trade-offs between one person’s benefits and another person’s costs. Second, participants in the public policy-making process (analysts, bureaucrats, and politicians) may disagree about such practical issues as what impacts will actually occur over time, how to monetize (attach value to them), and how to make trade-offs between the present and the future.

In this chapter we provide a non-technical but reasonably comprehensive overview of CBA. Although we introduce a number of key concepts, we do so informally, returning to discuss them thoroughly in subsequent chapters. Therefore, this chapter is best read without great concern about definitions and technical details.

## 1.2 Types of CBA Analyses

CBA may be conducted at different times in the project or policy life cycle. One type of CBA is called *ex ante* or prospective CBA. *Ex ante* literally means “before.” Thus, *ex ante* CBA is conducted before the decision is made to undertake or implement a project or policy. The policy may or may not be under consideration by a government agency. If it is, then *ex ante* CBA informs the decision about whether resources should be allocated to that specific project or policy or not. Basically, *ex ante* CBA attempts to answer the question: *would* this policy or project be a good idea, that is, would it have a positive net social benefit?

Another type of CBA is called *ex post* or *retrospective CBA*. *Ex post* literally means “after.” Thus, strictly speaking, *ex post* CBA is conducted after a policy or project is completed. It addresses the question: *was* this policy or project a good idea? Because *ex post* analysis is conducted at the end of the project, it is obviously too late to reverse resource allocation decisions with respect to that particular project. However, this type of analysis provides information not only about a specific intervention, but also about the “class” of similar interventions. In other words, it contributes to learning by government managers, politicians, and academics about the costs and benefits of future projects and whether they are likely to be worthwhile. Such learning can be incorporated into future *ex ante* CBAs. The potential benefit, however, depends on the similarity between the future project and the project previously analyzed. For example, *ex post* CBAs of experiments involving the efficacy of new surgical procedures or new pharmaceutical products can usually be generalized to larger populations. However, if the proposed intervention is much bigger than the experiment, there may be unknown scale effects. Also, if the proposed program has a more extended time frame than the experiment, behavioral responses may affect costs or benefits unpredictably.

Most projects take many years to “complete.” The impacts of a highway or subway system, for example, often continue for many decades (even centuries) after initial construction. In such cases, and, in fact, for any ongoing policy or project, prudent government analysts might well wish to conduct a CBA sometime after the policy or project has begun but before it is complete. To clarify that such an analysis applies to a still ongoing project, such studies are sometimes called *in medias res* CBAs (to maintain our fancy use of Latin). They attempt to answer the question: is continuation of this policy or project a good idea? An *in medias res* CBA can be conducted any time after the decision to undertake a project has been made (but before it is complete). Such studies are also called *post-decision analyses*.

An *in medias res* CBA might recommend the termination or modification of a particular policy or project. In practice, CBAs of infrastructure projects with large sunk costs are unlikely to recommend discontinuation of a project that is near to completion or even just after completion, but it does happen occasionally. Interestingly the Tennessee Valley Authority decided to complete the Tellico Dam when it was 90 percent complete, even though the incremental social costs exceeded the incremental social benefits.<sup>2</sup> Also, a Canadian Environmental Assessment panel recommended decommissioning

a just-completed dam on the basis of an *in medias res* analysis which showed that, with use, future environmental costs would exceed future benefits.<sup>3</sup>

Many businesses and critics of government complain about the burden of existing regulations and of too much “red tape.” *In medias res* CBAs of some regulations might find that the critics are correct and they should be scrapped or changed for the benefit of society as a whole. In fact, *in medias res* CBAs conducted during the 1960s and 1970s of industry-specific economic regulations showed that the costs of regulation often exceeded the benefits, thereby paving the way for deregulation initiatives in the trucking, airline, and telecommunications industries.<sup>4</sup> These decisions were made both economically and politically easier by the reality that, unlike many physical infrastructure projects, regulatory projects usually have significant ongoing costs, rather than sunk, up-front costs. The same point also applies to ongoing social programs, such as government-funded training programs.

In practice, the term *in medias res* CBA is not used often: such CBAs are referred to as *ex post*, retrospective, hindsight, or post-decision analyses. It is particularly important if this is the case, therefore, to be clear when an *ex post* CBA is conducted: it might be any time after the decision to implement a new policy has been made.

There is also a fourth type of CBA – one that compares an *ex ante* CBA with an *ex post* CBA or an *in medias res* CBA of the same project.<sup>5</sup> Considerable research has found, for example, that the costs of large government infrastructure projects are often underestimated.<sup>6</sup> In contrast, another study that assessed the accuracy of US regulatory cost estimates found that these costs tend to be overestimated.<sup>7</sup> This comparative type of CBA helps to identify past errors, understand the reasons for them, and avoid them in the future.

### 1.3 The Basic Steps of CBA: Coquihalla Highway Example

CBA may look quite intimidating and complex. To make the process of conducting a CBA more manageable, we break it down into 10 basic steps, which are listed in Table 1.1. We describe and illustrate these steps using a relatively straightforward example: the proposed construction of a new highway. For each step, we also point out some practical difficulties. The conceptual and practical issues that we broach are the focus of the rest of this book. Do not worry if the concepts are unfamiliar to you; this is a dry run. Subsequent chapters fully explain them.

Suppose that in 1986 a cost–benefit analyst, who worked for the Province of British Columbia, Canada, was asked to perform an *ex ante* CBA of a proposed four-lane highway between the town of Hope in the south-central part of the province and Merritt, which is north of Hope. This highway would pass through an area called the Coquihalla (an indigenous name) and would be called the Coquihalla Highway. A summary of the analyst’s *ex ante* CBA is presented in Table 1.2. The original numbers were present values as of 1986, which have now been converted to 2016 dollars to make them

Table 1.1 *The Major Steps in CBA*

- 
- 
1. Explain the purpose of the CBA
  2. Specify the set of alternative projects
  3. Decide whose benefits and costs count (specify standing)
  4. Identify the impact categories, catalogue them, and select metrics
  5. Predict the impacts quantitatively over the life of the project
  6. Monetize (attach dollar values to) all impacts
  7. Discount benefits and costs to obtain present values
  8. Compute the net present value of each alternative
  9. Perform sensitivity analysis
  10. Make a recommendation
- 
- 

Table 1.2 *Coquihalla Highway CBA (2016 \$ Million)*

	No tolls		With tolls	
	Global perspective (A)	Provincial perspective (B)	Global perspective (C)	Provincial perspective (D)
<b>Social benefits:</b>				
Time and operating cost savings	763.0	572.1	568.4	426.3
Safety benefits	70.5	52.8	49.3	37.0
New users	1.6	1.2	0.6	0.4
Alternate route benefits	28.6	21.3	18.4	13.9
Toll revenues	–	–	–	73.2
Terminal value of hwy.	104.3	104.3	104.3	104.3
<b>Total social benefits</b>	<b>968.0</b>	<b>751.7</b>	<b>741.0</b>	<b>655.1</b>
<b>Social costs:</b>				
Construction	661.8	661.8	661.8	661.8
Maintenance	14.9	14.9	14.9	14.9
Toll collection	–	–	16.4	16.4
Toll booth construction	–	–	0.6	0.6
<b>Total social costs</b>	<b>676.6</b>	<b>676.7</b>	<b>693.7</b>	<b>693.7</b>
<b>Net social benefit</b>	<b>291.2</b>	<b>75.2</b>	<b>47.3</b>	<b>–38.6</b>

*Source:* Adapted from Anthony Boardman, Aidan Vining, and W. G. Waters II, “Costs and Benefits through Bureaucratic Lenses: Example of a Highway Project,” *Journal of Policy Analysis and Management*, 12(3), 1993, 532–55, table 1, p. 537.

easier to interpret. How did the analyst obtain these numbers? What were the difficulties? We go through each of the 10 steps in turn.

### 1.3.1 *Explain the Purpose of the CBA*

Step 1 requires the analyst to explain why she is conducting a CBA. She should answer the question: *what is the rationale for considering a change in policy*, in this case, building a new highway? Stated broadly, the goal of CBA is to improve social welfare. More specifically, CBA attempts to maximize allocative efficiency, which we discuss in Chapter 3. That chapter argues that, where markets work well, individual self-interest leads to an efficient allocation of resources and, therefore, there should be no government intervention. *Prima facie* rationales for CBAs are *market failure* or *government failure*.<sup>8</sup> Where there is market failure, analysts use CBA to assess whether a particular intervention is more allocatively efficient than no intervention (or some other alternatives). Sometimes there is government failure: a government policy or project is currently in effect, but this policy appears to be less allocatively efficient than no intervention or some other alternative policy. In either of these situations CBA attempts to ascertain whether a new policy or program is more allocatively efficient than the existing policy. The analyst should explain the market failure or government failure that provides a purpose for the study.

In 1986, the existing routes to the interior of northern British Columbia were highly congested, dangerous (with many traffic accidents), and would not have the capacity to handle anticipated increases in traffic volumes. For political reasons, the government was unwilling to impose tolls on the existing routes. Widening the main road would have been prohibitively expensive because much of it was in a river canyon. The focus of the study was, therefore, on whether to build a new highway between Hope and Merritt in an alternative location, specifically in the Coquihalla Valley, which follows the Coldwater River.

### 1.3.2 *Specify the Set of Alternative Projects*

Step 2 requires the analyst to specify the set of alternative projects. In this example, there were only two feasible alternative highway projects: one built with tolls and one without. The provincial department of transportation decided that the toll, if applied, would be \$78.3 for large trucks and \$15.7 for cars (in 2016 dollars). Thus, the analyst had a tractable set of only two alternatives to analyze.

In practice, there are often difficulties even at this stage because the number of potential alternatives is often quite large. Even restricting the analysis to a highway in the Coquihalla valley, it could vary on many dimensions including, for example, the road surface (either bitumen or concrete), routing (it could take somewhat different routes), size (it could have more or fewer lanes), toll level (could be higher or lower), wild animal friendliness (the highway could be built with or without “elk tunnels”), or timing (it could be delayed until a later date). Resource and cognitive constraints mean that analysts typically analyze only a few alternatives.<sup>9</sup>

CBA compares one or more potential projects with a project that would be displaced (i.e., not undertaken) if the project(s) under evaluation were to proceed. The

displaced project is often called the *counterfactual*. Usually, the counterfactual is the status quo policy or no change in government policy. It does not mean “do nothing.” It means that government continues to do what it has been doing: while there would be no new highway, the existing highway would continue to be maintained. Table 1.2 presents the social benefits, social costs, and net social benefit if the highway were built (with or without tolls) relative to what the social benefits, social costs, and net social benefit would be if the highway were not built (the status quo). Thus, one can interpret these social benefits, social costs, and net social benefit as *incremental* amounts. *In practice, as in this example, the term incremental is often omitted for convenience, but it is implicit.*

Sometimes the status quo policy is not a viable alternative. *If a project would displace a specific alternative, then it should be evaluated relative to the specific displaced alternative.* If, for example, the government has committed resources to either (1) constructing a new highway project and maintaining the alternative routes) or (2) not constructing a new highway but expanding the capacity of the existing routes, and there is no possibility of maintaining the status quo, then the new highway project should be compared with the expansion of the capacity of existing routes, rather than with the status quo policy.

This CBA example pertains to a specific proposed highway. There is no attempt to compare this project to alternative highway projects in the rest of British Columbia, although one could do so. Rarely do analysts compare a project in one substantive arena of government, such as transportation, to projects in other arenas, such as health care or national defense. The limited nature of these kinds of comparisons sometimes frustrates politicians and decision-makers who imagine that CBA is a *deus ex machina* that will rank *all* policy alternatives. On the other hand, CBA evidence from different arenas can allow decision-makers to rank potential projects in terms of their net social benefit.

### 1.3.3 *Decide Whose Benefits and Costs Count (Standing)*

Next, the analyst must decide who has *standing*; that is, whose benefits and costs should be included and counted. In this example, the analyst conducted the CBA from the provincial perspective because taxpayers living there would pay for it, but thought that it was important to also take a global perspective. A CBA from the provincial perspective considers only the impacts (i.e., benefits and costs) that affect British Columbian residents, including costs and benefits borne by the British Columbian government. The global perspective considers the benefits and costs that affect anyone, irrespective of where they reside. Thus, it includes benefits and costs to Americans, Albertans, and even tourists using the highway from the United Kingdom or China. Including these two perspectives on standing with the no-tolls and with-tolls alternatives gives the four columns in Table 1.2 labeled A through D and effectively means there are four distinct perspectives on costs and benefits.

The issue of standing is quite often contentious. While national governments usually take only national (i.e., domestic) costs and benefits into account, critics argue that issues that have significant negative impacts on residents of other countries should be analyzed from a global perspective. Environmental issues that fall into this category include ozone depletion, global climate change, and acid rain. At the other extreme,

local governments typically want to consider only benefits and costs to local residents and to ignore costs and benefits borne by residents of adjacent municipalities or higher levels of government. Our highway example deals with this issue by analyzing costs and benefits from both the subnational British Columbian perspective and the global perspective. Note that it does not adopt or measure the usual default perspective of the nation. Although these perspectives are not technically alternatives, they function as such in this example because they result in different estimates of costs, benefits, and net benefit.

### 1.3.4 *Identify the Impact Categories, Catalogue Them, and Select Metrics*

Step 4 requires the analyst to identify the impacts of the proposed alternative(s), catalogue them as benefits or costs, and specify the metric for each impact category. We use the term *impacts* broadly to include both inputs (resources employed) and outputs (predominantly benefits). A list of the relevant impact categories is referred to as an *impact inventory*. Preferably, analysts will construct an *impact matrix*, which describes or summarizes the impact of each policy alternative (or the impacts of one policy alternative on different groups) on each impact category.<sup>10</sup> Sometimes the impacts are referred to as “ingredients” and steps 4 and 5 are labeled the “*ingredients method*,” although this terminology makes more intuitive sense for inputs than for outputs.

Different groups of residents will benefit from the highway. First, consider the users who currently travel on existing routes between Merritt and Hope, but will switch to the new highway. They will benefit from time saved (initially measured in hours), reduced vehicle operating costs (measured in dollars), and safety benefits due to a shorter, safer highway (initially measured in lives saved and the reduction in the number of accidents). Anticipation of these benefits is likely to attract some new users to travel this route (initially measured in number of vehicle trips). In the transportation literature, these new users are referred to as *generated traffic*. A third group consists of current users of the alternative routes who will continue to use these routes and will benefit from reduced congestion time on those routes (again initially measured in hours), because many other travelers will switch to the new highway. A fourth group is government, which may benefit from toll revenues (measured in dollars). A final benefit category for this project is the *terminal value* (sometimes called the *horizon value*) of the highway (measured in dollars). In practice, this highway will be in place for many years, but the analyst chose to predict and monetize the benefits and costs for only 20 years because no major refurbishment was expected to occur during that period. Sometimes we refer to such a period as the “life of the project.” The terminal value reflects the present value of the net social benefit of the highway for all subsequent years. The cost impact categories are construction costs, maintenance and snow removal, toll collection, and toll booth construction and maintenance (all measured in dollars).

Although this list of impacts appears comprehensive, critics might argue that some important impacts were omitted. These include several externalities that spill beyond the use of the highway for transportation, including health impacts from reduced automobile emissions, environmental impacts on the elk population and other wildlife,

and changes in scenic beauty. Also, the social cost of the land (the *opportunity cost*) should have been included.

It is important to try to include the full range of consequences of each project. However, from a practical perspective, analysts can consider only a manageable number of important impacts. Impacts associated with sunk costs should be ignored, although the analyst must be careful because recognizing economic sunkness is not simple. For example, when the Tellico Dam was being considered, the Tennessee Valley Authority argued incorrectly that “since the farm land behind the dam had already been purchased, the value of this land should be considered a sunk cost, even though the land has yet to be flooded and could be resold as farm land if the project was not completed.”<sup>11</sup> Who owns the land or has paid for it is often irrelevant. If, in fact, the land did have an alternative use, then there was an opportunity cost and land should have been included as an impact category.

Furthermore, as we discuss in Chapter 7, it is often incorrect to include secondary or “knock-on” effects. Such effects are often redistributive. For example, one might think that hotel businesses and gas stations in Hope, near the southern end of the highway, might suffer negative effects because the new highway would bypass the town. However, highway users would stay elsewhere and buy their gas elsewhere, in Merritt, for example. Thus, while business-owner residents of Hope might be worse off, other business-owner residents in the province would be better off. The effects cancel out, resulting in a net effect of zero. Therefore, they can be ignored in many circumstances.

From a CBA perspective, analysts are interested only in project impacts that affect the utility of individuals who have standing. (The caveat is that this applies only where human beings have the relevant knowledge and information to make rational decisions.) Impacts that do not have any positive or negative utility to human beings are not counted. Suppose, for example, the highway project would decimate the population of a particular avian species. Birds do not have standing. This impact should only be included if some humans regard it as a cost.

Politicians often state the benefits of some projects in very general terms. For example, they might say that a project will promote “community capacity building.” Similarly, they tend to regard “growth” and “regional development” as beneficial impacts, possibly because it might lead to increased tax revenue for their jurisdictions. In contrast, CBA requires analysts to identify explicitly the ways in which the project would make some individuals in the province better off through, for example, improved skills, better education, or higher incomes.

Analysts should also be on the lookout for impacts that different groups of people view in opposing directions. Consider, for example, land that periodically floods but would not do so if a proposed project is implemented. Residents on the flood plain generally view these periodic floods as a cost because they damage homes, while duck hunters regard them as a benefit because they attract ducks. Even though opposing valuations of the same impact could be aggregated in one category, it is usually more informative to have two impact categories – one for damaged homes, and another for recreation benefits.

In this example, the impact metrics are straightforward – hours of time saved, dollar value of operating and construction costs, for example. If environmental impacts had been included, however, the choice of metrics would not have been as straightforward.

For example, if the change in automobile emissions was included as an impact, the analyst might measure it by tons of various pollutants or the resultant health effects (e.g., changes in mortality or morbidity). The choice of metric often depends on data availability and the ease of monetization. For example, an analyst may wish to measure the number of crimes avoided due to a policy intervention, but may not have any way to estimate this impact. However, she may have access to changes in arrest rates or changes in conviction rates and may be able to use one or both of these measures to estimate changes in crime.<sup>12</sup> Bear in mind, however, that all surrogate indicators involve some loss of information. For example, the conviction rate might be increasing while there is no change in the actual crime rate.

### 1.3.5 *Predict the Impacts Quantitatively Over the Life of the Project*

The proposed highway project, like almost all public projects, has impacts that extend over time. The fifth task is to predict all of the impacts in each year during the discount period (the life of the project) for each alternative. More specifically, the analyst has to predict the *incremental impacts* of the highway relative to the current policy for the no-tolls and the with-tolls alternatives, and from the provincial and global perspectives. Obviously, there is considerable uncertainty in making these predictions. Analysts may determine the “most likely” impact in each time period or the expected impact in each period. In this initial case example, for simplicity, we ignore uncertainty in the predictions.

There were three different types of road user on the Coquihalla: truck drivers, drivers or passengers in cars on business, and drivers or passenger in cars on vacation. As we see in subsequent chapters, road users were partitioned in this way because their benefits vary quite a bit. For each of these three user groups, the analyst predicted for each alternative for each year: the number of vehicle-trips on the new highway, the number of vehicle-trips on the old roads (alternative routes), and the proportion of travelers that reside in British Columbia. With these estimates, knowing that the highway is 195 kilometers long, and with other information, the analyst could estimate for each year the following incremental benefits: the total vehicle-kilometers saved, the number of accidents reduced, and the number of lives saved.

The analyst predicted that the new highway would save 6.5 lives each year. Lives would be saved for two reasons. First, the new highway would be shorter than the alternative routes. As a result, the analyst expected that travelers would avoid 130 million vehicle-kilometers (vkms) of driving each year, and evidence suggests that, on average, there are 0.027 deaths per million vkms. The shorter distance would, therefore, save 3.5 lives per year ( $130 \text{ vkms} \times 0.027 \text{ lives lost per vkm}$ ) on the basis of less distance driven. The new highway was also predicted to be safer per kilometer because it would be a divided highway. It was expected that 313 million vkms would be driven each year on the new highway. Based on previous traffic engineering evidence, the analyst estimated that the new highway would lower the fatal accident rate by one-third. Consequently, the new highway was expected to save 3.0 lives per year due to being safer ( $313 \text{ vkms} \times 0.027 \text{ lives lost per vkm} \times 0.33$ ). Combining the two components suggests 6.5 lives would be saved each year.

In order to treat something as an impact, an analyst has to know there is a cause–effect relationship between some physical outcome of the project and the utility of human

beings with standing. For some impacts the expected cause–effect relationships are reasonably well established, for instance, for the causal relationship between motor vehicle usage and motor vehicle accidents. For other impacts, however, the causal relationships are less obvious. What, if any, is the impact of exhaust fumes from additional vehicle usage on residents’ morbidity and mortality? Would this be offset by fewer airplane flights? Demonstrating and estimating such cause–effect relationships often requires an extensive review of scientific and social science research. Sometimes the evidence may be inconclusive. For example, controversy surrounds the effect of chlorinated organic compounds in bleached pulp mill effluent on wildlife. Although a Swedish study found such a link, a later Canadian study found none.<sup>13</sup> In practice, predicting impacts can be difficult and contentious.

In order to predict impacts over future time periods, analysts often assume a particular growth rate and apply it to all future time periods. However, some impacts might increase at an increasing or decreasing rate. For example, the number of statistical lives saved in a year might increase not only because of more drivers using the safer route but also because, without the new route, there would be significantly more congestion on the old routes, leading to proportionately more fatal accidents. Analogously, the cost of highway maintenance might be relatively constant for some years and then increase due to vintage (age) or more users.

Prediction is especially difficult where projects are unique, have long time horizons, or relationships among relevant variables are complex. Many of the realities associated with doing steps 4 and 5 are brilliantly summarized by Kenneth Boulding’s poem on dam building, presented in Exhibit 1.1. Many of his points deal with the omission of impact categories due to misunderstanding or ignorance of cause-effect relationships and to the accuracy of estimations. He also makes points about the distributional impacts of costs and benefits, which we discuss later.

#### Exhibit 1.1 A Ballad of Ecological Awareness

The cost of building dams is always underestimated,  
 There’s erosion of the delta that the river has created,  
 There’s fertile soil below the dam that’s likely to be looted,  
 And the tangled mat of forest that has got to be uprooted.

There’s the breaking up of cultures with old haunts’ and habits’ loss,  
 There’s the education programme that just doesn’t come across,  
 And the wasted fruits of progress that are seldom much enjoyed  
 By expelled subsistence farmers who are urban unemployed.

There’s disappointing yield of fish, beyond the first explosion;  
 There’s silting up, and drawing down, and watershed erosion.  
 Above the dam the water’s lost by sheer evaporation;  
 Below, the river scours, and suffers dangerous alteration.

For engineers, however good, are likely to be guilty  
 Of quietly forgetting that a river can be silty,  
 While the irrigation people too are frequently forgetting  
 That water poured upon the land is likely to be wetting.

Then the water in the lake, and what the lake releases,  
 Is crawling with infected snails and water-borne diseases.  
 There's a hideous locust breeding ground when water level's low,  
 And a million ecologic facts we really do not know.

There are benefits, of course, which may be countable, but which  
 Have a tendency to fall into the pockets of the rich,  
 While the costs are apt to fall upon the shoulders of the poor.  
 So cost–benefit analysis is nearly always sure  
 To justify the building of a solid concrete fact,  
 While the Ecologic Truth is left behind in the Abstract.

– Kenneth E. Boulding

(Reprinted with the kind permission of Mrs. Boulding)

### 1.3.6 *Monetize (Attach Dollar Values to) All Impacts*

The analyst next has to monetize each and every impact. To *monetize* means to value in dollars. In this example, the analyst monetized the following categories of time saved: leisure time saved per vehicle (25 percent of the gross wage in the region times the average number of passengers) = \$13.1 per vehicle-hour; business time saved per vehicle = \$23.5 per vehicle-hour; and truck drivers' time saved per vehicle = \$27.4 per vehicle-hour. One of the most important impacts to monetize in transportation and health CBAs is the value of a statistical life saved, the VSL. The term “statistical life” is used to imply that the reference is not to a specific person's life. In this *ex ante* study, conducted in 1986, the VSL used was \$978,685 in 2016 dollars based on the literature at that time. A large body of recent research suggests that the VSL is much higher than that, as we discuss in Chapter 17.

Sometimes, the most intuitively important impacts are difficult to value in monetary terms. In CBA, the value of a benefit is typically measured in terms of “willingness to pay.” As we discuss in Chapter 3, where markets exist and work well, willingness to pay can be determined from the appropriate market demand curve. Naturally, problems arise where markets do not exist or do not work well. For example, scholars have spent many person-years trying to determine the appropriate VSL. Valuing negative environmental impacts is especially contentious. In practice, most CBA analysts do not reinvent these wheels, but instead draw upon previous research: they use best-practice “plug-in” values whenever possible. Although catalogues of impact values are not comprehensive, considerable progress has been made in coming up with reasonable plug-ins as we show in Chapter 17.

If no person is willing to pay for some impact or to avoid it, then that impact would have zero value in a CBA. For example, if construction of a dam would lead to the extermination of a species of small fish, but no person with standing is willing to pay a positive amount to save that species, then the extermination of this fish would have zero cost in a CBA of the dam.

Some government agencies and critics of CBA are unwilling to attach a monetary value to life or to some other impact. This forces them to use an alternative method of analysis, such as *cost-effectiveness analysis*, *qualitative cost-benefit analysis* or *multi-goal analysis*, which are described in Chapter 3.

### 1.3.7 *Discount Benefits and Costs to Obtain Present Values*

For a project that has impacts that occur over years, we need a way to aggregate the benefits and costs that arise in different years. In CBA, future benefits and costs are *discounted* relative to present benefits and costs in order to obtain their *present values* (*PV*). The need to discount arises for two main reasons. First, there is an *opportunity cost* to the resources used in a project: they could earn a positive return elsewhere. Second, most people prefer to consume now rather than later. Discounting has nothing to do with inflation per se, although inflation must be taken into account.

A cost or benefit that occurs in year  $t$  is converted to its present value by dividing it by  $(1 + s)^t$ , where  $s$  is the social discount rate. Suppose a project has a life of  $n$  years and let  $B_t$  and  $C_t$  denote the social benefits and social costs in year  $t$ , respectively. The present value of the social benefits,  $PV(B)$ , and the present value of the social costs,  $PV(C)$ , of the project are, respectively:

$$PV(B) = \sum_{t=0}^n \frac{B_t}{(1+s)^t} \quad (1.2)$$

$$PV(C) = \sum_{t=0}^n \frac{C_t}{(1+s)^t} \quad (1.3)$$

In the Coquihalla Highway example, the analyst used a real (inflation-adjusted) social discount rate of 7.5 percent. As we discuss in Chapter 10, the choice of the appropriate social discount rate can be contentious and is, therefore, a good candidate for sensitivity analysis. For government analysts, the discount rate to be used is usually mandated by a government agency with authority (e.g., the Office of Management and Budget, or the General Accountability Office in the USA, or the Ministry of Finance or the Treasury Board in Canada). However, as we demonstrate in Chapter 10, those rates are generally too high. For projects that do not have impacts beyond 50 years (that is *intra-generational* projects), we recommend a real social discount rate of 3.5 percent. If the project is *inter-generational*, then we recommend time-declining discount rates.<sup>14</sup>

### 1.3.8 *Compute the Net Present Value of Each Alternative*

At the beginning of this chapter we stated that the net social benefit of a project equals the difference between the (incremental) social benefits and the (incremental) social costs,

as in Equation (1.1). By definition, the *net present value (NPV)* of a policy alternative equals the difference between the *PV* of its (incremental) social benefits and the *PV* of its (incremental) social costs:

$$NPV = PV(B) - PV(C) \quad (1.4)$$

Thus, the *NPV* of a project or policy is identical to the *present value of the (incremental) net social benefit*:

$$NPV = PV(NSB) \quad (1.5)$$

The basic decision rule for a single alternative project (relative to the status quo policy) is simple: *adopt the project if its NPV is positive*. In short, the analyst should recommend proceeding with the proposed project if its  $NPV = PV(B) - PV(C) > 0$ ; that is, if its (incremental) benefits exceed its (incremental) costs:

$$PV(B) > PV(C)$$

When there is more than one alternative to the status quo policy being analyzed and all the alternatives are mutually exclusive, then the rule is: *select the project with the largest NPV*. This rule assumes implicitly that at least one *NPV* is positive. If no *NPV* is positive, then none of the specified alternatives are superior to the current policy, which should remain in place.

### 1.3.9 *Perform Sensitivity Analysis*

It should be clear that the *PVs* and *NPVs* discussed above are *predicted values*, based on certain assumptions. As the foregoing discussion emphasizes, however, there will be uncertainty about the assumptions – both the predicted impacts and the appropriate monetary valuation of each unit of each impact. For example, the analyst may be uncertain about the predicted number of lives saved and about the appropriate dollar value to place on a statistical life saved. The analyst may also be uncertain about the appropriate social discount rate. In order to get a handle on these uncertainties, the analyst might conduct sensitivity analysis which, with only one alternative, shows the values of a parameter that would change the recommendation from “go” to “no go,” or vice versa. Also, analysts might examine different scenarios, with for example, “most likely,” “optimistic,” and “pessimistic” assumptions. Or analysts might construct decision trees or perform Monte Carlo analysis, as we discuss in Chapter 11. The purpose is to obtain a better understanding of the distribution of the estimated *NPV*.

### 1.3.10 *Make a Recommendation*

Suppose that one is only faced with two alternatives, A and B, one of which may or may not be the status quo policy. Alternative A has a higher expected *NPV* and lower risk (smaller variance) than alternative B. In this situation, the analyst would unambiguously recommend alternative A. Now suppose, however, that Alternative A has a higher expected *NPV* but has more risk than alternative B. In this situation, it is not so obvious

what the analyst should recommend. One might think that the analyst should present the analysis, point out the trade-offs, and turn the decision-making over to the decision-maker. If so, a risk adverse decision-maker might choose alternative B. However, as we explain in Chapter 12, the *analyst can usually act as if society is risk-neutral and should therefore recommend the alternative with the largest expected NPV*.

In fact, there is some confusion about the appropriate decision rule. Both the *internal rate of return* and the *benefit–cost ratio* have also been proposed as alternative decision rules. This is one area where there is a right answer and wrong answers. The *appropriate criterion to use is the NPV rule*. As explained in Chapters 3 and 9, the other rules sometimes give incorrect answers; the *NPV rule* does not.

While the *NPV* criterion results in a *more efficient* allocation of resources, it does not necessarily recommend *the most efficient* allocation of resources because the most efficient alternative might not have been actually considered by the analyst or might not have been feasible because of budget constraints, political concerns, or other reasons. This point is illustrated in Figure 1.1. Consider a set of proposed projects that vary according to the amount of output ( $Q$ ), which in turn depends on the scale of the project. The benefits and costs associated with alternative scales are represented by the functions  $B(Q)$  and  $C(Q)$ , respectively. The benefits increase as the scale increases, but at a decreasing rate. In contrast, costs increase at an increasing rate. A small-scale project (for example,  $Q_1$ ) has positive net benefit relative to the status quo policy,  $Q_0$ . As the scale increases, the net benefit increases up to the optimal scale,  $Q^*$ .<sup>15</sup> As the scale increases beyond  $Q^*$ , the net benefit decreases. The net benefit is positive as long as the benefit curve is above the cost curve, it is zero where the cost curve and benefit curve intersect, and it is negative for yet larger-scale projects.

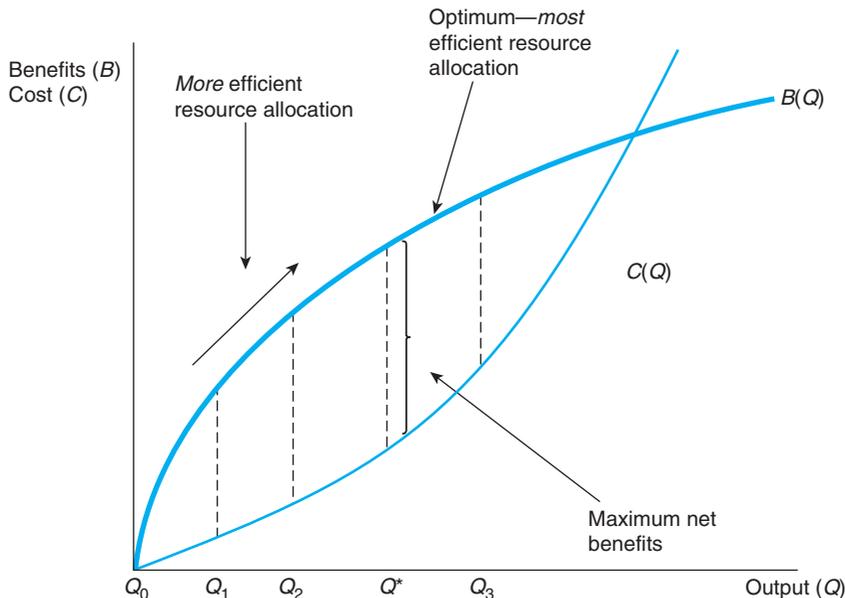


Figure 1.1 CBA seeks more efficient resource allocation.

Suppose that the analyst actually evaluates only two alternative projects, those with output levels,  $Q_1$  and  $Q_2$ . Clearly, output level  $Q_2$  is preferred to output level  $Q_1$ , which, in turn, is preferred to the status quo output level,  $Q_0$ . The analyst would therefore recommend  $Q_2$ . However, as the figure shows, the net social benefit is maximized at output level  $Q^*$ . The analyst could not recommend this optimal output level because it was not among the set of alternatives evaluated. As this example illustrates, use of the NPV criterion leads to a more efficient outcome than the status quo, but not necessarily the most efficient outcome.

In the highway example, three of the four alternative projects had positive expected *NPVs* and one had a negative expected *NPV*. The latter indicates that from the British Columbian perspective it would be more efficient to maintain the status quo and not build the Coquihalla highway than to build it and charge tolls. As discussed earlier, both the no-tolls alternatives were superior to the with-tolls alternatives. This result gives a flavor of the possibly counterintuitive recommendations that CBA can support. In this case, tolls lower the expected *NPV* of the tolled alternatives because they deter some people from using the highway, and so fewer people enjoy benefits; this reduces total benefits.<sup>16</sup>

Finally, as this discussion emphasizes, analysts almost always make recommendations, not decisions. CBA concerns how resources *should* be allocated; it is *normative*. It does not claim to be a *positive* (i.e., descriptive) theory of how resource-allocation decisions are actually made. Such decisions are made in political and bureaucratic arenas where politicians or administrators may have goals that are not totally congruent with allocative efficiency. CBA is only one input to this political decision-making process – one that attempts to push it toward more efficient resource allocation. CBA does not always drive choice between alternatives. Politicians are often not persuaded by economic efficiency arguments. Indeed, the Coquihalla highway was built with tolls, although they were removed in 2008, mainly for political reasons as far as we can determine.

## 1.4 Bureaucratic and Political “Lenses”<sup>17</sup>

CBA concerns how resources should be allocated. In practice, however, when bureaucrats or politicians conduct analysis, they have a tendency to *see* “costs” and “benefits” differently. Most of them have not taken formal courses in CBA. Although they may think they know what CBA is, they may be mistaken. Bureaucrats’ roles have a strong influence on what they think CBA is, or should be, about. Specifically, their perceptions of what constitutes “benefits” and “costs” are based on whether they are *analysts*, *spenders*, or *guardians*.<sup>18</sup> These labels are indicative of three different perspectives (lenses) bureaucrats bring to project evaluation. We assume the analysts’ perspective is standard CBA, which we have just illustrated. Guardians and spenders have quite different perspectives.

This section describes both perspectives and shows how they differ from CBA. This helps clarify what CBA actually is, in contrast to what some decision-makers or

politicians may think it is. This section also identifies many of the common mistakes in CBA, which often vary systematically according to an individual’s background and experiences. Even those trained in CBA may subconsciously modify their orientation toward those of guardians or spenders as a consequence of the immediacy of their daily bureaucratic roles. If you are in a government job, then you should make sure that you do not unconsciously drift into a guardian or spender perspective. We also hope that by understanding these different perspectives, analysts may be better able to communicate with guardians and spenders about how to conduct CBA appropriately. It might also help guardians and spenders be better able to communicate with each other about the “biases” inherent in their perspectives. Finally, this section should help students understand better why project decisions are often not consistent with CBA – they are often made by guardians or spenders, not analysts.

These three lenses are only archetypes. In practice, an individual engaged in the analytic or decision-making process may not exhibit all of the attitudes associated with a particular lens. Some bureaucrats may be conflicted, sometimes adopting one cognitive perspective, sometimes another. Guardians in line agencies can be prone to cognitive dissonance because they have dual allegiances. They may veer between being guardians, spenders, or both. In practice, though, most bureaucrats recognize what their tendency is.

#### 1.4.1 *Guardians*

Guardians are most often found in central budgetary agencies, such as the US Office of Management and Budget, or in controllership or accounting functions within line agencies. They naturally tend to have a bottom-line budgetary orientation. They often equate benefits with revenue inflows to their agency or other governmental coffers (at the same jurisdictional level) and to equate costs with revenue outflows from their agency or other governmental coffers (at the same level). Thus, they engage in *budget impact analysis*, also called *cash flow analysis* or *revenue-expenditure analysis*.<sup>19</sup> Guardians tend to regard actual CBA as naive, impractical, and, worst of all in their eyes, a tool whereby spenders can justify whatever it is they want to do.

The conceptual lens of “pure” provincial-based guardians is illustrated by the way they look at the costs and benefits of the Coquihalla Highway, as shown in Table 1.3. These evaluations of the no-tolls and with-tolls alternatives can be compared to the analyst’s evaluations that appear in columns B and D of Table 1.2, respectively.

To guardians, all toll revenues are regarded as benefits, whether paid by the jurisdiction’s residents (in this case, the province) or by non-residents. Construction costs are treated as a cost because they require a financial expenditure by the provincial government. Because guardians seek to minimize net budgetary expenditures, their preference, not surprisingly, is for the with-tolls alternative. Indeed, their gut reaction is to consider raising tolls to generate larger revenues, irrespective of its effect on levels of use or its impact on social benefits.

How does the guardian’s perspective differ from the CBA perspective? Most importantly, guardians ignore impacts valued by consumers and producers such as time

and lives saved. In this example they ignore social benefits that amount to \$751.8 million for the no-tolls alternative and \$581.9 million for the with-tolls alternative, both from the provincial perspective. When guardians are in control of a government service, it is easy to understand why one has to wait so long for the service. Neither your time nor anyone else's figures into their calculations! Similarly, guardians tend to ignore non-governmental social costs, such as congestion and pollution.

In the Coquihalla Highway example, all social costs happen to represent governmental budgetary costs, and so there is no difference between the CBA cost figures and the guardians' cost figures. In other situations, however, there might be a considerable difference between the two. For example, guardians treat the full cost of labor in a job-creation program as a cost, while CBA analysts consider only the opportunity cost (such as the lost leisure time of newly employed workers). Another manifestation of the same mistake concerns the treatment of resources currently owned by the government, such as offices or land. Guardians tend to treat these resources as free (i.e., having no opportunity cost) because using them for a project does not entail additional budgetary outlay.

Similarly, guardians treat all toll revenues as a benefit and ignore the losses suffered by citizens from paying tolls. From the CBA analyst's perspective, these toll payments are a transfer from residents to the government: the offsetting costs and benefits result in zero net benefit. On the other hand, provincial guardians treat subsidies from the federal government as a benefit because they are revenue inflows to their level of government. However, if the federal government has earmarked a certain amount of money to transfer to British Columbia, and if funds used for one purpose reduce the

Table 1.3 *Coquihalla Highway from a Provincial Guardian's Perspective (2016 \$ Million)*

	No tolls	With tolls
<b>Revenues ("benefits"):</b>		
Tolls from BC residents	0	219.4
Tolls from non-BC residents	0	73.2
Total "benefits"	0	292.6
<b>Expenditures ("costs"):</b>		
Construction	661.8	661.8
Maintenance	14.9	14.9
Toll collection		16.4
Toll booth construction		0.6
Total "costs"	676.6	693.7
<b>Guardian's net "benefit"</b>	<b>-676.6</b>	<b>-401.1</b>

*Source:* Adapted from Anthony Boardman, Aidan Vining, and W. G. Waters II, "Costs and Benefits through Bureaucratic Lenses: Example of a Highway Project," *Journal of Policy Analysis and Management*, 12(3), 1993, 532–55, table 2, p. 539.

amount available for other purposes, then federal funds for this highway should not be treated as a benefit from the provincial perspective.

Finally, guardians generally want to use a high social discount rate. Because of their financial background or their agency’s culture, they naturally prefer to use a financial market rate, which is generally higher than the social discount rate. They also know that using a high discount rate will make it more difficult to justify most infrastructure projects because costs occur earlier than benefits. Thus, they can limit spenders who, in their view, overestimate benefits, underestimate costs, and generally use money less efficiently than the private sector.

#### 1.4.2 *Spenders*

Spenders are usually employed within service or line departments. Some service departments, such as transportation, are involved with physical projects, while social service departments, such as those dealing with health, welfare, or education, make human capital investments. Other service departments, such as housing, make both types of expenditures. The views of spenders are somewhat more varied than those of guardians because the constituencies of particular agencies are more varied. Nevertheless, there are several commonalities.

Spenders tend to deliver government-mandated services to particular groups in society. They see their purpose as helping these groups and other members of society. Therefore, we characterize them as primarily engaging in *constituency-support analysis*. Most importantly, spenders tend to regard government expenditures on constituents as benefits rather than as costs. Thus, they typically see expenditures on labor (jobs) as a benefit rather than a cost. The conceptual lens of “pure” provincial-based spenders can be illustrated by the way they would look at the costs and benefits of the Coquihalla Highway, which is shown in Table 1.4.

Table 1.4 *Coquihalla Highway from a Provincial Spender’s Perspective (2016 \$ Million)*

	No tolls	With tolls
<b>Constituency “benefits”:</b>		
Project costs (from CBA)	676.6	693.7
Project benefits (from CBA)	751.8	655.1
Total constituency “benefits”	1,428.4	1,348.8
<b>Constituency “costs”:</b>		
Tolls from BC residents	0	219.4
Total constituency “costs”	0	219.4
<b>Spender’s “net benefit”</b>	1,428.4	1,129.4

*Source:* Adapted from Anthony Boardman, Aidan Vining, and W. G. Waters II, “Costs and Benefits through Bureaucratic Lenses: Example of a Highway Project,” *Journal of Policy Analysis and Management*, 12(3), 1993, 532–55, table 3, p. 542.