Web-Based Guide to Transportation Benefit-Cost Analysis

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ABSTRACT
Check out: http://www.dot.ca.gov/hq/tpp/offices/ote/benefit_cost/index.html

Originally begun as an ASCE committee activity, this comprehensive on-line guide to benefit-cost analysis (BCA) was completed under the sponsorship of the Office of Transportation Economics of the California Department of Transportation. The web site helps users, step by step, through the process of determining if BCA is an appropriate approach to an investment decision for a particular transportation project and then, if so, of properly conducting the analysis. Although not intended as an instructional aid *per se*, the site provides elementary guidance on setting up and conducting a BCA, explaining concepts and the basics of appropriate methodologies. It also lets users drill down to detailed technical descriptions of methodologies, analysis tools, and illustrative case studies. The site was developed in order to encourage increased use and proper application of BCA in transportation investment decisions for which this approach is appropriate.

INTRODUCTION

The Caltrans Benefit-Cost Analysis web site is the result of an initiative begun in 1997 by the ASCE Urban Transportation Division's Committee on Urban Transportation Economics and Policy, now part of the Transportation and Development Institute's Committee on Planning and Economics. Caltrans' Office of Transportation Economics in the Division of Transportation Planning, which had developed benefit-cost analysis spreadsheets to prioritize highway projects, had common interest in helping people properly apply benefit-cost analysis. With Caltrans funding, ASCE committee members and University of California Institute of Transportation Studies managed the development of the site. The site is a response to the concern that many transportation investment decisions have been made without adequate evaluation of alternatives in terms of economic benefits and costs, and to the need to provide clear statements of best practices in carrying out such evaluations.

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At the outset, the committee convened a series of panel of academics and practitioners to ascertain the nature of the need for information regarding transportation benefit and cost measurement. The panel had a series of discussions in which it was felt that most existing guides to benefit-cost analysis in transportation were either oriented to academic audiences and abstract concepts, or else focused to a single mode or type of project (e.g., highway only or transit only). It was also felt that there were many elements of environmental, social and economic benefits and costs that needed to be acknowledged in addition to the narrower traveler benefits and transportation agency costs. Finally, it was felt that there was no single prescriptive methodology that should be promulgated for universal use, but rather, there was a need for audiences to understand the range of both simple and sophisticated tools and measurement approaches that can be used. The panel also felt that with the rapid change in dollar valuation of cost and benefit factors over time, it was most useful to use the Internet to produce a reference tool that could be easily and quickly updated.

This paper presents the motivation for and structure of the web site and some of its noteworthy content. Readers are encouraged to experience the site and make suggestions for its improvement by visiting: http://www.dot.ca.gov/hq/tpp/offices/ote/Benefit_Cost/

WHY BCA AND WHY THIS WEB SITE?

Facing today's tight transportation funding, transportation officials responsible for planning and implementing projects need to ensure that their investments are the most cost effective. Or, as the saying goes, they need to make sure that they get "the most bang for the buck." However, since almost all transportation improvement projects are urgently needed and are usually delayed by years, if judged on their traffic merit alone, they all would seem to be not only good investments, but urgent as well. Unfortunately, a project's urgency does not guarantee that it is the best investment when compared to other similar or different types of projects. What is needed is a tool to objectively compare all projects based on their total benefits and costs over their lifecycles.

Since transportation planners and other officials come from a wide variety of academic, training, and experience backgrounds, some may have very limited experience with investment analysis concepts and methods. The idea behind the development of this web site has been to, in an stepwise interactive format, familiarize beginners with the basic concepts and methods, and enable those with some prior knowledge of benefit-cost analysis (BCA) to expand their knowledge and better understand the variety of methodologies and tools available to them.

WEB SITE STRUCTURE

The web guide was designed to be non-linear. That means it was not designed to be just an introductory textbook or "how-to" manual for beginners, nor was it designed to be just an intermediate or advanced discussion of application issues for experienced practitioners. Instead, it was intended to be a reference guide that could be used by both neophytes and more experienced analysts. Accordingly, it covers basic standards of practice, generally accepted valuation methods, tools of the trade, and case study examples of best practice. Because it is a web-based system, the user may use a search engine to enter the material from

any keyword and any of these perspectives. Using a rich set of hyperlinks, the user can follow the path of his/her preference in pursuing methods, examples or information on other resources, as desired.

The web site contains eight major areas, all accessed by links from the home page. The top part of the home page (Figure 1) describes the purpose of BCA and links to guidance about "When should benefit-cost analysis be used?" The lower part of the home page (Figure 2) presents the overall structure of the site, containing links to the eight major areas:

1. Guidance on setting up an analysis, and related issues;
2/3. How to measure benefits and costs of transportation projects (two separate areas);
4. How to calculate benefit-cost measures, such as the benefit-cost ratio, and related technical issues, such as discounting;
5. Suggestions on effective presentation of the results of an analysis;
6. Descriptions of some leading computer models that can help perform BCA for transportation projects;
7. Critical synopses of selected transportation BCA case studies;
8. Reference links to other web sites with pertinent information on BCA.

Quick links to these eight areas and to the home page are usually available along the left margin while navigating through the web site. Pages with detailed content are structured similarly, often including citations to supporting published sources and further reading.

SETTING UP AN ANALYSIS

This area of the web site addresses a collection of fundamental scoping questions that should be answered in order to properly identify the cost and benefit components of a particular project, and to structure their analyses effectively. Guidance is provided on:

- Documenting the nature and purpose of the project under consideration;
- Identifying the purpose of conducting a BCA and the appropriate level of effort, as well as choosing the type of BCA to be performed;
- Defining the base case and one or more alternatives to the base case;
- Identifying the sponsor's perspective with regard to the key persons and organizations impacted by the project, and how to deal with significant impacts on different groups;
- Determining the relevant geographic scope of the project;
- Establishing an appropriate time frame and schedule by which to account for project costs and benefits, and how to address residual values.

MEASURING COSTS

This area of the web site states that "costs" should generally be defined as the life-cycle resources consumed by a project obtained from the organization(s) providing the project. Cost components typically include initial outlays, periodic major rehabilitation or reconstruction costs, continuing costs of operations and maintenance, and end-of-project costs such as closeout cost and salvage value (a negative cost). Guidance is provided on generally accepted methods for estimating these cost components.

Although cost measurement for BCA is often seen as fairly straightforward, compared to benefit measurement, there exist some subtleties and potential pitfalls to which the web site gives attention. Included among these are:

- Discounting of future costs (and benefits), including selection of the discount rate;
- Dealing with opportunity costs;
- Dealing with inflation, and the distinction between economic and financial analyses;
- Proper treatment of transfer payments and avoidance of double-counting;
- Avoidance of sunk costs;
- Dealing with joint costs;
- Dealing with uncertainty and the role of sensitivity analysis.

Many of these concerns also apply to the measurement of benefits, discussed below.

MEASURING BENEFITS

The web site follows the convention that "benefits" are project impacts that significantly affect intended users and other parties, excluding the project provider(s). By this convention, a wide range of environmental and societal impacts fall into the benefit column. Since such impacts can be both desirable and undesirable, this convention creates the need to account for "negative benefits." Although this may seem awkward, until one gets used to it, the approach has the advantages of reducing potential for confusion and improving consistency across different BCAs performed for different projects.

Four types of benefits are highlighted as those most commonly found in BCAs for transportation projects:

- The value of travel time saved by transportation system users;
- The reduced vehicle operating costs incurred by transportation system users;
- The economic value of improved safety, usually from reduced collisions;
- The economic value of reduced air pollution emissions.

For each, the benefit is measured as the net difference in the impact when the project alternative is compared to the designated base case. Accepted measurement procedures for quantifying and valuating each of these impact types, along with related data sources, are presented in considerable detail. Adding complexity to the measurement of these benefits is the need to account separately for impacts on (1) trips that would use the same affected facilities either with or without the project, (2) trips that would change routes and/or modes because of the project, and (3) additional trips induced (or trips suppressed) as a result of the project. Time-of-day changes may add yet another dimension of complexity to the measurement of travel-related benefits.

The web site also discusses several other benefit types that are less commonly quantified in transportation BCA, including:

- The economic value of noise reduction;
- The value of external impacts (delays etc.) that occur during the construction period;
- The economic value of impacts on natural habitat and water quality;

- The economic value of direct effects on businesses and workers that are not accounted for elsewhere, which may be due to improved business productivity, improved logistics, and improved accessibility to customers and jobs;
- The economic value of direct effects on communities that are not accounted for elsewhere, which may be due to changes in property values, accessibility, aesthetics, or community pride.

These types of benefits are typically difficult to measure and even more difficult to valuate in dollar terms. Consequently, for projects where they are considered important, these impacts are often addressed outside of the BCA. In some cases, they are incorporated within the BCA using the techniques of hedonic pricing or contingent valuation, which are described in detail. This area of the web site also emphasizes the distinction between BCA and Economic Impact Analysis, a different type of investigation that deals with a broader array of economic development impacts of projects than BCA.

As with cost measurement, a number of subtleties and potential pitfalls to the analysis are discussed. Those especially related to proper benefit measurement include:

- Whether to consider changes in travel reliability and schedule delay, both of which unfortunately are not usually considered due to methodology limitations;
- Treatment of transfer payments and avoidance of double-counting;
- Dealing with uncertainty and the role of sensitivity analysis.

CALCULATIONS AND PRESENTATION OF RESULTS

The web site presents the different methods used in BCA to summarize the economic efficiency of a project alternative, relative to the base case and to other competing alternatives. The site describes four efficiency methods in detail – (1) Net Present Value, (2) Benefit-Cost Ratio, as well as the Incremental Benefit-Cost Ratio for projects with multiple alternatives, (3) Internal Rate of Return, and (4) Payback Period. The discussion addresses the strengths and weaknesses of the various methods. The closely related but conceptually distinct method of Cost-Effectiveness is also described.

Guidance is provided regarding the effective presentation of results. The goal for this area of the web site is to encourage creativity, clarity, and audience-awareness in conveying the findings of the BCA. The principle of using summary tables and graphics to emphasize important differences among alternatives is emphasized, as well as the value of illustrating the extent and sources of uncertainty that affect the results.

BENEFIT-COST MODELS

The web site highlights five leading public-sector computer tools specifically developed to facilitate BCA of transportation projects. Links to the actual software and to additional information are provided. The five highlighted models are:

- Cal-B/C – The California Life-Cycle Benefit/Cost Analysis Model (Caltrans)
- MicroBENCOST (NCHRP, Texas Transportation Institute)
- STEAM – The Surface Transportation Efficiency Analysis Model (FHWA)
- HERS-ST – The Highway Economic Requirements System - State Version (FHWA)

- StratBENCOST – Strategic Decision Support Tool for Highway Planning and Budgeting (NCHRP, HLB Decision Economics Inc.)

A simple spreadsheet that calculates and compares the principal efficiency and cost-effectiveness indicators can also be downloaded directly from the web site.

Each of the models listed above is described in detail with regard to the following features:

- The types of projects considered, described by the types of infrastructure improvements and travel modes represented;
- The scope of the analysis, described in terms of the complexity of the represented transport network and the level of detail achieved in traffic types and time periods;
- The categories of benefits explicitly considered;
- The categories of costs explicitly considered;
- The BCA efficiency measures and other quantitative impacts calculated;
- A detailed example, illustrating input data requirements and the key outputs produced;
- Links to additional information and software.

Eight additional computer models are also identified, most of which are either closely related to one of the principal models or are quite specialized (IDAS, NET_BC, RAILDEC, SPASM, IMPACTS, SMITE, SCRITS, and ABC). For each of these, the web site provides a brief description and links to further information.

CASE STUDIES AND REFERENCES

The web site provides synopses of actual benefit-cost analyses performed for seven projects. These highly diverse case studies are presented and critiqued in a parallel manner, relating to the concepts, methods, and recommendations on good practice contained throughout the web site. These case studies are also offered as useful models for how these ideas can be applied in practice. The seven case studies are:

- Commercial Vehicle Information Systems and Networks (CVISN) Program (United States)
- I-205/580 Ultimate Truck Bypass (California)
- Electronic Toll Collection on the Carquinez Bridge (California)
- Seattle Monorail (Washington)
- Public Transport Signal Priorities and Real-Time Passenger Information (Finland)
- Banning of Studded Tires (Japan)
- Airport Runway Expansion (Wisconsin)

The last area of the web site contains a reference list supplementing the many citations found elsewhere throughout the site. This reference area mostly contains hyperlinks to other on-line guides for performing BCA.

CONCLUSION

What started out as an effort to produce an online guide ended up providing something even more – a readily available review of available concepts, resources and methods for evaluating benefits and costs of any type of transportation. The effort to provide truly multi-modal

content is also particularly important as a way to bridge past inconsistencies in the approaches used for evaluating various air, sea, rail and road transportation alternatives. At the end, however, a web-based guide can go out of date and out of use in the same way a textbook becomes obsolete and out of print. The difference is that a web-based guide can potentially be kept fresh and up to date with less effort. The web-based design provides opportunity for a community of users to submit discussion, modifications and new information.

We hope the site will encourage the use of objective benefit-cost analyses in transportation investment decisions and that in so doing will encourage the transportation investments that best serve the public interest.

ACKNOWLEDGEMENTS
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The original concept and design of the web site were created by the Committee on Urban Transportation Economic and Policy (now the Committee on Planning and Economics, Transportation and Development Institute) of the American Society of Civil Engineers (ASCE). Besides the authors, key ASCE committee contributors include Jan Botha, Patrick DeCorla-Souza, Jonathan Gifford, James Hunt, C. Jotin Khisty, and David Reinke.

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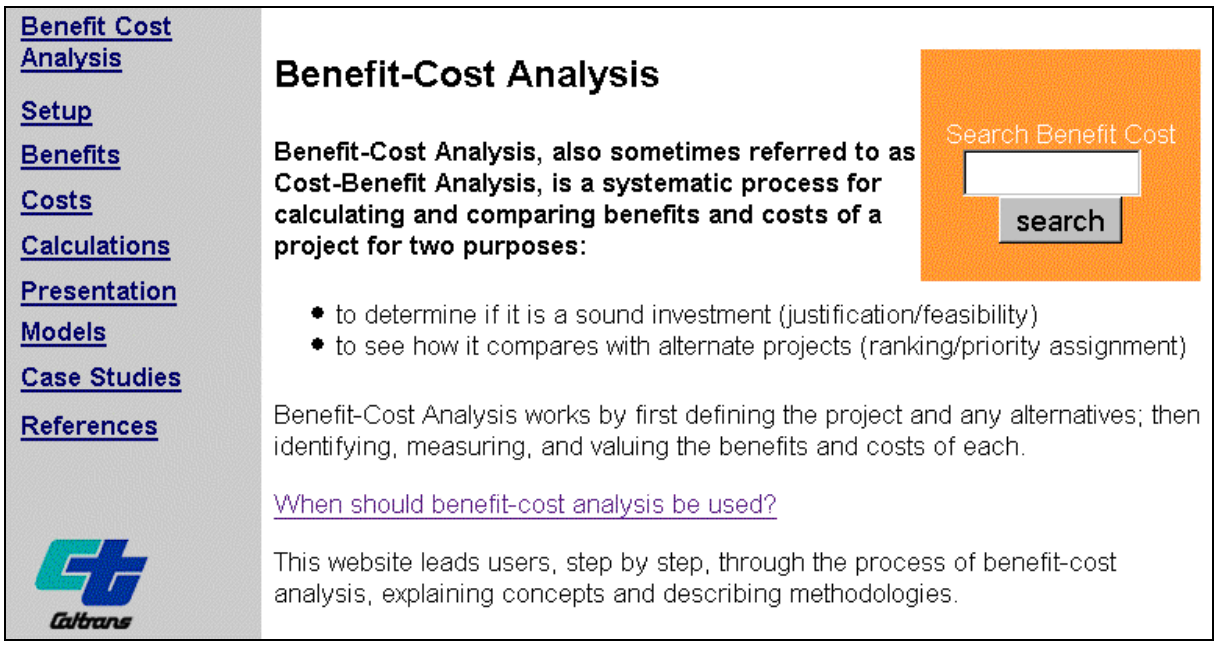

Figure 1. Home Page (Top Part)

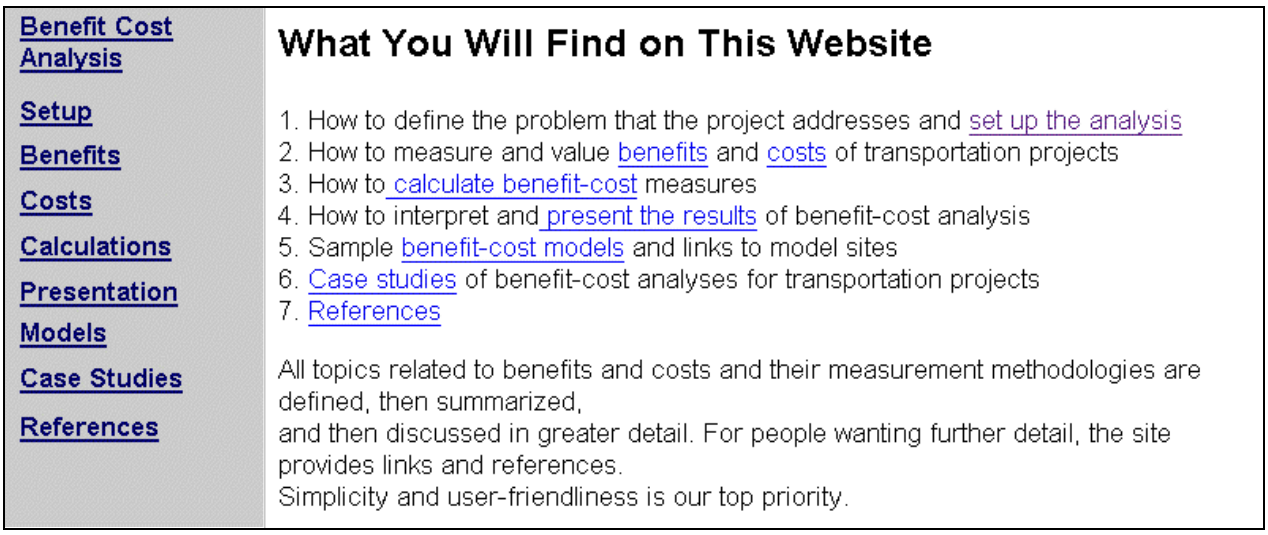

Figure 2. Home Page (Lower Part)