

# Engineering Economic Analysis Practices for Highway Investments

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Does an engineering economic analysis contribute worthwhile information about a highway investment or does it impede timely decision making? This question essentially underlies the problem statement for National Cooperative Highway Research Program (NCHRP) Synthesis Topic 41-03, Engineering Economic Analysis Practices for Highway Investments.

The results of the study, published as NCHRP Synthesis 424, affirm the benefits of using engineering economic methods by showing how select U.S. transportation agencies have applied exemplary practices in benefit-cost analyses and similar procedures.<sup>1</sup> The results indicate a remarkably wide range of applications in highway investment decision making.

## Economic Versus Financial Analyses

NCHRP Synthesis 424 distinguishes between economic analyses and financial analyses of highway investments; both involve streams of dollars and can easily become confused in practice. For example, in an economic analysis, questions may arise about whether

or not to include inflation; whether to use base-year or current-year dollars; the differences between an interest rate and a discount rate; and what to do when funding contributed by others reduces the project's apparent cost to the highway agency.

The report provides brief explanations highlighting the differences between the two types of analyses, along with examples of good practice by highway agencies. A project may be economically feasible—that is, worth doing—but financially infeasible, because it cannot be paid for. The opposite is also true: a project can be economically infeasible—the expenditure of taxpayer dollars is not economically justified—but financially feasible, because the money can be found to pay for it, although the project could prove a poor use of tax dollars.

Table 1 (page 44) illustrates these and other combinations of economic and financial possibilities to distinguish between the two types of analyses. The synthesis focuses solely on the economic analysis of agency investments.

## Developing Proficiency

Many U.S. state departments of transportation (DOTs) routinely conduct economic analyses for certain categories of investment—for example, for pavement and bridge preservation, by applying economic models in pavement and bridge management systems; for safety improvements, by considering the social costs avoided by reducing collisions; and for major projects, such as expanding the capacity of trunk lines or of large, complex urban transportation facilities.

The findings from this synthesis have demonstrated, however, that agencies conversant with economic concepts and methods regularly conduct more extensive applications of engineering economic analysis. These agencies have developed a proficiency that enables the integration of economic analyses into daily operations and the application of economic results to managerial and executive decision making.

Crews work during a weekend closure on the SR-520 bridge replacement and high-occupancy vehicle project in Washington State. Transportation agencies often analyze highway safety investments in economic terms, considering the social costs of fewer collisions.



PHOTO: WASHINGTON STATE DOT

<sup>1</sup> [www.trb.org/Publications/Blurbs/167096.aspx](http://www.trb.org/Publications/Blurbs/167096.aspx).

A roundabout is installed on SR-92 in Washington State to reduce collision risk and improve traffic flow. Roundabouts are a priority in Washington State DOT's strategic highway safety plan.



PHOTO: WASHINGTON STATE DOT

### Case Examples

Case examples were critical to the findings of the synthesis. Many regard benefit–cost analysis and similar methods solely as tools for project appraisal, for application early in project planning and design. This synthesis has shown, however, that state DOTs and other transportation organizations have applied engineering economic analysis successfully and productively to a much wider range of highway investment decisions, from project conception and planning to project delivery.

The cases presented in NCHRP Synthesis 424 are listed as follows; the cases detail the practices of a

sampling of agencies identified through a screening survey. The list is not exhaustive; other agencies also may have attained similar levels of proficiency in the use of economic analysis.

◆ **Planning.** One case example applies to critical Interstate bridge and tunnel crossings owned and operated by the Port Authority of New York and New Jersey, with a supporting economic analysis by the U.S. Army Corps of Engineers of maritime shipping to the Port of New York and New Jersey. Another case example covers mobility planning by the Washington State Department of Transportation (DOT).

**TABLE 1 Economic Versus Financial Assessments of Project Candidate Solutions**

Economic Justification	Financially Feasible	Financially Infeasible
Economically justified	<p>Solution is economically worth doing. The benefits justify the cost. Of the alternatives considered, the solution maximizes benefits to the public.</p> <p>Solution is financially feasible—funding is available in the amount and time needed to pay for the candidate project, including anticipated cost inflation.</p> <p><i>Implication:</i> With good management of delivery, a worthwhile project can be completed with the available budget.</p>	<p>Solution is economically worth doing. Its costs are justified by its benefits to the public.</p> <p>Funding is not sufficient, however, to cover the estimated costs including inflation; or the candidate project is ineligible for funding in the amount and schedule needed.</p> <p><i>Implication:</i> Although worth implementing, the solution cannot be paid for with the current design and funding. The candidate project should not be recommended. Other financially feasible solutions to the need or problem should be explored.</p>
Economically not justified	<p>Solution is economically not worth doing. The benefits do not justify the cost. Unless justified by other, noneconomic considerations, the project could be seen as a waste of taxpayer money.</p> <p>Funding is available to support the candidate project if worthwhile.</p> <p><i>Implication:</i> Consider revisiting the original need or problem to explore other solutions that are stronger economically, that increase benefits or reduce costs. Otherwise, consider redirecting the funding to viable project candidates that address other needs.</p>	<p>Solution is neither economically nor financially defensible. Even with other, noneconomic reasons to consider the solution, funding is not available in the amount and time needed.</p> <p><i>Implication:</i> Reassess the original need or problem to gauge its priority in relation to other needs. If the priority is relatively high, develop new, economically viable solutions and consider other financing options (including innovative funding mechanisms or redirecting funding from lower-priority project candidates) to fund the solution. Otherwise, move on to other needs and solutions.</p>

◆ **Programming and budgeting.** Two case examples illustrate methods used by Washington State DOT for mobility programming and safety programming; another presents the California DOT (Caltrans) approach to bridge programming and permitting, including environmental permitting considerations; and a fourth case illustrates the methodological development for an economics-based trade-off analysis by New York State DOT.

◆ **Resource allocation following budget approval.** The New York State DOT case example of economics-based trade-off analysis is instructive for projects at the resource allocation stage as well.

◆ **Project design and development.** A case example of pavement type selection, comparing the practices of Colorado DOT and Caltrans, addresses this aspect of project design and development, supplemented by a value engineering case example, which compares the practices of Caltrans and Florida DOT.

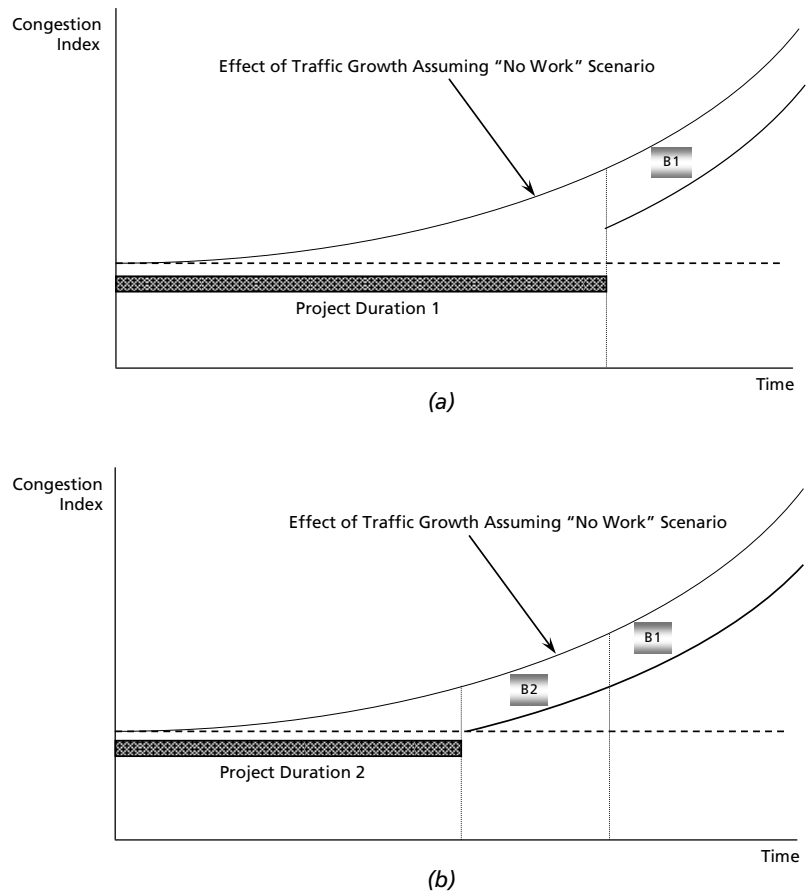
◆ **Accelerated project delivery.** Conventional construction and design-build options are considered in the case example for acceleration of project delivery, developed with Minnesota DOT.

Economic analyses involve comparisons of alternatives to evaluate differences in costs and benefits and to identify the preferred—or economically justified—approach that delivers the best value to road users and the public at large. For example, Figure 1 (right), from the Minnesota DOT accelerated project delivery case, illustrates the comparison of road user benefits from conventional construction (upper graphic) and from accelerated construction with design-build (lower graphic). The additional benefit component (B2) in the lower graphic denotes additional savings to road users from the faster completion of the project.

## Practical Frameworks

Although economic results are important to investment decisions, they are not the sole criterion in the final decision. Agencies may consider other factors, quantitative and qualitative, in a comprehensive assessment of which project alternative to recommend.

In addition to the application of engineering economic methods to various decisions in highway investment, the case examples also reveal agency practices in building analyses—such as compiling data, selecting a discount rate, accounting for risk or uncertainty in estimates, defining alternatives, and so forth. The case examples represent a variety of program areas, such as preservation, mobility, and safety; life-cycle stages in the decision process, such as planning, programming, resource allocation, design, and



**FIGURE 1** Illustration of highway user cost savings from project acceleration: (a) conventional construction; (b) accelerated construction with design-build. (B1 = benefit; B2 = additional benefit. Source: HDR-HLB Decision Economics, Inc., 2006, Figure 7, p. 11, with additional annotations by author.)

project delivery; and levels of the system analyzed—for example, link or project, corridor, program, and network.

Considered individually, the case examples show how engineering knowledge and the need to understand the impacts of particular decisions can be organized within a practical economic framework. Considered collectively, however, the case examples reveal common characteristics among agencies that successfully apply engineering economic practices across a range of projects.

Value engineering was integrated into the project development and environmental study of the I-595 expansion project in Florida.



PHOTO: DOUG KERR



PHOTO: COLORADO DOT

Concrete work on US-160 near Cortez, Colorado. Colorado DOT's pavement type selection practices are examined in NCHRP Synthesis 424.

## Characteristics of Proficient Agencies

Several characteristics differentiate agencies that are conversant with economic methods and are integral to the agency's makeup and approach to solving transportation problems and addressing needs:

- ◆ The influence of organizational champions and culture, with the support and participation of executive leadership;
  - ◆ A level of knowledge, proficiency, and comfort with economic methods;
  - ◆ Integration of economics into the business and decision-making processes, so that economic analyses are a part of routine business, not a distinct, somewhat isolated task;
    - ◆ Creativity in developing alternative solutions;
    - ◆ A willingness to experiment and innovate when available data and analytic methods do not fit a situation that requires a decision;
  - ◆ The reliance of upper management on the results of economic analyses in making investment decisions;
  - ◆ The availability of information technology to support not only the economic analysis but also important steps such as diagnosing a problem, defining realistic alternatives, and displaying results;
  - ◆ Providing staff training in economic methods and tools and encouraging personnel to apply these capabilities in their daily work;
  - ◆ Maintaining a healthy perspective on engineering economic analysis, viewing results as information, not as an automatic decision, that becomes part of the comprehensive understanding of a project solution; and
  - ◆ Recognizing that economic outcomes are an integral part of gauging highway system performance.

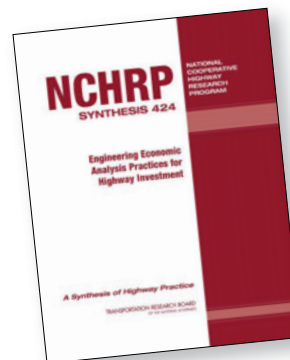
## Value of Economic Analyses

The case examples, together with reviews of the literature and interviews with agency personnel, identify the following benefits of economic analyses:

- ◆ The direct or tangible benefit consists of obtaining an economic result that shows the value or merit of a highway investment. This value may be in the benefits received by road users or in the costs avoided by road users and by the agency. Generally, economic performance—the benefits compared with the costs—is linked to the engineering or technical performance of the highway facility. Monetized benefits help in understanding the trade-offs between competing alternatives. The preparation of an economic analysis imposes a discipline that accounts for all costs and all benefits as comprehensively and as accurately as possible.
- ◆ The indirect or intangible benefit comes from encouraging a better decision-making process within the organization. This benefit provides an incentive to identify all realistic alternatives for solution; to a focus on the purpose of the proposed investment and to avoid “scope creep”—uncontrolled changes or growth in a project's scope; to avoid biases toward options, such as particular paving materials; and to support these objectives through clear agency guidance and communication, backed by analytical tools and effective data collection and processing.

## Completing the Steps

NCHRP Synthesis 424, *Engineering Economic Analysis Practices for Highway Investments*, describes the ways that exemplary state DOTs and other transportation agencies complete the steps of engineering economic analysis: articulating the highway system need or problem to be investigated; defining alternative solutions to be assessed; quantifying the parameters of the analyses; setting economic and engineering criteria for decisions; introducing other noneconomic or nonquantitative factors that may affect the outcome; completing the analysis; and interpreting the results. The synthesis also includes lessons learned from the successful implementation of engineering economic analysis within a highway organization.



For more information on NCHRP Synthesis 424, visit [www.trb.org/Publications/Blurbs/167096.aspx](http://www.trb.org/Publications/Blurbs/167096.aspx).