Benefit Cost Analysis
Transportation Systems Management and Operations

Fundamentals of Benefit-Cost Analysis for Transportation Systems Management and Operations

This information brief is a continuation of the FHWA Office of Operations Transportation Systems Management and Operations Benefit-Cost Analysis technical briefing series. Earlier briefs were published in 2012 and are available online at: http://www.ops.fhwa.dot.gov/plan4ops/resources/brochures.htm.

Project Decision Making

This technical brief explains the basic approach to economic analysis as applied to transportation decision making and how such an analysis is useful for understanding and evaluating transportation systems management and operations (TSM&O) programs and projects. This brief provides examples of economic analyses of TSM&O projects and describes the fundamental components of benefit cost analysis (BCA). These methods are demonstrated in the Transportation Systems Management and Operations Compendium, which covers a series of BCA studies conducted around the country by transportation planning agencies and research organizations.

Economic analysis can inform many different phases of the transportation decision-making process. In planning, it can be applied to basic cost and performance data to screen a large number of potential project alternatives, assisting in the development of program budgets and areas of program emphasis. It can also assist engineers in developing more cost-effective designs once a decision has been made to go forward with a TSM&O project. Similarly, an economic analysis can play a critical role in screening alternatives to accomplish a specific project goal and provide information for the environmental assessment process. The Federal Highway Administration (FHWA) has a long history of promoting the application of economic analysis to project planning, design, construction, preservation, and operation, including the use of life-cycle cost applications.

Economic analysis is a critical component of a comprehensive project or program evaluation methodology that considers all key quantitative impacts of TSM&O investments. It allows highway agencies to identify, quantify, and assign a value to the economic benefits and costs of highway projects and programs over a multi-year timeframe. With this information, highway agencies are able both to allocate scarce resources to maximize public benefits as well as to show a rational basis for their decisions.

Benefit-Cost Analysis

A benefit cost analysis, or BCA, attempts to capture all benefits and costs accruing to society from a project or course of action, regardless of which particular party realizes the benefits or costs, or the form these benefits and costs take. Used properly, a BCA reveals the most economically efficient investment alternative; i.e., the one that maximizes the net benefits to the public from an allocation of resources.

The BCA process begins with establishing objectives for an improvement to the operation and management of transportation assets. The next step is to identify constraints on potential agency options and specify assumptions about the future. The analyst then develops a full set of reasonable improvement alternatives to meet the objectives. This process begins with the development of a base case. The analysis period selected should be long enough to include at least one major rehabilitation activity for each alternative.

Selected FHWA BCA References

Operations Benefit/Cost Analysis Desk Reference – http://ops.fhwa.dot.gov/publications/fhwahop12028/index.htm.

TSM&O BCA Compendium – http://www.ops.fhwa.dot.gov/publications/fhwahop14032/.

TOPS-BC Tool - http://www.ops.fhwa.dot.gov/plan4ops/topsbctool/index.htm.

Economic Analysis Primer - http://www.fhwa.dot.gov/infrastructure/asstmgmt/amprimer.pdf.

TIGER BCA Resource Guide – http://www.webpages.uidaho.edu/~mlowry/Teaching/EngineeringEconomy/Supplemental/USDOT_Economic_Analysis_Primer.pdf.

Useful Applications for Benefit-Cost Analysis

A BCA considers the changes in benefits and costs resulting from a potential improvement to the status quo of a facility. In highway and TSM&O decision-making, BCA may be used to help determine:

- ***Whether or not a project should be undertaken*** (i.e., whether the project's life-cycle benefits will exceed its costs).
- ***When a project should be undertaken.*** A BCA may reveal that the project does not pass economic muster now, but would be worth pursuing 10 years from now due to projected regional traffic growth. If so, it would be prudent to take steps now to preserve the future project's right-of-way.
- ***Which among many competing alternatives and projects should be funded*** given a limited budget. A BCA can be used to select from among design alternatives that yield different benefits.

Management and Operations Strategies are...

Programs, projects, or services designed to get the safest and most efficient use out of existing and planned infrastructure. Examples include:

- Traffic incident management.
- Traveler information services.
- Traffic signal coordination.
- Transit priority/integration.
- Freight management.
- Work zone management.
- Special event management.
- Road weather management.
- Active transportation and demand management.

The investment costs, hours of delay, crash rates, and other effects of each alternative are measured using engineering methods and then are compared to those of the base case, and the differences relative to the base case are quantified by year for each alternative. The analyst assigns dollar values to the different effects (e.g., the fewer hours of delay associated with an alternative relative to the base case are multiplied by a dollar value per hour) and discounts them to a present value amount.

Based on the results of the BCA and associated risk analysis, the analyst prepares a recommendation concerning the best alternative from an economic standpoint. It is good practice to document the recommendation with a summary of the analysis process conducted.

Benefit-Cost Analysis for Operations Strategies

Due to the long-time use of BCA for more traditional infrastructure project assessment, many regions and States already have established procedures for conducting BCAs. These procedures may range from simple guidance on which measures of effectiveness (MOE) to use to detailed analysis frameworks, specified performance measures, and standardized benefit valuations to be applied. Therefore, care should be taken to be as consistent as possible with the established BCA guidelines and procedures in order to provide for meaningful comparability of results. This consistency will ensure that the TSM&O strategies may be effectively and accurately compared and prioritized alongside more traditional infrastructure investments without risking the overstating or understating of benefits due to the analysis methodology itself.

While consistency between TSM&O and non-TSM&O BCA procedures is generally desirable, analysts should be aware that BCA procedures designed for more established capital intensive infrastructure projects may not be entirely appropriate for analysis of TSM&O projects. Analysts should be aware that existing agency procedures or guidelines may serve to limit the full, comprehensive assessment of the benefits of TSM&O strategies in one or more of the following ways:

- **Existing MOEs may not be sensitive to the unique benefits of TSM&O strategies** – Many established BCA frameworks, designed for more traditional capacity infrastructure projects, may not include assessment of some of the key benefit areas often provided by TSM&O strategies, such as improvements in travel time reliability or improved agency efficiency.

- **Specified analysis data may be inappropriate for assessing TSM&O benefits** – Existing guidelines or procedures requiring the use of particular datasets (e.g., Highway Performance Monitoring System (HPMS) data, traffic counts, etc.) as inputs to the analysis may result in a bias against TSM&O strategies, unless the data is appropriate to the strategy being analyzed. For example, many traditional traffic count datasets only represent time periods free of incidents and inclement weather. Using this data as the basis for assessing the impacts of an incident management system or a weather information system would likely result in the severe underestimation of true benefits.

- **Required analysis methods, tools, or models may not be capable of capturing the full benefits of the TSM&O strategies** – For example, some regional BCA guidelines may specify that the established regional travel demand model be used as the basis for the traffic impact analysis. However, many regional travel demand models are focused on average traffic conditions, and may be inadequate for assessing TSM&O strategies focused on incident, construction work zone, or inclement weather conditions, or they may not be sufficiently sensitive to travel costs in order to assess pricing options.

- **Cost estimation parameters and frameworks may be inadequate** – Many traditional infrastructure projects have large up-front capital costs required for construction and implementation, and then much smaller operations and maintenance (O&M) costs spread over a long project life (e.g., 30 years). Many TSM&O strategies, on the other hand, have much smaller capital outlays required for implementation, but proportionately higher continuing O&M costs.

While many regions and agencies have made significant efforts to enhance their existing regional BCA guidelines and policies in recent years to be more compatible with TSM&O analysis needs – incorporating new MOEs (e.g., travel time reliability), updating modeling and analysis tool capabilities; and including automated archived data – operations analysts should still be aware of the potential constraints in utilizing existing frameworks, datasets, modeling tools, and cost parameters.

Typical Benefits and Costs of Transportation Systems Management and Operations Projects

Table 1 lists typical benefits and costs used for the evaluation of TSM&O projects. Travel time savings and delay, vehicle operating costs (VOC) and crash reduction or safety used to be the biggest benefits for most transportation projects. However, recently researchers have identified another increasingly important benefit: travel time reliability. The recent integration of reliability into the traditional BCA evaluation of TSM&O strategies adds a new parameter to transportation planner's repertoire. Due to uncertainty in travel time, travelers add "buffer time" to their trips to ensure they arrive at their destination on time. The decrease of such buffer time is also valued as a benefit when conducting a BCA of a TSM&O project.

As the Transportation Research Board states in numerous documents, reductions of travel time and buffer time are considered benefits (for more information visit http://www.trb.org/Publications/PubsSHRP2ResearchReportsReliability.aspx).

Table 1. Benefit and cost categories and their elements.

Agency Benefit/Costs	User Benefits/Costs Associated with-Transportation Systems Management and Operations Projects	Externalities (non-user impacts, if applicable)
• Design and engineering • Software and systems engineering • Construction • ITS field infrastructure • Preservation • Routine maintenance • Transportation management center	• Travel time and delay • Travel time reliability • Crashes • Vehicle operating costs	• Emissions • Noise • Other societal impacts

SOURCE: FHWA Economic Analysis Primer

Federal Highway Administration Resources and Support

To assist agencies in understanding and applying benefit cost analysis for TSM&O, FHWA has several resources available under its Planning for Operations Program. The resources include the Operations Benefit Cost Desk Reference, other information briefs, a Transportation Systems Management and Operations Benefit-Cost Analysis Compendium of sample case studies (See Table 2 for sample content), and the Tool for Operations Benefit Cost (TOPS-BC). These can be accessed at: http://www.ops.fhwa.dot.gov/plan4ops/focus_areas/analysis_p_measure/benefit_cost_analysis.htm.

Table 2. Conducting a Benefit-Cost Analysis for Transportation Projects - Contrasts of Transportation Systems Management and Operations Strategies and Infrastructure Project Strategies

Benefit-Cost Analysis Steps	Transportation Systems Management and Operations Strategies	Large Infrastructure Strategies
1. Establish objectives	Often have multiple strategies, reduce recurring and nonrecurring delay, improve reliability	Usually adding system capacity to address mostly recurring delay
2. Identify constraints and specify assumptions	Smaller projects are usually easier to implement due to lower environmental and community impacts compared with larger scale infrastructure projects	Large complex projects lead to cost uncertainty, potential environmental, political, or community challenge, and implementation time uncertainty
3. Define the base case and identify...	Multiple strategies offer many alternatives to status quo	Base case is often system breakdown, failure to meet minimal LOS
4. Set the analysis period	Period can be short, (5-15 years), but include equipment upgrades	Long term, usually 30-50 years
5. Define the level of effort for screening alternatives	Depending on the project, the BCA process can be very low cost and easily repeatable, or expensive and with different assumptions	Depending on the project, the BCA process can be very low cost and easily repeatable, or expensive and with different assumptions
6. Analyze the traffic effects	TSM&O BCA processes use responses to traveler information and have to take into consideration pricing uncertainties to estimate short-run results	BCA of infrastructure strategies require assumptions about future travel and other factors that may be complex and uncertain
7. Estimate benefits and costs relative to base case	TSM&O BCA processes use direct responses of traveler information and pricing uncertainties as well as assumptions about future travel that may be complex and uncertain to estimate costs and benefits of short-run strategies	Benefit cost estimation of infrastructure strategies require assumptions about future travel and other factors that may be complex and uncertain
8. Evaluate risks	Limited investments, limited risks	Large investments with uncertain project costs
9. Compare net benefits and rank alternatives	High BCRs are common	BCRs are usually single digit
10. Make recommendations	There is a variety of different TSM&O technologies which can be used to make strategy recommendations.	The longe-range nature of large infrastructure projects minimizes the amount of flexibility and determines their strategic design

SOURCE: : FHWA TSM&O BCA Compendium

Project Contacts

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