TRANSPORTATION RESEARCH

CIRCULAR

Number 477 October 1997

Assessing the Economic Impact of Transportation Projects

How to Choose the Appropriate Technique for Your Project

TRANSPORTATION
RESEARCH
CIRCULAR

Number 477, October 1997
ISSN 0097-8515

Assessing the Economic Impact of Transportation Projects

How to Choose the Appropriate Technique for Your Project

Glen Weisbrod
Economic Development Research Group

and

Burton Weisbrod
Northwestern University

Subscriber category
IA planning and administration
www.TRB.org
www.national-academies.org/trb

Transportation Research Board
National Research Council
2101 Constitution Avenue, NW
Washington, DC 20418

Preface

This Transportation Research Board (TRB) Circular is published at the recommendation of the Committee on Transportation Economics, which has provided extensive review of the contents. The Committee feels that the transportation profession will benefit from this concise, comprehensive primer on how to best assess economic impacts of transportation projects. The methods presented in this Circular are not specifically endorsed by the TRB.

This Circular is authored by Glen Weisbrod of the Economic Development Research Group and Burton Weisbrod of Northwestern University. The Transportation Economics Committee acknowledges the significant efforts made by these two economists in creating this document.

Contents

Introduction

WHY THIS PRIMER?

There is considerable confusion among public agencies and private groups regarding when and how to consider economic impacts in transportation decision making. As a result, important considerations may be ignored and irrelevant factors considered.

This primer is written for noneconomists. Its purpose is to help planners, engineers, and decision makers identify the appropriate ways to define questions regarding economic impacts of transportation and the appropriate methods to assess them. Its goal is not to make the reader an instant expert on economic evaluation, but to assist the reader to

- Identify the types of economic impacts that are relevant for decision making,
- Define the appropriate project evaluation perspective, and
- Select relevant methods for analysis and presentation of findings.

HOW SHOULD IT BE USED?

The issues and analytic methods discussed here apply for *all* modes of transportation, including streets and highways, public transportation, railroad services, and air and sea transportation. Using a “cookbook” approach, we describe nine steps for defining, analyzing, and presenting findings. However, there is no single “recipe” for assessing the economic impacts of transportation projects. Rather, there are many variations (and some complicated methods) embedded within these nine steps.

At a minimum, this primer can be used to provide the reader with an understanding of what is involved in assessing economic impacts. For some types of projects, this primer may also be sufficient to guide the reader in actually carrying out the analysis.

Background

WHY CONSIDER ECONOMIC IMPACTS OF TRANSPORTATION?

People want to improve their standard of living, and they see increased income as the way to achieve that goal. Transportation system enhancements are, in turn, a means of maintaining or improving economic opportunities, quality of life, and, ultimately, incomes for people in a particular region. Yet it is also clear that there can be both gainers and losers when there are changes in transportation facilities and services.

Thus, there are two major reasons for interest in understanding the nature of transportation project impacts. One is to guide decision making to maximize benefits of public investments. The other is to ensure that projects are appropriately designed with recognition of both the positive and negative economic impacts.

WHAT ARE THE DIFFERENT TYPES OF ECONOMIC IMPACTS?

Direct User Benefits

All modes of transportation—including roads, rail, sea, and air—provide direct benefits to users. These immediately realized benefits to users may be in terms of ease of access, comfort, safety, travel times, and travel costs.

Direct Economic Benefits

The user benefits, in turn, lead to monetary benefits for some users and nonusers (individuals and businesses) within a geographic area.

- For affected businesses, there may be economic efficiency benefits in terms of product cost, product quality, or product availability, stemming from changes in labor market access, cost of obtaining production inputs, and cost of supplying finished products to customers.
- For affected residents, benefits may include reduced costs for obtaining goods and services, increased income from selling goods and services to outsiders, and increased variety of work and recreational opportunities associated with greater locational accessibility.

All of these effects can ultimately lead to growth of business sales and income in the affected geographic area.

Indirect and Induced Economic Impacts

Ultimately, the direct benefits to businesses and the residents of communities and regions may also have broader impacts, including

- Indirect business impacts business growth for suppliers to the directly affected businesses.

- Induced business impacts business growth as the additional workers created by direct and indirect economic impacts spend their income on food, clothing, shelter, and other local goods and services.
- Other induced impacts shifts in broader population and business location patterns, land use, and resulting land value patterns, which may also affect government costs and revenues. These changes may ultimately affect income, wealth, the environment, and quality of life both overall and for particular groups of people in the affected geographic area.

Construction and Maintenance Spending Impacts

So far, we have discussed various facets of the long-term benefits associated with availability and use of transportation facilities and services. Depending on the particular purpose of the analysis, we can also recognize short-term economic impacts associated with the construction of transportation facilities and services and other long-term economic impacts associated with maintenance and operation of facilities and services. The economic impacts of construction and maintenance spending also include direct, indirect, and induced components, as defined above.

Measurement Concerns

There is thus a sequence of different levels of impact, illustrated in Figure 1, all of which spring from the same basic causes. Because of that relationship, care must be taken to avoid "double counting" benefits by adding together results of different levels of impact (for the same class of travel). Care must also be taken to appropriately account for geographic incidence of benefits (i.e., the fact that some local business gains may be at least partially offset by business losses elsewhere).

Finally, it must be recognized that construction spending impacts as well as indirect and induced impacts (also known as "multiplier effects") could also result from equivalent nontransportation expenditures in the given area. *All of these concerns are addressed in the descriptions of analytic methods that follow.*

WHAT IS THE APPROPRIATE WAY TO ACCOUNT FOR ECONOMIC BENEFITS?

Choose the Right Impact Measure

The specific types of impacts that should be measured and the ways in which they should be counted depend on the *intended purpose of the analysis*. Accordingly, this primer is intended to provide guidelines for how economic impacts of transportation *should* be measured and counted for different kinds of analyses.

Distinguish Locational Shifts

Some of the impacts will result from locational shifts. For instance, a new transportation facility may allow a new business to be supported or an existing business to be expanded in the area. This is a result of shifting locational advantages, which effectively cause businesses located elsewhere to contract or disappear. Transportation facilities may similarly raise property values

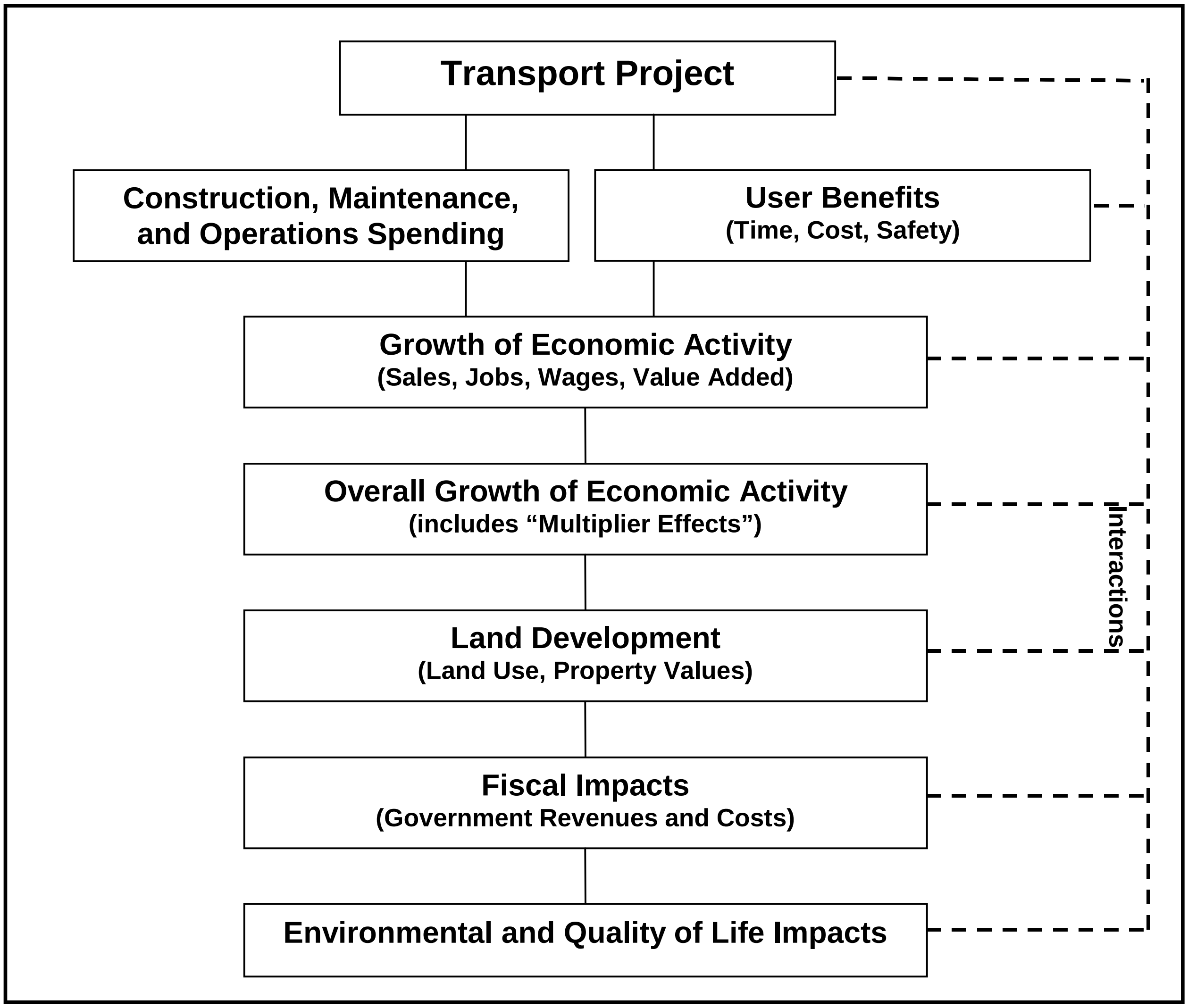

FIGURE 1 Elements of impact.

in areas served by them, while property values fall somewhere else. Thus, transportation projects can have direct effects on the region they serve and also external effects either favorable or unfavorable outside that region.

Recognize Productivity and Economic Growth Impacts

The fact that transportation investments can cause locational shifts of economic activity does not, however, mean that the economic impacts of transportation is just a "zero sum game." In general, businesses do not relocate their facilities unless there is an advantage in doing so. Locational benefits to businesses may allow them to provide new products or services, to serve areas where they were not previously available, or to provide existing products and services at lower cost. There may be locational shifts, but there can also be overall net benefits for society. Better transportation can increase the total production capability of the entire economic system.

Focus on Economic Benefits

There are both “economic benefits” and “noneconomic benefits” of transportation facilities and services. We define economic benefits as those that lead to increases in income. We define noneconomic benefits as those that do not directly or indirectly lead to increases in income, but provide other social benefits (such as community pride, “quality of life,” etc.). This primer focuses on the economic benefits.

HOW ARE ECONOMIC BENEFITS RELEVANT FOR DECISION MAKING?

Importance of Considering Economic Impacts

There is considerable confusion regarding the relevance of economic impacts for transportation decision making. On the one hand, there are proponents of transportation investments who believe that economic development is an important motivation for projects, and who are concerned that traditional transportation efficiency measures undercount the true benefit of particular transportation investments. On the other hand, there are skeptical decision makers who are concerned that economic impacts may be used as a guise under which projects that fail traditional benefit–cost (B–C) tests are justified by “double counting” of benefits. (Such double counting would occur if, for example, we were to count both the transportation cost savings to a producer and the increased profit from the plant or the increased property value of the land on which the plant is located, for the latter effects are simply a reflection of reduced travel time and costs.) Both of these concerns have some basis, but this should not obscure the reality that transportation projects can have important overall economic benefits.

Importance of Considering Complementary Resources

Transportation by itself can only bring about economic growth and development if all of the other necessary components for economic growth are present—for example, access to materials, qualified labor, equipment, and markets. Sometimes, those other ingredients are present and transportation investments are the missing ingredient needed to make additional economic growth possible. Other times, however, transportation investments by themselves may be insufficient to cause any further economic growth, but *transportation investments in conjunction with other nontransportation actions* could bring about substantial economic growth. Those other complementary actions could, for instance, be overcoming limitations of labor force skills, high business costs, unavailability of utilities, or regulatory constraints.

Therefore, we must carefully evaluate economic impacts of transportation in terms of the many ways in which they affect different geographic areas and economic sectors. The analytic methods must be carefully matched to the nature of the transportation project and the policy issues that are judged to be relevant.

Steps for Assessing Economic Impacts of Transportation

STEP 1: IDENTIFY THE TYPE OF TRANSPORTATION PROJECT

It is important at the outset to classify the transportation project that is to be studied in terms of project mode, type, purpose, and scale. The project classification options are listed below; these results will affect the appropriate forms of analysis, as described in the subsequent steps. [Specifically, the project mode and scale (1-A, B) will affect the study area definition in Step 4. The type of change (1-C) will affect the base case definition in Step 3. The project purpose (1-D) will affect the base case definition in Step 2.]

1-A. Mode of Transportation

Is it

1. Serving passenger or freight use?
2. Infrastructure—roads, bus stations, railroad facilities, truck or rail freight terminals, airport, or seaport facilities?
3. Vehicles—trains, buses, trucks, airplanes, or boats?
4. Operation of services—bus service, passenger rail transport, air service, freight service, or ferry service?

1-B. Scale of the Transportation Project's Service Area

Would the project serve

1. A specific site location?
2. A specific strip or corridor?
3. An entire systemwide area?

1-C. Type of Transportation System Change

Would it

1. Upgrade service for an existing transportation system?
2. Expand the service for an existing transportation system?
3. Maintain the services for an existing transportation system?
4. Be a new mode of transportation or service to be provided?

1-D. Purpose of the Transportation Project

Is it intended to help

1. Address an existing congestion problem?
2. Meet expected future demand?

3. Generate new economic development and create new demand?
4. Enhance the quality of life in an area?
5. Link existing activities?

STEP 2: IDENTIFY THE PURPOSE OF THE ANALYSIS

There are four types of purposes for evaluating economic impacts of transportation projects. The purpose of the project itself (1-D) is an important determinant of the analysis purpose. The selected analysis purpose will affect the methodology in steps 3, 5, and 6. The choices are:

2-A. Proposed Project Impact Assessment

Government regulations may require that plans for constructing a transportation facility or providing a transportation service be preceded by an Environmental Impact Study (EIS), which is intended to identify all of the various types of expected social and economic impacts that may occur for specific businesses, residents property owners, visitors, or others.

2-B. Public Information

For political reasons or public information reasons, it may be desirable to have an objective evaluation of the economic value of (B-1) maintaining an *existing transportation facility and service* or (B-2) constructing or starting a *new facility or service*. This may be to provide "after the fact" justification of decisions, or it may be to support public involvement in an ongoing decision making process.

2-C. Benefit–Cost Analysis

To guide decision making, it may be necessary or desirable to evaluate the relative benefits and costs of alternative options for constructing facilities, providing services, or maintaining the status quo. The issue may be whether to build a facility, or it may be which project among alternatives is the best one, or it may be which location is preferred among options for a given project.

2-D. Research Study

Research studies may attempt to measure or document the past economic impact of a transportation service by comparing before-and-after conditions in one or more economic impact dimensions (discussed in Section 1).

STEP 3: SELECT THE BASE CASE AND TRANSPORTATION ALTERNATIVES

The impacts of any project can only be measured in comparison to some base case. That base case should be a realistic representation of past, current, or possible future conditions and should correspond to one of three options.

3-A. Base Case Assumes *Change* from Existing Transportation Conditions

This is a comparison of existing or future conditions in which existing transportation services remain in place, relative to a hypothetical base case situation that represents how conditions would be without that transportation service.

3-B. Base Case Assumes *Continuation* of Existing Transportation Conditions

This is a comparison of future conditions that include the addition of new transportation facilities and services, relative to a base case situation that represents that same future period with existing transportation facilities and services being maintained.

3-C. Base Case Is a *Prior Time*, Before the Advent of Existing Transportation

This is a comparison of current conditions in which the transportation facilities or services exist with a time in the past in which they did not exist.

Table 1 shows the correct base case given the analysis purpose (as identified in Step 2).

Define Alternative Scenarios

If the study is evaluating alternatives for proposed new services (study purpose is 2-A, 2-B2, or 2-C), then the base case should be compared with one or more hypothetical alternative scenarios. Both the base case and any alternative scenarios should include specification of the following:

- Mode and type of facilities or service offered;
- Location (in terms of siting, routing, or alignment);
- Size of the facilities or services (in terms of capacity and cost);
- Area served by the facilities or services; and
- Change in the level or quality of service provided by the facilities or services.

TABLE 1 Step 1: Correct Base Case Given Analysis Purpose

If the Purpose of the Analysis Is (from Step 2):	Then Use This Base Case:
2-A Impact assessment of proposed *new services*	Base Case 3-B
2-B1 Public relations evaluation of existing services	Base Case 3-A
2-B2 Public relations eval. of proposed *new services*	Base Case 3-B
2-C B–C analysis for proposed *new services*	Base Case 3-B
2-D Research study of existing services	Base Case 3-C

Examples of Base Case Alternatives

- "No Build" Base Case–Northeast Corridor High Speed Rail Study. The alternative is electrified high-speed rail service. The base case is a "no build" scenario—that is, continuation of current highway, air, and rail facilities and services.
- "Partial Build" Base Case–Wisconsin Highway 29 Study. Alternatives are various levels of new highway construction. The base case is a scenario of partial road widening, as called for by normal growth of traffic over time.
- "Degradation" Base Case–Southeastern Pennsylvania Transportation Authority Transit Study. Alternatives are various levels of investment to reverse trend of degrading equipment and service. The base case is continuation of equipment and service degradation.

STEP 4: SELECT THE APPROPRIATE GEOGRAPHIC STUDY AREA

There is no subject that causes more error or confusion in economic impact analysis than the selection of the appropriate geographic area of study. The fundamental reason is that depending on how the geographic area is defined, certain economic effects will either be internal or external to the area, and the distribution of gainers and losers will differ. This is illustrated by the following example (Table 2).

Example: Treatment of Location Shifts and Interjurisdictional Spillover Effects

Consider a transportation project that successfully expands existing businesses and attracts other businesses to locate nearby—some moving from elsewhere in the city, some from elsewhere in the country, and some from other countries. Assuming that job growth is desired at all levels, then each geographic unit would see a different measurement of job benefits.

- From the viewpoint of a neighborhood jurisdiction, all of the new jobs attracted to the local area will normally be regarded as a benefit.
- From the viewpoint of a city jurisdiction, business expansion and business relocations from outside to inside the city will be seen as a benefit, but shifts within the city—gains in one part of the city being offset by losses in other parts of the city—will not be seen as a net overall benefit.
- From the viewpoint of a state jurisdiction, business expansion and relocations from outside to inside the state will be seen as a benefit, but shifts within the state will not be seen as a benefit.
- From the viewpoint of a national jurisdiction, business expansion and relocations from outside to inside the country will be seen as a benefit, but shifts within the country will not be seen as a benefit.
- From an international perspective, none of the relocations is a net benefit, but productivity improvements resulting from the transportation project will still be seen as a benefit.

In general, the measured benefit from a transportation project will change with the area of analysis. Analyses for smaller areas include resource-shifting effects that are excluded from net benefits at the more global levels. However, they also miss broader external benefits for outside businesses that are included at the more global levels.

Primary Study Area for Economic Impact Analysis Must Be Explicitly Defined by Considering Four Factors

1. The area of jurisdiction for the sponsoring agency, which could be the agency responsible for project funding, project spending (implementation), project evaluation, or a combination thereof. This area could be a neighborhood, city, county, state or province, nation, or the world.
2. The area of direct project influence. Whether the project involves a route/line or a specific terminal facility, the "area of direct influence" includes the area in which people "users or nonusers" are affected.
3. Interest in distributional impacts on a subarea. Some projects are motivated by a desire to assist the economic development (attraction of investment and income) for a specific subarea, and that development may be deemed to be a "socially desirable" goal even if the net impact of a project is merely a redistribution of income and wealth. In other cases, fear of "dis-benefits" to a specific subarea is also a social concern.
4. Interest in external area consequences. What might be economically efficient from the viewpoint of "self-interest" for a small jurisdiction may have consequences (favorable or unfavorable) for a broader area. There may be public interest in the "equity" (fairness) of impacts on external areas. There may also be separate consideration of the broader "efficiency" associated with external impact responses (i.e., will outside parties respond with policies or investments in ways that that will ultimately enlarge or diminish the otherwise-expected local benefits?).

STEP 5: SELECT THE APPROPRIATE TIME PERIOD FOR STUDY

The appropriate time period for study is determined by both the type of project (identified in Step 1) and the purpose of the analysis (identified in Step 2). Table 3 illustrates this relationship.

TABLE 2 Step 4: Guidelines for Selection of the Appropriate Study Area

If the Purpose of the Analysis Is (from Step 2):	Then the Study Area Should Encompass:
2-A Impact assessment	The project influence area and affected sub-areas.
2-B, D Public relations or research study	All areas of concern for publicity, discussion, or research purposes.
2-C B–C analysis for implementation decision making	The area of jurisdiction for the implementation agency (because a local, state, or national agency normally has a responsibility to its constituent area). Recognition should also be given to more localized impacts (insofar as there are social values ascribed to redistribution impacts) and to external impacts (insofar as there are equity and/or impact response concerns).

TABLE 3 Step 5: Choosing the Correct Study Period

If the Purpose of the Analysis Is (from Step 2):	Then the Time Period Should Be:
2-A Impact assessment of proposed *new service*	5-A A future year or 5-B Period of time after new service opens
2-B1 Public relations information on existing service	5-C The current year
2-B2 Public relations info. on proposed *new service*	5-A A future year or 5-B Period of time after new service opens
2-C B–C analysis for proposed *new service*	5-D A period of time from start of financing through life span of project
2-D Research study of existing services	5-E Period of time including pre- and post-project periods

The choice of time period is self-evident for analysis of past, present, or future conditions (Step 2-A, B, D). The only complicated case is B–C analysis (Step 2-C). For that analysis, we must account for the fact that financing costs and construction spending are incurred first, followed by the flow of construction dollars to vendors and suppliers. Project benefits to users do not even start until project completion, well after construction costs have been incurred. The project benefits continue for the life of the project, after which another round of equipment and facility replacement, reconstruction, or both is necessary to sustain benefits.

To compare benefit streams and cost streams occurring at different times, B–C analysis requires calculation of benefits and costs in terms of discounted net present value. As discussed in Step 9, the choice of discount rate can be critical, particularly for long-lived projects.

STEP 6: SELECT THE APPROPRIATE IMPACT MEASURE

Types of Impact Measures

There is a wide variety of overlapping measures. They include four categories.

- 6-A User Impacts (Components are listed; their values should be combined to measure total user benefit.)
  1. Money cost of travel
  2. Travel time
  3. Safety
  4. Comfort, reliability, etc.
- 6-B Economic Impacts (Alternative measures are listed; only one should be used to measure total economic benefit.)
  1. Employment
  2. Personal income (wages)
  3. Property values
  4. Business sales volume

5. Value added
6. Business profit

- 6-C Government Fiscal Impacts (Components are listed; their values should be combined.)
  1. Public revenues
  2. Public expenditures
- 6-D Other Societal Impacts (Components are listed; their values should be combined.)
  1. Air quality
  2. Other environment conditions
  3. Social conditions

Table 4 matches the impact measure with purpose of the analysis (from Step 2).

For an Impact Assessment Study (Purpose 2-A)

Potentially all of the many different aspects of economic impact can and should be discussed (6-A to D). However, to avoid double counting, there should be no attempt to add together the valuation of multiple measures of impacts across categories 6-A, B, C, or D, or to add together the valuation of multiple measures within category 6-B. (For example, 6-C2 government revenues reflect changes in 6-B3 property values, which themselves may reflect changes in 6-D1 air quality. Also, 6-B4 business impacts may reflect changes in 6-A2 travel times.)

For a Public Information Study (Purpose 2-B)

The number of additional jobs created (6-B1) is the most popular benefit measure, as it is most widely understood and appreciated. Other common measures of benefit are aggregate dollar measures of business sales (6-B4) and wage income (6-B2) created as a result of the project. Other measures of benefit, such as value added or gross domestic product (6-B5), are also legitimate indicators of economic impact, but are less well understood by the public. Fiscal government impacts (6-C), environmental impacts (6-D), or both can also be assessed for public relations purposes.

For a Benefit–Cost Analysis (Purpose 2-C)

There is typically a comparison of the aggregate financial benefit to the jurisdiction with the aggregate financial costs borne by residents of that same jurisdiction. There are two options:

TABLE 4 Step 6: Selecting the Most Appropriate Impact Measures

If the Purpose of the Analysis Is (from Step 2):	**Then the Impact Measure Is:**	
	Preferred	Also Acceptable
2-A Impact assessment of proposed *new service*	6-A, B, C, D	
2-B Public information (new or existing service)	6-B1	6-B2 or 6-B4
2-C B–C analysis for proposed *new service*	6-A or B2	6-B3 or 6-B5
2-D Research study of existing services	6B	

- The traditional measure of benefit is the monetary valuation of transportation system user benefits (6A—all parts totaled together).
- The alternative economic impact measure of benefit is income, expressed in terms of either personal income (6-B2) or value added (6-B5)—which is personal income plus business profits. [Property value (6-B3) can be another measure of economic benefit, but usually cannot be forecast well for assessing future benefits of proposed projects.]

Note: While fiscal benefits and costs for government (6-C) may also be compared, a project should be justified on the basis of net benefit for society (within the area of jurisdiction) rather than on the basis of net revenue or profit for government.

For a "Retrospective" Research Study (Purpose 2-D)

The benefit measure is often determined by the type of historical data that can be obtained, the type that is most frequently employment, business sales and property values (6-B1, 3, 4) or noneconomic factors (6-D).

To select the most appropriate benefit measure from the set of potentially appropriate measures, consider the trade-offs identified below.

Trade-Offs in Selecting Benefit Measures for Benefit–Cost Analysis

6-A. User Benefits

This is the traditional measure of *transportation system efficiency* benefit used by transportation agencies around the United States and world. It includes the sum of traveler cost savings and time savings (using an estimate of the value of time), plus a value for safety benefits (if data on safety and a value for that safety can be established.)

This measure may *overestimate* benefits to residents of a given jurisdiction insofar as it counts benefits to all users of the transportation facilities within that geographic area, including those who have origins and destinations (O-D) outside of the area and are merely passing through. However, it *underestimates* benefits to a jurisdiction insofar as it does not allow for any benefits to nonusers of the transportation system who live or work in the area and who may reap additional locational advantages and benefits beyond just the cost and time savings for travelers. (Such additional benefits to nonusers may include increased property values and improved quality of life as a result of cleaner air and a greater selection of local goods and services.)

6-B2. Personal Income Measure of Economic Benefits

This is the most common *economic measure of benefit*, and it has been adopted by some state transportation agencies in the United States as well as by their European counterparts for projects where there are believed to be significant additional benefits to nonusers of the transportation system. This measure reflects the change in wage income earned within the study area.

Income benefits occur as a result of user benefits, through the following process:

1. The transportation project provides business benefits resulting from reduced business vehicle travel times (affecting labor costs and markets) as well as reduced vehicle operating

costs, accident insurance costs, and schedule uncertainty costs (for bringing in manufacturing inputs and shipping out finished products).

2. Business results include one or more of the following: greater efficiencies of scale, lower product costs, improved product quality, and an expanded sales/service area—leading to expanded business activity (sales) within the study area.
3. Aggregate personal income rises as salaries rise, additional workers are hired as part of business activity expansion, or both.

This measure counts dollars generated as a consequence of enhanced business activity. As long as nearly all of the affected workers live in the study area, this is a reasonable measure of the personal income generated by the transportation project. It is broader than the user benefit measure in that it includes benefits to nonusers of the transportation system. However, it is still an *underestimate* of the true income impact insofar as there is also some net business income (profit) generated. That profit income is paid out as dividends to local business owners or else reinvested locally in buildings, equipment, or labor—thus further improving the economic base of the study area. This measure also *undercounts* total benefits in that it gives no value to user time savings for personal travel that does not directly lead to changes in business activity levels—for example, reduced travel time for shopping trips.

6-B5. Value Added Measure of Economic Benefits

A broader measure of the full income effect is the change in "value added" (also referred to variously as gross domestic product or gross regional product). This measure essentially reflects the sum of wage income and corporate profit generated in the study area.

In today's increasingly global economy, value added is an *overestimate* of the true income impact on a region insofar as it includes all business profit generated there—including that paid out as dividends to business owners who do not reside in the study area and that which is reinvested in corporate facilities outside of the study area (region). Thus, while value added is the most appropriate measure of impact on overall economic activity in a geographic area, the personal income (wage) measure is often preferred as a more conservative measure of income benefit to residents of the area.

6-B3. Other Measures of Economic Benefits

There is also income or wealth generated from increased property values. However, we do not count these in addition to wage or value added impacts to avoid double-counting of benefits. Property values rise as a result of increasing demand for property, which is itself frequently a direct consequence of rising incomes and profits. All of these factors—profits, personal incomes, and property value appreciation—are sources of wealth creation.

Of course, both the personal income and value added benefit measures are *underestimates* of total societal benefit to the extent that they do not fully reflect all of the benefits that may be encompassed in property values—such as the value of transportation-induced benefits from cleaner air or a greater selection of educational, social, shopping, recreational, and job opportunities available locally. Changes in property values, however, do encompass these benefits.

Hybrid Measure of Societal Benefit

In theory, it can be possible to calculate the—total societal welfare benefit—of a transportation project or policy by combining (1) the value of *business* travel benefits measured in terms of the overall income generated with (2) the value of a *nonbusiness* travel benefits measured in terms of "willingness to pay" for those benefits. While there is no double-counting here, the combining of income and nonincome benefits is viewed as potentially problematic by some economists, and obtaining valid data on willingness to pay for improved transportation is difficult.

STEP 7: SELECT THE APPROPRIATE ANALYSIS METHODS

As illustrated in Table 5, the selection of analytic tools to estimate program benefits depends on the purpose of the analysis (Step 2) and the desired impact measures (Step 6). The available tools are

- Transportation system models—tools to simulate and forecast the effects of transportation facilities and services on trip generation, mode split, trip routing, travel times, and travel costs.
- Economic models:
  1. Input/Output (I/O) Accounting Models—tools to estimate the effects of transportation construction and operations *spending* on business activity and employment.
  2. General Equilibrium Simulation Models—tools to handle I/O impacts (as above) plus the effects of travel *cost changes* on business productivity, competitiveness, and growth.

TABLE 5 Step 7: Choosing the Most Appropriate Analysis Techniques

If the Project Purpose Identified in Step 2 Is:	**And the Benefit Measure Identified in Step 6 Is:**	**Then the Impact Method Is:**		
		7-A Transportation Model	**7-B Economic Model**	**7-C Direct Measure**
2-A Impact of Assessment of Proposed New Service	6-A User Benefit	✓	—	✓
	6-B, C Construction $ Impact	—	✓ (I/O)	—
	6-B, C Economic Benefit	✓	✓ (Sim)	—
2-B Public Relations Information on New or Existing Service	6-A User Benefit	✓	—	—
	6-B, C Construction $ Impact	—	✓ (I/O)	—
	6-B, C Economic Benefit	✓	✓ (Sim)	—
2-C B–C Analysis for New Service	6-A User Benefit	✓	—	—
	6-B, C Economic Benefit	✓	✓ (Sim)	—
2-D Research Study	6-A User Benefit	—	—	✓
	6-B, C Economic Benefit	—	—	✓

3. Business Attraction and Tourism Market Models—tools to forecast the effects of transportation *linkage enhancements* on the markets for industry and tourism.

- Direct measurement techniques—methods for measuring the effects of existing transportation facilities and services through analysis of historical data.

The selection of specific analysis tools depends on the existing time, budget, and information constraints under which the study is operating. Some of the key options for analytic models are as follows.

7-A. Transportation System Models

Regardless of whether we are analyzing the narrow user benefits or the broader economic impacts of any transportation project, program, or policy, it is necessary to estimate how it will affect transportation system users in terms of travel times and costs. The only time that transportation system models are not necessary is when the analysis is a direct measurement research study or is restricted to economic effects of construction spending.

Supply-Side Modeling

The basic method for analyzing transportation user impacts is either a "full simulation model" or a "sketch planning model" of the relevant portion of the local, regional, or national transportation network. Such a model must cover the affected modes of travel with a base of information concerning the *transportation system supply* under alternative scenarios: (a) the capacity, (b) projected vehicle volumes and trip distribution patterns, and (c) performance—resulting travel times and costs for users of the affected travel modes, routes (links), and terminals or transfer points (nodes). Key outcome measures are net changes in VMT, vehicle miles traveled (or passenger-miles of travel), and vehicle-hours of travel (or passenger-hours of travel).

- Full simulation models estimate traffic patterns, volumes, and travel times for each link and node of the transportation network. Existing software packages, such as Tranplan, EMME2, and MINUTP, may be used to construct these network simulations and forecast transportation system user impacts. Simulation models are most applicable for situations in which trip diversion and rerouting are expected components of user impacts. They are also useful for separately estimating user impacts for various categories of users (e.g., different types of businesses) that have notably different O-D patterns.
- Sketch planning models, on the other hand, can suffice for situations where there are not many route or model diversion alternatives to be considered (e.g., a program affecting downtown-wide access). These "models" are essentially spreadsheet calculations, used to estimate the volumes and travel time and cost impacts of transportation service improvements.

Demand-Side Analysis

Information on *travel demand*—current and projected trip volumes by O-D combination under alternative scenarios—must accompany the suppy model. The simulation model is then used to forecast the resulting changes in volumes, travel times, travel costs, and volume/capacity ratios (the latter affecting safety) for the affected portions of the transportation system.

Example: Application of Separate Simulation Models for Various Business Categories (Wisconsin Highway 29 Study)

An O-D survey of business trucking patterns showed substantially different shipping patterns by type of business (e.g., food and packaging industries in the study area depended largely on east–west travel and hence stood to reap cost reductions from the new highway while other industries such as paper products depended more on north–south travel). To address such differences, separate simulation models and estimates of user benefits were calculated for each of 12 industry groups.

7-B. Economic Models

Economic models can be used to forecast personal income, employment, business sales, or value added impacts. The available models represent a continuum of sophistication and cost, so it is prudent to match the economic model to the problem at hand.

Input/Output Models

These are essentially accounting tables that trace the linkages of interindustry purchases and sales within a given county, region, state, or country. They utilize information on both technologies (what inputs from other industries are used to produce a dollar of product for each specific industry?) and local trade (how much of a given industry's purchases are supplied by other firms located within the study area?). The I/O model yields "multipliers" that are used to calculate the full (direct, indirect, and induced) jobs, income, and output generated per dollar of spending on various types of goods and services in the study area. I/O models calibrated for specific counties or aggregations of counties are commercially available from the Minnesota IMPLAN Group (IMPLAN model), Regional Science Research Institute (PC I/O Model), and U.S. Bureau of Economic Analysis (RIMS-II: Regional Input/Output Modeling System).

I/O models can be used to estimate the full income and job effects of construction and maintenance spending. They may also be used to estimate the full effects of new business attraction resulting from transportation projects *only if* there is some way to predict separately the direct business productivity effect and its business growth/attraction impact and treat them as an exogenous input to the model.

Macroeconomic Simulation Models

These are "econometric" and "general equilibrium" models' complex computer programs that trace the total effects over time of changing economic conditions in a study area. They include all of the functions of I/O models, plus additional functions to forecast effects of future changes in business costs, prices, wages, taxes, productivity, and other aspects of business competitiveness as well as shifts in population, employment, and housing values. Simulation models calibrated for specific counties or aggregations of counties are commercially available for rental, purchase, or custom studies. Sources include Regional Economic Models, Inc. (REMI Model) and DRI-McGraw Hill.

Simulation models, like I/O models, can be directly applied to estimate the full income and job effects of construction and maintenance spending. Unlike I/O models, they may also be used to estimate the full effects of business growth and attraction resulting from changes in travel and shipping costs (affecting business productivity). They may be used to estimate the full effects of other productivity factors beyond mere travel costs (e.g., economies of scale from expanding business and tourism markets), *if* those other impacts are separately identified.

Business Market and Tourism Attraction Models

Transportation facilities and services do more than just generate spending (handled well by I/O and simulation models) and reduce business costs (handled well by economic simulation models). They can also enhance specific linkages between producers and market locations, expand specific business markets, provide "just-in-time" shipping opportunities, and enhance product diversity—all affecting business productivity and generating direct benefits beyond the mere cost savings previously discussed. All of these factors depend very much on the specific location of activities in and around the study area. To identify such additional impacts typically requires specialized market studies of the potential opportunities for further business and tourism attraction.

7-A, B. Integrating Transportation System Models and Economic Simulation Models

The analysis of economic benefits from any transportation system change depends (at least in part) on the nature and magnitude of the user impacts. Accordingly, it is necessary to (1) first use a transportation system model to estimate the user impacts on travel times and costs, (2) translate those results into a change in business operating costs, and (3) use an economic simulation model to estimate the resulting overall effect on jobs and income. If the economic model forecasts significant changes in population or employment, it may be necessary to reapply the transportation system model to re-estimate traffic impact.

7-C. Direct Measurement of Impacts

A research study may document actual user impacts or economic effects through surveys of travelers, nearby businesses, or both as well as through secondary data on changes in employment, income, or property value patterns.

STEP 8: APPLY DATA TO CALCULATE ECONOMIC IMPACTS

The actual calculation of project benefits involves the application of appropriate data to the selected tools (from Step 7). The data include descriptions of the project and the base case conditions (resulting from the Step 7 models), together with applicable "rules of thumb" for estimating the value of user and economic impacts. These various data components can be classified into three groups: project costs, user benefits, and economic benefits. They can be applied and calculated as described below.

8-A. Project Costs

Project costs must be estimated when the purpose of the study is B–C Analysis (Purpose 2-C). They comprise (1) property and construction costs and (2) ongoing operations/maintenance costs. (Optionally, other "environmental externality costs" may also be added.)

1. Property acquisition and construction costs for roads, rail lines, and station/port facilities (for air, sea, and surface transportation modes) all vary over an extremely wide range, depending on the construction requirements, topography of the area, and preexisting land uses. (For some applications of B–C analysis, residual value of property at the end of the study period must also be estimated.)
2. Ongoing operations must encompass operations, maintenance, and periodic rehabilitation. (For example, maintenance costs for highways are typically $6,000-$10,000 per lane-mile; equivalent to $4,000-$8,000 per lane-km.)

8-B. Project User Benefits (Also Known as "Travel Efficiency" Benefits)

User benefits must be estimated for use as a direct element of traditional B–C analysis or as an intermediate factor necessary to estimate economic benefits for other kinds of analysis (as shown in the chart for Step 7). The primary components of user benefit are (1) cost savings, (2) time savings, and (3) safety improvements. These benefits are typically not one-time benefits, but rather occur over time. They may be negative during some periods due to construction or congestion conditions. They should be calculated for all classes of users of the transportation system, including:

- "Existing trip" users—those currently using the facility that is to be upgraded as well as those who continue to use other routes, modes, or facilities that may experience level-of-service impacts;
- "Diverted trip" users—those who are forecast to switch from other routes or modes of travel to use the new or upgraded facility; and
- "Induced trip" users—those making new trips that would not otherwise be made but for the transportation system improvement.

The cost, time, and safety benefits for *existing* and *diverted* trips should be directly estimated. For *induced* trips (which would not otherwise occur), there is typically no relevant travel time or safety benefit. A common sense expectation about the benefits for diverted and induced trips is that they will be positive (otherwise people would not switch to use of the new facility), but still less than the benefits accruing for existing trips (as otherwise people would have switched previously). However, within those bounds, the exact magnitude of benefits for induced trips may be large or small, depending on the nature of the new alternative relative to alternatives previously available. When it is not possible to accurately estimate the benefits for induced trips, they may be roughly estimated to be one-half of the per-trip benefit accruing for existing trips. (In economic terms, that is equivalent to a "consumer surplus" concept in which there is a linear demand response in terms of willingness to pay for increasing benefit levels.)

Valuation of User Benefits

In order to calculate the dollar value of user benefits, it is necessary to multiply the estimates of aggregate time savings and safety reduction benefits by appropriate figures for the value of time and value of safety. These dollar-equivalent figures are then added to the aggregate cost savings.

Typical figures for the valuation of each component are summarized in Tables 6, 7, and 8. For more information on the valuation of user benefits, refer to the key documents cited here: the

AASHTO Red Book, *HERS Manual*, NCHRP Report 7-12, and the *ITE Handbook*. (See bibliography for full citations.) A parallel document for the United Kingdom is the *NESA Manual*.

1. Valuation of Operating Cost Savings from Travel Distance Reduction There are transportation operating cost savings to the extent that the transportation project reduces total vehicle kilometers (or miles) of travel for existing travelers, achieved through either system routing improvements or modal diversion (to higher occupancy vehicles). For most modes of travel, total vehicle operating costs include some combination of fuel, oil, tires, maintenance, and vehicle depreciation—all of which vary by type of vehicle, its level of use, running speeds, and frequency of stops or speed changes. Given those factors, the cost relationships can be expressed in terms of dollars per 1,000 miles of travel. User cost savings are then estimated by multiplying these unit costs by the reduction in VKT (vehicle kilometers traveled or VMT) achieved by the transportation project.

For highway travel, typical values for total costs are available from the *AASHTO Red Book*, from which Table 6 is derived. (Different numbers are available from NCHRP Report 7-12, MVMA Report, and the United Kingdom's *NESA Handbook*; they provide lower estimates of operating costs because they exclude vehicle depreciation costs.)

2. Valuation of Travel Time Savings There are user travel time savings to the extent that the transportation project increases speeds or reduces VKT (or VMT). User time savings are estimated by multiplying an appropriate "value of time" by the aggregate person-hours of time savings achieved by the transportation project.

The difficulty in valuation of time is that there are inherently many different bases for determining appropriate values. In reality, there may be a different inherent valuation placed on travel times when deciding where to live, where to work , where to shop, what routes to use, and what modes of travel to rely on. Relative comfort, reliability, and hassle involved in that travel time also matter, and thus the value of time can also vary by time of day. All of this makes it difficult to establish the most appropriate valuation of travel time savings benefits for purposes of project B–C analysis. Careful attention to detail is required.

Typical values of time for surface transportation are shown in Table 7; most studies in the United States, the United Kingdom, and New Zealand yield values within +/-20 percent of these values. (A review of the literature on value of travel time is in the *UI Lit Review*; see bibliography for citations.)

These values of time reflect the value of saving time for people. It is also possible to calculate a value of vehicle operating time; however, it is commonly assumed that there is actually no additional value to saving time for vehicles except insofar as it is related to a savings in VMT, previously discussed.

3. Valuation of Safety Improvement (Accident Reduction) Benefits of accident reduction come from upgrading the capacity of facilities, rights of way, or vehicle characteristics. Values vary widely; the ranges of road accident rates and costs per accident are illustrated below. Widely accepted values for road accident rates are found in the *HERS Manual*. NCHRP Report 7-12 provides numbers that are roughly similar; slightly different numbers are estimated by the Urban Institute. (Values used in the United Kingdom's NESA system are, however, considerably lower even after adjusting for inflation and exchange rate changes. That is in part a reflection of very different health care costing.) Table 8 shows typical safety valuation for highways.

TABLE 6 Vehicle Operating Cost

Vehicle Type	Vehicle Operating Cost per 1,000 Miles of Travel		
	Cost at 20 mph (30 km/h)	Cost at 55 mph (88 km/h)	Cost at 65 mph (100 km/h)
Car	$192	$207	$222
Single-Unit Truck	$471	$517	$565
Tractor-Trailer Truck	$485	$655	$700

Source: *AASHTO Red Book*, adjusted for inflation to 1996 dollars.

TABLE 7 Typical Values of Time for Surface Transportation

Category of Travel	Typical Values		Common Range of Values
	per vehicle[a]	per vehicle[b]	
Freight: Tractor-Trailer Trucks	$23	$23	
Freight: Single-Unit Trucks	$18	$18	
Persons: Work-Related Trips	$12	$13	100–115% of driver cost[d] for on-the-job trips; 60–90% of wage rate for "commuting" trips
Persons: Nonwork Trips (shop, personal & recreation)	$6 (driver)	$8	60–75% of wage rate for drivers[e] 20–40% of wage rate for passengers[e]

[a] *HERS Report* values, updated from 1990 to 1996 at 3% annual inflation; these values were derived for road travel, but passenger values of time may also apply for rail, sea, and air travel
[b] Calculated as "per person" values multiplied by vehicle occupancy (here assumed to be 1.0 for trucks, 1.1 for car work trips, and 1.9 for car nonwork trips—with passengers for nonwork trips valued at 1/2 of the driver value)
[c] Based on *UI Lit Review* and discussions with U.S. DOT staff
[d] Driver cost calculated as average hourly wage for transport worker plus 15% for fringe and overhead
[e] For cars, typical vehicle occupancy would be 1.8 (i.e., 0.8 passenger and 1 driver per vehicle)

TABLE 8 Safety Improvement Valuation for Highways

Typical Rates for a 4-Lane Highway	Fatality	Injury (Nonfatal)	Property Damage Only
Accidents per 100 million VMT[a]	0.8–4.0	25–127	41–130
Costs per Accident[b]	$1.2–2.9 million	$24–83 thousand	$2 thousand

[a] *HERS Report* values
[b] Lower values are calculated from NCHRP Report 7-12 (in 1993 dollars); higher values are calculated from *HERS Report* (in 1991 dollars); all values have been updated to 1996 dollars using a 3% annual inflation factor

8-C. Effects on the Economy

Depending on the outcome of Steps 2 and 6, the effects on the economy may encompass some or all of the following: (1) direct jobs from spending on construction and ongoing operations, (2) long-term project benefits, and (3) indirect and induced impacts. Each of these impacts may be measured in terms of jobs (created or attracted) or in terms of the dollars (income, sales, or value added) that are associated with the jobs. The valuation of each component is summarized below. More information on the valuation of user benefits follows. (See bibliography for full citations.)

Direct Jobs from Construction and Ongoing Activity

The estimation of jobs created by spending on construction and facility operations and maintenance, and the associated income and business sales effects, are relevant for impact analyses, public relations studies, and research studies (Purposes 2-A, B, and D). (On the other hand, spending impacts are usually *not* included in B–C analyses "discussed below" as they are a reflection of project cost rather than a long-term project benefit.) Typical norms may be used to estimate the number of jobs generated per million dollars of spending (where the term "job" technically means employment of one person for one year). For example,

- Highway construction directly generates an average of 7.9 jobs per $1 million spent (1996 $) on construction (Source: "FHWA Jobs Generation," 1996).
- Public transportation directly supports an average of 24.5 jobs per million passenger-miles (Source: "APTA Report," average of 10 largest U.S. local public transport systems).
- Airports support an average of 75 to 1,000 on-site jobs per hundred thousand annual passengers (Source: studies at selected airports).

Direct Long-Term Project Benefits

Additional business sales and associated jobs and income are generated when there is increased personal and business productivity created by transportation system investments. That productivity—reducing living costs for people and operating costs (per unit of output) for business—can occur as a result of: (1) *improvements in travel efficiency*—reducing vehicle and driver costs for current travel, (2) *economies of scale*—from broader access to product/service markets and labor markets, (3) *logistic efficiencies*—including "just-in-time" processing efficiencies and intermodal access savings, or (4) *access to a more diverse set of products and services*—optimizing the usefulness of available products and services to meet specific business needs.

The *direct business cost savings from travel efficiency improvements* are not the same as the calculated user benefits. The differences are shown in Table 9. Note that the direct value of cost savings to business operations can be significantly less than the value of the user benefit. However, business cost savings also lead to additional "multiplier" impacts.

The extent and value of *other direct business* cost impacts—including effects of scale economies, logistic efficiencies, and enhanced product diversity—can only be estimated through use of specialized business surveys or economic models. Research to develop means of reliably estimating the value of such benefits is currently underway.

TABLE 9 Distinctions Between Calculated User Benefits and Direct Business Cost Savings

User Benefit (8-B)	Corresponding Cost Savings to Business (8-C)
Time Savings—business travel (“on-the-clock” worker time)	Value of additional productive labor hours (for nonsalaried portion of workers)
Time Savings—other trips (includes commuting)	(May lead to additional spending or affects wages for recruiting workers.)
Operating Cost Savings—business travel (pickups and deliveries)	Direct cost savings
Operating Cost Savings—other travel (includes commuting)	Increase in disposable personal income. (May also affect wage rates.)
Safety Improvements—business travel (“on-the-clock” worker time)	Reduction in insurance costs and worker absenteeism
Safety Improvements—other travel	Reduction in insurance cost, raising disposable income

It is critical to note that a given cost savings or productivity benefit to businesses does not necessarily trigger a proportional increase in jobs and income. The business response may be larger or smaller. Reduced costs and increased profitability could lead to reinvestment and business expansion in the area, or they may instead lead to investments (or profit distributions) outside the area. A simulation model of business competitiveness (e.g., the REMI model) is necessary to forecast the direct business growth results.

Indirect and Induced Impacts

When there is direct business growth resulting from increased business productivity, there can also be “indirect” and “induced” business impacts (as previously defined in Section 2). These impacts represent “multiplier effects,” and they can make the overall economic impacts substantially larger than the direct effects alone. Whether such additional impacts occur depends on the ability of an area to provide additional workers and capital resources or to attract them from elsewhere. However, if all that happens is that resources are shifted away from some other use to serve needs created by the new project, then there are likely to be no multiplier effects. The assumption that new workers and capital can be attracted (providing for multiplier impacts) is a reasonable assumption for local and state impact studies, but it is not always applicable for national impact studies. Typical multipliers are defined as follows:

- Output multiplier for a given industry in a given area = Total overall increase in dollars of business output for all industries (in that area) per dollar of additional final demand (purchases) of the given industry (in that area).
- Job multiplier for a given industry in a given area = Total overall increase in jobs for all industries (in that area) per new job created in the given industry (in that area).

I/O models, available for any given (county or larger) area, provide multipliers that are estimates of local spending impacts assuming continuation of current interindustry trade patterns and local flows of money into and out of the area. Their magnitudes vary depending on the industry in which spending occurs and the size of the area economy—which affects the portion of these impacts that remain in the local economy and the portion that "leaks out" to outside areas. Typical I/O multipliers are shown in the *RIMS II Handbook* and the *U.S. Chamber Report*. The multiplier values for most industries are in the range of 3 for national impacts, 2–2.5 for state impacts and 1.5–2 for local area impacts. Some examples from the *RIMS II Handbook* (1992) are shown in Table 10.

I/O multipliers have significant limitations. They assume that there are no changes in wages, property values, or prices of other product inputs or outputs, or in the ratio of output per unit of input (labor, capital, etc.). They also do not distinguish the period of time over which the estimated impacts occur. Economic simulation models can and do address these other issues, which can accentuate (or dampen) the actual impacts over time. However, the economic simulation models involve significantly more analytic sophistication and monetary costs than the I/O accounting models.

Example: Leveraging Transport Spending (SEPTA Transit Financing)

Economic multiplier effects resulting from spending (purchasing goods and services) are expected to be less than 4 to 1. However, transportation policies can also sometimes lead to business activity shifts that are totally different than the economic effects of spending money on other kinds of projects. This is illustrated by the situation in which funding for the Southeastern Pennsylvania Transportation Authority's (SEPTA) Philadelphia region public transportation system was in jeopardy. A study was commissioned to estimate the economic effects of reducing or eliminating public funding for SEPTA. The study found that failure to maintain the system infrastructure would necessarily lead to substantial reductions in service, triggering some business relocations to outside of the region, as well as reductions in future business growth in the region. The resulting stream of losses of economic activity over 20 years would—even in net present value terms—exceed the savings in transit subsidies by a ratio of more than 7 to 1. The high ratio came because a reduction in operating and maintenance subsidies was leading to a loss of the value of the full accumulated capital investment in the system infrastructure.

TABLE 10 Examples of Multiplier Values for Industries

Industry	**Output Multiplier**		**Employment Multiplier**	
	Largest State (CA)	**Smallest State (RI)**	**Largest State (CA)**	**Smallest State (RI)**
New Construction	2.5	2.0	3.3	2.1
Maintenance and Repair	2.4	1.9	2.2	2.0
Stone, Glass, Clay Products Mfg.	2.3	1.8	2.4	2.1
Fabricated Metal Products Mfg.	2.1	1.8	2.3	1.9
Motor Vehicle Equipment Mfg.	1.9	1.8	2.6	2.3
Other Transport. Equip. Mfg.	2.4	1.8	2.9	1.9
Transportation Services	2.4	1.8	2.3	1.8
Retail Trade	2.3	1.9	1.6	1.5
Business Services	2.3	1.9	1.9	1.7

STEP 9: PRESENT RESULTS

The appropriate format for presentation of results depends critically on the time horizon (Step 5) and the benefit measure (Step 6). There are three basic formats for presentation:

- Description of benefits resulting in a given year—applicable for impact assessments, public relations evaluations, and research studies in which there is a stable post-project impact (Step 5 study period is 5-A or C).
- Description of benefits as a stream over time—applicable for impact assessments, public relations evaluations, and research studies in which the post-project impact varies over time (Step 5 study period is 5-B or E).
- B–C indices—applicable for B–C analysis for decision making (Step 5 study period is 5-D).

9-A. Single-Year Impacts

Present results for the appropriate benefit measures (Step 6), and for the appropriate study area (Step 5), using the correct base case (Step 3). In addition:

1. Avoid double counting and under counting. Utilize benefit measures as defined in Step 6, and be sure not to add together impacts across categories (or multiple measures of economic impacts) when they apply to the same effect as seen from different perspectives. Note the extent of additional benefits that have not been measured or fully captured in the analysis.

   Also avoid double counting as would occur by adding increases in business profits to increases in real estate values, for the latter are a reflection of the former. (Greater profitability from a given location causes property values to increase there and decrease elsewhere. Thus, the increase in expected profits is "capitalized" in higher property values.)
2. Be explicit about constant versus nominal dollars. In general, use of *constant (deflated) dollars*, expressed in terms of the year of the study, are most understandable to the public. Sole reliance on constant dollars deflated for a prior year (such as 1987 or 1992) can be just as misleading as use of future-year inflated dollars.
3. Explain job impacts. Clarify whether job impacts are for a single year, recurring for a period of time, or are essentially "job-year" equivalents. Whenever possible, provide some explanation of the types of jobs being created (by occupation or industry) and how and why they are being created. That provides a sense of realism to what may otherwise appear as "black box" prognostications.

9-B. Stream of Benefits over Time

In addition to requirements for the appropriate benefit measures, study area, and base case (as in preceding part A), be sure to use the appropriate time period (Step 5). For B–C analysis, be sure that the time period encompasses the project's physical life. In addition:

1. Avoid double counting and under counting. Same as for preceding Part A.
2. Be explicit about constant versus nominal dollar streams. When studying a multiyear period of time, explanation of the annual level of dollar impacts is typically more

comprehensible for the public than the sum of impacts over the time period. It is also important to note how the year-to-year impacts vary over time—are they constant, or do they grow over time as population grows, or do they "blip" in certain key years? In general, use of *constant (deflated) dollars*, expressed in terms of the year of the study, are again most understandable to the public.

3. Explain job impact streams. When studying a time period, it is important to distinguish whether the number of jobs varies by year, holds for each year in the period, or is being presented as a sum of job-years to be realized over a period of time. Be clear on that distinction.

9-C. Benefit–Cost Analysis

Select Appropriate Indicators

There are several applicable "tests" for decision making:

- Feasibility—A project is "feasible" if there are the money and technical resources to do it. This test, by itself, is applicable if there is a desire to do the project regardless of resource costs—a rare circumstance.
- Cost-Effectiveness—This is the ratio of cost per unit of desired results (e.g., cost per ton of emissions reduction or cost per person served). This test is applicable when the benefit measure cannot be reliably translated into money terms. It is most usefully applied when there is a clear goal for the desired level of results—that is, an unambiguous unit of output.
- Net Present Value (NPV)—This is calculated as follows:

  NPV = Present value of project benefit minus *the present value of project cost*

  where "present value" is the discounted value of a stream of benefits or costs, and "benefit" is defined as per Step 6.

NPV reflects the value of the project at the time of decision making. The NPV test is the most comprehensive—encompassing, at its best, the money values of all favorable effects (benefits) and all unfavorable effects (costs). Included in costs should be the capital cost of borrowing or obtaining equity capital—that is, the interest required to obtain the funds. Any project with a positive NPV is "efficient." Among competing projects, the alternative that maximizes NPV is also the most desirable (i.e., "economically efficient") one. (See discussion of present value, later on.)

- B–C Ratio—This is calculated as follows:

  B–C Ratio = Present value of project benefit *divided by* the present value of project cost

By definition, any project with a positive NPV will also have a B–C ratio exceeding 1. However, a *large* project with a lower B–C ratio (e.g., 1.4) may still have a higher NPV than a *small* project with a higher B–C (e.g., 1.6). For agencies with constrained funding resources, the B–C test is thus the preferred basis for decision making among alternatives (such as the choice of project size, location, or configuration). While in theory, any project with a B–C ratio exceeding 1 is worthwhile, most agencies have recognized that there is some uncertainty associated with both the benefit and the cost estimates. Accordingly, it is not uncommon for agencies to desire a threshold of B–C exceeding 1.5 for large new projects and 1.3 for incremental projects (in which uncertainty is less.) (For example, see *B.C. Guidebook*, refer to Further Reading for full citation.)

Note: The *AASHTO Red Book* (1977) recommends use of an adjusted measure of user benefit for highway decision making, in which residual value of the property after depreciation is added to benefits, and maintenance costs are subtracted from benefits. However, many economists, including the U.S. Office of Management and Budget (OMB), now recommend a different treatment in which maintenance costs are recognized as an element of total life-cycle cost. In addition, it is now recommended that the residual value of a facility be based on market resale value of the property at the end of the study period, rather than on depreciation calculations.

Calculate Present Value

Both NPV and B–C tests require that costs and benefits be presented in terms of their value as of the time of the decision making. This involves a two-step process. First, all costs and benefits must be expressed in constant dollars (which effectively controls for future inflation). Then, a discount factor is applied to reduce the values of future costs and benefits to represent their present values. The formula is as follows:

Present value of a dollar of cost or benefit in a future year (n) = $1 / (1 + d)^n$

where d = discount rate

Selection of the appropriate discount rate is an important and controversial policy issue, reflecting political values. The lower the discount rate selected, the more likely will be that projects with high initial costs but benefits far off in the future will pass the NPV and benefit/cost tests. The principal criterion is the "opportunity cost of capital," which may be judged to be any one of the following:

- The real *cost of borrowing money* by the public sector agency (which is typically a low interest rate due to its tax free status); or
- The real *rate of return* that the money could have earned in the private sector (the "social opportunity cost"); this is normally similar to the cost of borrowing in the private sector; or
- The real *rate at which people effectively value receiving money now* rather than in the future (the "social rate of time preference").

Among these choices, an important consideration is the available alternatives for use of the real resources (labor, machinery, etc.) that can be paid for by the available money.

The "real" (constant dollar) discount rates used for B–C analysis of transportation investments are typically in the range of 4 to 8%. The OMB recommends a 7% discount rate, as representing the private-sector rate of return on capital investment. Other agencies, recognizing the social rate of time preference, have adopted lower discount rates. For decades, the Army Corps of Engineers used a 4% rate, which had the effect of favoring long-lived projects with net benefits many years into the future. The state of Wisconsin adopted a 5% rate. The United Kingdom Department of Transport's NESA B–C procedures call for a 7% rate. Analyses for major projects in Massachusetts have generally used a 7% rate. The B.C. Ministry of Transportation and Highways uses an 8% rate.

Next Steps: Research, Analysis, and Further Reading

This document has (hopefully) provided the reader with an understanding of the components of economic impact analysis and the types of analysis choices available and appropriate for that purpose. A range of computer-based transportation and economic modeling tools—requiring varying degrees of sophistication—are now available for evaluating the economic impacts of transportation investments. In addition, continuing research is providing new insights and methods for estimating the various elements of efficiency and business productivity benefits associated with transportation investments.

Further Reading

Selected sources of information used for this document are as follows:

A. DATA FOR ESTIMATING USER BENEFITS

AASHTO Red Book—American Association of State Highway and Transportation Officials. *A Manual on User Benefit Analysis of Highway and Bus Transit Improvements*, 1977.

HERS Manual—Jack Faucett Associates. *The Highway Economic Requirements System*. Federal Highway Administration, U.S. DOT, July 1991. (An update is scheduled for 1996-1997.)

ITE Handbook—Institute of Traffic Engineers. *Transportation and Traffic Engineering Handbook*. Prentice Hall, 1985.

IRMS—Bernardin, Lochmueller & Assoc. *Indiana Reference Modeling System*, 1995.

MVMA Report—Motor Vehicle Manufacturers Association. *Motor Vehicle Facts and Figures*, annual.

NCHRP Report 7-12—Texas Transportation Institute. M*icrocomputer Evaluation of Highway User Benefits*. National Cooperative Highway Research Program Report 7-12, Transportation Research Board, 1993.

UI Lit Review—Miller, Ted. *The Value of Time and the Benefit of Time Savings*. The Urban Institute, March 1989.

B. DATA FOR ESTIMATING ECONOMIC BENEFITS

APTA—Transit Fact Book, American Public Transit Association, annual.

FHWA Job Generation—Highway Infrastructure Investment and Job Generation. Federal Highway Administration, Office of Policy Development, Transportation Studies Division, June 1996.

NCHRP 25-4—Weisbrod and Neuwirth. "Economic Impact of Restricting Left Turns." *Research Results Digest*, National Cooperative Highway Research Program Project 25-4, Transportation Research Board, August 1996.

RIMS II Handbook—Regional Multipliers: A User Handbook for the Regional Input-Output Modeling System (RIMS II), 2nd ed. Bureau of Economic Analysis, U.S. Department of Commerce, May 1992.

U.S. Chamber Report—What 100 Jobs Mean to a Community. U.S. Chamber of Commerce, 1993.

C. EXPLANATIONS OF MEASUREMENT ISSUES FOR ESTIMATING ECONOMIC BENEFITS

B.C. Guidebook—British Columbia Ministry of Transport and Highways, Planning Services Branch. *Economic Analysis Guidebook*, April 1992.

Indiana Guide—Cambridge Systematics and Bernardin Lochmueller. *Major Corridor Investment-Benefit Analysis System*. Indiana Department of Transportation, 1996.

Iowa Guide—Wilbur Smith Associates. *Guide to the Economic Evaluation of Highway Projects*. Iowa Department of Transportation, 1993.

NCHRP Report 342—D. Lewis. *Primer on Transportation, Productivity and Economic Development*. National Cooperative Highway Research Program, Transportation Research Board, August 1996.

OMB Guidelines— *Benefit–Cost Analysis of Federal Programs: Guidelines and Discounts*. Office of Management and Budget, Circular No. A-94, *Federal Register*, Vol. 57, No. 218, November 1992.

TAC Guide—*A Primer* on *Transportation Investment and Economic Development*. Transportation Association of Canada, 1994. (This is a summary version of NCHRP Report 342.)