TRANSIT COOPERATIVE RESEARCH PROGRAM

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TCRP Report 20

Measuring and Valuing Transit Benefits and Disbenefits

Summary

Transportation Research Board
National Research Council

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Measuring and Valuing Transit Benefits and Disbenefits

Summary

CAMBRIDGE SYSTEMATICS, INC.
Washington, DC
with

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TRANSIT COOPERATIVE RESEARCH PROGRAM

The nation's growth and the need to meet mobility, environmental, and energy objectives place demands on public transit systems. Current systems, some of which are old and in need of upgrading, must expand service area, increase service frequency, and improve efficiency to serve these demands. Research is necessary to solve operating problems, to adapt appropriate new technologies from other industries, and to introduce innovations into the transit industry. The Transit Cooperative Research Program (TCRP) serves as one of the principal means by which the transit industry can develop innovative near-term solutions to meet demands placed on it.

The need for TCRP was originally identified in *TRB Special Report 213—Research for Public Transit: New Directions*, published in 1987 and based on a study sponsored by the Urban Mass Transportation Administration—now the Federal Transit Administration (FTA). A report by the American Public Transit Association (APTA), *Transportation 2000*, also recognized the need for local, problem-solving research. TCRP, modeled after the longstanding and successful National Cooperative Highway Research Program, undertakes research and other technical activities in response to the needs of transit service providers. The scope of TCRP includes a variety of transit research fields including planning, service configuration, equipment, facilities, operations, human resources, maintenance, policy, and administrative practices.

TCRP was established under FTA sponsorship in July 1992. Proposed by the U.S. Department of Transportation, TCRP was authorized as part of the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA). On May 13, 1992, a memorandum agreement outlining TCRP operating procedures was executed by the three cooperating organizations: FTA, the National Academy of Sciences, acting through the Transportation Research Board (TRB), and the Transit Development Corporation, Inc. (TDC), a nonprofit educational and research organization established by APTA. TDC is responsible for forming the independent governing board, designated as the TCRP Oversight and Project Selection (TOPS) Committee.

Research problem statements for TCRP are solicited periodically but may be submitted to TRB by anyone at any time It is the responsibility of the TOPS Committee to formulate the research program by identifying the highest priority projects. As part of the evaluation, the TOPS Committee defines funding levels and expected products.

Once selected, each project is assigned to an expert panel, appointed by the Transportation Research Board. The panels prepare project statements (requests for proposals), select contractors, and provide technical guidance and counsel throughout the life of the project. The process for developing research problem statements and selecting research agencies has been used by TRB in managing cooperative research programs since 1962. As in other TRB activities, TCRP project panels serve voluntarily without compensation.

Because research cannot have the desired impact if products fail to reach the intended audience, special emphasis is placed on disseminating TCRP results to the intended end users of the research: transit agencies, service providers, and suppliers. TRB provides a series of research reports, syntheses of transit practice, and other supporting material developed by TCRP research. APTA will arrange for workshops, training aids, field visits, and other activities to ensure that results are implemented by urban and rural transit industry practitioners.

The TCRP provides a forum where transit agencies can cooperatively address common operational problems. The TCRP results support and complement other ongoing transit research and training programs.

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NOTICE

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The members of the technical advisory panel selected to monitor this project and to review this report were chosen for recognized scholarly competence and with due consideration for the balance of disciplines appropriate to the project. The opinions and conclusions expressed or implied are those of the research agency that performed the research, and while they have been accepted as appropriate by the technical panel, they are not necessarily those of the Transportation Research Board, the National Research Council, the Transit Development Corporation, or the Federal Transit Administration of the U.S. Department of Transportation.

Each report is reviewed and accepted for publication by the technical panel according to procedures established and monitored by the Transportation Research Board Executive Committee and the Governing Board of the National Research Council.

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FOREWORD

By Staff
Transportation Research Board

This report will be of interest to transportation professionals and policy makers responsible for transit-investment decisions. The report categorizes and describes transit benefits and disbenefits, presents the dimensions of transit's economic impact, addresses the linkages between increased transit investment and use, and changes in long-term, regionwide economic conditions that can be measured with current analytic methods, and provides examples of transit benefits and disbenefits based on recent analysis.

It is generally accepted that investment in and use of public transit produces impacts, many of which are difficult to measure and value. These are often referred to as intangible, indirect, or external benefits and disbenefits. Benefits and disbenefits occur in areas such as social and economic development, employment, air quality, transportation system operations, mobility, urban form, and land use. Transit planning and research studies employ various measures and values to describe these benefits and disbenefits in both quantitative and qualitative terms. TCRP Project H-2 developed a compilation and comparison of the transit benefits and disbenefits and measurement techniques found in previous studies and currently used in practice.

The objectives of this research project were to (1) compile, define, and compare currently used categories of benefit and disbenefit; (2) compile and evaluate currently used measures and values; (3) develop improved or new benefit and disbenefit definitions, measures and values; (4) identify innovative concepts from other business sectors that can be applied to the measurement and valuation of transit benefits and disbenefits; (5) facilitate the application of current, improved, or new benefit and disbenefit definitions, measures, and values; and (6) improve current analysis techniques of measuring transit's long-range, regionwide economic impacts.

The results of this research are intended for use by transportation professionals and policy makers responsible for transit-investment decisions. Two reports were prepared by the research team: the *Summary* and the *Final Report on Measuring and Valuing Transit Benefits and Disbenefits*. TCRP Report 20 presents the *Summary*. The *Final Report* is available on loan from TCRP.

MEASURING AND VALUING TRANSIT BENEFITS AND DISBENEFITS

SUMMARY

Public transportation produces a wide range of benefits and disbenefits. Many are obvious and easy to measure. Many are far less obvious and remain difficult to measure and value. Transit planners and researchers employ various measures and analysis techniques to describe these benefits and disbenefits in both quantitative and qualitative terms. However, a comprehensive source of information on measures and values of transit benefits and disbenefits does not exist, nor are there consistent definitions of the measures and values used in assessing transit's impacts.

Recognizing this need, a special research project has undertaken, through the Transportation Research Board's Transit Cooperative Research Program (TCRP), to assess and advance the state of the art in the measurement and valuation of transit benefits and disbenefits. The project pursued the following objectives:

1. Compile, define, and compare currently used categories of benefit and disbenefit;
2. Compile and evaluate currently used measures and values;
3. Develop improved or new benefit and disbenefit definitions, measures, and values;
4. Identify innovative concepts from other business sectors that can be applied to the measurement and valuation of transit benefits and disbenefits; and
5. Facilitate the application of current, improved, or new benefit and disbenefit definitions, measures, and values.

The results of this research are intended for use by transportation professionals and policy makers responsible for transit-investment decisions.

The project was carried out in two phases. The first phase involved a comprehensive review of current practices and procedures used to measure and value transit benefits and disbenefits. From this review, researchers and the project panel that directed the study identified 10 specific areas in which improved analysis techniques would be most useful to analysts and decision makers.

From these 10, the problem of *measuring transit's long-range, regionwide economic impacts* was selected as the topic of greatest interest with respect to improving current analysis techniques. The second phase of the project, therefore, focused on approaches that might be used to better assess the long-range, regionwide economic impacts of increased

transit investment and use. This report summarizes the most significant results and findings of research on this critical topic.

In looking at long-term, regionwide economic impacts and how these impacts are defined and measured, the research indicates that the closer one looks, the larger the economic benefits are from increased transit investment and use. As increasing detail is incorporated into analyses, the scope and character of transit's economic benefits expand.

Given the current state of the practice, more factors and linkages may be evaluated in estimating these economic benefits. The scope of analysis, however, should reflect the scale of investment or related decisions to be made.

MOTIVATING FORCES

A variety of circumstances have converged in recent years which call for new, more effective means of evaluating investment and expenditures in basic public services. Nowhere is the interest in improved evaluation techniques and decision-making support more in evidence than in the transportation sector. The justification for and the relative priority of competing transportation investments must be established more broadly and more conclusively than before in environmental, social, and economic, as well as transportation, terms.

Several influences have fostered this interest:

- Enactment of the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) calls for a shift away from independent planning and investment for separate highway, transit, and rail systems, toward development of an integrated, multimodal system of services and facilities. ISTEA also broadens the scope of traditional transportation analysis and decision making by requiring that more rigorous consideration be given to a host of impacts and interrelationships, including broad-based community development goals, land use plans, and economic impacts. Finally, ISTEA calls for a new focus on management of the entire transportation network and provides flexibility in the use of federal funds to reinforce these interests.
- Enactment of the Clean Air Act Amendments of 1990 (CAAA) calls for more effective analysis techniques to establish a new and direct linkage between actions required to improve the nation's air quality, and the actions taken to enhance personal mobility and access.
- Enactment of the Americans with Disabilities Act of 1991 (ADA) alters the calculus by which transit investments are to be prioritized and carried out.
- The National Energy Policy Act of 1992 calls for attention to energy efficiency and reduction in the use of petroleum resources in the transportation sector.
- Executive Order 12893 issued by the White House on January 26, 1994, calls for wider use of benefit-cost analysis techniques to determine the investment worthiness of projects of all kinds seeking to use federal funds.
- Government deficits and budget constraints at all levels continue to call into question the priorities for public investment generally, the priorities among various types of infrastructure, and the priorities among maintenance, preservation, and expansion of public facilities and services.
- Debate continues over the relevance, importance, and impact of alternative transportation investments and strategies, with much of the debate centered on the comparative effects and consequences of transit and highway investment.

ORGANIZATION OF THE REPORT

Major findings from the project are summarized below and presented in greater detail in a companion Technical Report. The Technical Report is intended to guide and assist plan-

ning professionals and technical analysts in applying improved analytical techniques to this important area of inquiry. The authors intend this report to better inform decision makers and other nontechnical audiences about the scope of transit's economic impacts by

1. Illustrating the economic consequences of increased transit investment and use;
2. Describing the types of analyses that can be used to measure the linkages between increased investment and use, and the economic vitality of a metropolitan region; and
3. Highlighting the findings of recent efforts to employ more comprehensive analysis techniques in measuring the long-term, regionwide economic impacts of increased transit investment and use.

Chapter 1 provides a broad overview of the basic mission and objectives of modern-day transit investment and operations, and highlights the full range of impacts that have been traditionally analyzed. This overview provides a summary of the general state of the art in assessing transit impacts of all types.

Chapter 2 outlines in greater detail the scope and dimension of transit's economic impacts by diagramming the complex linkages by which increased transit investment and use result in enhanced regional economic prospects.

Chapter 3 provides an overview of new and emerging analysis techniques by which the value of these economic linkages can be more accurately assessed, and includes findings from a number of recent efforts to arrive at a more comprehensive estimate of the economic impacts.

Chapter 4 highlights findings and conclusions that may be significant to decision makers and analysts in understanding economic consequences of transit availability and use.

Three appendices are provided. Appendix A describes other research topics considered by the research team to be worthy of additional investigation in the effort to better assess transit's benefits and disbenefits. Appendix B includes diagrams that illustrate the linkages between transit investment and use and economic consequences for the region. Appendix C is a selected bibliography that may be of value in examining more closely the long-term, regionwide economic impacts of transit investment and use.

In addition, an unpublished Technical Report is available through the Transit Cooperative Research Program Office that examines in greater detail the current state of the practice in assessing transit benefits and disbenefits, and the more technical aspects of applying the methodologies outlined in Chapter 3 to assess transit's long-range, regionwide economic impacts.

CHAPTER **1**

CATEGORIZING TRANSIT BENEFITS AND DISBENEFITS

The impacts of transportation systems and facilities vary considerably in how they are described and analyzed. Despite these variations, six major categories of benefit and disbenefit are common to virtually all current analytical frameworks. These include transit's effects on mobility and access, the economy, the environment and energy, safety and security, social equity, and effects that are commonly considered "intangibles." Within each of these six major categories, there are numerous subcategories of impacts, both positive and negative, that flow from investment in and use of public transit, as well as from competing transportation systems and services.[1] Figure 1 highlights the six major areas of interest and the categories of impacts that were used by the research team to guide the assessment of current practice.

CURRENT PRACTICE IN MEASURING TRANSIT BENEFITS AND DISBENEFITS

Transit benefits and disbenefits are generally specified in terms that reflect broad public policy concerns or goals, as indicated in Figure 1. While the emphasis and the relative importance placed on these six areas has fluctuated over time, all have been the subject of attention over the last two decades. In that space of time, the goals and expectations of transit have expanded to become more complex and, in some instances, contradictory. Nonetheless, the transit literature, including current law, regulation, and policy, reflects a general acknowledgment that public transit services play a role in achieving a mix of public policy goals.

The actual measurement of transit benefits and disbenefits and the use of resulting data in each of these broad areas have been generally uneven, however. A very strong case can be made, in fact, that traditional approaches used to measure and value transit benefits and disbenefits do not fully reflect all commitments made concerning, or all expectations of transit services and facilities. The most pronounced shortcoming in traditional analysis is the inability to quantify the full range of transit benefits that are referenced in policy and goal statements and intuitively sensed by citizens, as well as by many planners and decision makers. As a result, transit benefits are traditionally understated when the merits of investment alternatives are weighed, resulting in understated estimates of transit cost-benefit and cost-effectiveness. This shortcoming is magnified because of the added uncertainties in measuring transit benefits over the long term. As a result, incomplete and imprecise estimates of long-term benefits are typically evaluated against short-term costs, further distorting cost-benefit and cost-effectiveness analyses applied to transit.

Finally, current analytical practice tends to focus on the operating characteristics and impacts of alternative transit investments at the project or corridor level. In this process, inadequate attention is commonly paid to the comparative impacts of continued reliance on automobile-oriented investments and improvements. Use of an automobile-oriented baseline for analysis is even more critical at the regional level over the long term. Seemingly justifiable individual highway projects and improvements may have cumulative consequences that are undesirable and unsustainable, while what appear to be questionable individual transit investments in the short term may be invaluable to the region over the long term. It is critical, therefore, to understand these interrelationships and linkages more fully and introduce techniques, including more appropriate baselines for analysis, to better measure progress toward transit goals and expectations.

Figures 2 through 7 contain a brief assessment of the current state of the practice in measuring and valuing transit benefits and disbenefits, as outlined in Figure 1. Each of the areas noted is addressed in greater detail in the Technical Report available through TCRP.

REVISING THE FRAME OF REFERENCE IN ANALYZING TRANSIT BENEFITS AND DISBENEFITS

Several broad conclusions arise from the review of current analytical practices.

- First, the most extensively used measures and techniques evaluate the access and mobility impacts of transit and the costs associated with providing access and mobility. It is also clear, however, that the stream of benefits (and disbenefits) from transit investment and use

[1] Public transit investment and operations have wide-ranging impacts. Whether that impact is positive, i.e., provides benefits, or negative, i.e., produces disbenefits, and to what extent these impacts are meaningful, varies significantly depending on baseline conditions, the type of decisions being made, the actors involved, and the relative importance and incidence of various impacts among affected parties and actors.

Mobility and Access Impacts
- Transit use
- Travel time
- Availability of transit services
- Service reliability
- Service quality
- Highway system impacts

Economic and Financial Impacts
- Public finance
- Cost-effectiveness of service
- Cost avoidance
- Affordability
- Economic growth
- Development and land use

Environmental and Energy Impacts
- Energy consumption
- Emissions
- Noise
- Ecology
- Land consumption/conservation

Safety and Security Impacts
- Rider safety and health
- Transit employee safety
- Nonrider safety and health
- Rider security
- Neighborhood integrity
- Barrier effects

Social Equity Impacts
- Levels of service
- Utilization
- Cost incidence
- Service availability
- Access to opportunities/destinations

Intangible Impacts and Factors
- Value to the community
- Value to the individual
- Other mechanisms and methodologies

Figure 1. Categorization of major transit impacts.

extends well beyond those measured in traditional access and mobility terms. In addition, in today's policy environment, the singular focus on traditional access and mobility measures is too narrow.

- The overall framework within which transit benefits and disbenefits are evaluated should be expanded to reflect the broader issues in transportation decision making that have been introduced by the CAAA, the ADA, ISTEA, and the National Energy Policy Act.
- Analysis of transit's impacts should be framed more broadly than to satisfy federal interest in making capital investment decisions under severe resource constraints. Local, regional, and state goals need to be more directly addressed in investment decision making.
- Finally, a revised framework should help identify areas and relationships that are not fully addressed in current practice. Perhaps the clearest example is the lack of attention to long-term, regionwide, or system impacts of transportation improvements.

A Quality of Life Orientation

Based on the need to revise the frame of reference in analyzing transit's impacts, Figure 8 graphically depicts how the six major impact categories discussed earlier might be reoriented to encourage a more comprehensive assessment of transit benefits and disbenefits. The principal organizing concept is the shared interest in improving the quality of life for individuals, for families, current and future, and for the community as a whole. In defining the elements that contribute to improved quality of life, the primary distinction to be made is between what may be called "fundamental" benefits, i.e., those characteristics that individuals and communities most want to consume more of, versus "intermediate" benefits, i.e., those whose principal importance lies in the production of fundamental benefits.

Under the concept in Figure 8, the six major areas of interest that are traditionally subjected to measurement are retained, but their relationship to one another is made more clear. Therefore, the new starting point for assessing transit benefits and disbenefits is the improvement in one's quality of life, i.e., an attempt to make operational one of the most frequently referred-to "intangible" benefits of transit.

Fundamental Elements and Benefits

In assessing the factors that contribute most to an individual's quality of life, the research team identified economic, safety and security, and environmental dimensions. Individually and at the community level, quality of life is improved if one has financial stability and growth, if one has good health and is not physically threatened, and if the surroundings in which one lives are orderly and not restrictive or harmful. These, therefore, constitute the "fundamental" benefits to be sought and disbenefits to be avoided by individuals and communities.

Access and Mobility as an "Intermediate" Benefit

This scheme views mobility and access, which have been the focus of most traditional assessments of transit and competing transportation alternatives, as "intermediate" benefits that contribute or produce impacts in each of the "fundamental" categories noted above. Transit is represented as one

Overview

Measurement of changes in mobility and accessibility are the most prominent and technically well-developed areas of impact measurement applied to transit. Although the concepts of mobility and accessibility often have been used interchangeably, they are fundamentally different, with different implications for both the traveling public and planners and providers of transportation services and facilities. Mobility generally refers to the ease with which one moves, measured in terms of alternatives available and travel time. Accessibility generally refers to extent to which desired destinations are served, measured in terms of the availability of and proximity of primary destinations to transportation services. Accessibility is emerging as the more important objective. One can have high levels of mobility (ease of movement) but if major destinations are not well-served (accessible), ease of movement is of little value. The focus on accessibility also provides increased emphasis on the linkage between transportation and land use patterns.

The evolution of the four-step travel demand modeling process, the emergence of disaggregate household and activity-based modeling systems, and continuing advances in computer technology and simulation techniques have introduced a level of precision and sophistication that is unmatched in any other major public policy area related to transportation, with the possible exception of mobile source emissions modeling and analysis. Current procedures for measuring mobility and access have been developed predominantly in support of highway planning and are rooted in the analysis of vehicle movement. For the most part, however, travel analysis techniques have been successfully adapted for application in transit, in combination with transit operating measures and performance monitoring techniques.

In assessing the impacts of public transit in terms of mobility and access, measures currently in use can be grouped into several categories. These are listed and described briefly in Figure 2.

Category of Benefit/Disbenefit	Nature of the Benefit	Basis for the Analysis
Transit Use	Levels of use	Transit ridership Modal split Ratios of use to seats-capacity
Travel Time	Travel time savings	Transit travel times and speeds Transit service frequency Auto travel times and speeds
Service Availability	Proximity to higher levels of service	Transit system configuration and service frequency
Service Reliability	Dependable service and equipment	Transit system performance Transit operating characteristics Auto use characteristics
Service Quality	Comfort and convenience	Transit operating characteristics Auto use characteristics
Highway System Impacts of Transit	Congestion reduction	Highway travel characteristics

Figure 2. Measures of mobility and access.

Overview

Measuring the economic impacts of transportation has been an area of rigorous endeavor for several decades. Techniques have evolved from analyses developed in the late 1950s for the interstate highway system, to a variety of parallel methodologies that have been applied to transit investment. Economic benefits and disbenefits are treated as important factors and they are applied and measured at: 1) the route level in monitoring operational performance; 2) the corridor level in performing alternatives analysis; and 3) the regional level in making long-term, systemwide decisions. The analytical approach taken and the application of findings, however, depend on the perspective of decision maker(s) and the goals against which progress is to be measured.

In assessing the economic impacts of public transit, the measures currently in use can be grouped into several categories, reflecting a combination of objective data and findings, and more subjective observations.

Categories of Impacts	Nature of Benefit/Disbenefit	Basis for Analysis
Public Finance	Demand on public resources	Year-to-year revenue base, expenditures
Cost-Effectiveness of Service	Return on investment	Trends over time, target ratios, and relative productivity across systems and alternative modes
Cost Avoidance	Expenditures rendered unnecessary by users, nonusers and government	User cost savings, avoided government capital costs and lower operating expenses
Affordability for Users	Ability to select among a range of mode choices	Absolute and comparative trip costs
Economic Growth, Effect of Transit Construction, Operation	Jobs and income generation	Direct, indirect and induced employment, disposable income to individuals, and revenue to businesses
Economic Growth , Effect of Transit Presence	Business access to customers and labor markets, government fiscal effects	Business sales and income, company growth rates, job creation, tax revenues
Development and Land Use	Development concentration, enhanced property values	Activity center growth rates and patterns, land use intensity, tax revenues

Figure 3. Measures of economic and financial impacts.

of a number of competing systems and services whose characteristics impact the extent to which mobility and access are improved and, therefore, the degree to which more fundamental benefits are made available. Emerging considerations of issues of mobility and accessibility have begun to emphasize the importance of access, i.e., the extent to which the transportation network allows all individuals to get to major destinations. Mobility, or ease of movement, is of little value unless the network provides effective access to major destinations. Important steps include charting, estimating, and better understanding the linkages among access, mobility, and the "fundamental" characteristics of quality of life.

Overview

Measurement of transit impacts on energy use and environmental quality is well established in the transportation community. The impetus for comprehensive analysis of energy and environmental impacts began in the early 1970s and stems largely from the National Environmental Policy Act of 1969, the Clean Air Act of 1970, and the oil shortages of the early and late 1970s. The National Environmental Policy Act of 1969 (NEPA) provided the broad analytical structure and process guiding air quality and other environmental analyses at the project level. The air quality impacts of transportation investment decisions have been the focus of federal ambient air quality standards since passage of the Clean Air Act of 1970. Since that time, measurement of the impacts of transit projects and plans on energy consumption has become a routine element in the evaluation of proposed transit improvements. More recently passage of the Clean Air Act Amendments of 1990 and the National Energy Policy Act in 1992 have reinforced the importance of air quality and energy conservation within the transportation sector. ISTEA also reinforces the earlier emphasis placed on fuel efficiency and energy consumption.

Similar requirements, standards and procedures have been enacted at the state level throughout the country. The result is that relatively demanding standards and processes for environmental impact analysis are being applied to both federal and non-federally-funded projects and decisions.

Category of Benefit/Disbenefit	Nature of the Benefit	Basis for Analysis
Energy	Reduced consumption	Auto consumption rates, levels Transit consumption rates, levels
Emissions	Reduced mobile source emissions	CAAA and state AAQS Auto emissions rates, levels Transit emission rates, levels
Noise	Reduced exposure	FHWA standards Decibel levels of highway and transit modes
Ecology	Reduced intrusion into sensitive settings	NEPA and related state and federal standards, requirements Sites and acreage affected
Land Consumption	Reduced consumption of land for transportation facilities	Acreage requirements

Figure 4. Measures of energy and environmental impacts.

Summary Measures

Several measures identified in Figure 1 are more properly "summary measures" that should be applied across all the "fundamental" and "intermediate" elements. The most obvious examples of these are measures of cost-effectiveness and social equity. Whenever either fundamental or intermediate benefits or disbenefits of transit (or other transportation investment options) are assessed, there should be analyses of: (a) how cost-effectively the benefit is achieved; and (b) how evenly or unevenly the benefits or disbenefits are being spread across population groups or geographic areas.

The "quality of life" framework in Figure 8 does not purport to dramatically alter basic notions of benefit and disbenefit assessment in transportation. In fact, it reinforces two very traditional notions that have been somewhat downplayed in recent years. First is the notion that transportation

Overview

There is ample evidence indicating that concerns over personal safety and security affect both user and nonuser behavior and attitudes about transit, particularly in our major metropolitan areas. The focus of transit safety concerns has traditionally been on the degree of exposure to accidents, their incidence and their severity. The safety characteristics of public transit are widely measured by tracking the type and frequency of accidents that either actually or potentially result in bodily harm or property loss. In these terms, transit is one of the safest of all modes of travel.

Fear of crime and threats to personal security, however, are at the core of today's public concern. Consequently, attitude surveys and opinion polling are being used increasingly to examine the scope of safety and security concerns that extend significantly beyond those reflected by traditionally reported incidents and safety statistics.

At present, definitions and data collection related to type and incidence of actual criminal and antisocial behavior associated with public transit are not fully standardized. It is clear, however, that real and perceived threats to personal security are a frequently noted disbenefit associated with transit. Contributing to this perception is the high-profile reporting that is done on events like major accidents and assaults across the country, including those that may occur within transit systems.

Category of Benefit/Disbenefit	Nature of the Benefit/Disbenefit	Basis for the Analysis
Rider Safety and Health	Exposure to physical harm from transit operations vs. other travel options	Accident rates, severity costs; physiological effects of use across modes
Transit Employee Safety	Exposure to physical harm	Accident rates, severity costs
Nonrider Safety and Health	Exposure to physical harm from transit operations	Accident rates, severity costs
Rider Security	Exposure to crime and antisocial behavior	Incident frequency and severity; perceptions; mitigation levels
Neighborhood Integrity	Intrinsic behavior activity; ease of access by nonresidents	Resident attitudes, perceptions; activity levels
Barrier Effects	Separation or division of local functions, facilities	Physical and operational characteristics of facilities

Figure 5. Measures of safety and security.

is a derived demand and, therefore, an intermediate benefit. Second is the notion that the classic planning hierarchy of broadly conceived goals, achievable objectives, and specific measures of success has increased relevance in an era when systems must be better integrated and their impacts more broadly defined and measured. Perhaps more importantly, the framework also implies directly that conventional measurement of access and mobility is fundamentally a subordinate concern, particularly at the long-range, strategic level, and is perhaps overemphasized in traditional evaluation processes.

Review of the literature and the current state of the art has revealed a number of areas in which transit impacts are not measured widely or consistently, or if they are

Overview

Social equity refers to the distribution of the benefits and disbenefits among segments of the population. Two concepts of social equity are generally noted or implied in analyses of transit impacts:

- Distribution of costs and benefits that flow directly from the provision and operation of transit services among segments of the population, i.e., achieving "fairness" so that no segment of the population is unduly burdened or aided; and
- Transit's impact on preexisting social and economic inequities outside the transportation arena, i.e., achieving greater "fairness" in the overall socioeconomic context by overcoming barriers to education, economic opportunity, health care, etc. The underlying assumption is that one of transit's missions is supporting social access for all members of the population, particularly for those without access to automobiles.

Except for measures of transit dependence (e.g., proportion of residents near stations or riders without cars), social equity is a summary measure. That is, most of the measures listed in Figure 1 can be converted into measures of social equity by disaggregating data according to demographic and/or geographic subgroups of the population. In current practice, some but not all of the available measures are disaggregated and used for analyses of social equity, most frequently in a day-to-day service planning and performance-monitoring at the route or corridor level.

Social equity analyses are based on evaluation measures applied to population subgroups and then compared to each other, to some guideline, or to a normative standard to determine whether or not equity objectives are being met. These measures are usually numerical rather than judgmental. These typically focus on: income levels; auto ownership; ability to use traditionally-configured modes of transportation—i.e., persons with disabilities; race/ethnicity; and, geographic location (city/suburb, political jurisdictions).

Category of Benefit/Disbenefit	Nature of Benefit	Basis for Analysis
Level of Service	Amount of service available	Transit system operating characteristics with respect to target population concentrations
Utilization	Level of service consumed	Ridership characteristics by target population groups
Cost Incidence	Proportionate costs	Costs with respect to income Costs with respect to service consumed
Service Availability	Existence of alternatives for those with limited auto access	Transit system configuration with respect to target population concentration
Access to Opportunities and Destinations	Major destinations are equally accessible to all population segments	Existence and extent of transit service to sites by type

Figure 6. Measures of social equity.

Overview

Transit impacts and the perception of transit benefits and disbenefits are not always well defined or based on empirical evidence, measurement or analysis. The application of well-defined measures is most extensive at the performance and operational level where resulting values are used to assist managers and policy makers in day-to-day service planning, development of annual budgets, and investment priorities. As the scope of analysis is enlarged geographically and extended over time, impact analysis tends to be based on fewer measures and, in some cases, conducted with less analytical precision or on a more theoretical base. More generalized characterizations of transit system impacts tend to be substituted for the more immediate and detailed analysis of system performance and financial/budgetary impacts that typically preoccupy managers and policy makers in the short run.

In recent years, the traditional focus on short-term transit operating performance has given way to much broader interests, both in the substance of transit impacts and in their scope and scale. In the absence of consistent analytical approaches across these areas of interest and levels of analysis, an array of intangible or less well-defined benefits or characterizations of transit impacts has emerged. These characterizations and concepts are scattered throughout the literature and tend to be more in evidence in the broader, longer-term context, where traditional analytical techniques are less useful or less in evidence, and in advocacy materials.

In recent years, however, greater systematic quantification has been attempted in assessing characteristics such as "quality of life," "livability," and "sustainability." Comprehensive systems of measures and benchmarks including references to several transportation characteristics or measures already noted, are being introduced in many areas. Examples include Oregon Benchmarks (270 indicators), British Columbia State of Sustainability Report (90 indicators), and the Sustainable Seattle Project (20 indicators). These approaches parallel the overall framework described in this report in that they identify linkages between economic, environmental and social characteristics.

Category of Benefit/Disbenefit	Nature of the Benefit/Disbenefit	Basis for Analysis
Value to the Community	Economic Competitiveness	Gross comparisons with other metropolitan areas
	Quality of Life	Multiple factors, measures for current/future conditions
	Sustainable Development	Multiple factors, measures of resource consumption for future conditions
Value to Individuals	Personal Well-Being	Attitudes and Preferences
Other Mechanisms and Methodologies	Variable	Attitudes and Preferences

Figure 7. Intangible impacts.

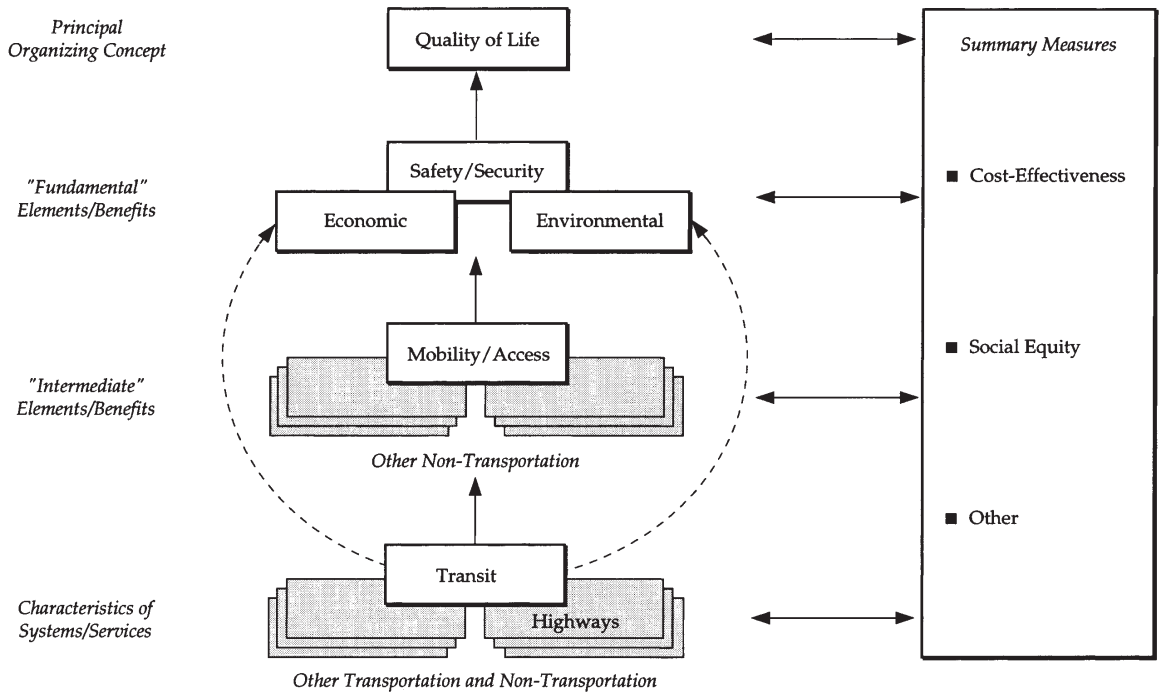


Figure 8. Framework for transit impact measurement and valuation.

measured at all, the results have not been incorporated fully into transportation planning and decision-making processes.

The transportation research community identified other areas as worthy of more focused attention. These are described in Appendix A. After review of the recommended topics, the panel and the research team agreed that the greatest value could be gained from focusing Phase II of the project on means to enhance the measurement of the macroeconomic impacts of transit, i.e., the long-term impacts of increased transit investment and use on the regionwide economy.

CHAPTER **2**

THE DIMENSIONS OF TRANSIT'S ECONOMIC IMPACTS

The economic prospects of a metropolitan region over the long term are directly linked to either real or relative improvement in two key areas: (1) the standard of living for individuals and households; and (2) increases in the economic activity of business and industry.

These two conditions, in turn, are influenced directly and indirectly by the nature of the transportation system, its use, and the levels and types of transportation investments to be undertaken, including transit improvements. Changes in travel conditions and characteristics over the regional network, changes in traveler responses, and the effects of other, nontransportation policies and actions will, in part, determine the standard of living and the level of economic activity in the region. Tracing these effects involves interrelationships among a number of variables. For clear indications of the *economic* consequences, however, the common metric for analysis ultimately must be dollars and cents—the *monetary* effects of a variety of impacts. In some instances, there is ample data and experience in estimating monetary impacts. In other instances, however, the data or demonstrable evidence is lacking from which to estimate monetary impacts.

Another way to characterize this situation is to view the relationships among variables, causes, and consequences as "hard" or "soft." As an example, the relationship between mode choice—automobiles or transit—and air quality consequences is "hard," i.e., easily estimated in quantitative terms though less easily expressed in monetary terms. The impact of increased transit availability and use on corporate productivity and competitiveness, however, is extremely "soft" from an analytical standpoint and can only be pursued at this time through qualitative assessment techniques.

Because of the limits of current knowledge, a "mixed metric" approach is, therefore, necessary. Dollar impacts are used where they can be credibly estimated; nonmonetary units are used or referred to where they can be credibly estimated; and cause-and-effect linkages are noted or suggested where neither monetary nor nonmonetary units can be credibly estimated. The intention, however, is to advance the state of the practice with respect to the estimation of monetary impacts.

Despite these measurement caveats, transit investment and use can be expected to influence the standard of living and the level of regional economic activity directly. It will also affect these factors indirectly in several ways, as described in greater detail below:

- Through the economic consequences of transit's environmental impacts;
- Through the effect of transit investment and use on government finance and fiscal conditions;
- Through productivity impacts and effects on private sector competitiveness; and
- Through the economic consequences of transit's safety and security impacts.

In each of these four related areas, a series of linkages can be diagrammed to chart in greater detail how increased transit investment and use ultimately may lead to improvements in regional economic prospects. The initial step in tracing these effects is to examine how increased transit investment and use may alter travel behavior, construction activity, and land use organization. The scope of these changes, in turn, will affect gross regional product, household income, business profits, and government fiscal condition which are the critical economic variables that determine a region's long-term economic prospects.

CHARTING THE LINKAGES AND ECONOMIC IMPACTS

In the series of diagrams that follow, including those in Appendix B, key linkages have been identified between

1. Increased transit investment and use;
2. Effects on travel behavior, construction and building activity, and land use organization; and
3. Subsequent impacts that these changes may have on key variables important in determining economic consequences for the region.

Many of these linkages and impacts have been empirically demonstrated, i.e., known to occur based on actual data and analysis. In other cases, the relationships and linkages can only be hypothesized, i.e., they are presumed to occur but are not fully documented or conclusively proven.

Throughout the diagrams, there are impacts that are both positive and negative, illustrated with up or down arrows. In

cases where the positive or negative nature of the impact is not certain, the diagrams indicate only that a change is expected by using a "delta" symbol (Δ). In addition, each diagram indicates where the primary economic impact is expected to occur, i.e., at the household level (H), on business and/or industry (B), on the government (G), or on the community (C) as a whole. Finally, the diagrams note the importance of "supporting policies" in generating the impacts that are shown. Recognition of the role of supporting policies such as growth management, parking policy, tax policies, and others, is critical, since the act of increasing transit investment and use will not, by itself, produce the maximum effect illustrated or suggested. A combination of supporting policies and transit and other investment actions are essential in realizing the impacts noted.

For technical analysts, the diagrams and specification of the linkages serve to identify the key variables that must be incorporated into any analytical methodology that is intended to produce estimates of transit's long-term, regionwide economic impacts. While these linkages may be generally acknowledged, analytical techniques that begin to capture the breadth of these effects in economic terms have been designed and applied only recently.

TRANSIT AND ENVIRONMENTAL QUALITY

How its transportation system functions is a significant determinant of a region's environmental quality. Because of the extent of their use, automobiles and trucks are the transportation modes most frequently associated with negative environmental impacts. Establishing an economic value for these environmental impacts, however, has been a highly imprecise and often judgmental task. As scientific disciplines have steadily increased knowledge about the causes and consequences of environmental damage, some progress has been made in the valuation of these effects. In many areas, however, the broad impacts of transportation system development and use on the natural and manmade environment defy quantitative valuation.

The ability to divert personal vehicle users to alternative modes, over both the short and long term, is expected to have a significant impact on improving environmental quality in a number of dimensions.

The environmental benefits of increased transit investment and use flow from three broad categories of impacts, as illustrated in Figure 9, including changes in travel behavior, construction and building activity, and land use organization. The working hypothesis is that increased transit investment and use will result in reductions in airborne emissions, noise, levels of stress and physical barriers. In addition, it will reduce degradation of or improve the quality of the water supply and conserve valued natural resources, all of these leading to long-term economic benefits for the region in the form of increased gross regional product, increased personal income, increased business profitability and enhanced government fiscal position.

Travel Behavior Impacts on Environmental Quality

The majority of environmental benefits, certainly those most often quantified, result from changes in travel behavior. By travel behavior, the authors mean the trip-making frequency, duration, timing, location, and choice of mode.

Air Quality. Of all the environmental consequences described in Figure 9, the field of air-quality analysis is subject to the most well-developed analytic techniques, specifically in the area of emission estimates. The Environmental Protection Agency has developed a series of computer models that allow states and metropolitan planning organizations (MPOs) to estimate the air-quality implications of transportation usage. The air-quality models allow estimation of levels of hydrocarbons, carbon monoxide, oxides of nitrogen, and particulate matter under a variety of operating and atmospheric conditions. Although federal and/or state law dictate emission reduction targets and provide a benchmark against which to measure impacts, it is not standard practice to assign monetary values to varying emission levels. A body of research is underway, however, that may eventually make it possible to estimate confidently the monetary impacts of changes in mobile-source emissions.

- For work trip commutes, an average single-passenger automobile is estimated to produce 2.09 grams/passenger-mile of hydrocarbons (HC), rail transit 0.01 grams, and bus transit 0.20 grams. Vanpools and carpools produce 0.36 and 0.70 grams/passenger-mile of hydrocarbons, respectively.
- Similar peak-hour emissions savings over single-occupant automobile use are provided by transit for carbon monoxide (CO) and nitrogen oxides (NO_x).
- The monetary cost of motor vehicle emissions nationally has been estimated from $10 billion to $200 billion annually.

Noise. Noise from transportation usage is another negative environmental impact. Noise can affect hearing ability and increase tension and stress. Increasing noise levels, for residential properties in particular, may depress property values, which may reduce tax revenue to area jurisdictions. Noise emission studies relate noise levels to traffic volumes, the rate of noise emissions per vehicle, and the distance from a "receptor" site. Noise prediction models have been in use since at least the late 1960s.

- 1982 Federal Highway Cost Allocation Study estimated a cost of $21 per household for each 1-decibel increase in noise; and

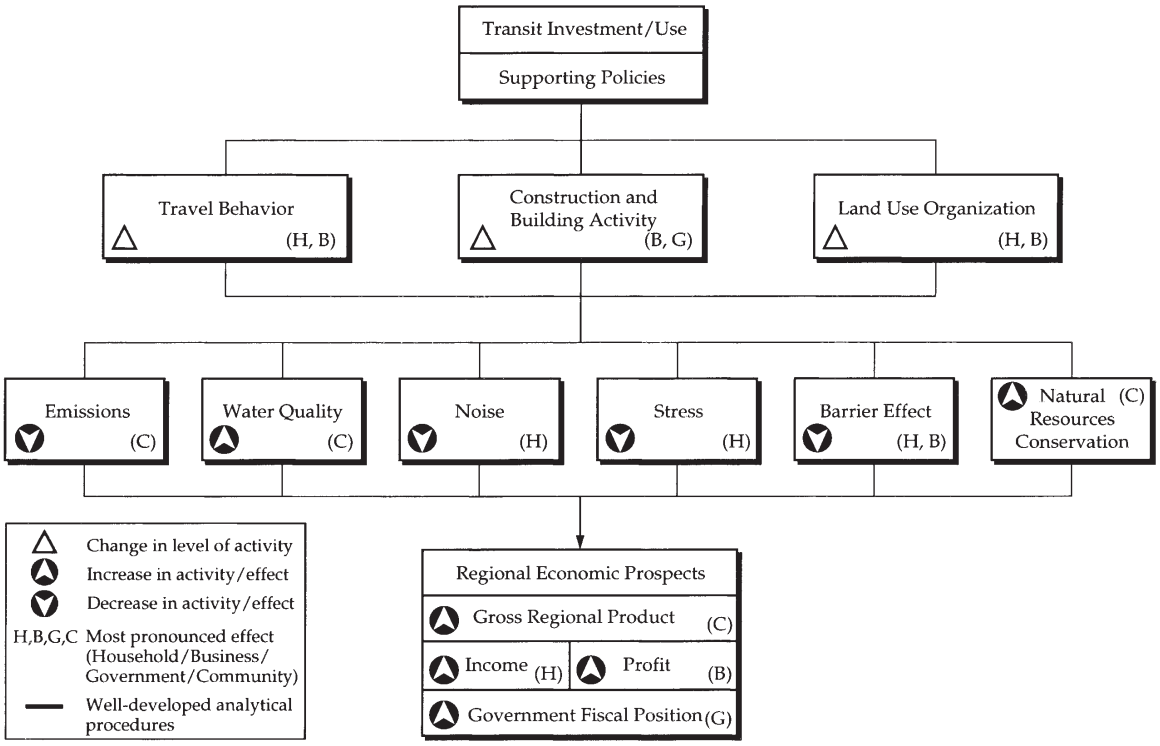


Figure 9. Environmental overview.

- The Virginia and Maryland DOTs will construct noise barriers up to a cost of $20,000 and $40,000 per home protected, respectively. The Maryland DOT standard calls for reductions if noise levels are at 67 dBAs (a vacuum cleaner at 10 ft) or greater.

Construction and Building Activity Impacts on Environmental Quality

Another effect of increased transit investment and use may be to reduce the amount of road-building required. Increased paved surfaces can increase the flow of stormwater into streams and rivers, with less natural filtration, at a higher temperature, and generally at a higher rate of flow than would otherwise be the case. In addition, automobiles and trucks, poorly maintained ones in particular, deposit heavy metals and other toxins that are carried away by rainwater. The proportion of total surface area that may be covered by impermeable surfaces in a watershed or other area before significant environmental degradation occurs is difficult to assess. Reduced demand for automobile travel and use slows the construction of impermeable roadway and parking surfaces.

Barrier Effects. Roadways of different types frequently cause localized restrictions on community and neighborhood access. Limited-access, high-volume, high-capacity roadways can sever ties and reduce connectivity in a community. Arterial roadways can also produce barrier effects by virtue of the traffic volume carried and the speed at which it travels, making access along and across these facilities difficult. Transit investment potentially reduces the need for facilities which may act as barriers, as well as reducing the barrier effect of high-volume traffic.

Land Use Organization Impacts on Environmental Quality

The land use organization effects of transit refer to the potential to attract more concentrated and mixed-use development around station areas than may otherwise occur in lower density, automobile-oriented patterns. Concentrations of mixed land uses connected by high-quality transit service can be expected to produce shifts in travel away from automobile use, especially single-occupant automobile use, and towards use of the transit system and nonmotorized modes like walking and biking. The magnitude of this outcome is highly dependent on the type and intensity of the transit services as well as supporting policies designed to make areas around transit stations and stops relatively more attractive for development than other areas.

Recent studies have sought to document and estimate the relationship among density, land use mix, and travel demand. In general, these efforts have established a positive relationship among development density, land use mix, and reduced percentages of single-occupant vehicle use.

Energy Conservation. Increased transit investment and use can provide for increased conservation of natural resources. This is most readily estimated in the case of energy conservation, where more compact, mixed-use development patterns, greater transit intensity, and lower automobile dependence result in greater energy efficiency and lower per capita energy consumption (Kenworthy and Newman, 1987). Transit is usually more efficient in terms of energy expended per person for commuting purposes. Increased transit ridership with or without system expansion should, therefore, enhance the energy conservation advantage of transit.

Automobiles at normal peak-hour occupancies of 1.07 to 1.14 persons per automobile consume 5,389 to 5,058 BTUs per passenger-mile. Automobiles at 1.60 passengers per automobile consume 3,604 BTUs per passenger, while light and heavy rail consume 3,710 and 2,993 BTUs, respectively.

Natural Resource Conservation. Compact development facilitated by investment in transit and supportive policies would be expected to facilitate conservation of land for agricultural use, public recreation, and open space, and to help to preserve ecologically sensitive areas. Overall public infrastructure costs, including the construction and maintenance of utilities and transportation facilities, may be lower when the area to be covered is smaller. The environmental linkages, therefore, benefit the region's economy, both in terms of cost savings to consumers and cost savings to government.

TRANSIT AND GOVERNMENTAL FISCAL CAPACITY

The decision to undertake significant investment in or expansion of public transit has obvious major economic consequences in terms of fiscal and budgetary implications for state and/or local governments. Traditionally, the effect on government fiscal capacity is viewed narrowly in terms of short-term capital investment requirements for the construction of the transit improvements being proposed, and the impacts on annual transit operating and maintenance budgets.

As investments in transit are planned and carried forward, broader fiscal impacts are also likely. Figure 10 highlights an expanded framework for analyzing fiscal impacts beyond those associated with project-level capital and operating costs. Changes in travel behavior, construction and building, and land use will affect elements of state and local budgets *beyond* the transportation projects and transportation-related budget line items. Only recently have efforts been made to quantify how transit investments may result in cost-avoidance in other public services and their respective budgets.

The specific revenues and expenditure categories that may be of interest are noted in Figure 10 and include:

1. State and local taxes;
2. Fees and fares from the operation of the system; and
3. Government transfers.

Of these three types of revenues, the tax component is the most complex to analyze. A wide variety of taxing mechanisms, structures, and rates may apply across jurisdictions within a metropolitan region, or across regions themselves. The most important of these tax-related revenue sources include:

1. Corporate and personal income taxes (local, state and federal);
2. Sales taxes (state and local);
3. Property taxes (local);
4. Employee taxes (state and federal);
5. Fuel and related taxes (state and federal); and
6. Franchise/license fees (local and state).

Issues related to changes in travel behavior, due to changes in the extent, quality, and cost of services, complicates analysis of fares and fees. In the case of tax revenues, various fiscal impact models and techniques can be utilized to estimate impacts. In the case of fares, fees, and rider responses, there are general rules of thumb, and in some areas sophisticated travel demand models that can be used to assess the "price elasticity" of transit ridership, i.e., the degree to which increased fares reduce ridership.

The expenditure side of the fiscal equation can be focused on a much broader range of budget areas and programs than just transit or transportation, as indicated in Figure 10. It is a relatively straightforward matter to assess the effects of increased transit funding on traditional transportation programs and budgets. What is not well established is how these shifts in expenditures and travel behavior may impact the availability, cost, and use of other public services. Although emerging evidence has begun to suggest that there may be significant savings from increased transit investment and use in health and education, these findings have not yet become a significant feature in public budget deliberations.

Travel Behavior Impacts on Fiscal Capacity

Transportation Budgets. In terms of transportation revenues and expenditures, an increase in transit mode share occasioned by increased transit investment and use would likely increase both transit capital, and operating and maintenance (O/M) expenditures. To some degree, there may be a parallel decline in highway-related capital and O/M expenditures.

Tax Base Expansion. The influx of federal and state funding to a region for transit purposes can trigger increased business activity and revenue, as well as personal income, which will lead to added tax revenues. As business activity and employment increases, local governments may experience reduced unemployment claims and related reductions in human service or welfare costs. It is frequently claimed that

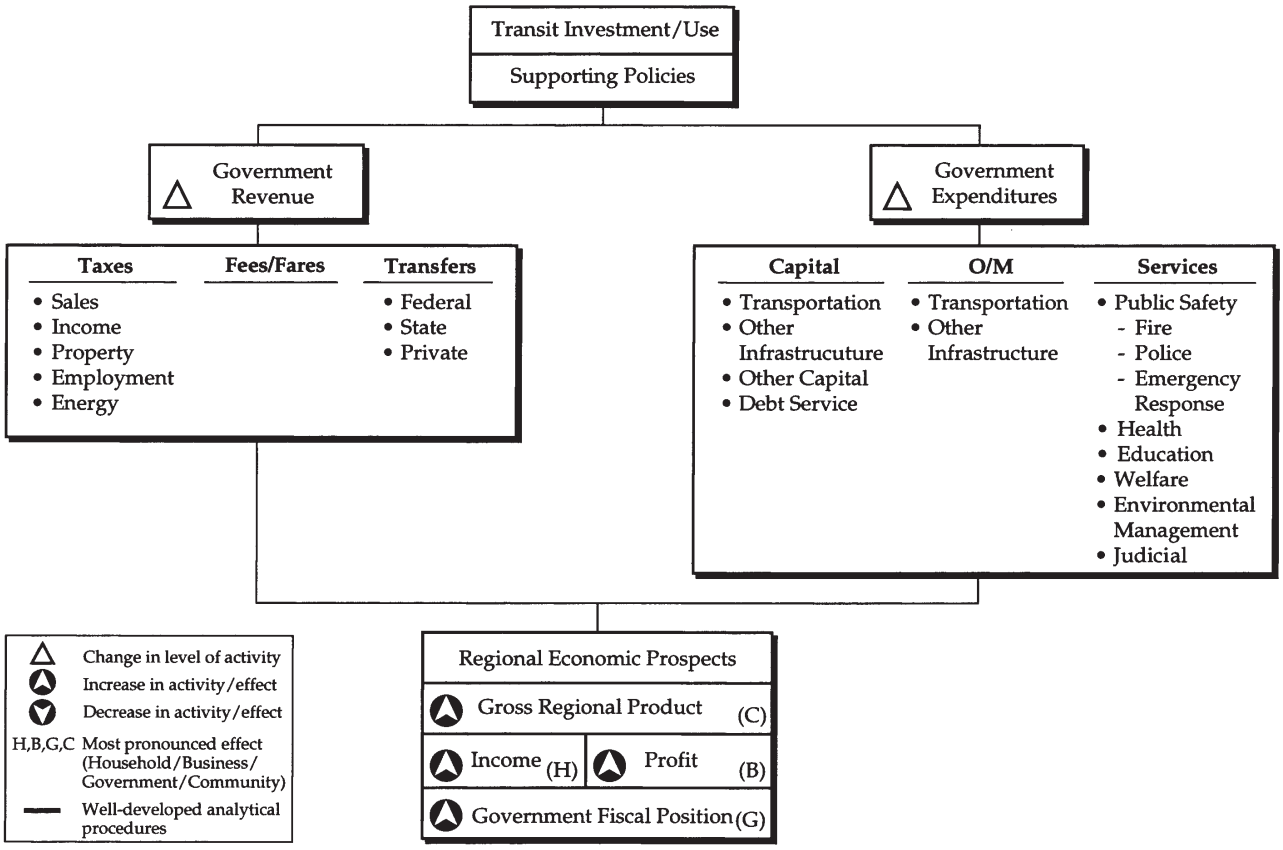


Figure 10. Government fiscal overview.

these impacts would also occur if funding was committed to projects other than transit in the region. For the most part, however, state and federal funds flowing to transit are not available for a broad range of other purposes. The investment and attendant benefits would be forgone in most cases if the investment were not made in transit.

Fuel Tax Revenues. On the revenue side, reductions in automobile use from current or projected levels would likely result in reductions in personal vehicle-related taxes and fees, and revenues derived from vehicle use, most importantly gasoline taxes.

Cost Avoidance. Increased transit investment and use affects government fiscal condition in other ways. To the extent that increased transit use leads to reduced incident and accident frequency and severity, the public sector costs associated with safety enforcement, the judicial system, and emergency services might be expected to decline, with some potential for reductions in associated fixed capital costs in these areas as well over the long term.

Among the most interesting effects of increased transit investment and use now being explored more rigorously are changes to government costs for other public services as a result of improved or expanded transit. Increasingly, it is being demonstrated that improved access to services, commerce, and employment may, in fact, reduce public expenditures in several program areas such as health, education, and social services, where rising costs and/or declining levels of service are placing extraordinary stress on state and local budgets.

Enhanced access to health care and related services may improve the health of residents generally and the health of specific segments of the population that place the greatest demand on the public health care system. Government, business, and private costs of care may decline, and the productivity of the work force may improve. A similar hypothesis can be offered for improved access to education, with a presumed increase in the quality of the labor force with resulting increases in labor productivity and overall employment. Finally, improved access to employment opportunities for workers may also have a potentially significant impact on government revenues and expenditures. These kinds of effects, i.e., cost avoidance in other public service sectors, are rarely considered or evaluated in assessing the economic benefits and costs of transit.

- In the Flint, Mich., area, aggressive efforts have been made to consolidate all government-funded transportation including transit, human service agency transporta-

tion, and school transportation, in recognition of the significant cost savings that can be achieved in school districts and human service agencies.
- In Miami, Fla., Metro-Dade monthly passes have been sold to Medicaid agencies as a substitute for separate Medicaid agency transportation services costing $15 per client trip. Medicaid agencies realize significant saving, transit revenue and ridership is increased, and Medicaid clients are able to travel anywhere, anytime.

Construction and Building Activity Impacts on Fiscal Capacity

Public Expenditures. Increased transit investment and use is presumed to lead to an increase in construction and building activity supported by public capital budgets and expenditures. The capital investment in transit will lead to increased requirements for financial support for operations and maintenance as well. It will also lead to an increase in debt burden, assuming that much of the capital investment will be supported by bond sales, as is typical for major capital investments and procurements. Finally, an increase in transit capital investment and/or construction is likely to involve a change in the mix and amount of government transfers, i.e., state and federal funding, coming into the region.

A strong relationship exists between the capital cost of transit improvements and the continued operating and maintenance costs associated with those improvements. Particularly in the case of expanded transit service, operating and maintenance costs will rise. Considerable evidence suggests that these operating and maintenance costs and resulting state and local government fiscal liability have been systematically underestimated in the past. These transit costs may or may not be balanced by a broader accounting of benefits including avoidable costs to government in other functional areas. However, when looked at independently, these long-term operating costs are significant and represent a potential "disbenefit" in the overall effort to estimate the effect of increased transit investment and use on government fiscal position.

Land Use Organization Impacts on Fiscal Capacity

The relationship between transit investment and use, and economic activity is complex. Accessibility affects land development decisions which, in turn, affect the value of underlying real estate and, therefore, real estate taxes. Changes in accessibility also affect existing and potential labor force availability and, as a result, long-term business location decisions.

Density and Mix. The effects of transit on land use are most pronounced in the case of high-capacity, fixed-guideway transit. Land use patterns in the vicinity of new or enhanced transit services is a matter that is determined to a considerable degree by local goals and policies reflecting the desirability of more intense or dense development by adjacent property owners. Where added development, density, mix, or changing character is considered undesirable and is constrained through zoning and related land use and development controls, and/or community resistance, little, if any, land use reorganization is likely to occur. Under these circumstances, little in the way of land use-related fiscal impacts of any consequence can be expected from the effects of transit. If, however, intensified development is desirable and not constrained, there is evidence that proximity to major new or expanded transit services can induce market changes of significant magnitude to make more intense development economically feasible from a private financial standpoint. Supporting policies, land use controls, or direct incentives can heighten this response significantly.

Both local governments and transit agencies can realize economic gains from enhanced access to transit. For local governments, real estate taxes rise because of higher development densities and higher land values. Increased density also requires less in the way of both transportation infrastructure and other supporting urban infrastructure, compared to areas with lower density. Reduced infrastructure requirements result in reduced costs to government. For transit agencies, economic gain can result from the sale of excess land or the lease of development rights over transit station facilities.

Pace of Development. In addition to the effects of changing development density and land use mix, increased transit investment and use has been shown to be a factor in accelerating the pace of development in specific markets and settings. While the extent of this effect is, again, dependent on the nature of supportive (or constraining) development policies, an accelerated pace of buildout and lease-up of space acts to increase the net present value of the development, accelerating private revenues subject to taxation, and accelerating assessment and collection of related property taxes. Improving the revenue flow not only enhances the budgetary posture of government, but in so doing, may have an indirect positive effect on the debt burden by lowering the costs to borrow funds to support any of a range of public undertakings.

A number of fiscal impact models, techniques, and tools are available to expand the scope of analysis to address the effects of transit investment and use on nontransportation programs and budgets. Several recent studies have attempted to quantitatively assess the impact of a transit investment on various aspects of the fiscal position of local or state governments.

- It is estimated that tax revenues in Northern Virginia will grow to $1.2 billion (net of the government's contribution) for the period 1978–2010 because of Metrorail (KPMG Peat Marwick, 1994).

- The Philadelphia region and state of Pennsylvania were estimated to lose $88 million annually if rehabilitation of the SEPTA systems was targeted to only half of the current system over the next 5 years (The Urban Institute and Cambridge Systematics, Inc., 1991).
- In the Chicago region, government revenues were projected to decrease $86 million in 2014 if current transit funding levels were continued, while revenues would increase $148 million annually under a scenario of transit expansion and investment (Cambridge Systematics, Inc., 1995).

Character of Development. Finally, additional changes in the character and pattern of development associated with increased transit investment and use, i.e., more active, "livable," pedestrian-oriented, comfortable, aesthetically enjoyable places and spaces, can be assumed to add value to the property in question as well as surrounding properties, thereby increasing tax revenues.

TRANSIT AND PRIVATE SECTOR PRODUCTIVITY AND COMPETITIVENESS

Figure 11 indicates key linkages between transit investment and use, and changes in gross regional product (GRP), i.e., a measure of the value of regional production and private sector productivity. While it can be shown that in the long term, changes in transit investment may lead to increased GRP, changes in productivity as a result of transit investment are more difficult to examine. Increases in transit investment may have the following impacts on businesses:

- Lower cost and time of travel for employees;
- Improved accessibility of the labor force to business and vice versa; and
- Support for a greater density of business development, increasing the attractiveness of the region to new business.

The translation of these impacts into productivity increases may not be readily apparent. For example, if transit shortens commuting time, this may not appear directly in measured output, as individuals are likely to report to work for the same number of hours. Improved labor force access, however, may provide productivity increases through the ability of the business to change its labor mix, i.e., attract a more productive labor force, and thus to lower unit labor costs. Lower unit labor costs may attract more businesses and population, so that as the region grows, future GRP is likely to exceed levels from before the transit investment, accounting for inflation. The long-term impact on productivity, however, is indeterminate and these effects are widely variable across industries. For example, labor-intensive businesses and industries may benefit more directly from increased transit investment and use than capital-intensive industries.

The methods currently in use to analyze the impact of infrastructure investment on productivity generally focus on the benefits to business, as measured by the impact on pro-

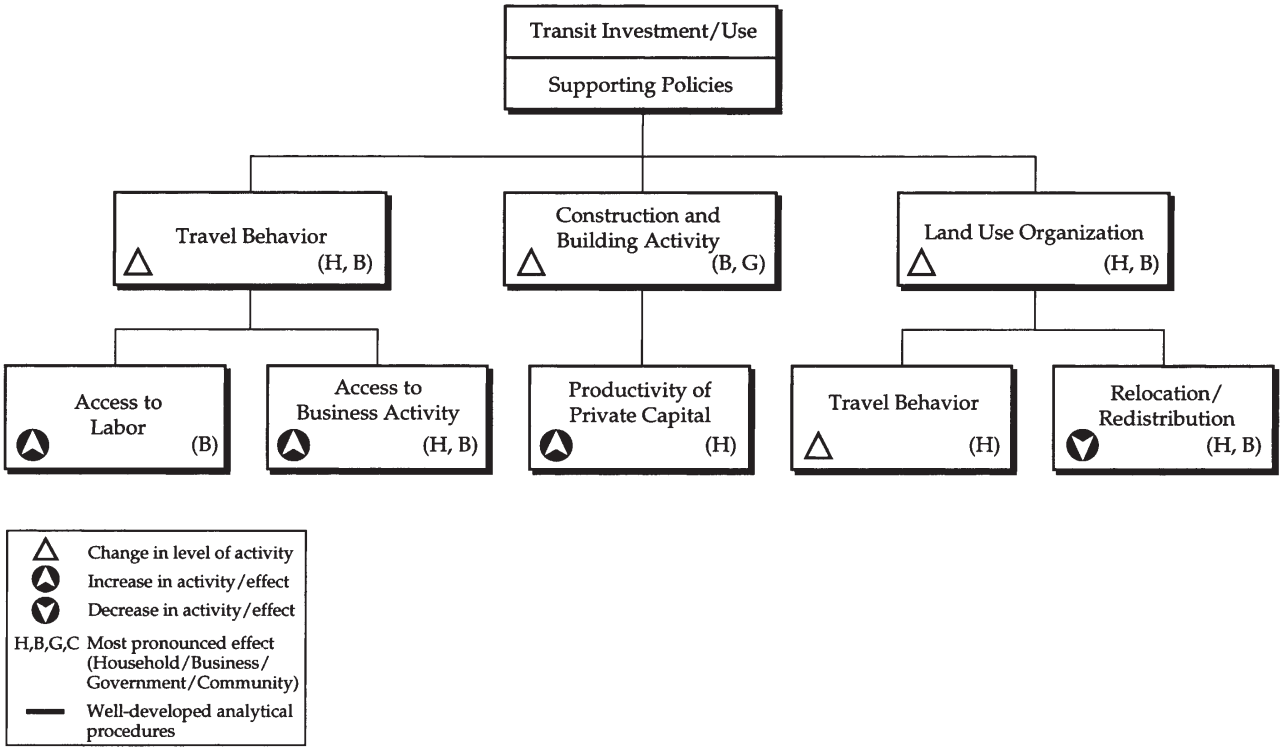


Figure 11. Economic productivity/competitiveness overview.

duction or the cost of production. The primary benefits of transit include accessibility of businesses to a broader labor pool and, conversely, access of workers to additional employment opportunities. The improved accessibility is associated with reductions in travel time and, hence, reductions in transportation cost.

Similarly, transit investment and use provides improved access to business activity. This may take the form of increased demand for regional goods and services in industries such as tourism and the retail and commercial sectors. It may also manifest itself in improvements in the provision of services. These changes can improve the competitiveness of regional firms and, hence, result in a positive influence on economic activity and regional product.

TRANSIT AND SAFETY AND SECURITY

The enormous economic loss that is associated with traffic fatalities, injuries, and property damage is among the motives for improving transportation safety. In addition, emerging concerns over personal security throughout the transportation system have arisen. Threats to personal security, in turn, impact levels of use, public expenditures to mitigate real or perceived security problems, and property values in areas that may be less safe or secure due, in part, to characteristics of the local transportation network.

Six subcategories of safety-related transit benefits and/or disbenefits were noted in Figure 5. Of the six, rider safety and health, and personal security at the rider and neighborhood levels might be expected to vary significantly across modes.

Figure 12 illustrates basic linkages between increased transit investment and use, and safety and security concerns considered to be of major economic consequence. The authors expect increased transit investment and use to result in reduced traffic accidents of all types. At the same time, real and perceived threats to personal security for riders and at the neighborhood level may change as a result of increased availability and use of transit.

Accident Experience and Exposure

Considerable documentation shows that accident, injury, and fatality rates for users of public transit are lower than for users of private motor vehicles. Decreases in actual accident exposure and incidence can be translated into economic effects in various ways. Many cost factors and measures of accident incidence, frequency and severity are used in analyzing these effects.

In general, traffic accident costs fall into three categories, all focused on the health effects of crashes: (a) medical treatment, property damage, and emergency services costs; (b) lost productivity and/or wages for households and employers; and (c) administrative costs. In a prior analysis conducted for the Office of Safety and Traffic Operations of the Federal Highway Administration, The Urban Institute estimated the following comprehensive costs for police-reported crashes (The Urban Institute, 1991):

• Fatality	$2,723,000
• Incapacitating Injury	229,000
• Nonincapacitating Injury	48,000
• Possible Injury	25,000
• Property Damage Only	4,500

In addition to the traditional examination of health effects, however, other economic consequences can be expected from changes in the frequency and severity of traffic accidents. Insurance and repair costs may decline with reductions in accidents for both households and businesses. Incident-related traffic delays might be reduced for travelers regardless of mode. Similarly, both capital as well as operating and maintenance costs for government might be expected to decline with a reduction in traffic crashes, incidents, and related damage.

Finally, both ridership and public support for transit has been shown to increase in part as a function of reduced accident exposure and experience. These reactions produce added operating revenue from fares on the one hand, and enhance the prospects for increased public financial support for both capital and operations on the other.

With real and perceived increases in safety for transit users and nonusers, both transit ridership and general levels of public support might be expected to increase, resulting in potential increases in revenues to operating agencies.

Personal Security

The impacts of public transit on the broader issue of personal security are far less clear than transit's effects on accident exposure. Two dimensions of personal security are important. The first involves travelers themselves. The second involves concern over the integrity of neighborhoods made more accessible by increased transit services.

Traveler Effects. Automobile drivers and passengers generally perceive themselves to be secure in their private vehicles; transit users and nonusers are typically less confident of the personal security in and around transit facilities and systems. Much of the data on perceived levels of personal security around transit facilities and services, however, tends to overstate the risk when contrasted with data about actual incidents of antisocial behavior or assaults. If the threats to personal security associated with a transit facility are, in fact, real, and based on actual incidents and patterns of behavior and activity, there are the added economic consequences of personal injury, in terms of health effects.

In addition, economic impacts can be associated with varying levels of public support, ridership response, and the

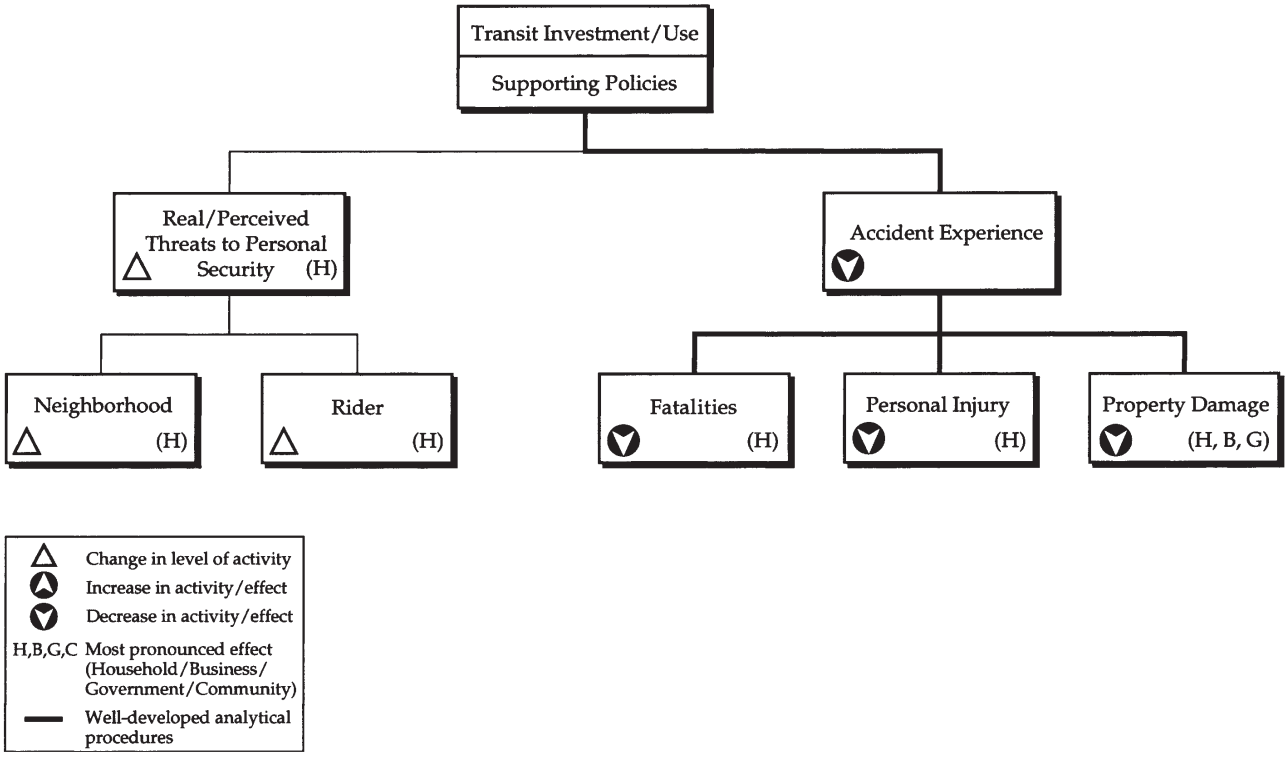


Figure 12. Safety and security overview.

level of expenditure required of government to ensure personal security. With threats to personal security, operating revenues may decline and additional government expenditures will be required to fill the gap. Security expenditures, including labor, might also increase as well, raising operating and maintenance expenditures further. Somewhere in this cycle, service levels are likely to be reduced to minimize the added costs to government, with the repeat effect of further reducing ridership and revenues.

Neighborhood Effects. At the neighborhood or community level, increased access via public transit is sometimes associated with increased intrusion by nonresidents whose presence and behavior may be in some way undesirable or disruptive. This attitude and belief has been associated with broad negative attitudes based on socioeconomic status, race, and ethnicity. While difficult to document, concerns over effects on property values, predominantly in high-value residential neighborhoods, have been alluded to in several areas during consideration of transit expansion alternatives. These perceptions, however, run counter to a large body of evidence indicating that the value of residential property in the vicinity of high-capacity, fixed-guideway transit facilities, in fact, increases.

Major urban rail transit agencies are undertaking increasing analysis of safety and security concerns. There is far less information on the perceptions and facts related to personal security associated with regular route bus services and facilities. One recent study of public opinions in Greensboro, NC, identified two important findings that are considered broadly representative:

- Regular transit patrons and nonusers have widely varying perceptions, with nonusers perceiving two to four times the problem around the bus system as do frequent users; and
- Areas around the bus system rather than the system and facilities themselves are seen to be a problem, i.e., a somewhat larger community-based security issue.

CHAPTER 3

MEASURING AND VALUING THE ECONOMIC IMPACTS

ANALYZING THE LINKAGES

The current ability to estimate relationships and predict or forecast the value of transit benefits and disbenefits varies considerably. With respect to assessing the long-term, regionwide economic impacts of transit investment and use, a wide array of analytical tools is available. These vary considerably in technical complexity, data requirements, and suitability for use in varying settings and conditions.

While no single analytical approach fully combines measurement of all the economic factors and impacts identified above, progress is being made on techniques that incorporate a broader range of key economic causes and effects. Some of these techniques involve the use of simple "spreadsheet" analysis that is designed to estimate changes in overall travel costs and their impact through the economy. On the opposite end of the spectrum in terms of complexity are analyses that link several types of sophisticated computer models and cover a broad array of the economic impacts outlined above.

Figure 13 lists the general types of analytical tools that may be employed in making a comprehensive assessment of transit's long-term, regionwide economic impacts. How these emerging analytical techniques are applied and findings from selected recent analyses are highlighted below.

Transportation Models

Three main types of traditional transportation models are central to the assessment of transit's economic benefits and disbenefits, travel demand models, transportation cost analysis techniques, and transportation sketch planning and impact spreadsheets.

Travel Demand Models. Forecasting or modeling future travel demand is essential. If the transit investment being considered does not change travel patterns, then almost all other impacts from the investment will be reduced in magnitude. Travel demand modeling and forecasting techniques are well-established, highly sophisticated, and continuing to evolve. Virtually every metropolitan area utilizes traditional travel demand models to forecast future traffic growth.

Transportation Cost Models. Estimating the possible changes in user cost and total transportation costs is also a central step in measuring the economic impacts of transit investment and use on a regional scale. A variety of approaches ranging in sophistication are available to derive transportation cost estimates for users, nonusers, businesses, industry, and government. Among the most interesting and useful are emerging sketch-planning and impact "spreadsheet" models that have wide application where data and resource limitations are encountered.

Recently, a much simplified, spreadsheet sketch-planning procedure has been developed that allows estimates to be made of key measures of effectiveness for various transportation improvements. Separate spreadsheets have been developed to analyze: (1) transit system improvements; (2) highway capacity improvements; (3) carpool incentives; and (4) automobile-use disincentives. Each of the four spreadsheets provides estimates of several of the key measures included in more sophisticated analytical procedures described below:

- Benefits and costs to transportation system users;
- Annualized cost to public agencies;
- Effect on total transportation costs;
- Change in emissions for hydrocarbons, carbon monoxide, and nitrogen oxides; and
- Change in gallons of motor fuel consumed.

The spreadsheets take into account the following effects:

- Discounting of costs and benefits over time;
- Congestion-related effects of changes in vehicle-miles of travel on speeds;
- Induced (or disinduced) traffic occurring as a result of changes in highway congestion levels;
- Effects of speed on automobile and truck emissions and fuel consumption; and
- Benefits to travelers resulting from increased trip-making due to travel time and cost savings.

Sample applications of the spreadsheets have been made on hypothetical investment options as well as for a set of

Transportation Models and Methods

- Travel demand model systems
- Transportation cost models

Intermediate Economic and Land Use Models and Methods

- Descriptive techniques
- Quantitative methods—statistical and other analyses
- Integrated land use/transportation models

Integrated Transportation/Economic Models

- CSI/REMI models
- Macroeconomic productivity models

Figure 13. Model and analysis typology.

alternative investments for the I-15 corridor in Salt Lake City, Utah. The results are contained in the Technical Report that was prepared as a companion piece to this document, and are also incorporated in the Participant's Notebook for National Highway Institute, Course number 15257, "Estimating the Impacts of Transportation Alternatives," dated May 1995.

The emergence of both highly sophisticated analytical techniques like those described in the sections that follow, as well as simpler sketch-planning and spreadsheet applications like those featured in the recent National Highway Institute (NHI) course, offer interested agencies, decision makers, and stakeholders a new battery of tools for estimating long-term, regionwide impacts of alternative transit and transportation investments.

Intermediate Economic and Land Use Models

Intermediate economic and land use models attempt to estimate a number of specific impacts independently or in limited combinations. The analysis techniques are described as *intermediate* because they stop short of summarizing the full range of possible impacts. Among the most significant factors analyzed are the effects of transportation investments on land values, housing values, commercial property values and lease rates, development intensity, household and business location, business sales revenues, business costs, business access to labor, cost of living, and tourism.

Integrated Transportation/Economic Models

Integrated analysis of transportation and economic impacts involves techniques that allow broad summaries of combined impacts and effects. Typically these kinds of analyses involve a combination of more traditional modeling and forecasting techniques, linked with impact estimating techniques. These modeling systems and analyses can be designed to chart or forecast regional, state or national activity and consequences. Figure 14 contrasts these types of analyses, highlighting the steps typically involved in federally-sponsored, corridor-level "Alternatives Analysis" or "Major Investment Studies," the steps involved in a broader, integrated analysis at the regional level, and the approaches being used in macroeconomic analysis of infrastructure investment impacts at the national level.

The first row of activities in Figure 14 illustrates the procedures applied to transit alternatives analysis (AA) and now to major investment studies (MIS) for all modes. The focus of these studies, which are generally for an entire corridor, is on linking changes forecast in travel demand and usage for each option to agency and user costs, total transportation costs, and what is termed intermediate land use and economic impacts. The land use and economic impacts are described as intermediate because the focus has almost always been on the proximity impacts of transit improvements—those impacts occurring in the vicinity of stations or in the corridor, rather than on overall impacts on land use or economics for the region due to the major investment.

There have been numerous alternatives analyses and major investment studies, and these procedures account for the vast majority of activity devoted to analyzing transit benefits and disbenefits. The characteristic of this approach, when applied properly, is a step-by-step evaluation of the items in each of the four boxes, where all information is developed consistently. The emphasis has historically been on the first two boxes—travel demand and transit agency and user costs, although much more attention is now devoted to extending such studies to total transportation costs and to intermediate land use and economic impacts. Methods for dealing with total transportation costs have been given somewhat short shrift and are treated in much more detail in the CS/REMI framework illustrated in the second row.

The CS/REMI framework shown in the second row provides a more comprehensive and regional perspective on total transportation costs and overall economic indicators such as business sales and personal income for a region. In this approach, systemwide or network total transportation costs are developed for each option and these costs are then used in an overall regional economic model, usually the REMI model, to develop an iterative and year-by-year fore-

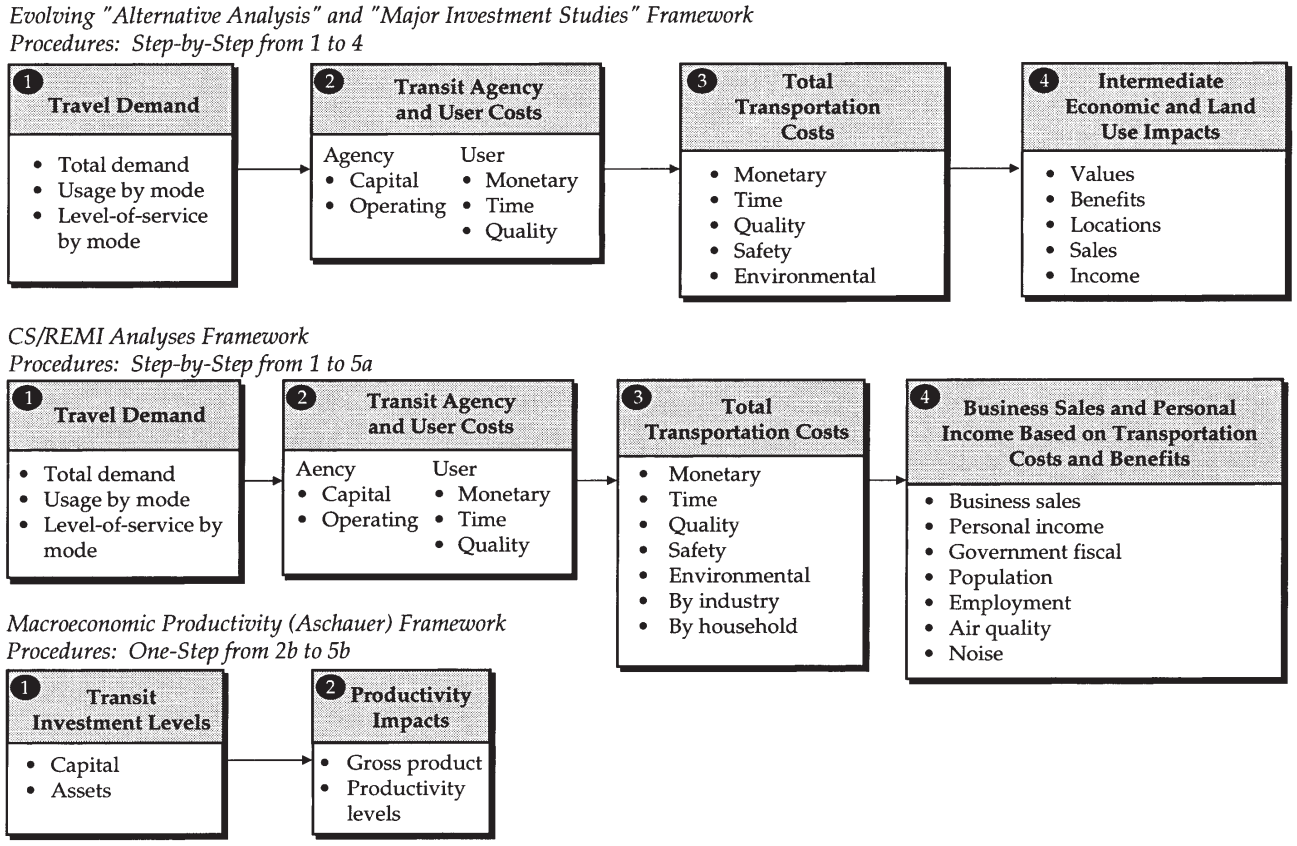


Figure 14. Analytical framework.

cast of economic conditions associated with each transportation investment alternative. This type of analysis is most appropriate at the regional or state level for alternative investment programs, although it is also applied to large, individual projects. In contrast to the AA/MIS process, the CS/REMI methodology in the second row will capture a more complete picture of overall benefits and disbenefits. Costs of using the CS/REMI methodology are not necessarily higher than the major investment study approach, since in both approaches, variations in level of detail can more than make up for the comprehensiveness of coverage.

The third row illustrates the macroeconomic productivity approach, associated with David Aschauer but also the subject of extensive research by other economists. In this approach, investments in infrastructure are directly associated with changes in productivity or cost functions for industries. Intermediate numbers for agency and user costs are not produced directly in these methods. Rather, the relationships developed are between investment levels and the most broad measures of economic output. These methods currently cannot differentiate by type or location of transit expenditure, so they are most appropriate for a determination of whether investment levels have been associated with weak or strong impacts on overall economic performance.

Each of these three major analytical frameworks makes a substantial contribution to knowledge about transit benefits and disbenefits at a particular level of detail. The first two approaches will tend to become more and more similar as progress is made towards automating the linkages between each of the boxes. Research sponsored by the federal government and conducted by Cambridge Systematics, Inc. is now developing the necessary linkages between the procedures.

Areas of Emerging Analytical Interest

While these analytical techniques are continually being improved, additional steps are being taken to enable broader analysis of the economic impacts of transportation investments. For example, because the value of travel time and transportation options varies from one person to another, efforts are underway to define and analyze the *overall quality of the travel experience* in terms that are of greatest importance to travelers. This approach involves a host of travel characteristics and analysis of the customer's willingness to pay for various combinations of attributes that reflect comfort, convenience, and reliability, as well as more traditional cost and time factors.

Other efforts are underway to better assess the *interrelationships of transit and highway services*, particularly in congested urban corridors. This notion is being expanded further in research to develop techniques to better analyze *multimodal transportation options* on a comparable basis rather than analyzing each independently, e.g., new rail services, bus service expansion, high-occupancy vehicle (HOV) facilities, highway expansion, tolls on existing highways, travel demand management measures, bicycle facilities, and transit fare changes.

Finally, new approaches are under development to better assess what analysts call *cross-sector* benefits of transit investment. These include measures of the extent to which expenditures on transit may benefit other sectors of the economy, e.g., education, health and welfare, business and industry, etc.

INTEGRATED INVESTMENT ANALYSIS: A PROMISING NEW APPROACH

Among the array of techniques that are available to expand the assessment of transit's long-term, regionwide economic impacts is an approach that can be described as "Integrated Investment Analysis." Figure 15 provides an illustration of the factors and techniques that can be incorporated into such an analysis. The findings from two recent applications of this emerging analytical technique are highlighted below.

Summary of Findings from Philadelphia and Chicago

There have been relatively few comprehensive, integrated analyses of the long-term, regionwide economic impacts of increased transit investment and use. Philadelphia and Chicago, the two analyses that have been completed in the last 5 years, however, have generated positive findings that have been influential in broadening legislative, business community, and public support for transit investment.

The ability to measure the broader, long-term economic benefits and disbenefits to both the metropolitan region and the state of alternative levels of transit investment has advanced the debate over transit's importance beyond the simple review of ridership statistics, access to central cities, and transit's social service function. The analyses done in Philadelphia and Chicago expand the analytical ability far beyond these limited areas and demonstrates dramatically that transit investment and use provide substantial and lasting economic returns.

Integrated Investment Analysis of SEPTA in Philadelphia. In Philadelphia, four transit investment scenarios were defined. The baseline involved rehabilitation of the Southeastern Pennsylvania Transportation Authority system (SEPTA), and continuation of existing services. The alternative investment and service options involved varying levels of reduced investment and service reductions over specified time frames. The most conservative of these was a 50 percent reduction in service over 5 years, with investment directed to rehabilitate only that portion of the system that was presumed to remain in service.

In comparison to the alternative of fully rehabilitating SEPTA, the cumulative loss to the metropolitan area and the state through 2020 from a 50 percent reduction in service over 5 years was estimated to include:

Business Sales	Reduced $2 billion annually (1990 dollars) in the metropolitan area; Reduced $500 million annually (1990 dollars) to the rest of the state;
Employment	Reduced 26,000 annually in the metropolitan area; Reduced 4,000 in the rest of the state;
Personal Income	Reduced $1.1 billion (1990 dollars) in the metropolitan area; Reduced $300 million (1990 dollars) in the rest of the state;
Population	Reduced 58,000 in the metropolitan area; Reduced 7,000 in the rest of the state;
Government Finance	Combined state and local tax revenue would be reduced $88 million (1990 dollars).

Benefit/cost analysis was used to assess the net public benefits of the reduction scenarios relative to the base rehabilitation case. It compared the following elements:

- The economic "benefit" of reducing or eliminating SEPTA, which would be the savings in public spending to rehabilitate SEPTA and continue services; and
- The economic "cost" of reducing or eliminating SEPTA, which would be the loss of personal income due to contraction of the state economy as a result of the degraded transportation system.

The benefit/cost analysis showed that investment in SEPTA facilities and services at the levels of the proposed 10-year capital program would have substantial economic benefits that far outweigh the public subsidy costs for the residents of Pennsylvania. It specifically showed that rehabilitation and continued operation of SEPTA would return $3 to the region and state for every dollar spent on SEPTA, just in transportation benefits alone. In terms of total economic impact, the return to the region and the state would be over $9 for every dollar spent on SEPTA. Fully rehabilitating SEPTA, and continuing to operate SEPTA services, thus was found to have a very high economic payoff for the region and for the state of Pennsylvania as a whole.

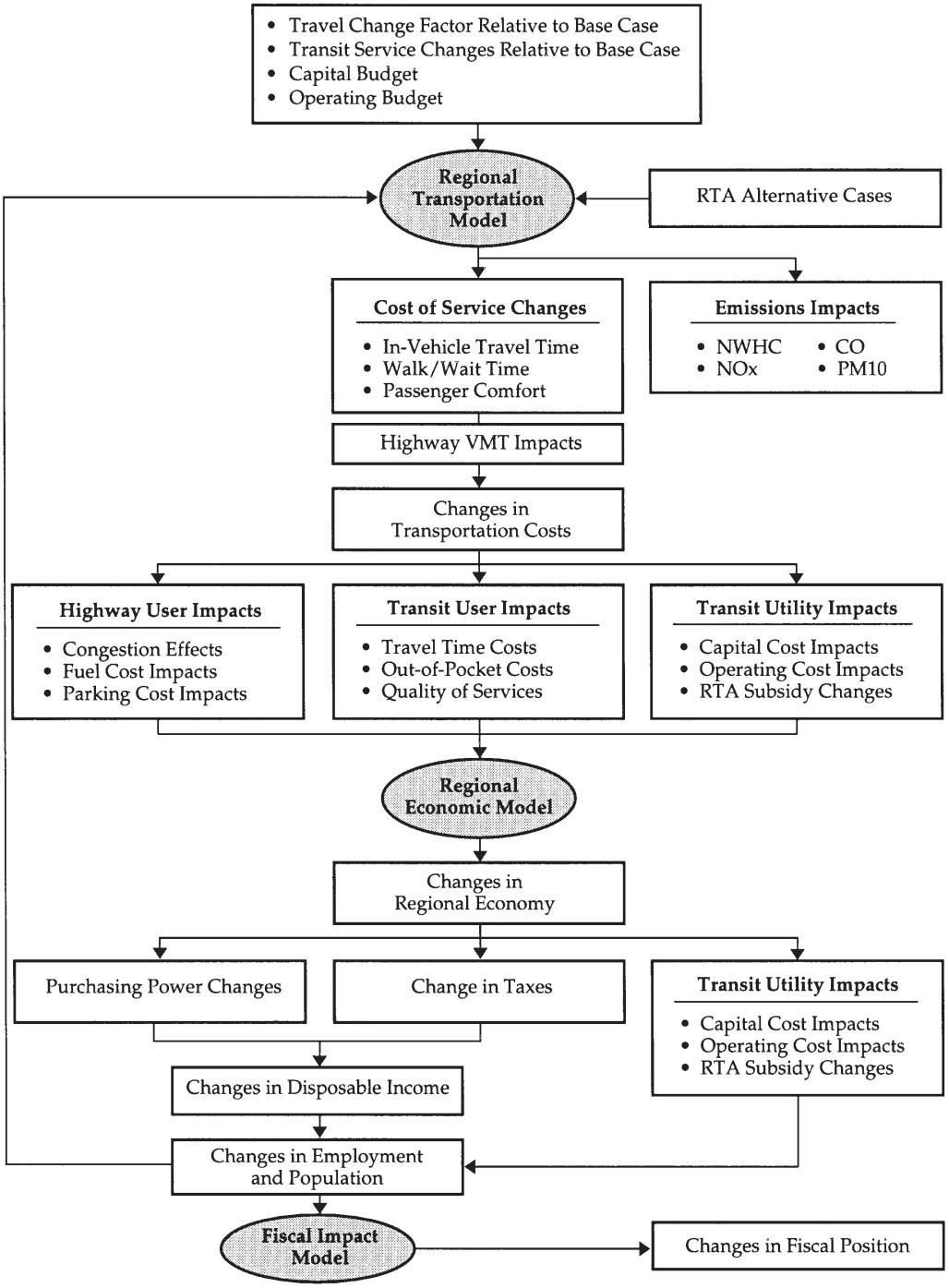


Figure 15. Integrated modeling and analysis approach.

Integrated Investment Analysis of RTA in Chicago. For Chicago, a similar analytical approach was used for an analysis of the RTA system, including the development of four alternative investment scenarios, use of regional transportation models to forecast changes in travel and associated costs, and analysis of the impacts of these changes through a regional economic model and a fiscal impact model.

The development of alternative scenarios was done somewhat differently than in the SEPTA case, however, and included a system expansion scenario. The baseline for the Chicago RTA analysis was a "Baseline/Deterioration Scenario" that assumed that funding for the RTA system would continue at current levels over the 20-year analysis period. The scenario assumed no additional funding,

upgrading, expanding, or improvement of services or facilities beyond current plans. The baseline scenario, therefore, represents an erosion of the current system and of the quality of service and operation over time, with a loss of market share (ridership) by public transportation as the lack of new investment results in continued system disrepair and deterioration.

Alternative investment scenarios included a "Disinvestment Scenario" in which funding would be provided at an even lower rate, and a "State of Good Repair Scenario" in which investment would be provided to ensure the upkeep of essential system components and reliable operations at current levels. The outcome of the analysis clearly showed that trying to "save money" compared to the baseline of current investment had enormous negative economic consequences, while the increased investment scenarios showed very positive impact. The State of Good Repair Scenario yielded the following economic benefits to the Chicago region and the state of Illinois:

Business Sales	Increased by an annual average of $5.0 billion (1994 dollars) in 2014 for the metropolitan area, compared to a *decrease* of $2.6 billion for the disinvestment baseline scenario in 2014. Increased by an annual average of $331 million (1994 dollars) in 2014 for the rest of the state, compared to a *decrease* of $171 million for the disinvestment baseline scenario.
Employment	Increased by 36,000 in 2014 for the metropolitan area, compared to a *decrease* of 25,000 for the disinvestment scenario. Increased by 4,300 in 2014 for the rest of the state, compared to a *decrease* of 2,300 for the rest of the state for the disinvestment baseline scenario.
Personal Income	Increased to an annual average of $3.1 billion (1994 dollars) in 2014 for the metropolitan area, compared to a *decrease* of $1.8 billion (1994 dollars) for the disinvestment baseline scenario in 2014. Increased to an annual average of $168 million (1994 dollars) in 2014 for the rest of the state, compared to a *decrease* of $96 million for the disinvestment baseline scenario.
Population	Increased 91,000 in 2014 for the metropolitan area, compared to a *decrease* of 55,000 for the disinvestment baseline scenario. Increased 7,300 in 2014 for the rest of the state, compared to a *decrease* of 4,100 for the disinvestment baseline scenario.
Government	Increased revenue and expenditures by $148 million in 2014, compared to a *decrease* in revenue and expenditures of $86 million for the disinvestment baseline scenario.

Like the SEPTA analysis, impact estimates were made iteratively for each succeeding year of the analysis period. From this annual information, it is important to note that the majority of the impacts occur in the latter years of the analysis period. This raises a critical issue for decision makers and other transportation stakeholders, i.e., how to fully consider longer-term impacts—in this case, substantial economic benefits—in a decision-making environment that has historically been focused on annual budget cycles and typically characterized by the threat of recurring deficits and a reluctance to increase taxes or raise public revenues.

Additional Findings from the Philadelphia and Chicago Analyses. Both the SEPTA and RTA studies also covered emissions, energy consumption, and impacts on the mobility levels of special groups. In addition, the studies used fiscal models to determine the impacts on government finances at the state and local levels. Emissions and energy consumption were reduced by higher transit investment levels, and increases in government revenues associated with transit-induced economic growth provided additional benefits.

By reviewing the SEPTA and RTA analyses, conducted using similar techniques, it can be concluded that for metropolitan areas with extensive, mature transit systems and services, there is substantial long-term economic payoff to both the region and the state in keeping those systems fully operational and in a good state of repair. It also can be concluded that, based on the Chicago example, further expansion of the systems may provide positive economic returns to both the region and the state.

What has yet to be assessed in a comparable way, however, is the scope and scale of regional and statewide economic returns for investing in major system expansion where existing systems and services are not as extensive or well-established. This focus was therefore recommended for case study analysis as a follow-up to the current effort.

CHAPTER **4**

SUMMARY AND CONCLUSIONS

The work carried out under the H-2 project has led to a number of findings and conclusions that are important to both decision makers and analysts seeking a better understanding of the broad economic consequences of transit availability and use. The most significant of these are highlighted below:

■ **Transit is increasingly perceived as a service that directly and indirectly influences how effectively the community achieves its broad goals.**

Public transportation services and the rationales for investing in public transportation continue to evolve. Viewed in broad terms, transportation investment decisions made at the federal, state, and local levels have tended to support consistently the notion that the benefits of increased availability of and use of transit outweigh the disbenefits.

The ability to measure the magnitude of transit's benefits and disbenefits, however, remains uneven and incomplete for several reasons. First, the objectives that transit is expected to serve are varied, have increased in number, and are sometimes poorly defined and conflicting. Second, the markets for which transit services are designed vary substantially, adding to the difficulty of calculating and "netting-out" benefits and disbenefits. Third, there is uneven data on the broad range of consequences flowing from transit investment. And, finally, there are a number of technical, analytical difficulties that arise in the effort to link and sum the causes and effects of transit investment and use. Nonetheless, public transit has become inextricably linked to the pursuit of an improved quality of life whose major dimensions are economic growth and prosperity, enhanced environmental quality, and improved personal safety and security. The mobility and access provided by various transit services tends to enable progress on each of these fundamental fronts.

■ **Techniques for assessing the economic impacts of transit investment and use are not as well developed as techniques for assessing other, related transit and transportation impacts.**

The ability to measure the environmental and safety impacts of transit is far more advanced than the ability to assess transit's broad-based, communitywide economic impacts. Similarly, the ability to forecast short-term impacts of alternative transportation investments is far greater than the ability to forecast long-term effects. In addition, more precise analytical procedures are available to assess the impacts of repair and rehabilitation of existing infrastructure than are available to assess the impacts of expanding the capacity of infrastructure, where the question of alternative courses of action are more complex. Finally, the analytical tools available today are more reliable in dealing with discrete project-level and site-level effects and are less precise in assessing regionwide or statewide effects. Given these circumstances, the H-2 project focused on the application of improved techniques for assessing the long-term, regionwide economic consequences—benefits and disbenefits—of transit investment and use, as an area where the greatest value could be added to the current state of the practice in analyzing transit's benefits and disbenefits.

■ **There are promising approaches emerging with varying levels of sophistication that can improve the assessment of transit's long-term, regionwide economic impacts.**

Although the current state of the art is evolving rapidly, there are new, emerging options for conducting analyses of transit's broader economic impacts which vary considerably in their scope and sophistication. Among the most useful are

- Emerging sketch-planning and spreadsheet models that are driven by the outputs of widely available, traditional transportation demand and cost models; and
- Integrated transportation and economic models.

The former can be applied in a broad variety of circumstances, with limited data and resources, and somewhat limited but fundamental outputs. Sketch-planning and spreadsheet models allow analyses of traditional transit improvements, highway capacity improvements, carpool incentive programs, and automobile-use disincentives in terms of transportation user costs, public agency costs, total transportation costs, vehicle emissions, and fuel use. A multimodal spreadsheet model of this type was developed by Cambridge Systematics, Inc., and KT Analytics, Inc., and applied in a hypothetical evaluation of five investment options in Salt Lake City, Utah. The Salt Lake City analysis

was incorporated as a case study into a course offered by the National Highway Institute. The analysis produced a wide range of data on the costs and benefits of alternative investments, including transit improvements, and allowed the calculation of a cost/benefit ratio for each. Greater detail on the use of the multimodal spreadsheet model in the Salt Lake City case study is contained in the companion H-2 Technical Report available through the TCRP.

In contrast, the use of integrated transportation and economic models requires significant resources and considerable attention to data development, scenario specification, and data processing through the use of complex, computer models. This more sophisticated approach has been used recently in Philadelphia for the SEPTA system, and in Chicago for the RTA transit network. A similar analysis was begun in 1996 for the New York MTA transit network. The results of these analyses include annual and cumulative projections of population, employment, business sales, personal income, and government revenues and expenditures. These projections, in turn, allow estimates to be made of the dollar return to the regional and state economy for each dollar invested in the transit alternative being examined.

In Philadelphia, the analysis indicated that the economic return to the region and the state would be over $9 for every dollar spent to fully rehabilitate and continue to operate the existing SEPTA system. Similar conclusions with somewhat smaller dollar-for-dollar returns were reached in the Chicago RTA analysis. To date, however, no comparable analyses have been carried out to assess the long-term economic impacts of major expansions to urban transit systems, or of major transit improvements in new urban areas.

■ **The use of evolving multimodal spreadsheet models is best suited for communities and regions where transit plays a comparatively smaller role in serving regional travel needs, and where transit service is largely provided by bus and similar on-street shared-ride services.**

The spreadsheet approach to analyzing transit's economic impact in smaller, less transit-intense urban areas without fixed-guideway systems recognizes the facts that: (a) in these areas the economic consequences of transit investment may be subordinate to the social consequences; and (b) a significantly higher proportion of transit's economic benefits will flow from changes in user costs rather than from nonuser impacts on the economy as a whole. The spreadsheet models being developed and applied provide the quickest and least demanding analytical approach to assessing user costs and other impacts on the economy. In addition, neither the data nor the budgetary or staff resources needed to conduct a comprehensive, integrated transportation and economic modeling analysis are likely to be available in smaller urban areas.

■ **The use of more sophisticated integrated transportation and economic modeling procedures is best suited for larger communities and regions with mature multimodal transit networks where transit plays a significant role in serving regional travel needs, particularly during the peak hours when increasingly severe congestion occurs across major portions of the highway system.**

In urban areas where transit availability is well-established and service and use are relatively intense, the impact of transit on the broader economy is likely to be significantly larger than the economic impacts resulting from estimates of user costs alone, as suggested by the Philadelphia and Chicago analyses. In addition, analyses based on more sophisticated integrated transportation and economic modeling may be a critical step in engaging and demonstrating to a wide range of local, regional, and state leaders and decision makers that maintaining mature transit systems and services in a state of good repair is likely to be of major consequence to the regional and state economy. Finally, major urban areas with mature regional transit networks are likely to have available both technical staff capabilities and the budgetary resources to conduct an analysis of this scope and complexity.

■ **The use of an integrated transportation and economic modeling approach to assess the economic consequences of significant additions to regional transit capacity have not been attempted to date, but will be increasingly useful, if not critical, in supporting efforts to establish new, high-capacity regional transit systems and services in the face of competing transportation and other public service needs.**

In urban areas that have undertaken construction of major new transit systems and services in the last three decades, there is generally an opinion that the investment in transit has benefited the region. Yet there are also analyses that have purported to show that these investments in expanded transit capacity, most notably rail transit, have not fulfilled expectations, and that other courses of action might have been preferable.

Although the Philadelphia and Chicago analyses strongly suggest that the former position is more likely to be correct, neither of these contrary positions has been informed by comprehensive analysis of long-term, regionwide economic impacts of new system development that could be provided through the use of an integrated transportation and economic modeling approach. Broader use of this analytical technique would shed important light on this unresolved argument and potentially assist in bringing more financial resources to bear in areas where major expansion of transit networks is under consideration.

APPENDIX A

POTENTIAL RESEARCH TOPICS IN MEASURING AND VALUING TRANSIT BENEFITS AND DISBENEFITS

In addition to the work on improving the analysis of long-term, regionwide economic impacts, there were several other topics identified that warrant some consideration. Each is listed and described briefly below.

VALUE OF TRANSIT AVAILABILITY: TRANSIT AS AN OPTION

Recent literature here and abroad suggests that "access" is the single most important objective of transportation systems and services, rather than mobility. This reflects the notion that travel is an intermediate or derived demand that arises out of the necessity or desire to conduct personal and business activities at a variety of sites and destinations. High levels of mobility do not necessarily reflect high levels of access to major destinations. In addition, it has been difficult to arrive at a sound, operational definition of mobility. The critical distinction is how well transit route structures generally serve major origins and destinations. That is, from the consumer's point of view, "Does it take me where I want to go?" The ability to access transportation services that, in turn, access major destinations is, therefore, a critical dimension of benefit and disbenefit (see Figure A.1).

A closely related issue is the importance of transit as an option for those who may not be transit dependent. A variety of recent events has graphically demonstrated the value of system redundancy and the value of balance among highway and transit travel options within metropolitan transportation systems, for example, earthquakes in San Francisco and Los Angeles, severe weather and climatic disasters in South Florida, the Midwest, and the East Coast, and the sudden absence of transit resulting from labor strikes and other disruptions. The measurement of and value assigned to "redundancy," "options," or "balance," however, are not well established or broadly applied. Significant advances could be made in this very basic subject area.

THE RELATIONSHIP BETWEEN TRANSIT, DEVELOPMENT DENSITY AND RESULTING TRAVEL DEMAND

The relationship among the high-density, mixed-use development, the intensity of transit services, and associated travel patterns has been the subject of a wide range of inquiry. The hypothesis borne out in most studies holds that higher density, mixed-use development supports, and is supported by, higher levels of transit intensity. The consequences include reduced vehicle trips and reduced trip lengths, resulting in lower emissions and energy consumption along with presumably positive changes in the physical character of the built environment.

Among the most recent analyses to address this set of issues is work done by Dr. John Holtzclaw in the San Francisco Bay area. In his analysis, he found that higher development densities in combination with high levels of transit service translate into reduced trip lengths such that 1 passenger-mile traveled on transit effectively substitutes for or replaces 8 passenger-miles of automobile use. Other sources have put the ratio at closer to 3 to 1.

The approach taken in the analysis represents a new means to gauge the value of the transit/single-occupancy vehicle (SOV) tradeoff and could be further developed for broader application in Phase II of the H-2 project.

THE RELATIONSHIP BETWEEN TRANSIT, CBD STRENGTH, AND REGIONAL ECONOMIC VITALITY

The relationship between transit intensity and the vitality of Central Business Districts (CBDs) and central cities is featured throughout the literature. Two factors make this relationship important. First, CBD-bound work trips are traditionally the largest travel market focused on a single destination. Second, it is during peak hours that highway capacity in corridors serving CBD-bound travel is increasingly unable to accommodate demand. In these circumstances, transit provides essential added capacity when it is neither possible nor desirable to expand the highway system. As a result, mode splits and ridership levels are typically highest in CBD corridors during peak hour.

Often, however, this relationship is downplayed because the largest travel market and the fastest growth in travel demand is in the suburbs. Both work trips and CBD-oriented travel are decreasing in relative significance in most metropolitan areas.

Planning literature has also examined the relationship between the vitality of CBDs and the overall economic strength of entire metropolitan regions, generally confirming the hypothesis that regions having strong CBDs exhibit

1. Transit Availability: Transit as an Option
2. The Linkage between Transit Intensity, Development Density, and the Characteristics of Associated Travel Demand
3. The Linkage between Transit, CBD Strength, and the Regional Economy
4. Regional Development Shifts vs. Net New Development Impacts
5. Cost-Avoidance Impacts of Transit
6. Impacts of Transit on Safety and Security
7. The Variable Value of Transit by Socioeconomic Group
8. Preferences and Attitudes: Transit Weights and Values from Market Research
9. Baselines for Benefit and Disbenefit Analysis

Figure A.1. Areas for additional Phase II research: better measurement of transit benefits and disbenefits.

greater economic strength which, in turn, is associated with an enhanced quality of life.

Neither the relationship of transit intensity to CBD vitality, nor the relationship of the health of CBDs to overall regional economic strength, has been examined thoroughly, however. Regional transportation planning would be better informed if a number of factors involved in these relationships were explored in greater detail. The ultimate objective would be to measure indirectly the role of transit in the strength of regional economies.

THE VALUE OF DEVELOPMENT SHIFTS VERSUS NET NEW DEVELOPMENT

Considerable evidence exists suggesting that transit services and improvements by themselves do not result in the creation of net new development within a region. In most cases, the factors affecting and influencing private development decisions are, in fact, too diverse and complicated to even allow conclusive analysis of this proposition. Yet it is apparent that the introduction of new transit services and facilities, particularly fixed-guideway systems, has coincided with major changes in development and the physical landscape immediately adjacent to station areas. These changes understandably are viewed positively, and are seen as a direct consequence of the transit investment by local officials.

Analysts, however, have been able to conclude only that this phenomenon represents at best a shift in development that would have occurred elsewhere in the region absent the transit investment. As a consequence, little effort has been made to examine the full value of these development shifts. Additional analysis and analytical techniques could be brought to bear on this issue from two perspectives. First, measurement can be improved in analyzing the impacts of transit availability and investment on existing and projected development markets. Second, improved analytical tools can be applied in evaluating the mechanisms that can maximize the positive development impacts of transit in the broader framework of community growth and development objectives.

THE LONG-RANGE, MACROECONOMIC IMPACTS OF TRANSIT

There is considerable conventional wisdom that in the long term, increased transit intensity—both availability and use—has broad economic value for the region. Limited analysis across countries and across major metropolitan areas has hinted that this notion is correct. Unique analyses in single regions have provided clearer evidence that the conventional wisdom is correct. Yet to date, no effort has been made to systematize this effect, nor to incorporate the results of systematic analysis of macroeconomic impacts into transit or multimodal transportation decision making.

In addition to questions surrounding actual analytical techniques and the ease with which they can be applied, there are questions to be examined concerning the extent to which this effect may vary according to the size of the urban area in question, the modes of transit available or under consideration, and the characteristics of the regional economy and population. One of the most urgent and fruitful areas for continued research in Phase II may be the examination of macroeconomic techniques that integrate multimodal transportation modeling with economic impact

analysis at the regional level, their application, and their potential results.

COST AVOIDANCE FROM TRANSIT

Recent analyses of the full cost of driving have identified areas within broad public budgets in which potential savings might be possible if reliance on personal vehicles was reduced. Some of the potential savings fall within traditional transportation-related governmental budget categories, e.g., traffic enforcement and adjudication, traffic-related public safety costs, etc. Other potential savings fall in areas that have only been associated rhetorically with transportation systems and services, e.g., health, education, etc. The prospect for significant public cost avoidance from increased provision and use of transit has not been examined in a systematic way.

Similarly, the availability and use of transit provides theoretical opportunities for cost avoidance by individuals, as well. This is particularly true for low-income and disadvantaged segments of the population. Transit availability may remove the necessity to buy and maintain a car, allowing disposable income to be used instead for improving basic shelter, food and health care. The cost-avoidance value of transit for individuals also has not been examined systematically.

REAL AND PERCEIVED SAFETY AND SECURITY CHARACTERISTICS

Traditional transportation statistics on accidents, injuries, and fatalities show public transit to be one of the safest modes of travel. In contrast, personal safety and security continue to be among the primary concerns of both riders and nonriders, reflecting fears that relate to the prospect of potentially threatening interpersonal encounters while on board transit vehicles or in transit facilities. Real and perceived threats to personal security recently have become a more frequently noted disbenefit associated with transit.

One reason for this phenomenon may be the high-profile reporting that is done on single events that statistically are not nearly as significant as they may appear when reported. The treatment of subway and bus accidents, as well as the horrifying nature of recent isolated subway shooting incidents has heightened public attention and prompted stepped-up responses from transit managers. To echo these public concerns, even the 1992 federal ISTEA legislation included first-ever requirements for transit security investments from federal formula funds (Section 3013(f)) and additional reporting by the U.S. DOT on safety conditions (Section 3026).

Significant increases in research are being undertaken to examine the dimensions of public perceptions of transit safety and security problems, the extent to which they are at odds with actual experience, and which types of actions by transit agencies might be most successful in reducing actual incidents as well as the perception of problems.

Much of the most sophisticated research is being done in the largest transit systems where concerns about personal safety and security are focused on subway and rail systems. This work goes well beyond the accumulation of traditional accident records, delving into areas that represent basic market research. Little has been done, however, to synthesize the varying approaches to data gathering, data analysis, or findings. Just as importantly, application of the results of recent work has been weak, based on the opinions of many staff members involved in the efforts. Phase II activity might, therefore, be directed toward a systematic review of survey instruments and data collection techniques, analytical approaches and procedures by which to use the analytical results to materially and perceptually improve the transit experience for both users and nonusers.

THE VARIABLE VALUE OF TRANSIT ACCESS BY SOCIOECONOMIC GROUP

Current analysis and evaluation techniques do not introduce meaningful information into the decision-making process on how the value of transit may vary among several types of transit markets. The most critical absence of data and measures in the decision-making process is in measuring the benefits and disbenefits of transit across traditional socioeconomic groups and demographic groups.

As an example, current measurement techniques assign variable monetary values of time saved (or lost) for work trips and nonwork trips. No distinction is made, however, between the value of a trip or time savings for varying socioeconomic groups. If the value is set strictly as a function of income levels, time savings and trips made by higher-income individuals and households would be valued more highly, i.e., of greater benefit, suggesting that services and investment be targeted at the wealthiest segments of society. In contrast, public policy in other areas provides for targeted assistance to low-income and otherwise disadvantaged individuals and households, i.e., the value of investment and service is inversely related to income.

While considerable research has been done on the social equity of various transit fare structures and systems, very little has been done to measure and reconcile the valuation of transit benefits broadly across socioeconomic lines. Recent demographic shifts and future trends strongly suggest, however, that this area be given additional attention in the transportation decision-making process, as well as in other areas of infrastructure investment.

Perhaps more importantly, concern for the mobility of disadvantaged and dependent segments of the population, and the actions to ensure that public transit is available to meet these needs, has not been traced through to or effectively linked to the more fundamental reasons for providing transit services. With the exception of requirements under the

Americans with Disabilities Act, the value and/or cost to society of ensuring that disadvantaged and dependent citizens have access to employment opportunities, job training opportunities, social services, health care, etc., is not being assessed or factored into transportation decision making at the present time. As a result, the implications for the provision and investment in a wide range of other public services and facilities are not being considered at a time when there is mounting urgency to increase efficiencies and reduce costs across all public services. An area that deserves increased attention is the linkages among transit services to disadvantaged and dependent persons, the long-term demand and cost of public services on which they most depend, and the role of transit in accelerating individuals' progress toward becoming fully productive citizens.

MEASURING PREFERENCES AND ATTITUDES TOWARD TRANSIT: ESTABLISHING AND APPLYING WEIGHTS AND VALUES IN EVALUATING TRANSIT IMPACTS

Despite recent analysis on the characteristics of personal transportation at the national level, the forces, dynamics, attitudes, and preferences of travelers at the local and metropolitan level are not well compiled nor well understood. Origin and destination databases are woefully outdated in most areas; on-board surveys of transit riders to track the characteristics and motivations of transit users are conducted on a limited scale and only intermittently, except in the largest transit systems. In short, the urban, regional travel market is not understood to the same degree that successful manufacturers or retailers understand their respective markets. Product design in the transit industry suffers accordingly, and with it, service utilization and cost-effectiveness.

A clear example of this mismatch and absence of information is the demand in major metropolitan areas among certain subgroups for jitney, gypsy cab, and related "private" small-vehicle services. This phenomenon reflects a ready market that is not being served effectively by the current transportation network. Market research practices and techniques, and the sustained application of improved market research data in transit and transportation planning and decision making are behind the times. Research to bring state-of-the-art private sector market research practices more into play may offer a relatively cost-effective way to enhance the customer-based examination of transit benefits and disbenefits. Progress on this front could serve multiple purposes. It might be viewed as a means to act on the expanded public-participation requirements of ISTEA. It also could provide a vehicle to introduce customer and citizen weights and values more directly into local planning and decision-making processes. Finally, it could provide an essential means to upgrade available data sources to support and speed enhancement of transportation modeling techniques.

APPENDIX B

LINKAGE DIAGRAMS FOR ANALYZING THE LONG-TERM, REGIONWIDE ECONOMIC IMPACTS OF TRANSIT

Empirical Versus Hypothetical Relationships. In each of the four major areas in which the long-term impacts of transit investment and use are being examined, a series of diagrams (Figures B.1. through B.10.) are presented that begin with a broad, general picture of the key relationships and linkages being posited, followed by somewhat more detailed diagrams tracing more specific causes, effects, and linkages between key variables. In many cases, these linkages have been empirically examined in various ways in the past. In the instances where analytical tools are most highly developed, the lines connecting variables and measures are shown in bold. In other cases, however, the analytical tools and approaches may be less well developed and the linkages are more hypothetical in nature. The connections in these latter cases are drawn more lightly.

Transit Investment and Use. Each sequence of relationships begins with a presumed increase in the level of transit investment and/or use. In addition, a "Supporting Policies" notation is included to signal that transit investment and use alone is not the sole determinant of the scale of the impacts that follow. To maximize the impacts charted in the diagrams requires not only increased transit investment and use, but also a wide range of public and private actions to ensure that those investments are as attractive to prospective users and as efficient to operate as possible.

Generic Second-Order Impacts. Increased transit investment and use is projected to have generic impacts of three broad types including changes in *travel behavior*, *construction activity*, and *land use organization*. (The scope and consequences of land use and development impacts of transit are being examined in greater detail in TCRP Project H-1, An Evaluation of the Relationships Between Transit and Urban Form, and are only addressed in general terms in the discussion that follows). Within each of the four major areas being examined, various linkages are repeated in the diagrams. There has been no effort in the linkage discussion itself to address or avoid double counting or the repeat listing of potential economic impacts. The focus has been on ensuring that the full range of major effects is incorporated wherever they occur for illustration purposes.

Economic Impacts and Outcomes. In each diagram and description, the concluding impact or consequence of the linkages is identified under the heading of "Regional Economic Prospects." This general heading is used to encompass the varying economic impacts as they may be viewed from an individual/household, business, government, or community standpoint. For the region as a whole, *gross regional product (GRP)* is used as an example of a fundamental measure; for the individual or household, (disposable) *income* is the basic measure; and, for business and industry, *business sales* and *profit* are the fundamental measures. For government, the ultimate economic impact is specified as *fiscal position*, meaning the relationship of public revenues and expenditures.

Positive and Negative Impact Indicators. Throughout the diagrams, up and down arrows are used to indicate the presumed or known direction of the effects in question. The arrows are not the result of direct analysis by the research team. Rather, in specifying the direction of the impact, the research team has tried to err on the side of the general hypothesis stated earlier, that increased transit investment and use has a broad range of impacts that can, in turn, be characterized in economic terms. The positive or negative direction of the impacts may not hold true in all cases. They are provided, however, to add clarity to the examination of linkages, and consistency with the overall hypothesis being tested. In several cases, it is obvious that the direction of impact cannot be determined or is dependent on "netting out" positive and negative effects. In those instances, a "Δ" symbol has been used to note only that there is an indeterminate change that is forecast for the variable or measure in question.

Focus of the Impacts. In each cell in the linkage diagrams, there is a letter indicator to identify where the primary impact might be expected, i.e., on individuals/households (H), on business/industry (B), on government (G), or on the community as a whole (C). While it is common in most analytical schemes dealing with transit impacts to distinguish between system users and nonusers, this distinction is not specifically featured in the diagrams of long-term impacts. It is, however, a significant element of some of the more sophisticated analytic methods being used today. Like the arrows indicating the direction of impact, these designations may be arguable, and in many cells the impacts may fall on more than a single sector. The symbols for where major effects may be felt have been included, however, to recognize overtly that impacts, economic and otherwise, fall unevenly across major sectors of the regional economy. The diagrams that follow illustrate presumed or known relationships between a host of variables. These variables represent the link between transit and the strength of a region's economy.

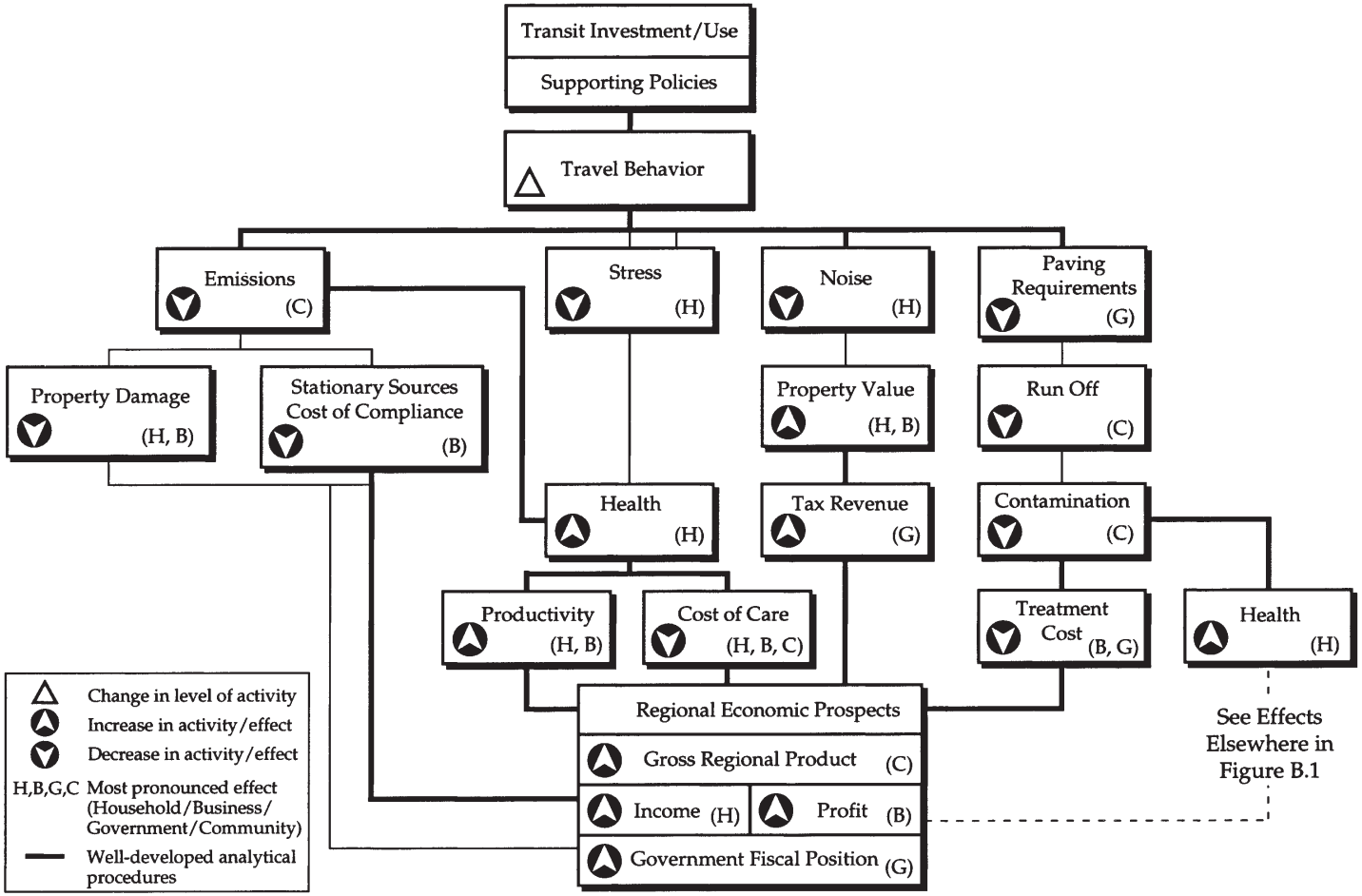


Figure B.1. Transit benefit framework—University of Wisconsin-Milwaukee.

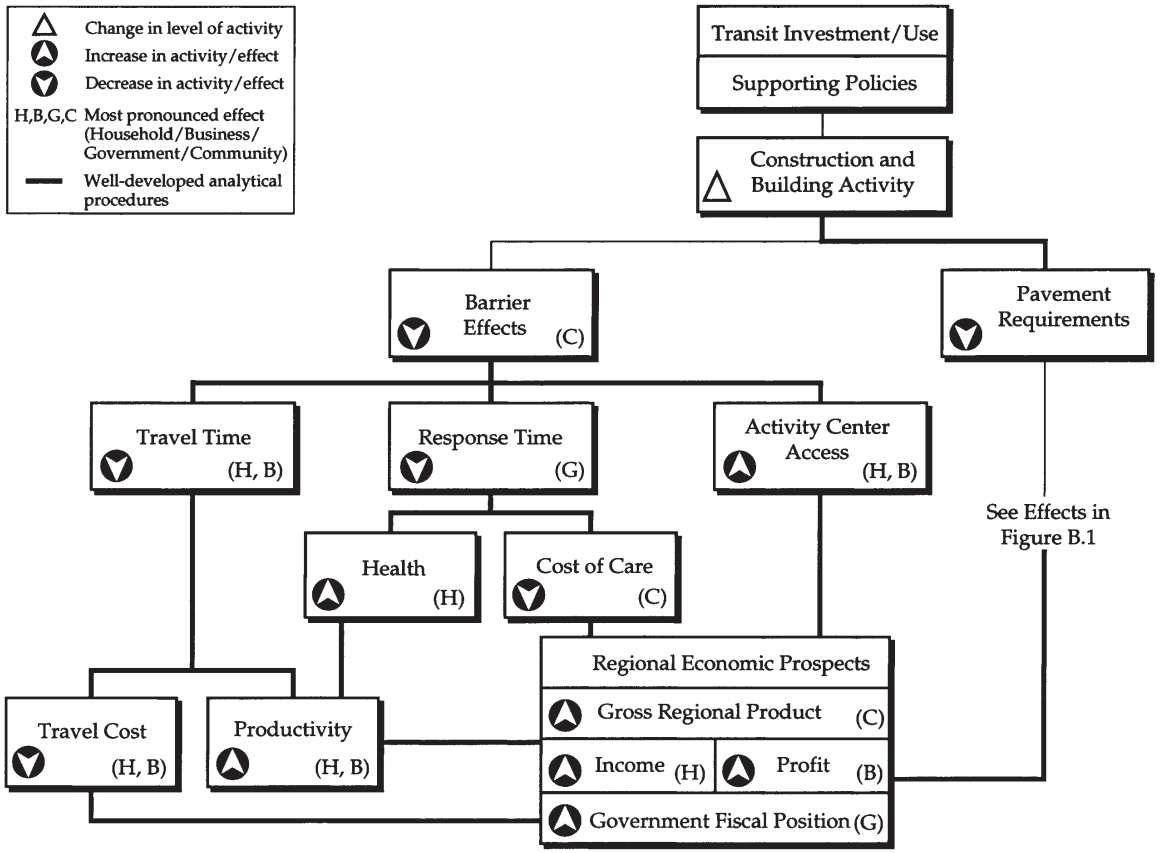
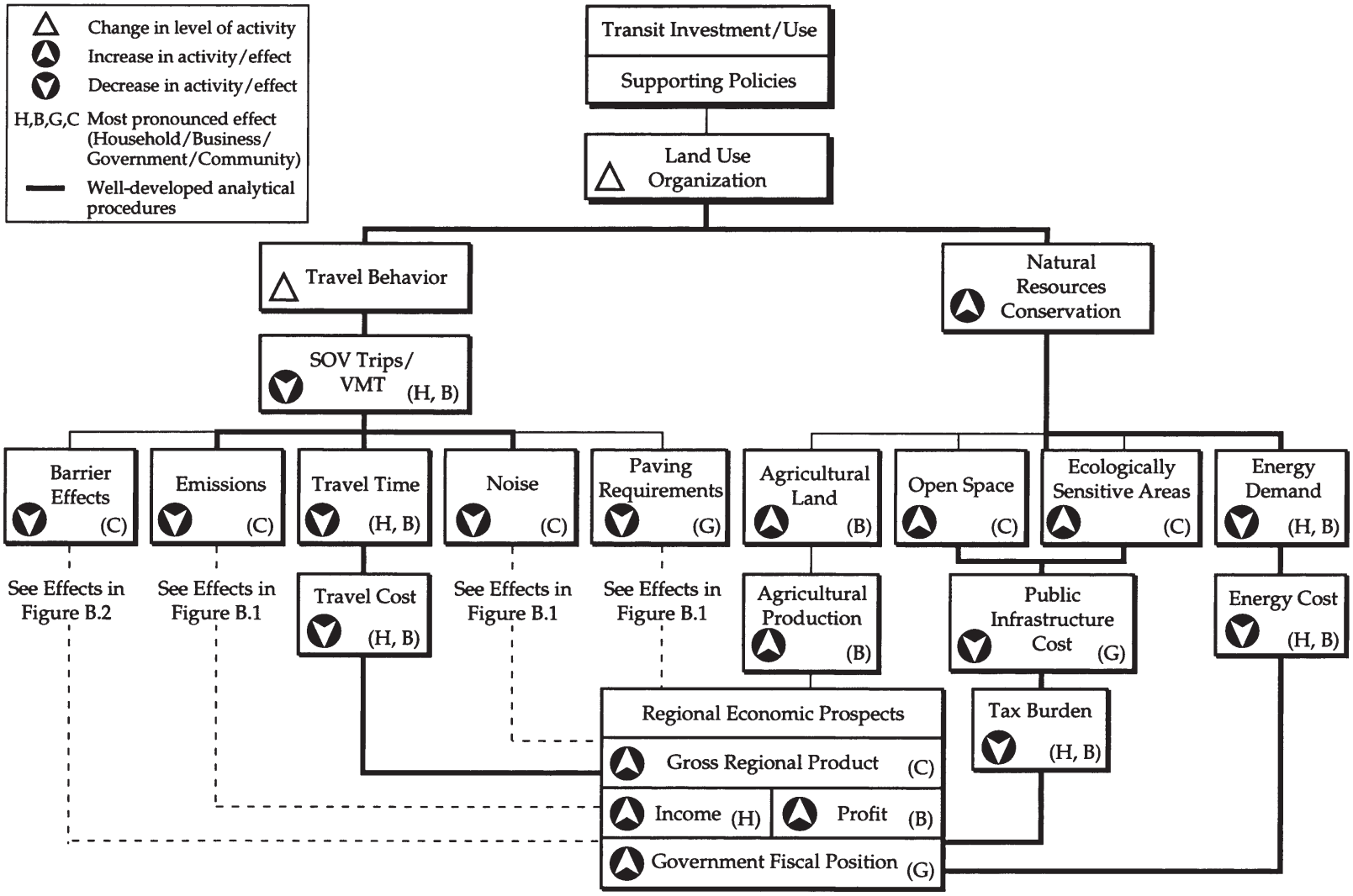


Figure B.2. Transportation system impacts.


Change in level of activity
Increase in activity/effect
Decrease in activity/effect
H,B,G,C Most pronounced effect (Household/Business/ Government/Community)
Well-developed analytical procedures
Transit Investment/Use
Supporting Policies
Land Use Organization
Travel Behavior
Natural Resources Conservation
SOV Trips/ VMT (H, B)
Barrier Effects (C)
Emissions (C)
Travel Time (H, B)
Noise (C)
Paving Requirements (G)
Agricultural Land (B)
Open Space (C)
Ecologically Sensitive Areas (C)
Energy Demand (H, B)
See Effects in Figure B.2
See Effects in Figure B.1
Travel Cost (H, B)
See Effects in Figure B.1
See Effects in Figure B.1
Agricultural Production (B)
Public Infrastructure Cost (G)
Energy Cost (H, B)
Regional Economic Prospects
Gross Regional Product (C)
Income (H)
Profit (B)
Government Fiscal Position (G)
Tax Burden (H, B)

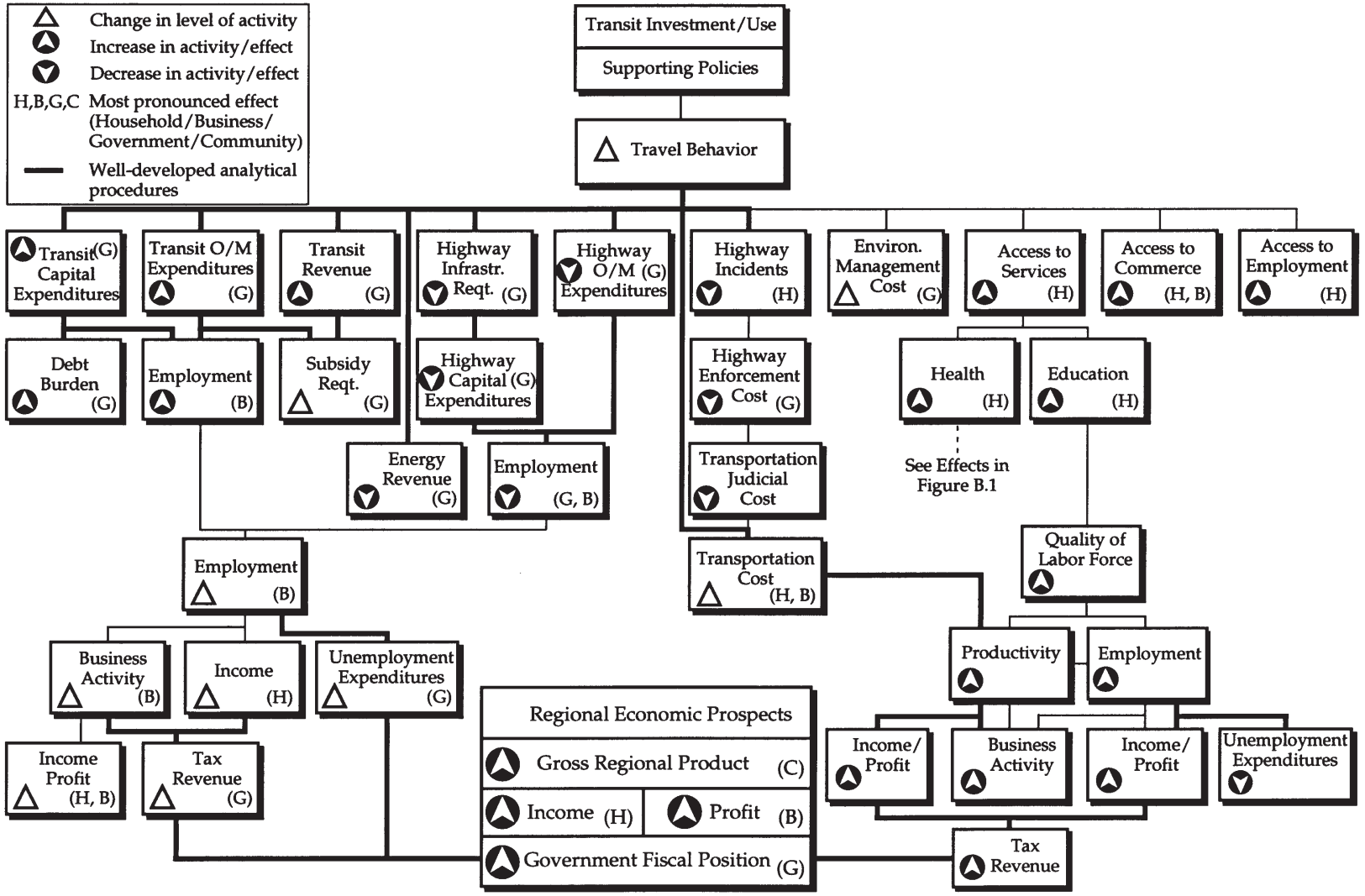


Figure B.4. Summary of use of criteria in studies.

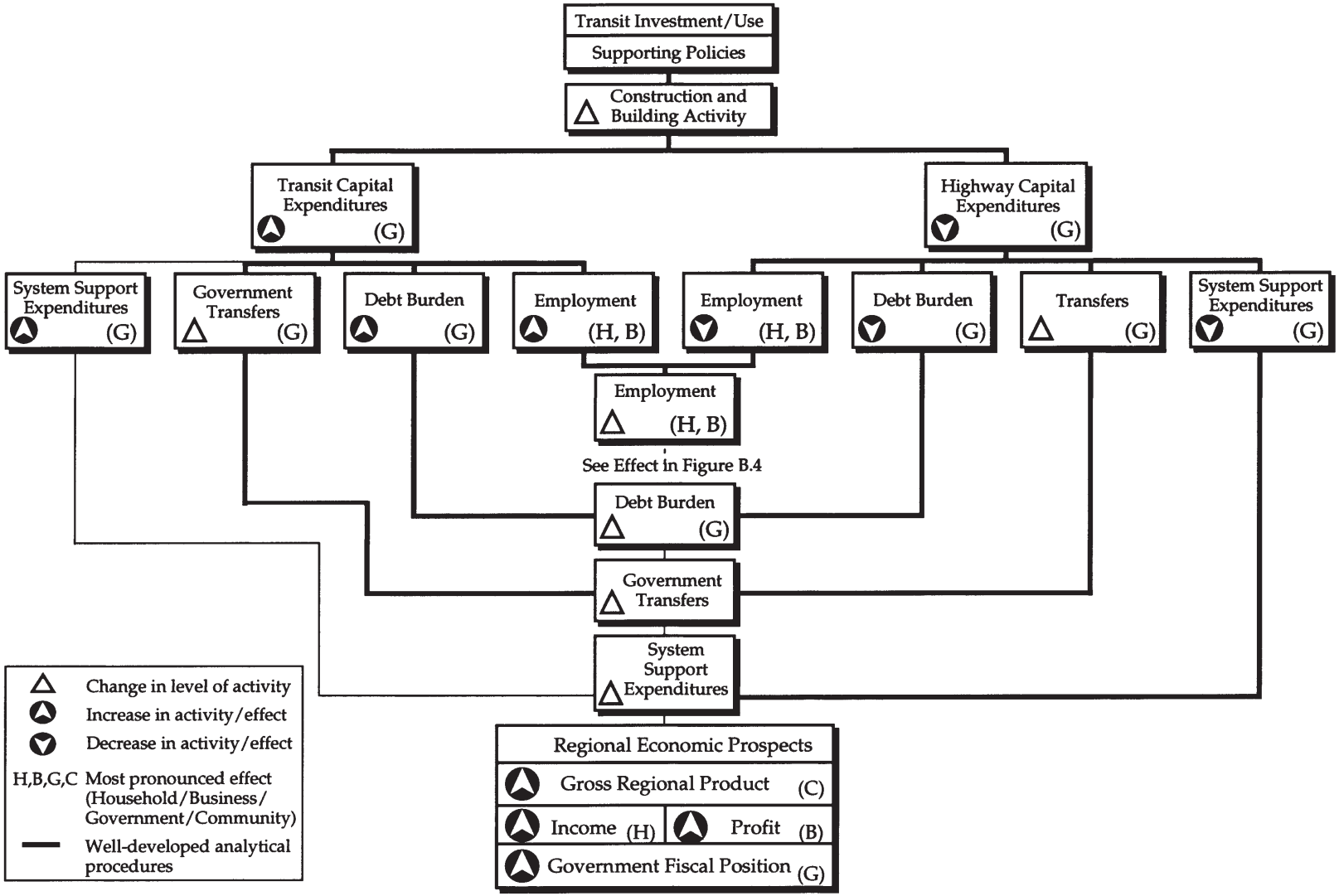


Figure B.5. Federal Transit Administration's alternatives criteria.

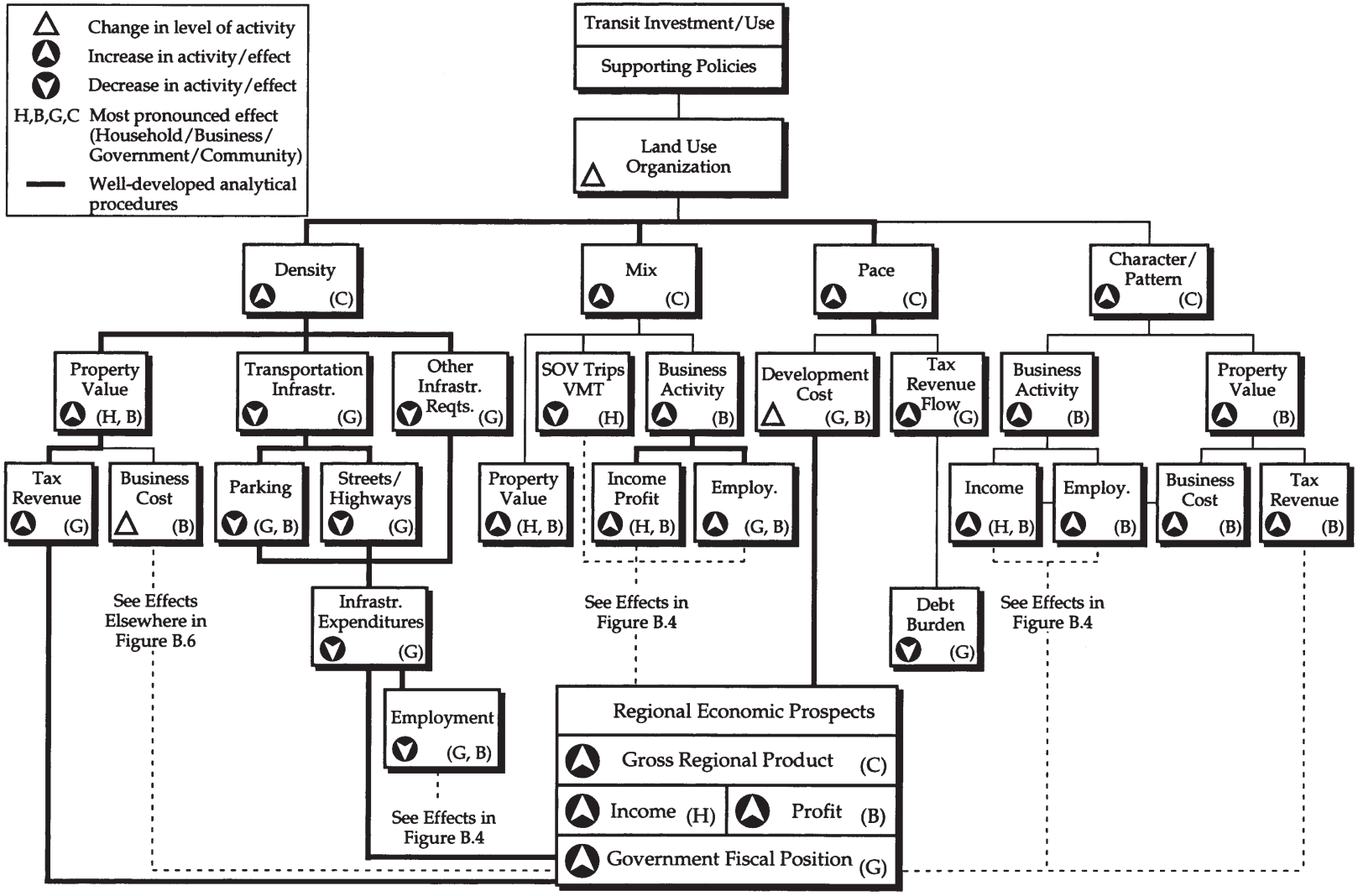


Figure B.6. Factors to be included in metropolitan transportation planning.

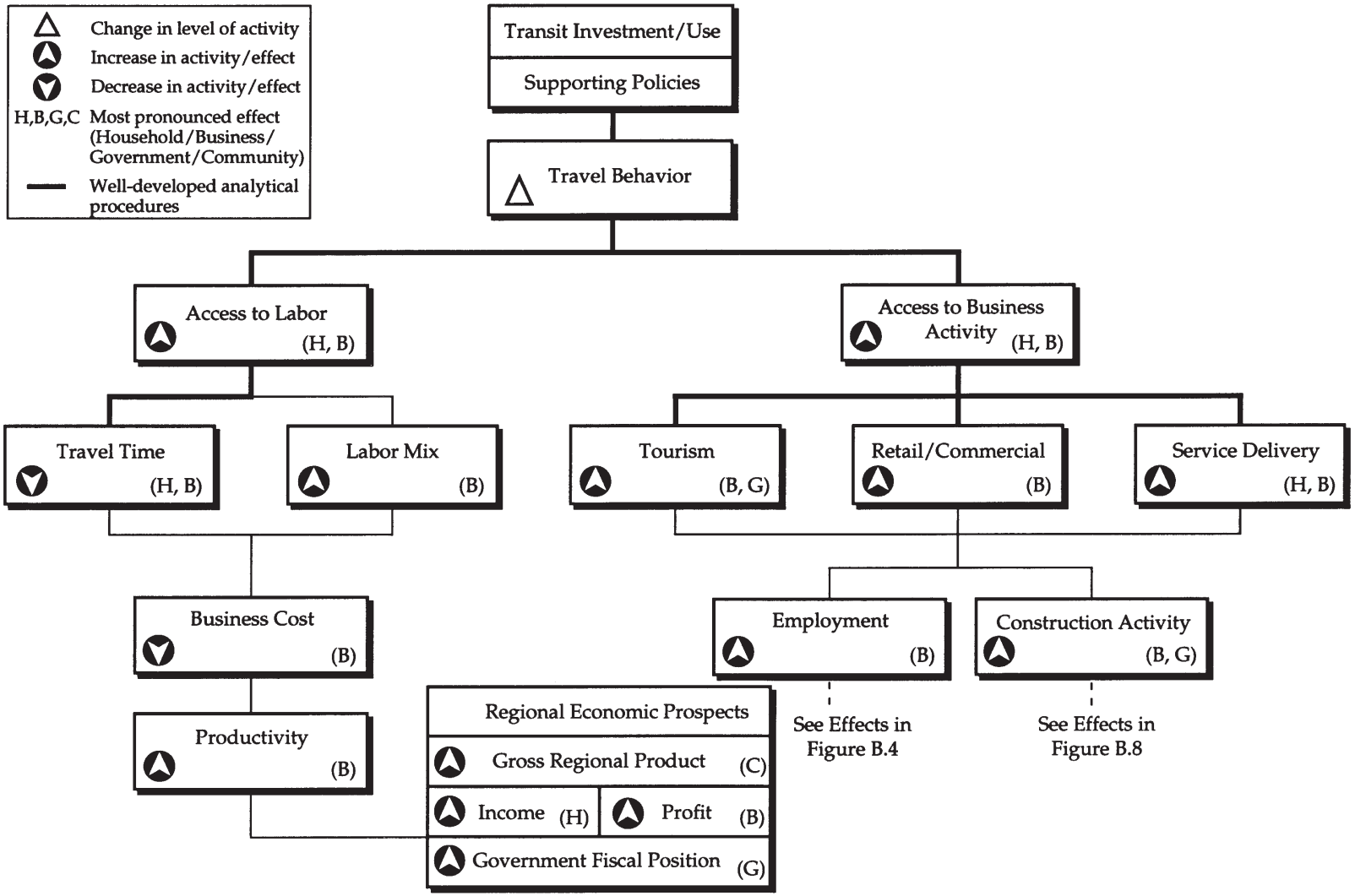


Figure B.7. Economic productivity/competitiveness: travel behavior effects.

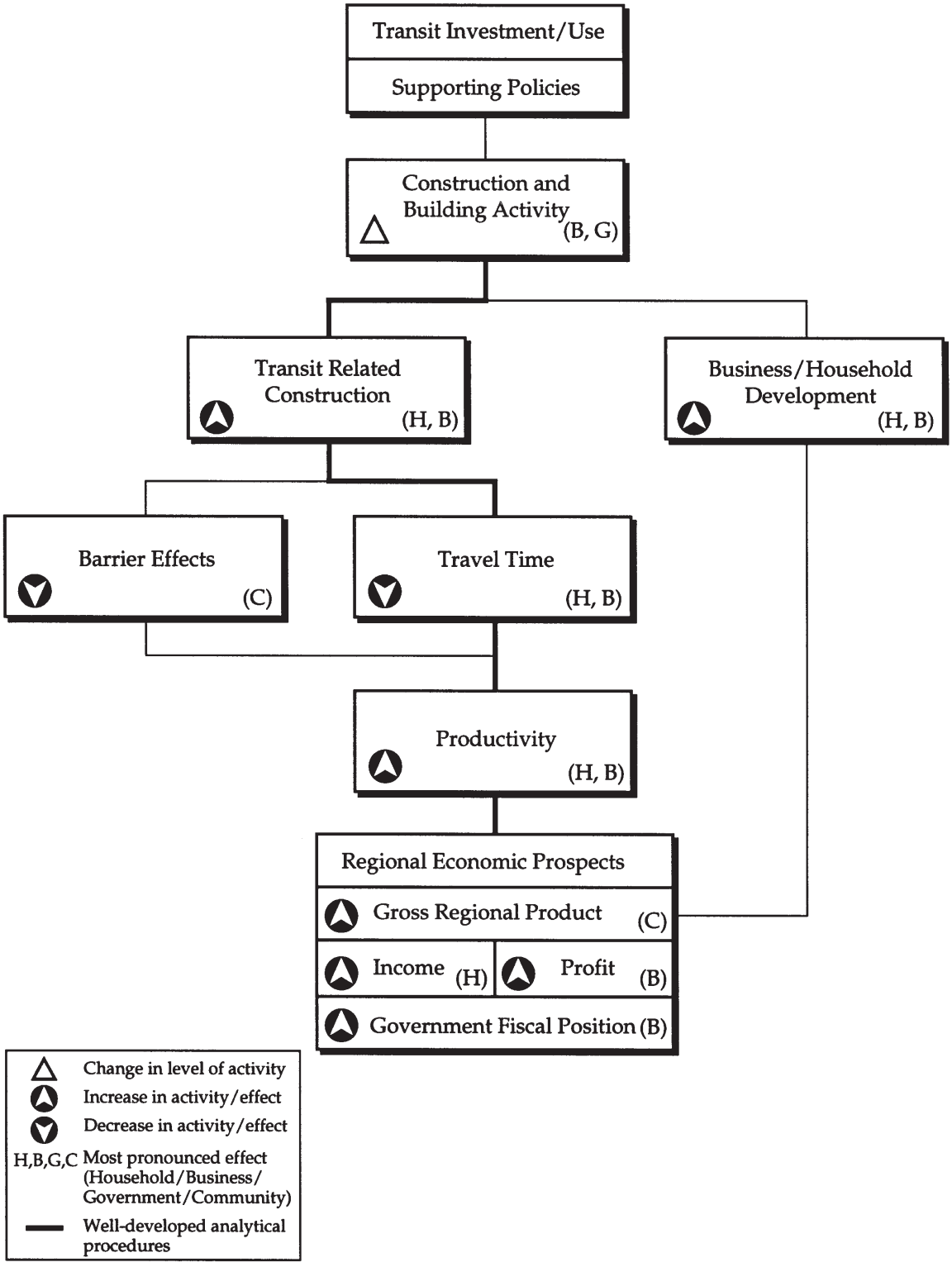


Figure B.8. Economic productivity/competitiveness: construction activity effects.

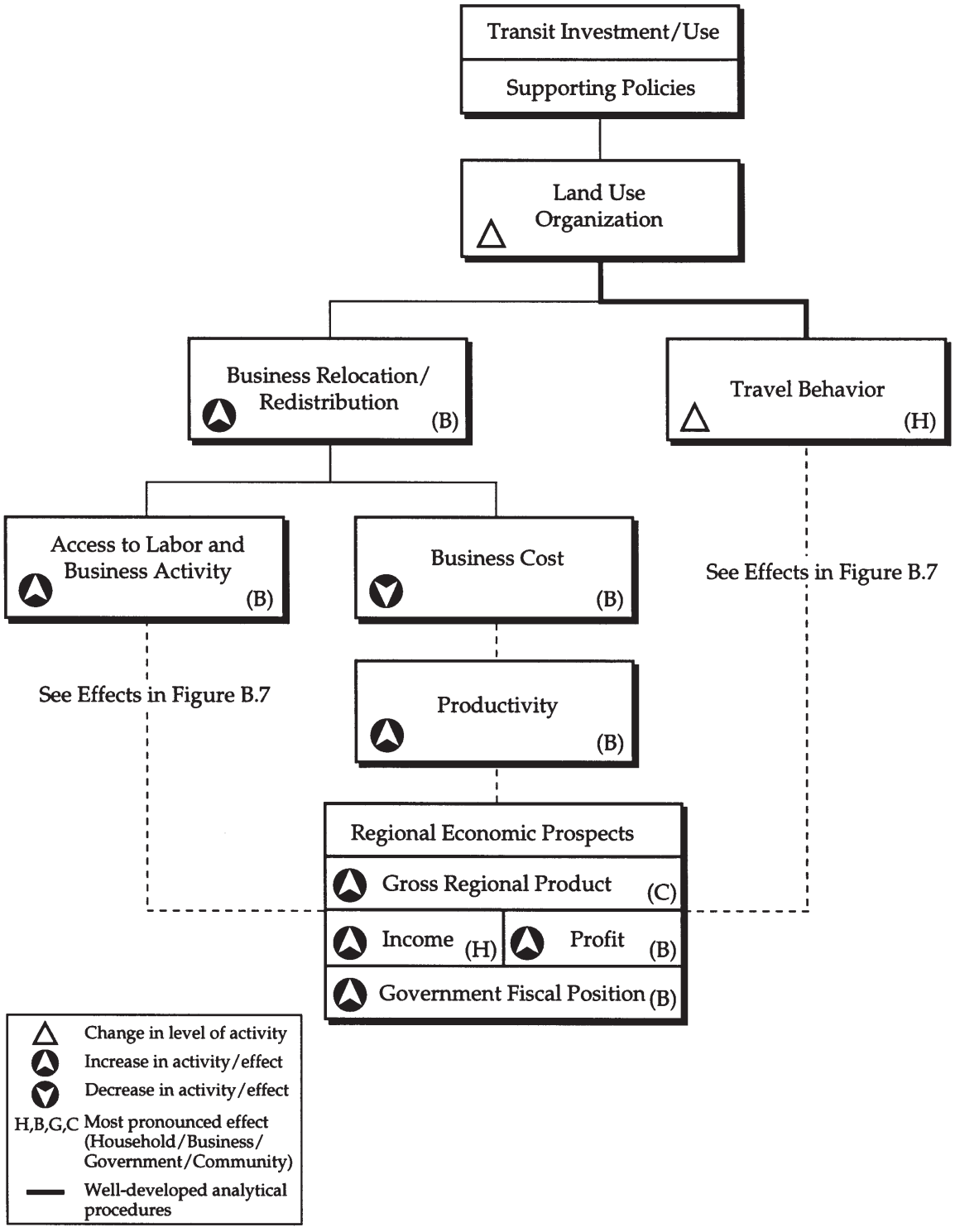


Figure B.9. Economic productivity/competitiveness: land use organization effects.

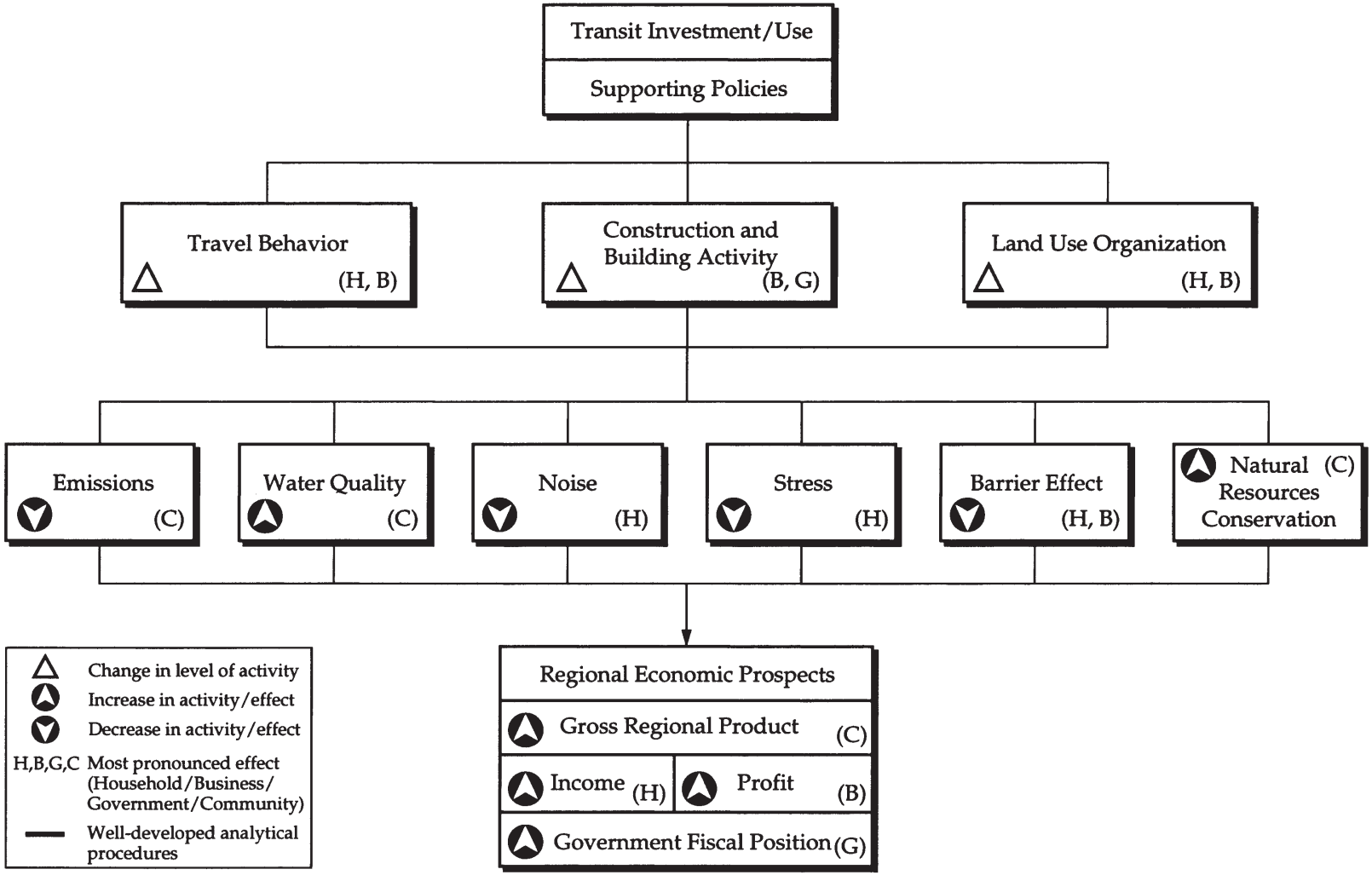


Figure B.10. Safety/security.

APPENDIX C

SELECTED BIBLIOGRAPHY

American Public Transit Associaton, "Public Transit Works for America," APTA, Washington, D.C. (1992).

American Public Transit Association, "Employment Impacts of Transit Capital Investment and Operating Expenditures," APTA, Washington, D.C. (April 1983).

American Public Transit Association, "National Impacts of Transit Capital and Operating Expenditures on Business Revenues," APTA, Washington, D.C. (January 1984).

American Public Transit Association, "The Economic Benefits of Public Transportation," APTA, Washington, D.C. (May 1983).

Aschauer, David A., "Transportation Spending and Economic Growth—The Effects of Transit and Highway Expenditures," Prepared for the American Public Transit Association (September 1991).

Beimborn, E. and Horowitz, A., *Measurement of Transit Benefits*, Urban Mass Transit Administration, Washington, D.C. (June 1993).

Cambridge Systematics, Inc., "Investments in Public Transportation: The Economic Impacts of the RTA System on the Regional and State Economies," prepared for the [Chicago] Regional Transportation Authority, January 1995.

Cervero, R., Hall, P., and Landis, J., *Transit Joint Development in the United States: A Review and Evaluation of Recent Experiences and an Assessment of Future Potential*, UMTA, Washington, DC (September 1991).

Cervero, R. and Landis, J., *BART at 20: Land Use Impacts*, Institute of Urban and Regional Development, University of California at Berkeley (January 1995).

Cervero, R. and Landis J., "BART at 20: Property Value and Rent Impacts," Paper presented to the Annual Meeting of the Transportation Research Board, Washington, D.C. (January 1995).

DeCorla-Souza, Patrick and Jensen-Fisher, Ronald, "Comparing Multimodal Alternatives in Major Travel Corridors," Preprint, prepared for the Transportation Research Board 73rd Annual Meeting (January 9–13, 1994).

Federal Transit Administration, "A Review of Methodologies for Assessing the Land Use and Economic Impacts of Transit on Urban Areas," Cambridge Systematics, Inc., Cambridge, Mass. (June 1995).

Holtzclaw, John, "Using Residential Patterns and Transit to Decrease Auto Dependence and Costs," prepared for the Natural Resources Defense Council, June 1994.

Kenworthy, Jeffrey R. and Newman, Peter W. G., "Learning from the Best and Worst: Transportation and Land Use Lessons from Thirty-two International Cities with Implications for Gasoline Use and Emissions," School of Environmental and Life Sciences, Murdoch University, Perth, Western Australia, Australia (1987).

KPMG Peat Marwick, "Fiscal Impact of Metrorail on the Commonwealth of Virginia," prepared for the Northern Virginia Transportation Commission, November 1994.

Litman, Todd, "Transportation Cost Analysis for Sustainability," Victoria Transport Policy Institute, Victoria, British Columbia, Canada (1995).

Lomax, Timothy J. and Memmott, Jeffrey L., "The Cost and Benefits of Urban Transit in Texas," Texas Transportation Institute, Texas A & M University, sponsored by Texas Department of Highways and Public Transportation in cooperation with Federal Transit Administration (November 1989).

MacKenzie, James J., Dower, Roger C., and Chen, Donald D.T., *The Going Rate: What It Really Costs to Drive*, World Resources Institute, Washington, D.C. (June 1992).

Maclaren, Virginia W., "Urban Sustainability Reporting," *Journal of the American Planning Association*, Vol. 62, No. 2, pp. 184–202, Chicago, Ill. (Spring 1996).

The Urban Institute/Cambridge Systematics, Inc., "Public Transportation Renewal as an Investment: The Economic Impacts of SEPTA on the Regional and State Economy," for the Delaware Valley Regional Planning Commission (June 1991).

The Urban Institute, "The Costs of Highway Crashes: Final Report," prepared for the Federal Highway Administration (June 1991).

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Abbreviations used without definitions in TRB publications:

AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
APTA	American Public Transit Association
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
IEEE	Institute of Electrical and Electronics Engineers
ITE	Institute of Transportation Engineers
NCHRP	National Cooperative Highway Research Program
NCTRP	National Cooperative Transit Research and Development Program
NHTSA	National Highway Traffic Safety Administration
SAE	Society of Automotive Engineers
TCRP	Transit Cooperative Research Program
TRB	Transportation Research Board
U.S.DOT	United States Department of Transportation