The Thesis Committee for Stephen Daniel Evans
Certifies that this is the approved version of the following thesis:

The Economic Development Impacts of Investing in An Interstate 10 Expansion Project in Texas

APPROVED BY
SUPERVISING COMMITTEE:

Supervisor: ______________________________
C. Michael Walton

____
Jolanda Prozzi

The Economic Development Impacts of Investing in An Interstate 10 Expansion Project in Texas

by

Stephen Daniel Evans, B.C.E.

Thesis

Presented to the Faculty of the Graduate School of

The University of Texas at Austin

in Partial Fulfillment

of the Requirements

for the Degree of

Master of Science in Engineering

The University of Texas at Austin

August 2012

Dedication

This thesis is dedicated to my family. As time passes, my appreciation increases for my parents' love and for the sacrifices they have and continue to make for their children. I deeply respect, admire, and love my parents. My siblings also have been lifelong blessings. Thank you each for your faith and the example that you set for me and others.

Acknowledgements

I gladly acknowledge individuals who contributed time and advice throughout the process of my writing this thesis. Dr. Michael Walton has served as my graduate advisor and guided me through my studies and thesis-writing. I appreciate the time and advice he has given me. Jolanda Prozzi has overseen my research and thesis work, providing direction and professional advice. Vicki Simpson has been instrumental in answering my questions and encouraging me throughout the course of my graduate education.

I want to thank the staff of Economic Development Research Group, Inc., for allowing me to incorporate in this thesis some results from a TxDOT research project that were generated by the TREDIS model. In particular, Kirsten Hughes and Brian Alstadt have provided advice and support.

I acknowledge the contribution of Zack Graham in providing me the travel impacts that would result from the implementation of the Interstate 10 project. Mr. Graham modeled the project improvements in the San Antonio-Bexar County MPO travel demand model and was very helpful in answering my questions.

My Austin friends also have supported me immeasurably. Thank you each for your patience with me, for listening to and encouraging me, and for being such wonderful friends and people.

Thank you to each one of my family members and friends who proofread parts of this document. I greatly appreciate your time and comments, which certainly improved this thesis.

Abstract

The Economic Development Impacts of Investing in An Interstate 10 Expansion Project in Texas

Stephen Daniel Evans, MSE

The University of Texas at Austin, 2012

Supervisor: C. Michael Walton

Transportation planners, engineers, and administrators face the difficult tasks of prioritizing and justifying proposed investments in transportation infrastructure, particularly as government budgets tighten and alternative investments compete for public funding. One means by which professionals can prioritize and justify large transportation investments is by describing how a proposed project will impact an area's economy in terms of creating new jobs, raising aggregate income, and increasing business revenues. The report begins by examining the general impact of transportation investments on economic development. Then it surveys various methods and tools that have been proposed for estimating economic impacts. Among these, the TREDIS economic impact model is selected and used to estimate the economic impacts of a current interstate highway project in Texas.

Table of Contents

List of Tables

List of Figures

Chapter 1: Introduction

Economic development increasingly has become a factor in transportation planning. This trend is evident in the most recent federal transportation bills. The Transportation Equity Act for the 21st Century (TEA-21) established the National Corridor Planning and Development Program, which provided funds "for the coordinated planning, design, and construction of corridors of national significance, economic growth, and international or interregional trade" (FHWA TEA-21). SAFETEA-LU, the most recent federal transportation bill, addressed the same aspects of economic growth and trade through its National Corridor Infrastructure Improvement Program (FHWA Fact Sheets). Factors considered in the selection of projects for funding included whether a project would facilitate economic growth in areas underserved by the highway infrastructure and how congestion in a corridor would contribute to economic costs. At the state level, an increasing number of states have included economic development criteria as part of overall transportation planning or funding processes (Weisbrod 2000). The Kansas Department of Transportation recently pilot tested an approach for scoring potential highway projects that included an economic impact score for highway expansion projects (KDOT 2010). The North Carolina Department of Transportation performed a transportation project prioritization process that incorporated an economic competitiveness component, which was based on how a particular project impacts an area's number of jobs, wages, and productivity over time (NCDOT (a) and (b)). Also, several states have used economic development programs as a means to fund projects that facilitate economic growth and development. Consideration of economic development impacts is now important to transportation policy-making and transportation agencies.

Transportation planning agencies may be interested in economic development impacts for any number of reasons. Agencies may use economic development as one component in the planning, selection, and funding of transportation projects. States may have special programs that provide funds or loans to projects that are expected to stimulate economic growth and development. Some agencies may assess economic development impacts as part of an environmental impact assessment process. Finally, agencies may want to use information about economic development to educate the public about potential project impacts (Weisbrod 2000). Whatever the case, transportation agencies have needs for assessing economic impacts of transportation projects.

Because of constrained budgets and limited funding, transportation agencies have a need to prioritize and schedule infrastructure investments. Economic impact analyses of proposed projects are a means to demonstrate the economic importance of particular investments, compare the potential economic impacts of proposed projects, and determine which and when investments should be made relative to other infrastructure investments. Further, results from an economic impact analysis of a transportation project may serve as justification for investments in infrastructure over alternative investment areas such as education, fire and police protection, and healthcare services.

While a clear need for economic impact analysis exists, transportation agencies face difficulties in assessing the economic impacts of transportation projects. Some analysis methods and tools are rather complex to the extent that agencies may be deterred from attempting to estimate economic impacts of projects. Further, agencies require analysis tools that do not consume much of agency resources including personnel, time, and money.

These issues should be addressed effectively by economic impact analysis tools. An analysis tool should be understandable so that few agency staff members are required to operate the tool and so that staff members do not have to devote significant time and energy just to learning how to operate the tool. Staff inexperience should not preclude the use of an effective economic impact tool. Also, an analysis tool must be a cost-effective investment even to be considered a feasible means for estimating economic impacts. Economic impact analysis tools should be comprehensive as well, accounting for transportation-related factors that affect economic development. For example, some computer analysis models have not adequately incorporated such factors as accessibility to various types of markets (e.g., labor, supplier, and consumer), and in failing to incorporate such factors, these models may not capture the full economic impacts resulting from a transportation improvement (Weisbrod 2008).

The previous issues motivate this study. Agencies need to estimate the economic impacts resulting from transportation projects in an understandable and comprehensive manner. Various methods and analysis tools are available, yet one recently developed tool effectively addresses many of the preceding issues. The Transportation Economic Development Impact System (TREDIS) is a benefit/cost and economic impact analysis tool that was specifically designed for estimating the economic impacts of transportation projects. This report demonstrates the application of this tool to the estimation of economic impacts of an Interstate 10 (I-10) capacity expansion project in San Antonio, Texas. The objectives of this report are to estimate the economic impacts of the highway expansion project and to demonstrate the usefulness of the TREDIS model in estimating economic impacts.

Much of the content and structure of this report is intended to establish a basis from which to appropriately evaluate results of the conducted economic impact analysis. Chapter 2 addresses the relationship between transportation investments and economic development, as well as the economic benefits typically resulting from transportation investments. Chapter 3 reviews economic impact analysis, and Chapter 4 covers general and specific methods and tools used to conduct an economic impact analysis. Chapter 5 concentrates specifically on the TREDIS model, addressing the structure and functionality of the model. The fifth chapter also includes examples of how TREDIS has been applied. Chapter 6 defines the case study of this report that involves the estimation of economic impacts resulting from a capacity expansion project in Texas and provides the results from the economic impact analysis. Chapter 7 summarizes the key outcomes of the economic impact analysis and highlights needs that may be addressed through further research efforts.

Chapter 2: The Connection between Transportation and Economic Development

"Space without adequate transport facilities presents a barrier; it is transport which breathes economic life into space."

- J.B. Thompson, Geographer (Cambridge Systematics 2002)

In its essential functions, a transportation facility provides access to desired locations and mobility to get from one location to another. America's highways support the travel of more than 4 trillion passenger-miles annually (RITA). Clearly, access and mobility are critical needs that undergird the purpose of transportation, yet transportation offers more than just access and mobility. Transportation provides opportunities for people to interact socially and economically. Concerning social interactions, families and friends can see each other more frequently and easily because of sufficient transportation systems such as the nation's network of airports, which allow people to traverse great distances in relatively little time. Concerning economic interactions, commerce and trade are enabled when producers and markets are physically connected through transportation networks. Approximately 2000 years ago, European markets received goods from distant lands because of caravan routes such as the Salt Route, the Spice Route, and the Silk Road. Producers, traders, and merchants took part in a supply chain that allowed income and the number of jobs to grow. Even intermediate locations benefitted by providing rest and service areas to travelers. In modern times, Congress recognized the importance of transportation's role in enabling regional economic development by funding the Appalachian Development Highway System and the Denali Access System with the intention of improving transportation and economic development in the respective regions (Weisbrod 2008; FHWA SAFETEA-LU summary).

Transportation is certainly linked to economic development. Several questions exist, though, pertaining to the nature and strength of this link. This chapter addresses the transportation-economic development relationship by noting how transportation investments can facilitate economic development. Difficulties in understanding the relationship are mentioned as well. Economic development concepts are mentioned, and economic benefits resulting from transportation investments are presented. To place the concept of economic development in a real-world transportation context, examples are cited of state programs that incorporate economic development considerations.

THE ELUSIVE AND IMPORTANT TRANSPORTATION-ECONOMIC DEVELOPMENT RELATIONSHIP

Researchers have attempted to answer the question of if and how transportation investments stimulate economic development. A relationship does exist between the two, yet defining a "reliable, measurable, causative" relationship between levels of transportation investment and economic development has remained elusive (Drew [b]). It is understood that several variables are involved in economic development, and transportation is one of these variables: "What is unclear is whether transportation improvement contributes more to increasing productivity than other investments (whether they are public or private)" (Drew [b]). Increased productivity is linked to future economic growth. Policy-makers are tasked with prioritizing investments that lead to economic growth, so understanding how transportation investments stimulate economic development is important in choosing the best investment strategies from a range of alternatives. These alternatives can range from any public infrastructure projects (e.g., transportation projects or water treatment plants) to non-infrastructure investments in areas such as education or health services. Indeed, in the context of limited financial resources and the desire for quality transportation services, Bell and Feitelson (1990) note an important consideration: "One element to consider in setting spending priorities to obtain maximum benefits from limited resources is the linkages between transportation and economic development" (Bell and Feitelson).

Defining "Economic Development"

Before addressing various aspects of the relationship between transportation and economic development, it is important to understand what is meant by "economic development." Economic development occurs when income and business output increase in a given area (Forkenbrock). Increased production is associated with either an increase in the use of resources (e.g., land, labor, materials, and capital) or more productive use of existing resources. Benefits derived from transportation investments are due to reductions in transportation costs, which may be considered in terms of travel times, safety, fuel and operating costs, and environmental metrics (e.g., air pollution). When a reduction in transportation costs exceeds the amount of the original transportation investment, net incomes rise in an area and economic development occurs: "Improvements that yield transportation cost savings in excess of the costs they impose lead to real increases in income- the essence of economic development" (Forkenbrock). Adams and VanDrasek (2007) note that economic development occurs when resources are brought "into fuller production of valued goods and services in ways such that overall benefits exceed overall project costs over time."

Economic development spurs continual economic activity in terms of increasing an area's wealth, number of jobs, tax base, and/or quality of life. Economic growth in these areas is typically desired to improve various aspects of residents' lives. As personal income levels rise, residents' financial well-being is improved. The creation of more jobs in an area may expand the type and quality of employment, which allows for greater job satisfaction and enhanced "upward occupational mobility" (Weisbrod 2000). Economic development may diversify an area's industries and businesses, promote stable jobs and incomes, and enhance social, entertainment, and shopping opportunities for residents, resulting in an improved quality of life (Weisbrod 2000).

When economic development is desired, planners or agencies may have particular "objectives" in mind for improvement. Several of these objectives are shown in Figure 2.1 below. In order to measure economic development with regards to achieving a particular objective, performance indicators are needed. Use of performance measures can indicate if and to what extent economic development occurred. Various performance indicators are shown in Figure 2.1 with each corresponding objective.

Objectives	Performance Indicators
Income	Average or median wage rates and employee or household incomes.
Employment	Employment or unemployment rates, often measured as *full time equivalents* (FTEs)
Productivity	Production of goods and services as measured by Gross Domestic Product (GDP)
Competitiveness	Efficiency and productivity compared with competitors.
Business activity	Gross sales volumes.
Profitability	Business profits or return on investment.
Property values	Value of land and buildings, or changes in those values.
Investment	Value of capital investments
Tax revenues	Value of tax revenue
Affordability	Transport costs relative to income. Transport expenditures by income class.
Equity	Differences in wealth, poverty and outcomes (longevity, health, etc.) between groups.
Desired outcomes	Health, longevity, education, crime, environmental quality, life satisfaction, etc.

Figure 2.1- Various economic development objectives and corresponding indicators (Litman)

The General Hypothetical Relationship

The general relationship between transportation and economic development is represented in Figure 2.2 below.

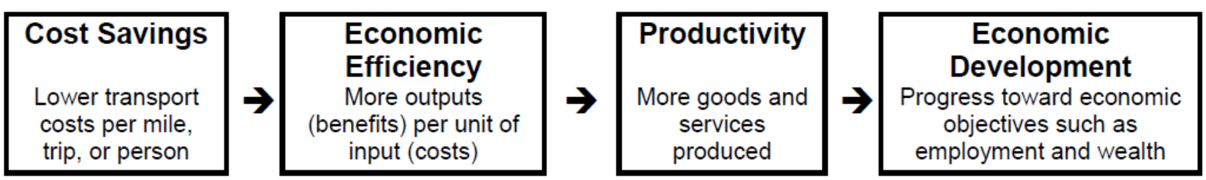

Figure 2.2- How economic development occurs as a result of a transportation improvement (Litman)

An initial transportation investment or improvement lowers transportation costs for both businesses and passengers. Lower transportation costs allow businesses to realize a cost savings, which results in greater production efficiency as the cost per unit output decreases. The increase in efficiency allows businesses to increase production, hire more workers, or do both. The increases in efficiency and productivity can be assessed by the various performance indicators, as mentioned previously and shown in Figure 2.1. The performance indicators can demonstrate how progress is being made in a tangible manner toward particular economic development objectives.

Figure 2.3 below provides a framework for understanding a general transportation improvement by depicting a cycle of highway investment and the investment's resulting impacts for a given area. Transportation investments create immediate construction jobs in the short term and improve accessibility over a longer term. Improved access allows manufacturing and services industries to expand, generating more jobs and income, which increases the tax base. The increase in tax revenues partly justifies the initial transportation investment. Also, as the economy grows, demand for more transportation services will increase as well. Eventually, more transportation investments will be required to provide or improve access and maintain the economic health of the region (Lombard).

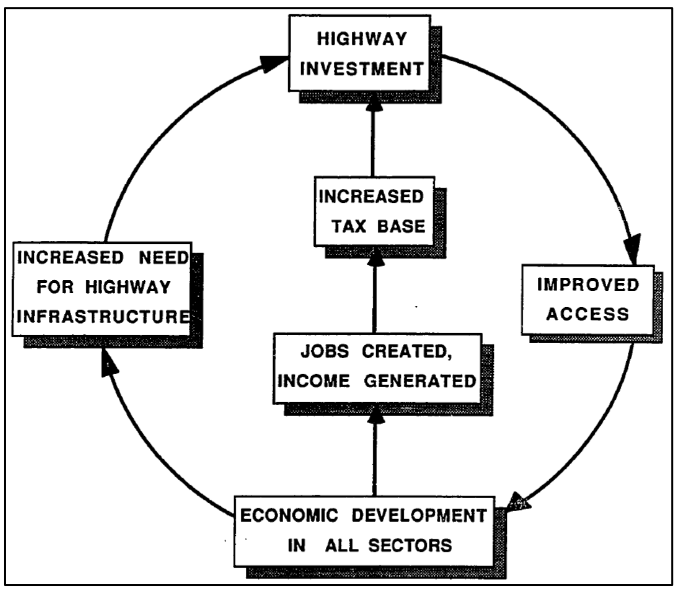

Figure 2.3- Cycle of highway investment and resulting impacts (Lombard)

Difficulties in Understanding the Relationship

The interaction between transportation systems and development is complex due to numerous underlying variables and is based upon the economy in an area and the extent to which a transportation system is developed. Experts may understand some aspects of the transportation-development relationship, but attempts to understand the transportation-development relationship by combining disparate aspects of the relationship are problematic. Furthermore, Drew (1990 [a]) suggested that links between transportation and economic development are generally subjective. Thus, a need exists "for isolating underlying causes of development deficiencies in a systematic way, identifying policies and infrastructure investments to deal with the causes, and then assessing the impacts of alternatives against specified goals" (Drew [a]). Further complicating the understanding of the transportation-economic development relationship is that engineers and planners rarely collaborate closely with peers in economic development on transportation problems (Drew [a]).

Stephanedes (1990) acknowledged the difficulty in determining economic effects resulting from transportation improvements. The traditional perspective in the literature was that transportation improvements were necessary prior to a region's economic development. Since the 1970s, though, this view has been challenged. Stephanedes (1990) mentioned that studies from the Soviet Union and China, as well as the railroads in the United States, indicated transportation occurred after or, at best, concurrently with economic development. Transportation improvements may lead to few, if any, economic benefits. Stephanedes (1990) cited several examples that support this notion, including investment in Canadian infrastructure that would not attract industries; little correlation between highways and economic development in the Ozark plateau of Arkansas; and counties in Connecticut and Pennsylvania that were not within 25 miles of a metropolitan area.

SOME ECONOMIC DEVELOPMENT CONCEPTS

Transportation-related Factors that Affect Economic Development

Transportation investment affects economic development because transportation facilities enable the "movement and interchange of activities between locations," and economic growth and concentration of economic activity depend upon access to markets and other economies (Weisbrod 2008). Several transportation-related factors affect economic development. Many of these factors are provided in Figure 2.4 below and were compiled in order to establish a basis for evaluating the extent to which various economic models incorporated the factors (Weisbrod 2008). Most of the noted factors either enable economic development or relate to the performance of transportation systems. Congestion is the only factor mentioned that reduces economic development, though the opposites of listed factors (e.g., inaccessible markets, poor reliability, or relatively high travel times) may have negative effects on economic development as well. Essentially, Weisbrod (2008) concluded "that many facets of travel time, cost, reliability, market access, intermodal transfer connections and travel route connectivity can all come into play as relevant factors affecting the economic growth of industries and locations." Transportation investments can impact the economy, and the extent of impacts is dependent upon the types of markets present (i.e., labor, supply materials, and customer), types of market characteristics present (i.e., size, quality, and cost), mode of transportation, and industry or commodity of interest (Weisbrod 2008).

(A) *Mechanisms enabling economic development*

Development of routes enabling new trade between industries and between locations

Improvement in travel cost and travel time for various passenger and freight movements

Reduced uncertainty and risk, diminishing loss and improving reliability

Expansion of markets, allowing for "economies of scale" in production and distribution

Increasing productivity resulting from access to more diverse inputs and broader markets for outputs.

(B) *Mechanisms reducing economic development*

Congestion-induced negative impacts on trade flow volume, travel time, cost, reliability and market access

(C) *Aspects of transportation performance*

Travel time and expense

Logistics processing time and expense

Reliability of schedule

Spoilage or loss rate

Accessible markets (suppliers, labor, customers)

Access to intermodal facilities, interconnections

Cargo capacity, weight and volume limitations

Time, day and seasonal variations in above factors

Induced impact on demand and traffic growth

Figure 2.4- Ways in which transportation improvements may affect economic development (Weisbrod 2008)

Consideration should be given to how businesses make decisions affected by transportation improvements: "[Transportation] can affect supplier and buyer markets and cost, affecting the pattern and magnitude of economic growth among various industries and locations" (Weisbrod 2008). Weisbrod (2008) noted four ways in which transportation improvements can affect economic development from a business development perspective:

1. By enabling new forms of trade among industries and locations,
2. By reducing cargo loss and enhancing reliability of existing trade movements,
3. By expanding the size of markets and enabling "economies of scale" in production and distribution, and

4. By increasing productivity through access to more diverse and specialized labor, supply and buyer markets.

Site Location Factors

Firms consider several factors in determining where to locate particular business operations (Lombard). The first aspect of a firm's location decision consists of selecting a geographic region that will allow for the efficient supply of production inputs and subsequent distribution of products to markets. Based upon a selected region, a firm will then assess sub-regions in order to choose a particular site that minimizes production costs. Site selection is a function of various factors including the following factors, which represent a summary of important site-selection factors determined in various econometric studies (McNamara):

- Agglomeration factors
  - Population and population density
  - Number of manufacturing plants
  - Industrial site attributes
- Labor quality/cost/availability
  - Size of labor force
  - Wage rate
  - Labor productivity
- Transportation facilities
  - Interstate highway access
  - Distance to airport
- Site facilities and services
- Taxes
- Access to capital
- Public services factors such as fire protection ratings

McNamara noted that several location survey studies indicated that "critical determinants" in firms' site selection processes include transportation linkages (both roads and airports), land availability, and labor availability. However, Hartgen et al. (1990) concluded that transportation access was not a primary variable in site location decisions: "An affirmative location decision will not occur in the absence of good accessibility, but, conversely, the presence of a good highway is not apt to be a decisive factor" (Hartgen et al.). Of course, if an affirmative location decision is partly contingent on the existence of adequate transportation access, then one may reason that transportation is an important aspect in site location decisions.

Concerning site locations, metropolitan areas attract manufacturers because of available labor, capital, transportation facilities, and other resources. Results from econometric studies also indicate that firms realize cost advantages when locating in an area that already has an established economic base. Further, firms prefer sites that are located near concentrations of population and business activity. Rural areas may find it increasingly difficult to attract manufacturers as some firms shift their operations to third-world countries in order to employ low-skill, low-wage laborers (McNamara).

Type of Industry and Business Function

Transportation improvements have different effects on different types of industries and even on the different functions within an industry. Weisbrod (2008) provided historical examples that indicated "transportation improvements can reduce transport costs differently among various industries." Different industries will require different types and qualities of transportation services and systems. Additionally, the link between economic development and transportation investments should be assessed based upon function and not just industry sector (Bell and Feitelson). For example, advances in telecommunications and computers have allowed companies to "spatially separate different parts of their production processes" including management, research and development, and production phases (Bell and Feitelson, 9, 13, 18). Each particular function now can occur in the most appropriate location with regards to cost, skilled labor force, transportation needs, and other factors: "The result of the intrasectoral spatial differentiation of functions has been that places increasingly specialize in function, rather than in sector" (10, 23, Bell and Feitelson). Five types of American cities have been identified with regards to their role in the nation's economy- headquarter cities, innovation centers, module production places, migration entreports, and retirement centers (Bell and Feitelson, 24). Each type of city generally has different transportation needs and demands. Business operations in headquarter cities and innovation centers may rely more heavily on air transportation services compared to a production place that may rely heavily on the efficient movement of goods into and out of a region. Because economic activities have been spatially separated according to function rather than by sector, motivations for locating businesses are important in understanding patterns of economic development. Similarly, the demands on transportation systems should also be evaluated in light of motivations for locating businesses in a particular area (Bell and Feitelson). Transportation systems influence the location of particular activities and are influenced by the location of these particular activities, and different activities have different trip demands (Drew [a]). For example, industries "that manufacture and use low-value, high-bulk materials" (Lombard) are particularly sensitive to freight transportation, so these types of industries may choose to locate in areas with sufficiently developed freight transportation systems.

Chandra and Thompson (2000) studied the relationship between interstate highway construction spending and the level of economic activity using historical data from the United States from 1969 to 1993. The authors focused on highways in non-metropolitan areas. Empirical evidence suggested "that highways have a differential impact across industries: certain industries grow as a result of reduced transportation costs, but the impact is ambiguous for other industries" (Chandra and Thompson). That is, various sectors may be affected differently by highway construction. Counties through which a highway directly passed ("highway counties") experienced earnings increases in manufacturing, retail trade, and services industries; adjacent counties experienced earnings increases in the manufacturing industry while experiencing earnings reductions in government and the retail trade industry. These results seem to indicate that "regional highway investments aid the nationally oriented manufacturing industry but lead to the reallocation of economic activity in more regionally oriented economies" (Chandra and Thompson).

Government and the Business Climate

Government impacts an area's economic development by creating a particular business climate. The government can promote policies and/or services that attract or repel businesses into an area. Attractive business climates typically entail good returns on investment that may result from government policies and/or services. The level of certainty within a business climate is important as well. Business leaders prefer business climates in which conditions are deemed certain to some extent. Economic development can be enhanced by public policies that increase perceived returns on capital and labor resources and/or that strengthen certainty on returns (Forkenbrock).

The Time Lag between Transportation Investment and Economic Development

The correlation between transportation investment and economic development is not understood clearly. One matter of interest concerns the time lag between investment in transportation systems and later economic development. Transportation investments have a dynamic impact on economies: Short-term effects are evidenced in construction-related employment increases and increased market access, and long-term effects include increased productivity and attraction of new businesses to an area. Alam et al. (2005) noted that the time lag between investment and economic development "significantly affects how the benefits of an investment are evaluated." Public infrastructure projects create evident jobs and short-term economic gains, yet longer-term effects are more difficult to assess and capture. For example, economic benefits resulting from business attraction and cost reductions are not necessarily realized immediately upon completion of construction. These economic benefits occur over a longer time period as businesses and households make location decisions. The timeframe in which full economic effects may occur extends beyond the completion of development and may be difficult to define. Effects may be realized more quickly if appropriate and favorable public policies and social aspects are in place to encourage development and usage of transportation facilities. Alam et al. (2005) used the data envelope approach to analyze the time lag between transportation investment and consequent economic development in four representative zones in Bangladesh. For Bangladesh, results indicated that "the lag time ranges from 2 to 3 years for short-term analysis, 6 to 8 years for medium-term analysis, and 15 to 20 years for long-term analysis" (Alam et al.).

ECONOMIC DEVELOPMENT BENEFITS RESULTING FROM TRANSPORTATION INVESTMENTS

Economic development is generally desired by communities, so implementing strategies to encourage development is important. Economic activity is increased through business creation, attraction, expansion, and retention. Economic development agencies can promote such increased economic activity by taking any of the following actions (Weisbrod 2000):

1. Reduce business operating costs and increase business productivity;
2. Expand the size of business markets;
3. Increase business access to needed labor, supplies, services, and materials;
4. Promote the advantages of their areas.

The above actions can be accomplished in a variety of ways, and transportation is one means by which each action can be achieved. Transportation improvements can reduce businesses' travel times and costs and boost business productivity. New or improved transportation systems allow businesses to expand their reach farther into supplier, materials, labor, and consumer markets. Also, a good and reliable transportation system gives an economic development agency an incentive with which to attract business investment. The preceding benefits are among several economic development benefits resulting from transportation investments. Many of these types of economic development benefits are mentioned and discussed below.

Improved Access to Labor and Consumer Markets

A good transportation system provides access to raw materials, suppliers, labor markets, and consumer markets (Forkenbrock). A good transportation system also keeps transport costs relatively low, thereby keeping production and distribution costs low by mitigating "barriers to mobility, giving the manufacturing, retail, and service sectors better access to varied, specialized, and productive sources of labor; a diverse selection of inventory and raw materials; and a broad customer base" (Cambridge and EDRG, 2003). Transportation improvements give businesses greater access to labor markets and skilled workers, which can improve businesses' productivity, efficiency, and quality of goods and services. Transportation improvements can expand the reach of businesses into consumer markets that were not previously serviceable. Increased output may lower per capita production and distribution costs as economies of scale are achieved (Cambridge and EDRG, 2003).

Business Attraction

Business attraction refers to when a business- not previously represented in a given area- locates in the area, bringing new investment and employment (Seskin). A good transportation system attracts business, because good transportation facilities give businesses an advantage over competitors (Forkenbrock). Measures of business attraction include changes in the types of businesses within a region and the rates at which businesses come to a region. Business attraction reflects a region's relative cost factors, which include the following (Seskin):

- Labor,
- Sites,
- Utilities,
- Quality of life,
- Business climate,
- Capital, and
- Transportation.

The influence of each factor listed above may vary by industry and by facility type (e.g., office building, industrial plant, etc.). Transportation has an important influence on attracting businesses to particular locations, and Seskin (1990) noted that "[failure] to include and quantify the value of these business attraction benefits as part of a highway impact assessment would result in an unnecessary underestimation of the benefits associated with a project." Seskin (1990) used a four-step process to estimate business attraction benefits that included determining an industry's or sector's sensitivity to transportation and estimating business attraction potential.

A business' perception of a region's transportation system also affects business attraction. For example, roadways that have been upgraded in functional classification may affect business location decisions in ways that are not necessarily attributable to changes in travel time. Businesses may be attracted to a location based upon the functional class of a roadway more so than that a roadway allows for a relatively smaller travel time (Seskin).

An adequate and efficient transportation system increases an area's competitiveness relative to other locations. Good transportation systems attract businesses and enable existing businesses to expand. For example, manufacturers generally require access to major highways and potentially to intermodal facilities. Efficient transfer and intermodal facilities can reduce costs for manufacturers. Another example of business attraction involves cases when national and multi-national firms make office or headquarters location decisions based upon whether or not cities have frequent, nonstop commercial air service (Cambridge and EDRG, 2003).

Reduced Business and Logistic Costs

Transportation improvements provide a region's businesses with a competitive advantage by lowering business costs, which results in increased profits, access to new markets, and more competitive products (Seskin). If travel time reliability improves as a result of a transportation investment, businesses may be able to reduce warehousing and logistics costs; consolidate operations and thereby lower expenses; and expand their range of alternatives for entering markets and locating new plants. Cost savings give companies the opportunity to hire more workers, raise employee wages, and/or increase spending on research and development. A study of transportation's role in the Wisconsin economy demonstrated that highway pavement improvements and capacity expansions reduced costs to Wisconsin businesses, which could allow businesses to increase output and/or hire new employees (Cambridge and EDRG, 2003).

Increased Private Sector Productivity

Attaran and Auclair (1990) developed two econometric regression models to measure separately the association between the stock of highways and the productivities of (1) the private sector and (2) labor and capital. The regression models indicated that highway stock leads to improved private-sector productivity. The models also indicated that highway stock has a greater effect on improving productivity relative to how non-highway infrastructure improves productivity. Essentially, highway deficiencies may reduce economic production and productivity (Attaran and Auclair). Lombard concluded that highway investments do impact "private sector investment and labor productivity on an aggregate scale" (Lombard).

Property Values

The extent to which land values increase as a result of a transportation improvement depend on factors such as the degree of improvement in accessibility, the level of demand for such accessibility, and negative effects resulting from congestion, noise, and pollution. Proximity to a highway that contributes to negative impacts (i.e., congestion, noise, etc.) will lead to lower land values. However, land values may increase greatly as a result of a transportation improvement in areas where demand exists for adequate highway access and the supply is limited (Litman).

Tax Revenues

Additional economic activity resulting from a transportation investment may increase state tax revenues supported by personal income, sales, motor fuel, and business taxes (Cambridge and EDRG, 2003). Weisbrod and Weisbrod (1997) remarked that government revenues could be affected when economic impacts on total business sales, wealth, or personal income expand or contract the tax base. Perera (1990) noted that in Ontario, the government recovered "more than 35 percent of the total cost of an improvement…from personal taxes, indirect business tax, tariffs, and local property and business tax." The TRIM model indicated that the federal, provincial, and local governments recovered different proportions of the improvement investment- 18 percent, 12 percent, and 5 percent, respectively. Results from a study for the Utah Department of Transportation indicated that a positive relationship exists between transportation improvement projects and sales tax revenues (Schultz et al., 2010).

Tourism

In an appropriate context, changes in tourism also should be considered when assessing economic benefits resulting from a transportation improvement. Information can be gathered about visitor origins and destinations and visitor expenditures. This information can be combined with an assessment of the potential for growth and local attractions to yield a tourism demand forecast. This forecast and data about tourism expenditures can be used to estimate the economic impacts resulting from increased tourism activities that were stimulated by a transportation improvement. Economic impacts may be estimated by a regional economic model and provided in the form of direct, indirect, and induced expenditures (Seskin).

Travel costs and perceptions about the quality of travel experiences to particular destinations affect personal travel decisions. Accessibility is an important contributor to an area's success in attracting tourists and associated tourist revenue. Adequate transportation facilities may encourage longer and more frequent tourist trips, resulting in increased spending on goods and services (e.g., meals, lodging, fuel, and souvenirs) (Cambridge and EDRG, 2003).

Other General Benefits of a Good Transportation System

Transportation investments can benefit even people who do not use a given transportation facility. As a result of lower transportation costs, consumers may pay less for goods at markets, employees may receive higher wages, and business owners may see their net incomes rise (Forkenbrock). Transportation improvements may reduce congestion, resulting in savings related to the costs of time delays and fuel consumption. Transportation investments support jobs in various fields such as those in transportation and warehousing services, transportation equipment manufacturing, motor vehicle and parts dealerships, and other transportation-related industries (Cambridge and EDRG, 2003). Concerning the welfare of households, a good transportation system affords "households access to a broader range of higher-paying jobs, a wider selection of competitively priced consumer goods and housing options, and a convenient selection of health and human services" (Cambridge and EDRG, 2003). Additionally, auto ownership costs and travel costs are reduced, and accident rates may be reduced (Cambridge and EDRG, 2003).

EXAMPLES OF STATE PROGRAMS PROMOTING ECONOMIC DEVELOPMENT THROUGH TRANSPORTATION

State programs have been created to specifically promote economic development through transportation investments. The Revitalize Iowa's Sound Economy (RISE) program was created in 1985 in an effort to spur development within Iowa. The program was funded through a state tax increase of 2 cents per gallon, which provided about $33 million annually. Half of the program's funds went toward road improvements meant to attract new businesses to the state and to keep and expand existing businesses within the state. The Iowa Department of Transportation initiated research "to develop a methodology that [could] be used to factor economic development considerations into the programming of improvements for the commercial and industrial network" (Drew [b]).

Wisconsin created the Transportation Economic Assistance (TEA) program in an effort to assist businesses and communities in funding transportation improvements necessary for economic development. The program's goal was to attract employers and create more jobs within Wisconsin. TEA program applications incorporated multiple economic criteria including transportation costs and benefits, numbers of jobs, and local funding. Some of the most important criteria used include the ratio of transportation improvement cost to the number of direct jobs, value of increased wages, and the income and tax benefits to the state's economy. Transportation improvements under the TEA program led not only to reduced transportation costs, but also to changes in Wisconsin's economy due to resulting economic development. Changes in transportation user costs and benefits (e.g., travel times, travel costs, and safety) were measured by the Highway Investment Analysis Package (HIAP). Changes in economic development impacts (e.g., jobs, wages, and income taxes) were measured by a REMI model that was customized for Wisconsin's economy (Drew [b]). Under its current "Corridors 2020" highway prioritization program, the Wisconsin DOT has an Economic Development and Planning Section that collaborates with the business community and economic development organizations in order to identify economic needs and opportunities within Wisconsin (Kreis et al.).

In the late 1980s, Oregon created an Immediate Opportunity Fund for the purpose of supporting economic development in the state through the construction and improvement of roadways and streets. Increases in particular motor vehicle gas taxes were used to support the Fund, which was only accessible when other financial resources were unavailable or insufficient. The Fund was intended to achieve three objectives (ODOT):

1. Provide needed street or road improvements to influence the location, relocation or retention of a firm in Oregon.
2. Provide procedures and funds for the Oregon Transportation Commission to respond quickly to economic development opportunities.
3. Provide criteria and procedures for various public and private entities to work with the Oregon Department of Transportation (ODOT) in providing road

improvements needed to ensure specific job development opportunities for Oregon or to revitalize business or industrial centers.

CONCLUSIONS

While no definitive relationship has been established between transportation investments and economic development, several general conclusions can be made. Essentially, transportation investments may remove or mitigate the influence of any barriers to development (Drew [b]). It is clear that transportation enables economic development. That is, transportation accessibility and mobility are necessary for economic development to occur, yet transportation alone is not necessarily sufficient to produce economic development. Development is fostered through a combination of different elements (Drew [b]). Furthermore, different industries have different transportation needs, and transportation improvements affect industries in different ways and to varying degrees. Transportation investments do lead to several economic development benefits including reduced business costs; increased business attraction for an area; and improved access to labor, suppliers, and consumer markets.

Chapter 3: Economic Impact Analysis

Economic impact analysis accounts for more than just the traditional notion of project benefits and costs. It captures the economic impacts of improved accessibility, market expansion, and enhanced connectivity. A transportation improvement does not merely reduce travel times and travel costs; indeed, its impact (is not localized but) extends to the entire regional economy. Traditional benefit/cost analysis does not capture the latter sort of impact, while economic impact analysis can account for such economic impacts.

This chapter addresses economic impact analysis, which is used to assess and account for economic impacts resulting from transportation investments. The need for economic impact analysis is discussed initially, followed by a definition for "economic impact". Various types of economic impacts are described, and transportation user benefits are distinguished from economic development benefits. Other addressed issues include economic impact measures, measurement issues, and considerations for assessing economic development impacts.

NEED FOR ECONOMIC IMPACT ANALYSES

Administrators, engineers, and planners face the increasingly difficult task of prioritizing capital investments. Interest groups, the public, and planning agencies each have needs and desires that may conflict with the needs and desires of other entities (Perera). Evaluating economic impacts resulting from transportation investments is important not only in comparing project alternatives, but also in comparing alternative uses of public spending. That is, public funds are available to alternatives other than just transportation projects, such as education and public services (TRR 1274 Foreword). Furthermore, social, cultural, environmental, and now economic factors must be considered in making investment decisions. Analyses that use only primary user benefits and costs, as opposed to analyses that include economic benefits, are "considered inadequate when negotiating for funding of transportation improvements" (Perera).

The lack of adequate funding at federal, state, and local government levels necessitates a rigorous approach to ranking highway projects based upon estimated project benefits. While benefit/cost analysis has been used for many years, economic impact analysis has yet to be fully developed. User benefits pertain to travel times, operating costs, and safety metrics. Regional economic benefits relate to business expansion, business attraction, and tourism. According to Seskin (1990), three elements should characterize highway investment decisions. First, an accurate and comprehensive framework is needed to assess benefits, including economic benefits resulting from transportation investments. Second, several benefit assessment methods could be integrated into a single framework. Each assessment method has its advantages and disadvantages, and each benefit type should be calculated by the method best suited for determining the given benefit. Third, results from a benefit assessment system must be understandable and useful. Investment alternatives should be sorted and ranked clearly and unambiguously (Seskin).

USER BENEFITS AND ECONOMIC IMPACTS

User Benefits

The traditional framework for assessing impacts resulting from highway improvements consists of determining user benefits, which are in the form of travel time savings, changes in vehicle operating costs, and reductions in accidents and fatalities. At least two scenarios are compared: The "no-build" scenario and a "build" scenario involving a transportation improvement (e.g., new roadway construction, roadway capacity expansion, etc.). Differences in travel times between scenarios, which may be determined by using a regional travel demand model, indicate the impact that a transportation improvement project could have within a region if a project were implemented. Transportation improvements also can lead to changes in travel speeds or operating conditions, both of which affect vehicle operating costs. Various metrics may be used to calculate vehicle operating costs including travel speeds, reductions in acceleration or deceleration, and reductions in waiting or idling times. Calculation of safety improvements consists of estimating the number of accidents, injuries, and fatalities for each scenario and noting the differences in safety (Seskin). Transportation user benefits begin when the improved facility is first used, whereas economic impacts can occur from the first day of construction. Additionally, economic impacts result over time and thus are not immediately fully realized (Perera).

Defining Economic Impacts

Economic impacts have been defined as the "effects on the level of economic activity in a given area" (Weisbrod and Weisbrod) and can be quantified in terms of any one of the following measures (Weisbrod and Weisbrod):

1. Business output (revenue or sales volume)
2. Value added (gross regional product)
3. Wealth (including property values)
4. Personal income (including wages)
5. Jobs

The above measures will be discussed later in this chapter. Net economic impacts reflect expansions or contractions in an area's economy that result from changes in facilities, projects, and/or programs. Gross economic impacts characterize the contributions to an area's economy by facilities, projects, and/or programs. Economic impacts should not be misconstrued with individual "user benefits" or broader social impacts, which typically are concerned with changes in amenities or quality of life (i.e., health, safety, etc.). User benefits and social impacts may only constitute economic impacts should either affect the economic activity in a given area (Weisbrod and Weisbrod).

Economic impacts result in fiscal impacts, "which are changes in government revenues and expenditures" (Weisbrod and Weisbrod). The tax base from which government revenues are collected may be expanded or contracted when economic impacts influence business sales or personal incomes. Furthermore, demand for public services may change because of economic impacts on employment and population levels.

It is important to note that fiscal impacts are not equivalent to economic impacts (Weisbrod and Weisbrod).

Social and environmental benefits are typically not included in economic analyses, largely due to a lack of consensus on the valuation of these types of benefits. Social benefits may relate to improvements in quality of life such as making communities more livable, sustainable, and aesthetic (e.g., through landscaping or improving transit stations). Environmental benefits may relate to reducing pollution and improving air quality in a community (Cambridge and EDRG, 2003).

Effects of Economic Impacts

Perera (1990) noted that economic impacts "measure the secondary effects of capital expenditures on the regional economy…. [and] affect income, employment, and production and generate tax revenues and consume resources." Economic impacts resulting from transportation improvements can affect any of the following areas (Perera):

- Business and industry,
- Residential development,
- Tax revenues,
- Regional and community development, and
- Resources.

Additionally, impacts may be permanent or temporary; beneficial or detrimental; and direct, indirect, or induced. The latter impacts affect business and industry and are discussed in detail later in this chapter. Transportation improvements may lead to business expansion, business attraction, and reductions in the costs of moving goods and services, which allows businesses to be more competitive and thereby promotes regional development and growth. Transportation improvements also may redistribute traffic patterns, which may encourage economic development in higher trafficked areas and discourage development in areas that experience decreases in vehicular traffic.

Improvements in accessibility may stimulate tourism and recreational activities, which should be considered in areas where these activities are relevant. Transportation improvements can affect the agricultural industry by increasing profitability as a result of improved access to markets; alter land use from agricultural to residential, commercial, or industrial land uses; and change agricultural productivity. Other industries such as mining and forestry benefit from lowered transportation costs resulting from transportation improvements. Possible negative impacts of improvements include when right-of-way acquisition displaces businesses along a corridor, reduces the number of jobs and services available along a corridor as a result of displaced businesses, and precludes customers from accessing businesses because of a right-of-way barrier effect (Perera).

Residential development can be affected by transportation improvements in at least two ways. First, transportation improvements may lead to increases in employment, which generally requires more dwelling units to house workers. Second, right-of-way acquisition may reduce the housing stock and cause relocation or replacement of dwelling units. Transportation projects also may change community growth patterns, direct income levels in an area, and public revenues and expenditures (Perera).

Government expenditures generate tax revenues for the various levels of government. The primary source of tax revenue for local governments is the property tax. Right-of-way acquisition may reduce the available land that can be taxed, reducing property tax revenues. However, a transportation improvement may increase accessibility to an area and encourage commercial, industrial, or denser development. The increase in accessibility and/or attractiveness of land for various land uses generally will lead to increased property values, which increases tax revenues for local government. Conversely, a transportation improvement may decrease property value if detrimental environmental or safety effects occur. It is also important to consider how public services may change as a result of any transportation improvement; an improvement may stimulate growth and result in greater demand for public services, which will require increased public expenditures to meet the new demand (Perera).

Other areas affected by impacts resulting from transportation improvements include resources and land values. Construction and operation of a transportation project will directly consume resources, of which four broad categories exist: Land, labor, materials, and energy. Impact assessments for each category can be made to determine economic impacts relevant to each resource category. Land values will increase due to lower transportation costs resulting from a transportation improvement. Including this increase in land value with the aforementioned economic benefits will result in double-counting the economic effects of transportation improvements. However, aggregating the increase in land values for all properties in an impact or study area would provide “the value of an improvement to the community or society at large” (Perera).

A summary of the above categories of economic impacts is provided below in Figure 3.1. Note that impacts are classified according to class and category, as well as permanence and whether impacts are direct, indirect, or induced. Perera (1990) noted that the most important impact categories (in order) seem to be business growth, recreation and tourism, and property tax.

Class	Category	Effects	Direct	Indirect	Induced	Temporary/Permanent
Business & Industry	Facility Construction	Expenditure on labor and materials for construction	x			T
		Secondary effects induced by direct expenditures		x	x	T
		Losses to firm in the vicinity		x		T/P
	ROW Acquisition	Loss of jobs and services due to relocation	x			T
		Redistribution of jobs and services within the corridor		x		T
		Loss of land	x			P
	Business Growth	Expansion of existing businesses	x	x	x	P
		Attract new businesses or labor	x	x	x	P
		Deter businesses that depend on remoteness	x	x	x	P
	Tourism & Recreation	Expansion of existing businesses	x	x	x	P
		Deter businesses that depend on remoteness	x	x	x	P
		Divert potential business	x			P
	Agriculture	Increase or decrease in productivity and profit	x			T
		Encourage conversion of land to other use		x		P
	Mining & Forestry	Improved accessibility to markets	x			P
Residential	Regional Economy	Replacement & Relocation housing needs		x	x	T
		Attracts additional workers and families		x	x	P
Tax Revenues	Property Taxes	Loss of tax revenues due to acquisition	x			P
		Property value changes and associated tax revenues		x	x	P
	Public Service Needs	Require additional expenditure			x	P
Regional & Community	Community Region	Changes to pattern of community growth				?
		Changes to public revenues and expenditure		x		?
		Gain or loss in direct incomes	x			?
		Environmental changes				T
Resources	Land	Covered under ROW acquisition	-	-	-	-
	Materials & Labor	Covered in effects of facility construction	-	-	-	-
	Energy	Consumption associated with direct, indirect, and induced effects	x	x	x	P

Figure 3.1- Classification summary of economic impacts (Perera)

TYPES OF ECONOMIC IMPACTS

Generative, Redistributive, and Transfer Impacts

Economic impact analyses typically are either predictive or evaluative impact analyses. Predictive economic impact analysis forecasts economic impacts that result from proposed investments. Examples of predictive analyses include Environmental Impact Studies and Major Investment Studies. Evaluative economic impact analysis assesses economic impacts after a project has been constructed or an investment has been made. Analyses also may compare various investment alternatives including a no-build or "no-project" alternative.

TCRP Report 35 (Cambridge Systematics et al., 1998) distinguishes between three types of economic impacts: Generative, redistributive, and financial transfer impacts. The key characteristic of generative impacts is a region's net economic growth, which results when underused resources are used more or when resources are used more efficiently. Generative impacts demonstrate "increases in economic productivity, the competitive advantage of a region, and quality of urban living" (Cambridge Systematics et al., 1998). Examples of generative impacts are provided in Figure 3.2 below along with examples of the other two types of economic impacts. Redistributive impacts track shifts in economic activities in an area. Economic activity may occur regardless of any investment, but the economic activity would likely be more geographically dispersed without investment compared to a situation involving a targeted investment, such as a transit corridor investment. Thus, redistributive impacts may or may not be considered true economic impacts, yet these impacts are important considerations for policymakers that may want to understand how economic activity can be generated in a particular area. Examples of redistributive impacts are provided in Figure 3.2. Transfer impacts are actually accounting or financial impacts rather than economic impacts and involve the transfer of money from one entity to another entity. Concerning the three preceding types of impacts, only generative impacts result in net economic gains for society at large, though all three impacts can be important for conveying information about economic activity (Cambridge Systematics et al., 1998). Examples of the three different types of economic impacts are provided in Figure 3.2 below.

Generative Impacts	Redistributive Impacts	Financial Transfer Impacts
• User benefits (travel time savings, safety benefits, changes in operating costs) • Employment and income growth unrelated to system construction, operation, or maintenance • Agglomeration/urbanization benefits (e.g., higher productivity, lower infrastructure costs) • External benefits (e.g., air quality) • Accessibility benefits (e.g., access to employment) • Reduced development cost due to reduced parking	• Land development (e.g., clustered development around transit stations) • Employment and income growth due to land development • Increased economic activity within corridor	• Employment and income growth related to system construction, operation, or maintenance • Joint development income to local agencies • Property tax impacts

Figure 3.2- Categories of transit-related economic impacts (Cambridge Systematics et al. 1998)

Direct, Indirect, and Induced Economic Impacts

An economic impact also can be categorized as a direct, an indirect, or an induced economic impact. One other possible category is a dynamic economic impact, which characterizes shifts in population, business location patterns, and/or land uses over time. Direct impacts represent changes in the growth of businesses that are directly affected by a transportation project or investment. Businesses experience direct impacts when projects and/or investments lead to changes in businesses' operating costs and/or access to markets including labor, supplier, materials, and consumer markets (Weisbrod 2000). These direct impacts result from a combination of reduced operating costs, enhanced productivity, and increased sales, which allows existing businesses to expand operations while also attracting new businesses to the area. Direct economic impacts also accrue to consumers using the transportation system (Cambridge and EDRG, 2003). Indirect impacts are changes in business activity "resulting from changes in sales for suppliers to the directly-affected businesses (including trade and services at the retail, wholesale and producer levels)" (Weisbrod and Weisbrod). Indirect economic impacts occur when new businesses to the area and expanded existing businesses increase demand for raw materials, supplies, equipment, and services. Suppliers and equipment manufacturers respond to the increasing demand by increasing output and hiring new workers. As an interesting example of indirect benefits, consider that reliable transportation has contributed to the increase in e-commerce over the past several years. In addition to businesses that directly benefitted from improved reliability and lower transportation costs, delivery companies such as Federal Express (FedEx) and United Parcel Service (UPS) have benefitted indirectly as each company's sales increased on the heels of greater demand spurred by e-commerce. Investments in transportation have allowed FedEx and UPS to meet such demands adequately (Cambridge and EDRG, 2003). Induced impacts are changes in business activity that occur as a result of workers' spending additional income on food, clothing, and other goods and services. The sum of direct, indirect, and induced impacts equals the total impact on economic growth. The ratio of the total impact to the direct impact is called an "economic multiplier," and the nondirect impacts (i.e., indirect and induced impacts) collectively are called "multiplier effects" on business activity (Weisbrod 2000). Figure 3.3 below shows the process by which various economic effects occur, starting with how projects can alter business costs or access to markets, which lead to changes in business activity (i.e., direct effects). The direct effects cause changes in needed supplies and in workers' wages, resulting in changes in business activity to supplier businesses (indirect effects) and to consumer businesses (induced effects). Total economic effects can be measured in terms of business output, gross regional product, wages, and/or employment figures.

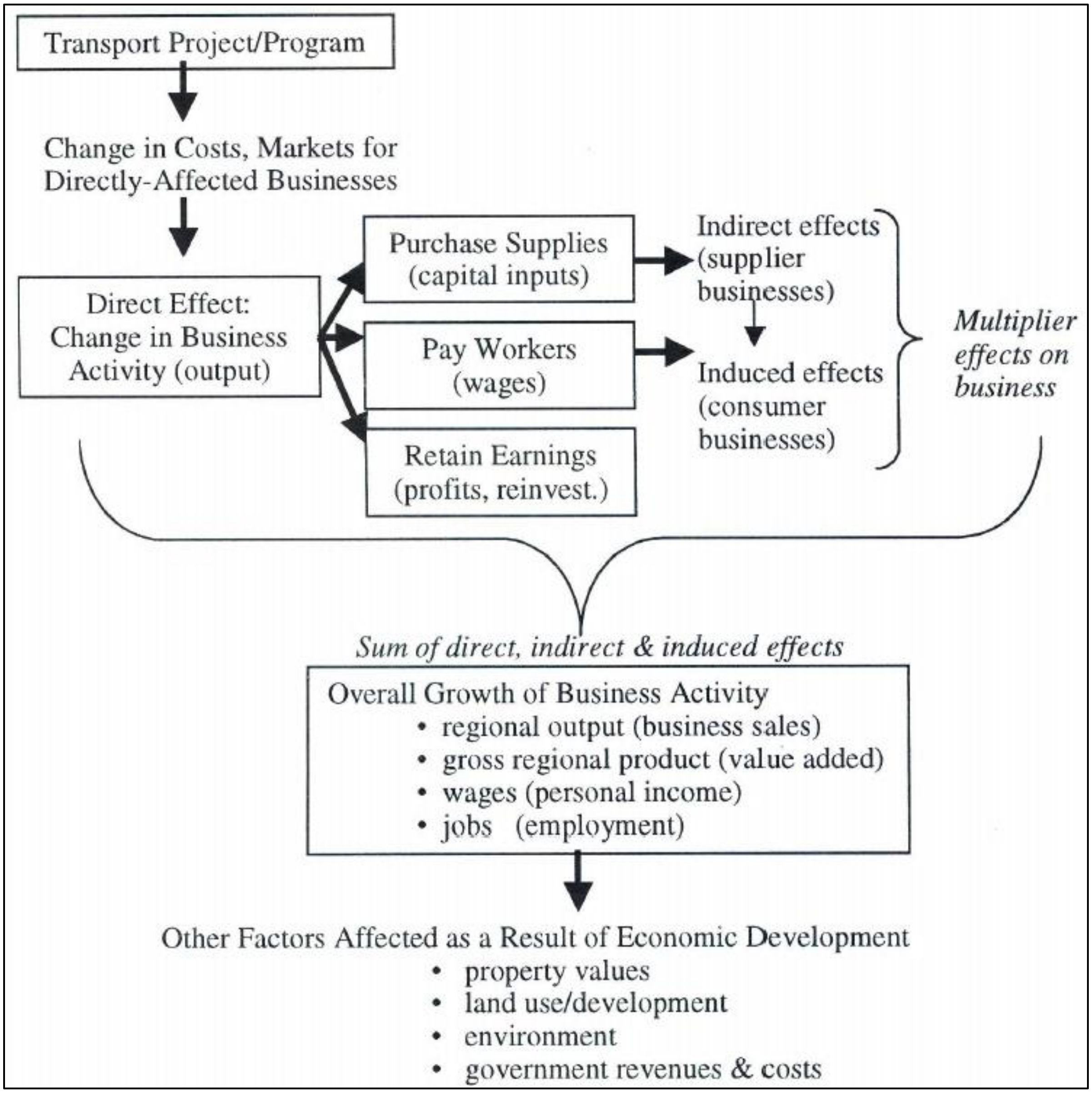

Figure 3.3- Types of economic development impacts (Weisbrod 2000)

Often Overlooked Transportation Economic Impacts

Evaluation of economic impacts resulting from transportation projects may not include the full scope of economic impacts that occur over time. Some impacts are often overlooked or not considered. Figure 3.4 below includes typical impacts that are considered in economic impacts analyses, as well as some aspects that are generally not included in such analyses. Of the often overlooked impacts, two are salient. Transportation projects may lead to savings in household spending on vehicles and fuel, and such savings may allow a household to spend money elsewhere, thereby supporting local employment and business activity. Also, roadway improvements eventually may increase traffic and cause sprawl, which can result in congestion and alter per capita vehicle costs, energy consumption, and the amount of pollution emissions (Litman).

Table 40 **Transportation Economic Impact Analysis**

Generally Considered	Often Overlooked
• Project impacts on local employment and business activity. • Increased traffic speeds and reduced congestion delay • Reduced vehicle operating costs.	• Impacts on future consumer expenditures on vehicles and fuel, and their effects on future local employment and business activity. • Parking facility costs and its impacts on development patterns and affordability. • Generated traffic and sprawl effects, and resulting impacts on downstream congestion, per capita vehicle costs, accidents, energy consumption and pollution emissions. • Basic mobility and non-drivers' ability to access services, schooling and employment. • Mobility management options as alternatives to conventional solutions.

This table identifies economic impacts that are often overlooked in conventional analysis.

Figure 3.4- Transportation economic impacts that are typically considered, along with impacts that are often overlooked (Litman)

Important Distinction Concerning the Value of Project Benefits and Economic Development Impacts

As mentioned previously, user benefits and social benefits are different from economic impacts. User benefits and social benefits are not economic impacts unless either benefit affects the flow of money in an economy. More generally, the economic value of project benefits is not the same as economic development impacts, which affect the economic activity in an area. Weisbrod (2006) noted that a danger exists in the "blurring" of these distinct aspects during analyses involving impacts and benefits. In some cases, a project's benefits and economic impacts are similar. Business-related travel time savings and travel-related money savings (e.g., personal household costs) are components of project benefits and also affect the economy. In some cases, economic development impacts may be broader than factors counted toward the net value of project benefits. Economic impacts in an area can encompass the short-term effects of construction spending, whereas in benefit/cost accounting, net income benefits from construction spending may not differ from spending the same amount of money for alternative purposes. Economic impacts also may be narrower than some factors counted toward the net value of project benefits. For example, personal travel time savings (user benefits) and environmental benefits (social benefits) can be valuated in monetary terms and are project benefits, but neither of these benefits necessarily affects the flow of money or jobs in an area's economy (Weisbrod 2006). Figure 3.5 below provides a breakdown of how various benefits may be counted as user, social, and/or economic development benefits. Weisbrod (2006) notes that a recent trend has been to report separately (1) economic impacts that affect the flow of money in an economy and (2) project benefits.

	Travel Efficiency Benefit	Full User Benefit[1]	Societal Benefit	Econ Development Benefit
$ Passenger Time Savings for personal travel	Yes	Yes	Yes	-- [7]
$ Passenger Time Savings for business travel	Yes	Yes	Yes	Yes
$ Travel Vehicle Operating Expense Savings	Yes	Yes	Yes	Yes
$ Shipper/Recipient Productivity Gain[2]	--	Yes	Yes	Yes
$ Indirect (Downstream) Productivity Gain[3]	--	--	Yes	Yes
$ Value of Environmental Benefits[4]	--	--	Yes	-- [7]
$ Local Income Growth from Business Attraction [5]	--	--	-- [6]	Yes

1 Transportation system users are defined as the travelers for passenger travel and the shippers for freight travel
2 defined as additional net income produced through cost savings or scale or production economies for shippers
3 "downstream" income effects on other businesses that indirectly also realize productivity or cost benefits
4 value of air quality, water quality, noise improvements, expressed in terms of "willingness to pay"
6 Attracting additional business activity from one location to another is only a societal benefit insofar as there is a benefit of redistributing income growth from richer areas to poorer areas.
7 Personal time savings and environmental improvement do not directly affect the flow of dollars in the economy (though in theory they could lead to indirect changes in economic patterns if they affect migration rates).

Figure 3.5- Distinction between economic impacts and the economic value of project benefits (Weisbrod 2006)

MEASURING ECONOMIC DEVELOPMENT IMPACTS

Standard Economic Growth Measures

Economic growth in an area is typically captured by using at least one of four standard measures: Regional output, value added, personal income, and employment. Regional output refers to the revenues generated by all business sales of goods and services in an area. The value of business sales accounts for both final sales and inter-industry sales of intermediate products, which are products that are sold to other industries for the purpose of being used in businesses' production processes. Business people typically understand this measure the best compared to the other standard economic growth measures (Weisbrod 2000).

"Value added," also referred to as gross regional product (GRP), is the value of final goods and final services produced in an area. "Final" refers to the case in which goods and services "are not purchased for further processing or resale within" an area (Weisbrod 2000). Value added equals output minus the cost of purchasing intermediate products (Weisbrod 2000) and "reflects the sum of wage income and corporate profit generated in the study area" (Weisbrod and Weisbrod). Economists generally accept value added as the best measure for reflecting changes in an area's economic activity.

Personal income represents the full monetary income that a person intakes. Various components comprise personal income including wages and investments. Wages are compensation to workers for workers' services, and wages are a portion of business output and value added. The general public understands this measure, which is actually an underestimate of the income impact because some generated profit may be paid out in dividends or reinvested in buildings, equipment, or workforce training (Weisbrod 2000; Weisbrod and Weisbrod).

The most popular measure for conveying economic impacts to the public is employment figures. Employment refers to the jobs associated with economic activity, and employment figures are easier to obtain compared to other impact measures

(Weisbrod 2000). However, jobs figures have limitations in that the figures may not indicate the quality of employment opportunities, and the figures “cannot be easily compared to the public costs of attracting those jobs (through subsidies, tax breaks or public investments)” (Weisbrod and Weisbrod).

Other Economic Growth Measures

Other measures highlight particular economic development impacts rather than encompassing the overall change in an area’s economy. These measures include productivity, investment, property values, and taxes. Productivity refers to the level of efficiency achieved in production and “is generally expressed as a ratio of output or GRP to the cost of some input (labor or capital) involved in its production” (Weisbrod 2000). Productivity may increase based upon more efficient use of existing resources or upon the use of resources that have shifted locations. Personal incomes and business investment are affected by productivity. Capital investment refers to money that is spent in an area for the purpose of improving land, constructing buildings or facilities, and purchasing equipment. Capital investments may occur as a result of an area’s attractiveness for business and commerce. Typical measures used to track capital investments include total investment made in an area or construction spending within an area. Changes in property values reflect changes in demand for real property (i.e., land and buildings). Increases in population, personal incomes, and business activity may increase demand for property and consequently increase property values. Property values can indicate business growth and also serve as indicators for property owners’ wealth. Taxes and government expenditures are “fiscal impacts” that do not represent changes in an area’s economy. Changes in revenues or expenditures may indicate the direction and status of an area’s economy, though taxes and government expenditures are not considered fundamental measures to be used in assessing the economic development impacts of transportation projects (Weisbrod 2000).

Selecting Appropriate Economic Impact Measures

Selection of an appropriate economic impact measure depends on the purpose of the corresponding analysis. A public information study that is intended to provide the general public with information about a proposed project should use economic impact measures readily understood by the public, such as jobs figures. A benefit/cost (B/C) analysis compares project benefits and costs to aid in planning and decision-making, and B/C analyses typically use personal income or value added measures to represent a project's economic benefit. A retrospective study incorporates benefit measures based on historical data such as data about employment, business sales, and/or property values (Weisbrod and Weisbrod).

Choosing Appropriate Perspectives for which to Determine Economic Impacts

A transportation project may have impacts on multiple geographical levels and on different public and private entities. The appropriate perspective for viewing economic impacts should be considered when calculating economic impacts, and the perspective can be based on a number of factors including justification for an investment (e.g., traffic congestion relief, regional economic development, or national competitiveness) and the funding source (local/state/federal dollars and/or private funds) (Cambridge et al., 2006). Figure 3.6 below demonstrates how economic impacts can be disaggregated by geographical or sector-specific perspectives. Figure 3.6 also notes common inputs and final outputs for each perspective.

Input	Output	Final Output
National Economic Impacts		
• Reduced Transport Costs • Reduced Logistics Costs • Business Market Expansion		• Exports and Imports • Total U.S. output • GDP (Value Added) • Personal income
Local/Regional Economic Impacts		
• Change in local production costs[a] • or Change in final demand[b] • or Change in accessibility/quality of rail, air/sea port, highway[c]		• Total local output[a,b] • Output from new business attraction[c] • Local personal income[a] • Local GDP (value added)[a] • State and local tax revenue[a] • Value of externalities (discussed elsewhere)
Sector-Specific Economic Impacts		
• Change in production costs	• Employment by freight carriers (by mode) • Output by freight carriers (by mode) • Profits by freight carriers (by mode)	• Employment at logistics firms • Output and Profits logistics firms • Employment in non-transportation sectors[d] • Output in non-transportation sectors[d] • Profits in non-transportation sectors[d]

[a]Denotes econometric model;
[b]Denotes multiplier analysis;
[c]Denotes business attraction model; and
[d]Denotes stratification by North American Industrial Classification System.

Figure 3.6- Assessing economic impacts from different perspectives (Cambridge et al. 2006)

Issues in Measuring Economic Development Impacts

The measurement of economic development impacts is complicated by the lack of a clear understanding as to what constitutes an “economic development impact.” It has been noted that the meaning of the term is “multifaceted” and that the academic literature is not consistent in defining the term (Weisbrod 2000). Confusion sometimes exists when the term "economic impact" is used synonymously with "economic development impact," because "economic impact" may be associated sometimes with the study of social benefits and costs (Weisbrod 2000). Aside from terminology, other issues are relevant to the measurement of economic development impacts including study area issues, double counting, and transfers of economic activity.

Study Area Issues

Economic impacts are viewed from different perspectives and can be perceived as positive, negative, or neutral depending on an entity's or person's perspective. The geographical boundaries of an area partly dictate how impacts should be perceived for that particular area. Smaller geographical areas, such as neighborhoods, are more likely (relative to larger areas) to realize true economic activity when businesses relocate to the area. Larger geographical areas are more likely to realize impacts resulting from the redistribution of businesses within an area. From a national perspective, economic activity resulting from national transportation expenditures may have little, if any, contribution to the nation's overall economy because such activity may be largely related to a redistribution of activity within a nation. As a result, national-level studies examining economic effects resulting from national transportation spending have focused on how transportation investments affect national productivity (Weisbrod 2000). Noting that particular economic effects will be either internal or external to a study area depending on how the study area is geographically defined, Weisbrod and Weisbrod (1997) specify four factors to be considered in defining a study area for economic impact analysis:

1. The area of jurisdiction for the sponsoring agency;
2. The area of direct project influence;
3. Interest in distributional impacts on a sub-area; and,
4. Interest in external area consequences.

Double-Counting

The various economic impact measures overlap in nature and "basically represent different ways to view aspects of the same economic growth" (Weisbrod 2000). To avoid "double counting" the economic values of the impacts, the economic values of the measures should not be added. For example, profits and worker income comprise the value added measure and part of the business output measure. Consequently, the measures of income, value added, and business output should not be added together, because doing so would magnify the value of economic impacts that resulted (Weisbrod and Weisbrod).

Transfers of Economic Activity

Transportation investments can alter the amount of benefits that existing transportation facilities provide. For example, a newly constructed highway may draw businesses and ultimately customers away from locations along an alternative existing facility. Development and subsequent economic benefits increase along the new facility at the expense of the existing facility, which suffers from lost business activity. In this instance, net economic development may not have occurred. Rather, transfers in business activity result because businesses relocate from the existing facility to the new facility. A tangible example is when a state invests in a transportation improvement: If economic activity near the improvement occurs due to the relocation of businesses within the state, such activity does not constitute overall new economic development. Instead, the economic development at the site of the improvement is a transfer of business activity. Care must be taken to identify and account for such transfers of business activity. Additionally, this generalized example underscores the importance of clearly defining a study area so that benefits and costs within study areas are correctly quantified and understood (Forkenbrock).

Relative Use of Various Impact Measures

NCHRP Synthesis 290 (Weisbrod 2000) includes a survey of state, metropolitan, and provincial transportation agencies. The survey results indicate the relative use of various measures used to describe economic development impacts. User benefits, which are measures of transportation system efficiency, tend to be the most common measures used to describe project benefits. Examples of user benefits include travel time, travel expense, and safety. Employment is the economic development indicator that is most used by responding agencies. Other economic development indicators (e.g., personal income, business output, value added, and productivity) also are used, though to a lesser extent than the employment indicator. Figure 3.7 below shows survey results concerning how often responding transportation agencies have used particular economic impact measures (Weisbrod 2000).

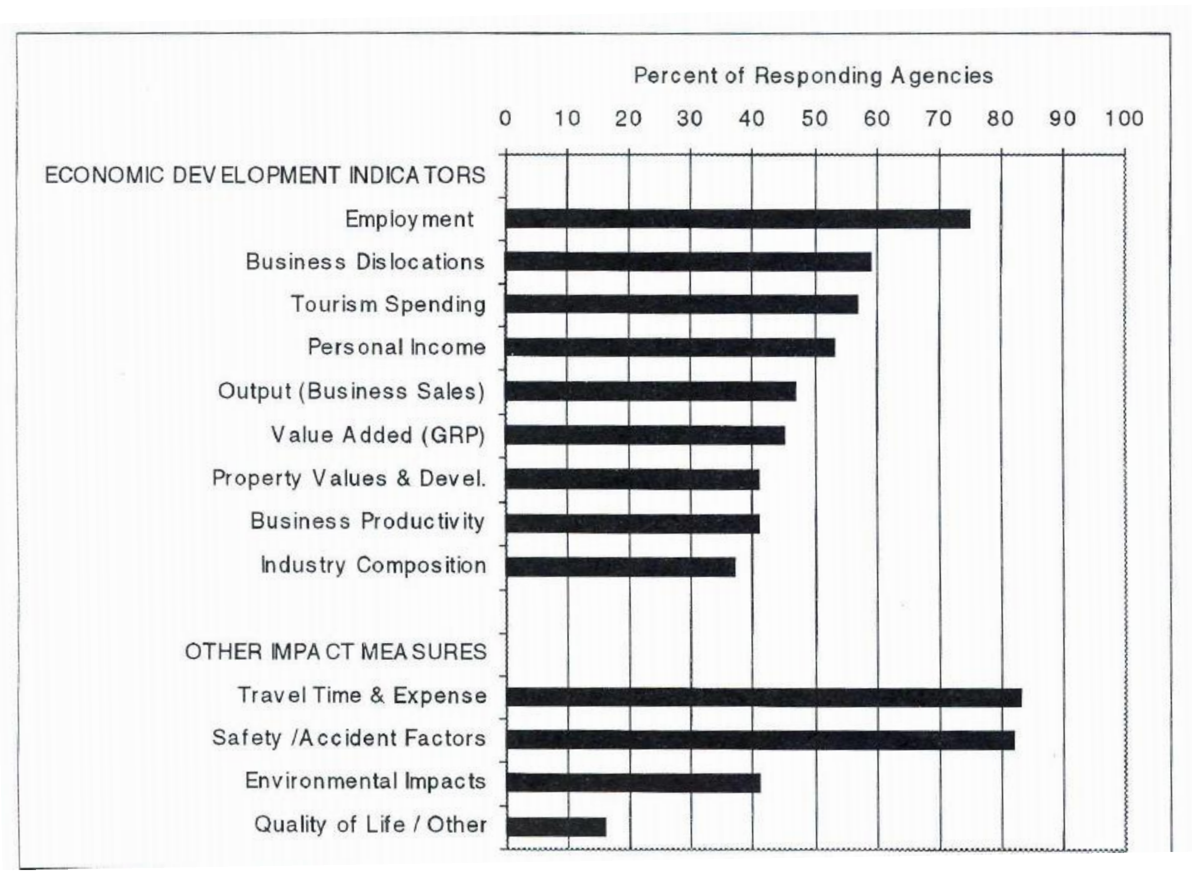

Figure 3.7- Transportation agencies' use of various economic impact measures (Weisbrod 2000)

Considerations for Assessing Economic Development Impacts

Weisbrod (2006) reviewed issues and analysis methods relevant to forecasting economic impacts resulting from transportation projects and noted several factors that at least should be considered when formulating an approach to estimating economic impacts. These factors are shown in Figure 3.8 below. Three categories were addressed: Analysis inputs, models and tools, and results from models and tools. Concerning analysis inputs, the author emphasized the importance of connectivity, multimodal accessibility, and the varying effects of transportation projects across different industry sectors. Models and tools should incorporate the preceding inputs, as well as be able to differentiate between economic development impacts and those benefits that do not affect the flow of money in an economy. Lastly, distinctions should be made in the results indicating the types of impacts captured, the location in which such impacts occurred (e.g., local, regional, or national), and the recipients of particular benefits and costs.

Considerations for Assessing Economic Development Impacts of Transportation Projects

Analysis Inputs

1. Recognize multimodal implications, such as how a highway project can also affect travel patterns and access to airports, marine ports, rail intermodal terminals and/or international trade routes.
2. Recognize the potential for impacts to hit certain industries that particularly depend on the reliability and functionality of specific modes, travel routes and terminals.
3. Recognize the potential value of connectivity and reliability improvements for both commuting and goods movement, and obtain measures of changes in those factors.

Analysis Models and Tools

4. Use analysis methods that can assess inputs including changes in access, reliability, multi-modal interchange and connectivity, as well as standard network times and costs.
5. Use analysis methods that can identify when transportation impacts are magnified or constrained by other economic growth factors, such as utility infrastructure, financing, labor skills and capacity for growth.
6. Avoid confusion by using analysis methods that can separate economic (flow of dollar) impacts from value of benefits that do not directly affect the flow of dollars.

Results

7. Distinguish forms of impact: (a) economic, (b) social and (c) environmental effects.
8. Distinguish areas of impact: (a) local, (b) state, (c) national and (d) global impacts, as appropriate for those who will be using the analysis results.
9. Distinguish benefit and cost perspectives: (a) savings for travelers, (b) savings for all users including freight shippers and recipients, (c) generation of income in the economy, and (d) the value of all benefits to society.

Figure 3.8- Various factors to consider when determining how to assess economic impacts resulting from transportation projects (Weisbrod 2006)

CONCLUSIONS

Transportation agencies and professionals have an exigent need to use economic impact analysis to support transportation investment decisions. Economic impact analysis can be used not only to justify transportation investments, but also to demonstrate a transportation investment's potentially superior impact on an economy relative to the impacts of alternative public investments (e.g., in education or public services). Economic development impacts are described in terms of business output, value added, income, and employment. Positive economic impacts consist of greater business revenues, increased value added, and income and job growth. Which impact measures are chosen depends on the purpose of an analysis and the intended audience. Different types of impacts include direct, indirect, and induced impacts. Economic impact analyses should account for impact measurement issues including double-counting, the definition of a study area, and transfers of economic activity. Also, economic impact analyses should capture impacts on connectivity and multimodal accessibility, as well as how industries are affected differently by transportation improvements.

Chapter 4: Economic Impact Analysis Methods and Tools

Public agencies have multiple reasons for evaluating economic development impacts, and the purpose for evaluating such impacts may dictate the method used for impact analysis. Motivations for conducting an economic impact analysis generally fall into at least one of the following four categories (Weisbrod 2000):

1. Forecasting of expected impacts of proposed projects for investment decision-making;
2. Planning and regulatory review of proposed projects;
3. Public education about the current economic value or role of an existing facility; and,
4. Evaluations of the actual impacts of past (completed) projects.

Analysis methods and tools may be appropriate for more than just one motivation category. For example, post-project evaluations may inform the public how economically important a particular project or facility is to an area. Also, the selection of an analysis method is not dependent only on the purpose of a study. Other relevant factors include the availability of resources (e.g., time and money), the experience and knowledge of an analyst, and the familiarity of study sponsors with particular analysis methods (Weisbrod 2000).

This chapter focuses on appropriate methods to estimate the economic impacts of proposed projects for the purpose of informing investment decisions (i.e., the first category listed above). As mentioned previously, methods may apply to more than just one category, so any methods discussed in this chapter may be appropriate for studies with motivations other than informing investment decisions. The purpose for focusing on the first category is rooted in the importance of investment decisions. A project's economic impact often is considered when other investment alternatives compete for limited public dollars or "when politically sensitive projects require justification on grounds more extensive than operational efficiency" (Jarzab). It is important that projects demonstrate a relatively great economic impact on an area, so as to justify public investment over other alternatives. In essence, transportation agencies have a need and an interest in assessing the economic development impacts of a proposed transportation project (Weisbrod 2008).

As discussed in previous chapters, various professionals (planners, engineers, and administrators) face the difficult task of selecting projects and justifying selections under budget and time constraints, as well as social and political pressures. In a survey of various transportation agencies, nearly half of agencies that had assessed a project's economic development impacts also "justified some specific projects primarily on the basis of economic development benefits" (Weisbrod 2000). Economic impact analysis informs the decision-making process for all involved parties by indicating a proposed project's potential economic impact in terms of changes in employment, income, and business output.

ELEMENTS OF AN ECONOMIC IMPACT ANALYSIS

In practice, an economic impact analysis of transportation investments consists of three components: Data, analysis methods and tools, and staff resources (Weisbrod 2000). Each element is briefly discussed below.

Data

Various data and data sources are available for use in different analysis methods and tools. Business and employment data for a study region are relevant to economic impact analysis, and census data and travel data are two sources commonly used in analyses. Depending upon the purpose of the analysis, other information that may be used includes data related to business markets, property values, and tourism (Weisbrod 2000). Figure 4.1 provides response information from a survey administered as part of NCHRP Synthesis 290. The information indicates the relative use of different sources of economic data by transportation agencies that had assessed the economic development impacts of a program or project. The most commonly used economic data sources include census data, population and workforce data, local interviews or surveys, and local/regional economic forecasts. Market studies and case studies are used relatively less than the preceding types of economic data sources.

ECONOMIC DATA SOURCES USED IN ASSESSING ECONOMIC DEVELOPMENT IMPACTS

Source of Economic Data	Agencies Using this Data Source for Assessing Economic Development Impacts (%)
Census and other population and workforce data	84
Local interviews or surveys	79
Local/regional economic forecasts	70
Freight or commodity flow data	58
Economic Census or BEA business data	56
Tourism, convention, and visitor data	52
County Business Patterns and other employment data	56
Business market studies of local area	40
BTS travel data	35
Case studies of other areas	35
Private business data sources (ABI, D&B, etc.)	33
Property value data	30
All other types of data	19

Note: BEA = U.S. Bureau of Economic Analysis; BTS = U.S. Bureau of Transportation Statistics; ABL = American Business Lists; D&B = Dun & Bradstreet.

Source: Survey of transportation planning agencies (question 12); results among respondents answering yes to question 7.

Figure 4.1- Data sources used by responding transportation agencies in a survey (Weisbrod 2000)

Analysis Tools and Methods

Various economic impact assessment methods and data sources are used by different entities and within different studies. While diversity in methods and data sources exists, a "common procedure" is typically used to assess economic benefits resulting from transportation projects (Horowitz et al.):

1. Calculation of direct user benefits such as time savings, vehicle operating cost savings, and safety improvements.

2. Measurement of business cost benefits accruing to industries affected by the transportation improvement. Such benefits include improved reliability, cost reductions for services and for shipping goods, increased productivity and competitiveness, and business expansion.
3. Calculation of indirect benefits of impacted businesses and residences that stimulate broader impacts on the economy through the interactions among industries and residential spending.

Transportation tools, such as travel demand models and/or network models, can provide information about a project's direct user benefits that serve as inputs into economic analysis tools (Weisbrod 2000). Transportation network models can identify operating cost savings that result from a transportation improvement, and savings results can be combined with construction data in economic models to forecast economic impacts (Jarzab). Economic analysis tools forecast economic impacts in a study area and may consist of market studies, case studies, input-output models, or economic simulation models. Other tools may be employed for additional purposes, such as a fiscal model to estimate tax/revenue impacts or a benefit/cost system to track a project's benefits and costs (Weisbrod 2000).

Staff Resources

Based on a survey of transportation agencies (Weisbrod 2000), it is not common for transportation agencies to employ full-time staff members for the purpose of assessing economic development impacts. At the state and provincial levels, staff members typically work part-time on economic development and part-time on planning or policy issues. The number of staff members that work part-time on economic development issues generally ranges from one to four persons. Also, most state transportation departments use their planning or policy divisions to address economic development issues. Based upon the same survey, most states and MPOs employ outside contractors to carry out economic development impact analyses. However, over 70 percent of responding state and MPO agencies used in-house planners/engineers for such analyses, and about one-third of all responding agencies (including Canadian provincial agencies) used in-house economists (Weisbrod 2000).

The remainder of this chapter focuses on the second element of an economic impact analysis: Methods and tools. Some survey-type methods and different types of studies are reviewed first, followed by computational methods including input-output models and economic simulation models.

SURVEY-TYPE METHODS

Survey-type methods may be used to assess economic development impacts, and each method may have different applications. Interviews and surveys of local businesses and economic development experts can provide important local information and serve as a basis for estimating potential impacts of a project. Business surveys, vehicle logs, and windshield surveys can provide data to be used in economic forecasting models (Weisbrod 2000). These types of methods are mentioned and briefly described below.

Expert Interviews

Interview subjects are typically public officials, planners, or business leaders that have a good understanding of an area's business conditions and economic development opportunities. During expert interviews, subjects generally discuss an area's transportation needs and constraints, threats to economic growth, and how transportation improvements can encourage economic development. Interview results typically consist of qualitative information concerning how changes in transportation infrastructure or services may affect an area's business activity (Weisbrod 2000).

Business Surveys

Business surveys generally provide quantitative and qualitative information about how transportation investments (or lack of investment) may or may not affect economic activity in a region. Generally, more responses may be obtained through surveys compared with interviews, yet surveys may not have the important capabilities of interviews in that answers may be clarified and "key points of interest" may be discussed further (Weisbrod 2000). Common applications of business surveys include assessing both the significance of existing transportation facilities and the future importance of improving the same facilities (Weisbrod 2000).

Truck Origin-Destination Logs

Truck origin-destination logs have been used to identify how businesses use an existing transportation system, assess the value of shipments, and estimate potential business cost savings resulting from proposed highway projects (Weisbrod 2000).

Shopper Origin-Destination Data

Shopper surveys have been conducted to estimate how a proposed transportation facility may affect a community's economy. Shopper surveys can be conducted at the point of sale in stores. Another method involves collecting license plate data at business locations (with permission) for the purpose of deriving shoppers' origin-destination patterns (Weisbrod 2000).

Corridor Inventory Methods

A "windshield survey" may be used to assess the types of businesses located on a particular stretch of highway or right-of-way. The results from this survey can be used in a spreadsheet-based model to analyze how businesses may be impacted as a result of transportation changes (Weisbrod 2000).

MARKET STUDIES

A market study can be used alone or with other analysis techniques to assess economic development impacts resulting from proposed transportation projects. Generally, market studies identify existing levels of supply and demand in a region for a particular business activity and then serve as "a basis for forecasts of how supply and demand would change under alternative future scenarios" (Weisbrod 2000). When transportation is considered, a market study may evaluate how a proposed transportation project could affect a particular market size and/or the cost of conducting business in an area. Changes in market size or business costs may alter a region's competitiveness or future growth. Also, transportation-focused market studies are usually specific to a site or corridor (Weisbrod 2000).

Case Studies

A case study reflects the conditions of a study area before and after a project is implemented. Study areas in case studies are typically local areas such as downtowns, small towns, and neighborhoods. In order to understand potential impacts of a proposed project in a given area, case study results of similar completed projects in similar study areas may be reviewed. Researchers may find case studies useful especially for small town study areas where data are limited, and case studies are useful in presentations to the public because case study results are more readily understandable than complex economic analyses and technical terms (Weisbrod 2000).

Models for Estimating Economic Impacts of Transportation Investments

Regional economic modeling was increasingly used in the 1990s for the purpose of estimating economic development impacts resulting from transportation investments. Essentially two methods are available for regional economic modeling of impacts from transportation projects: Input-output models (coupled with other methods) and regional simulation models (Weisbrod 2000). Both types of models are reviewed below, and specific models of each type are noted and discussed. Preceding these reviews is a review of the historical development of economic impact analysis methods and tools.

History of Development of Computational Analysis Methods and Tools

In the 1960s and 1970s transportation network models were developed to forecast future traffic demands and trip patterns. At the same time, input-output models were developed that tracked dollar flows among product supplier and buyer industries. Used together, the two types of models provided a foundation for estimating the regional economic impacts resulting from transportation improvements (Weisbrod 2008). In the 1980s the availability of commercial computing applications increased. The development of regional economic analysis techniques and the increasing availability of computers allowed transportation planning agencies to forecast or predict economic development impacts that would result from proposed transportation projects. Following this time period, economic development impact studies increased in the 1990s (Weisbrod 2000). Over time, several types of economic impact assessment models have emerged: Regional impact models, land use development models, macroeconomic models, regional economic simulation models, and local access models (Weisbrod 2008). Input-output models and regional economic simulation models are reviewed and discussed below.

Input-Output Models

In the 1930s Professor Wassily Leontief developed an analytical framework now called input-output analysis. The purpose of an input-output framework is to characterize how various industries in an economy are related and interdependent through each industry's production and consumption processes. Input-output analysis describes "the flows of products from each industrial sector, considered as a producer, to each of the sectors, itself and others, considered as consumers" (Miller and Blair). Information about these flows is stored in an interindustry transactions table. Rows represent how a producer's output is distributed throughout an economy, and columns represent "the composition of inputs required by a particular industry to produce its output" (Miller and Blair). More plainly, regional I-O models generally have an accounting framework that consists of an I-O table that indicates the inputs purchased and the outputs sold for each industry in a region (Beemiller). I-O models are based on a system of linear equations in which each equation represents how an industry's output is distributed throughout a region's economy (Miller and Blair). I-O models can estimate income and job effects resulting from changes in business activity (e.g., plant closings or openings). With the aide of "budget breakdown" tools, I-O models also can estimate the effects resulting from changes in spending in such areas as tourism or construction activities (Weisbrod and Weisbrod).

Input-output analysis may be conducted at a local, regional, national, and international level. Applications include regional economic planning by states (Miller and Blair) and analyzing the regional economic impacts of certain projects (Beemiller). Economic impact analysis should account for interindustry relationships within a region "because these relationships largely determine regional responses to project changes" (Beemiller). Data-intensive models, such as models based on an input-output framework, should probably not be used for forecasting impacts of projects that have not reached the preliminary engineering phase. Models requiring extensive amounts of data will not prove helpful if analyzed projects have not reached their respective preliminary engineering phase (Jarzab).

Lombard (Lombard) notes some of the shortcomings of I-O models: They are data-intensive, costly, and time-consuming; may rely on outdated data and have lag effects; and may have limited capabilities with regards to policy analysis. Moreover, I-O models do not provide dynamic impacts over time, and when used alone, I-O models "assume that there are no impacts on wage levels, property values, prices or costs of other product inputs or outputs, no change in labor or capital productivity (the ratio of output per unit of input), and no change in population or business in/out migration patterns" (Weisbrod and Weisbrod).

Early Input-Output Based Economic Impact Models

In the 1980s computer simulation models emerged that forecasted regional economic growth resulting from transportation projects. These models incorporated regional input-output (I-O) models, which estimated how growth in an industry would impact growth of other industries in a given region. Before transportation spending effects could be assessed, though, the impacts of changes in travel times and costs on industry economic growth had to be estimated. Developed in the mid-1980s, the regional economic impact model for highway systems (REIMHS) used factors to translate highway spending and travel cost savings into increases in household and business incomes. Regional I-O multipliers were then applied to estimate the total additional business growth. Weisbrod (2008) highlighted several points about these types of early models. First, REIMHS was initially applied in North Central Texas before being used for highways in other states. Second, the PC I-O Model had been used to assess economic impacts resulting from the introduction of high speed train operations in the northeastern corridor of the United States. The PC I-O Model was the first regional input-output model system in the United States (Lahr and Khoroshevskiy). Third, the two preceding I-O models “were notable for incorporating differences in transport mode use and travel cost savings among industries and among regions, yielding economic impact results that also varied among industries and regions.” Lastly, limitations of these models include that the models assume travel patterns with fixed trip origins and destinations and that the models do not allow for additional market access impacts. Also, I-O models used alone cannot demonstrate the effects of changes in freight costs or market access (Cambridge et al., August 2006).

Input-Output Model Examples

Transportation impact studies in the United States that incorporate I-O models generally use one of three models: IMPLAN, RIMS II, or PC-IO (Weisbrod 2000). Each of these models is described below in addition to another model called TRIM.

IMPLAN

IMPLAN is an economic impact modeling system that can estimate economic impacts from a zip code level to a national level. The system has been used by more than 1,000 public and private organizations since its initial distribution in 1993. IMPLAN uses social accounting matrices (SAMs) that characterize the structure and the industry interactions within a specific economy by tracking the dollar values of business transactions in a geographic region. The business transactions are reported by businesses and government agencies, and the economic transaction impacts are estimated for the region. Unlike traditional I-O models, IMPLAN’s matrices also account for “non-market” transactions such as taxes and unemployment benefits. SAMs can function as multiplier models, which estimate the magnitude and distribution of economic impacts (direct, indirect, and induced) resulting from a change in a particular economy

(Implan.com). IMPLAN produces multipliers for employment, business output, value added, personal income, and total income (Lynch 2000). IMPLAN may address a variety of economic issues including how many jobs a particular project may create, what sorts of effects a new industry may generate in a study area, and what significance a particular company has in the local economy (Implan.com).

IMPLAN allows access to all social accounts, multipliers, trade estimates, and other background data, and background industry information may be customized for particular projects. The data used in IMPLAN consists of information about local demographics, local industry production, regional imports and exports, and the gross domestic project (Implan.com). Lynch (2000) noted that County Business Patterns data and Bureau of Economic Analysis (BEA) data are the "primary sources of employment and earnings data."

IMPLAN results include 440 industry reports that can be partitioned by impact type: Employment, output, labor income, and value added. The reports also provide results according to direct, indirect, and induced impacts. A tax impact report indicates impacts on local, state, and federal tax revenues. The current IMPLAN model includes a trade model that tracks over 500 commodities, estimates regional imports and exports, and allows for multi-regional input-output (MRIO) analysis. MRIO analysis detects not only local economic impacts, but also economic impacts in surrounding counties and/or states (Implan.com).

RIMS II

According to Beemiller (1990), the BEA developed a nonsurvey method for estimating regional I-O multipliers called RIMS (Regional Industrial Multiplier System). RIMS was developed in the 1970s and was based on work by Garnick and Drake. BEA has enhanced RIMS, which is now known as RIMS II (Regional Input-Output Modeling System). RIMS II is a static I-O model in which "direct requirements coefficients are derived from the BEA input-output tables for 500 industries in the US, and from county wage and salary data for the BEA's 4-digit Standard Industrial Classification (SIC) tables" (Lombard). Regional multipliers are estimated for individual employment, earnings, and output. Lombard (1991) notes that RIMS II may have difficulty demonstrating how a change in transportation costs (as a result of highway construction) affects industries or an economy.

Beemiller (1990) estimated regional economic impacts by employing a hybrid approach, which consisted of using survey information on direct output effects along with RIMS II multipliers. Impact estimates were compared for cases involving direct output effects based on survey information and effects estimated by RIMS II. It was found that the hybrid approach to estimating economic impacts was more accurate than relying solely on nonsurvey methods. Furthermore, it was found that survey information had to be collected on only the most important inputs (Beemiller).

PC I-O

Data Resources, Inc. (DRI) initially developed the Personal Computer Input-Output Model (PC-IO) in 1990 as a small-scale input-output system that linked to DRI's U.S. Model of the U.S. Economy. The Energy Information Administration used the PC-IO Model to establish "baseline forecasts of industrial activity supporting the Annual Energy Outlook" (DRI). At one time, the PC-IO Model used 114 sectors for its interindustry sectoring scheme, which emphasized those industries that had "interesting energy use characteristics" or "important implications for energy demand and supply" (DRI). A macroeconomic model uses the gross domestic product (GDP) as an aggregate output measure, and the GDP is comprised of 46 final demand categories. The 46 final demands are allocated to the industries in which the final demands are produced, and "a set of coefficients [compute] the output by industry required, directly and indirectly, to satisfy the set of final demands" (DRI). The PC-IO essentially determines the intermediate sales between industries and the final demands from industries. The model can show the composition of growth by industry in addition to growth in GDP (DRI).

TRIM

In 1974, the Ministry of Transportation of Ontario developed the Priority Planning System (PPS), which was a "computerized method for the systematic assessment of highway improvement priorities so that improvements could be implemented in such a way as to optimize benefits to the general public" (Perera). The system determined the following user benefits for alternative improvement scenarios: Travel time savings, vehicle operating savings, and accident savings. Positive savings represent benefits, and negative savings are disbenefits. The Ministry also developed a model called the Transportation Impact Model (TRIM), which is based on an input-output model of the Ontario economy. TRIM estimates direct, indirect, and induced economic impacts resulting from capital investments in transportation infrastructure (Perera; Lombard).

Economic Simulation Models

Economic simulation models predict economic change in an area and provide estimates of economic development impacts resulting from transportation projects or policies (Weisbrod 2000). Economic simulation models can estimate directly the income and job effects resulting from shifts in business location, industry activity, and spending. These models, unlike I-O models, also can estimate the effects over time of changes in relative costs, prices, productivity, business competitiveness, and population in/out migration. Economic simulation models entail more "analytic sophistication" but are more expensive than I-O models (Weisbrod and Weisbrod). An economic impact model should be used to forecast economic impacts of relatively important and high-dollar projects, so that the investment of time and money in such a model is effective (Jarzab). Studies that use economic simulation models typically have a long-term analysis period (e.g., 20 to 30 years) and indicate changes in jobs, personal income, business output, and gross regional product. These studies usually comprise four components (Weisbrod 2000):

1. A base case forecast of future economic growth or decline in the region.

2. Some technique to estimate how businesses would grow in response to direct changes in their relative operating costs and access to markets.
3. Input-output (I-O) tables to calculate overall changes in the flow of money in the regional economy, including indirect and induced effects.
4. Forecast of a new scenario representing how future economic growth or decline would be different than the base case if the project were to be implemented.

The approach for using an economic simulation model can follow one of two directions. Input-output (I-O) models track changes in the flow of money across an economy, which is represented by the third component above. I-O models are "static" in that the results from the model represent a snapshot in time, rather than a characterization of an economy over the analysis period. Time is encompassed in the other three components, which are estimated or forecasted by using additional models or methods that account for business responses to changing economic factors such as changes in business operating costs that result from transportation improvements. The other direction is to use a dynamic simulation model, which forecasts economic changes over time for a base and an alternative scenario, essentially incorporating all four of the above components into one model (Weisbrod 2000).

Up until about the mid-1980s, the use of economic impact models was hindered primarily by a lack of data and computing power, rather than a lack of advancement in economic theory. However, advances in computing technology increased access to data sources while reducing time and financial constraints (Jarzab). Use of regional economic models increased greatly in the 1990s (Weisbrod 2000).

REMI and TranSight

Regional Economic Models, Inc. (REMI) was founded in 1980, and the company has developed a suite of models designed to aide regional policy analysis (REMI brochure). The REMI model is the "most frequently used regional forecasting/simulation model in the United States" (Weisbrod 2000). Clients include universities, consulting firms, and all levels of government. The REMI model covers the following five topic areas: Economic development, the environment, energy, transportation, and taxation/forecasting/planning. Transportation applications include the demonstration of a transportation project's economic viability, as well as studies about toll roads, major highway improvements, airport impacts, and transit-oriented development. The REMI model forecasts the future economy for a region and estimates how the same economy changes as a result of some policy change. REMI users specify a policy change by adjusting policy variables in the model (REMI brochure). The REMI model structure integrates elements from different types of models, and REMI models have the following characteristics (REMI brochure):

- REMI models include inter-industry relationships that are found in I-O models.
- REMI models are dynamic, meaning the models show economic changes over time.
- REMI models rely on equations and response estimations that employ advanced statistical techniques.
- REMI models address the spatial dimension of an economy, which is important in accounting for productivity and competitiveness benefits resulting from the clustering of industries and the concentration of economic activity in cities.

The REMI model that is specifically designed for transportation applications is called TranSight. TranSight allows for analysis of alternative transportation scenarios and provides short-term and long-term impacts on jobs, income, population, and other economic metrics. Essentially, TranSight demonstrates how a transportation improvement affects employment and economic development (REMI brochure). TranSight can forecast impacts across multiple modes including roadway (car or bus), rail, and marine modes. Economic benefits can be estimated for individuals (e.g., cost savings benefits) and businesses (Kreis et al.).

TranSight couples the REMI model with travel demand models, and a proprietary "transportation cost matrix translates changes in vehicle miles travelled to changes in labor access, intermediate input access, and delivered prices," which are factors that can alter a region's competitiveness and encourage economic growth (REMI brochure). TranSight contains three cost matrices for commuter, accessibility, and transportation costs. The commuter cost matrix describes commuter time savings, and the transportation cost matrix describes cost savings in transporting goods and services that result from a transportation efficiency improvement. The accessibility cost matrix describes how households have access to consumer goods and services and how businesses have access to intermediate inputs. Other possible inputs include construction costs, operations and maintenance costs, and levels of funding from different sources. TranSight also includes data related to emissions rates and costs, value of time measures, fuel efficiency, accident rates and costs, and fuel and non-fuel operating costs (REMI TranSight). The TranSight model structure is shown below in Figure 4.2. Note that project-specific data and data obtained from a transportation model, such as a travel demand model, are fed into the TranSight model. The TranSight model then uses its cost matrices and policy variables to forecast economic results.

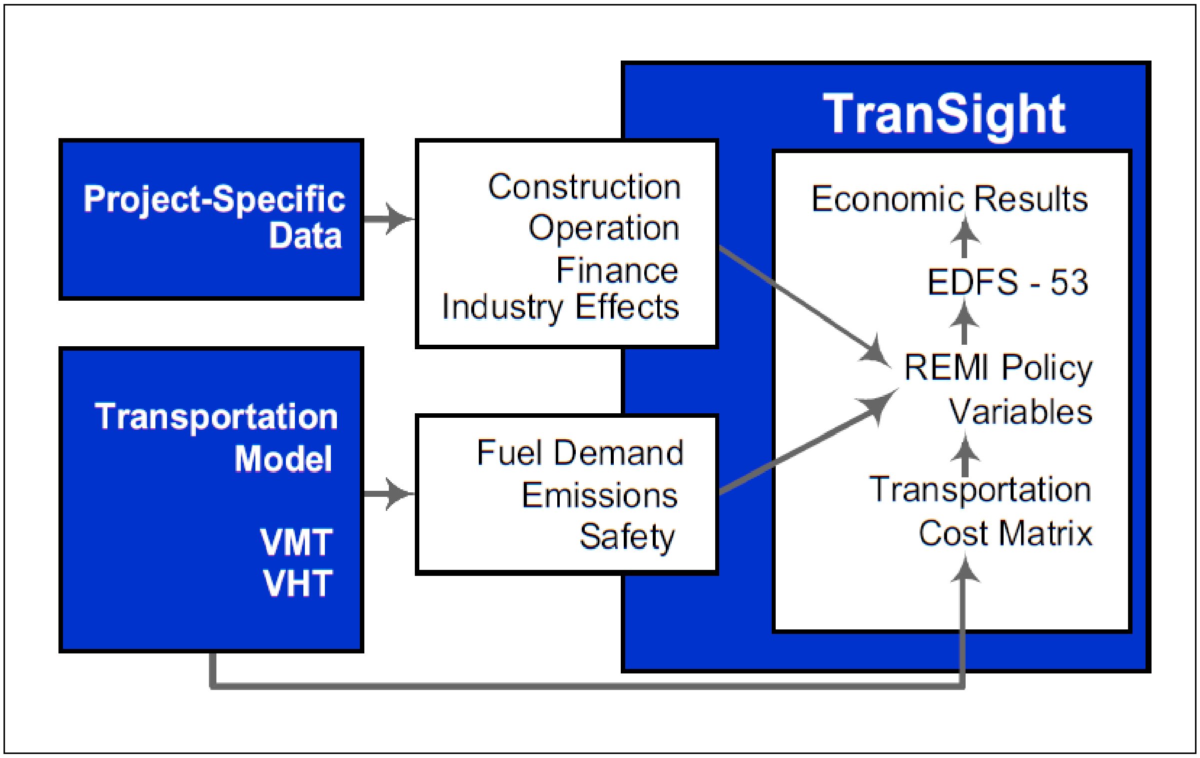

Figure 4.2- TranSight internal logic model (Kreis et al.)

*EDFS-53: 53-Sector Economic and Demographic Forecasting System

Within TranSight, impacts of transportation projects essentially modify the "effective 'distance' between multi-county regions and thus [increase] reliance on supplier-buyer relationships between those areas" (Weisbrod 2008). Weisbrod (2008) notes a shortcoming in this method: "That approach relies on generalized distance measures between regions, a concept that does not necessarily recognize differences in speeds and travel times between modes or among parts of the transportation network, nor the effect of shifting reliance on highway, rail, air and marine modes by various industries."

Data entry for a project generally requires about two hours. The main inputs into TranSight are vehicle-miles traveled and vehicle-hours traveled, although the following factors have been recommended for inclusion if available (Kreis et al.):

- Baseline versus adjusted (i.e.- build option)
- Model region (county, multi-county, etc.)
- Transport mode (car, bus, train, etc.)
- Time-of-day travel (peak/non-peak)
- Road type (freeway, arterial, etc.)
- Trip-parameter data (percentages by non-commercial, heavy commercial, light commercial, and weekday/weekend)

TranSight outputs include the following (Kreis et al.):

- Employment by industry
- Output by industry
- Wage rates and personal income
- Population by demographic group
- Gross regional product

Transportation Economic Development Impact System (TREDIS)

TREDIS is a web-based economic development impact and benefit/cost analysis tool that is designed specifically for capturing effects of transportation investments. The system covers highway, rail, marine, and air modes and can be used for multi-modal projects. Also, TREDIS can be applied to both passenger and freight transportation projects. The model may be used as a sketch planning tool or as a comprehensive planning tool. Examples of TREDIS applications include the following (tredis.com):

- Estimating the economic impact of constructing and/or operating a transportation facility (roadway, rail line or air/sea terminal) or service;
- Examining alternative strategies for managing a transportation corridor;

- Performing a comprehensive freight performance evaluation;
- Weighing the benefits and costs of alternative transportation investment strategies or policies;
- Estimating the impact of congestion on households and industries (by sector), based on their usage of different modes; and,
- Systematically evaluating the economic benefit of improving multimodal access to consumer, producer, and labor markets.

TREDIS has several modules that function together to estimate the economic development impacts of transportation projects. The model's modular structure is shown in Figure 4.3. Each of the modules can be used by itself or combined with other modules. Essentially, project cost information and changes that result from transportation improvements (e.g., changes in travel times and travel costs) are input into the Travel Cost Module, which translates these changes into direct cost savings to both households and industries in an economy. The Market Access Module incorporates changes in market access and intermodal connectivity to determine "effects on agglomeration, dispersion and scale economies for industry sectors" (tredis.com). The Economic Adjustment Module relies on a dynamic multi-region economic impact model to forecast long-term impacts on employment and income growth. The Benefit-Cost Module accounts for the net-present value of various benefits and costs from local, state, and federal agency perspectives. A Tax and Finance Module is available to determine a project's impacts on local, state, and federal revenues and to provide economic impacts of tax, toll, and/or pricing scenarios on public and private entities. A Freight and Trade Module characterizes how a project impacts economic flows and commodity flows to, from, and within a study area. Also, TREDIS can be used with other models and tools such as travel demand models or economic forecasting software (tredis.com).

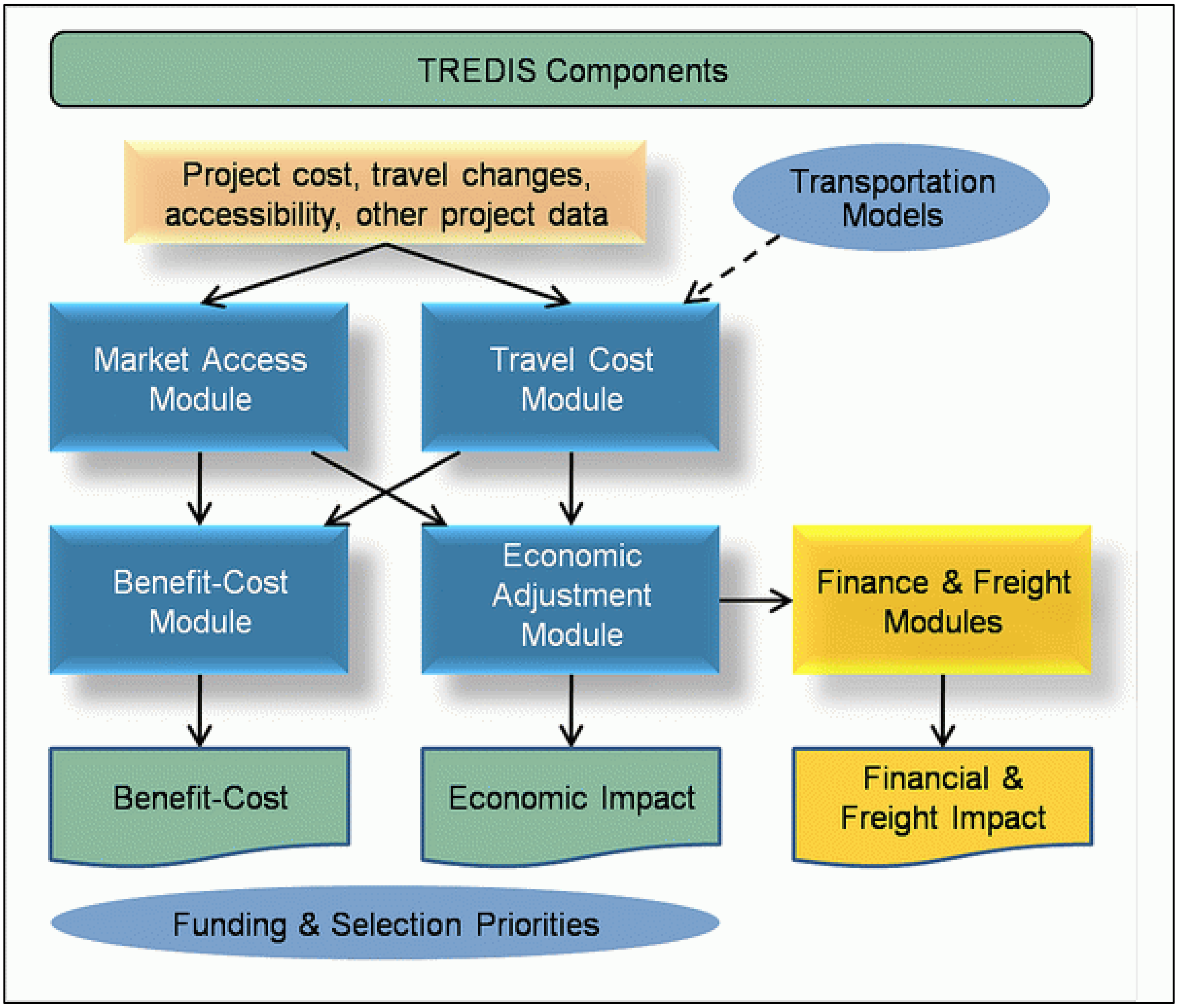

Figure 4.3- The TREDIS modular structure (tredis.com)

TREDIS allows for the input of a variety of data. The types of TREDIS input data are provided in Appendix A, along with the types of data that are pre-loaded in TREDIS (e.g., economic measures and market access data). Some typical input categories include project cost information, traffic characteristic data (e.g., traffic volumes, VMT, VHT, and safety data), and access characteristics (e.g., size of labor and consumer markets). Model setup and data input may require between 15 minutes and several hours depending upon the desired level of model sophistication (tredis.com). TREDIS provides numerous outputs in various tables, which are described in Appendix

B. Output results typically include project costs and benefits, as well as economic impacts in terms of business revenue, value added, jobs, and wage income.

Figure 4.4 below provides a comparison of the IMPLAN, TranSight, and TREDIS. TranSight and TREDIS are clearly more comprehensive tools in terms of capturing economic impacts resulting from transportation projects.

	IMPLAN*	**REMI TranSight***	**TREDIS**
Designer	Minnesota IMPLAN Group (MIG, Inc.)	Regional Economic Models, Inc. (REMI)	Economic Development Research Group, Inc.
Type of Model	Input/Output	Dynamic	Dynamic
Initial Cost	Varies (on the order of $10,000)	Varies (>$100,000)	Varies depending on study area
Annual Cost	Varies for region files desired	Varies (≈ $20,000)	Varies
Inputs	Job Cost and Location	Emissions (VOC), Fuel Demand	Modes and Mode Characteristics
	Industry Category	Safety	Safety/Accident Data
	A Set of Multipliers for the Region	VMT, VHT, Time Savings (from a transportation planning model)	Traffic Characteristics (Vehicle trips, VMT, VHT)
			Project and Public/Private Sector cost information
			Origin/Destination Patterns
			Market Access Impacts
			Contingent Development
Outputs	Impact Data ("what if" data, e.g. what if industry X adds 200 jobs in a county)	Population by Demographic Group	Costs and Benefits, Travel Cost Savings by Industry
		Output by Industry and Gross Regional Product	Business Value/Output, Value Added
		Wage Rates and Personal Income	Wage Income
		Employment by Industry	Employment
		Gross Regional Product	Value of Commodities Produced and Demanded
			Tax Impacts
			Market Access Impacts by Source and by Industry
Transportation Terms	No	Yes	Yes
Economic analysis intensive	No	Yes	Yes
Support Available	Yes	Yes	Yes
*Schultz et al. (2006)			

Figure 4.4- Summary comparison of economic models

Other Types of Models

Other types of models exist that incorporate elements of transportation or economic growth. However, these models may not be designed to estimate the economic impacts of transportation projects. Transportation land use models forecast land density and development patterns, as well as the sensitivity of these aspects to transportation conditions. These models rely on the basic input-output concepts, yet operate at a more detailed spatial level. Transportation land use models integrate "economic growth and I-O forecasts with transportation networks to derive multi-faceted measures of access to markets and demand for locations" (Weisbrod 2008). Consequently, impacts of transportation improvements on business market expansion and residential or business location changes can be assessed. Measures of access typically entail road travel times and costs between the populace and business activities. These models usually do not consider rail, air, or marine modes. Examples of the preceding types of land use models include MEPLAN, PECAS, and TELUM (Weisbrod 2008).

Macroeconomic models, also known as computable general equilibrium (CGE) models, address "large scale macroeconomic principals of investment and cost of labor, capital and transportation as industry inputs," and changes in industry inputs are used in production functions to estimate changes in industry outputs (Weisbrod 2008). Examples of CGE models include the Spatial CGE Model of Norway (PINGO) and ASTRA. Some CGE models have integrated economic simulation models with transportation models to estimate how proposed projects impact business growth and freight shipment patterns by industry and region. CGE models generally function "at a coarse regional level of spatial detail," so changes in transportation connectivity and access may not be captured in CGE models (Weisbrod 2008).

Market access impact models demonstrate how local business attraction and location decisions are affected by changes in transportation access. These models may be used independently to inform economic development strategies or coupled with other transportation and economic models to form a complete analysis system. LEAP (local economic assessment package), EDR-LEAP, and CDSS (congestion decision support system) are examples of this model type (Weisbrod 2008).

RELEVANT LITERATURE CONCERNING ECONOMIC IMPACT MODELS

A study by Kreis et al. (2006) reviewed various methods and 13 software packages used to forecast economic impacts of proposed transportation projects. Based upon the authors' analysis, two models were determined to meet the State of Kentucky's needs as defined in the project scope. These models were the TREDIS model and the REMI-TranSight model. The TREDIS model was found to compute economic benefits for a broader range of transportation projects, while the REMI-TranSight model had more clients and was found to be more economical to acquire and operate over time. Both models, though, require users to make large time and financial investments in order to capture the full benefits of using either model. It was believed that use of either economic impact model would increase accountability, objectivity, and transparency in transportation project selection and funding. Practices by different state DOTs were reviewed to determine if and how each DOT incorporated economic impact analysis into transportation planning.

A 2005 Texas Transportation Institute and Texas A&M University study (Burke et al.) also reviewed how state DOTs assessed economic impacts of transportation projects on each respective state's economy and what type(s) of methodologies were employed. Most responding states used some variation of an input-output model. Other studies and reports have reviewed various benefit/cost and economic impact methods or models including Lombard (1991), Schultz et al. (2006), and Weisbrod (2008). Weisbrod (2006) discussed the development of methods that have been used to estimate the economic development impacts of proposed transportation projects. Cambridge Systematics et al. (2006) discussed methods and tools used in the assessment of economic impacts of federal investments in large freight transportation projects.

EVALUATING ECONOMIC IMPACT ANALYSIS METHODS

A report sponsored by the Federal Transit Administration (Cambridge Systematics et al. 1998) used various criteria to evaluate economic impact analysis methods for transit investments. It was noted that the criteria also "represent universally accepted features of good analytical methods and study design" (Cambridge Systematics et al. 1998). Thus, the criteria may be applied to other areas using economic impact analysis, including general transportation projects (e.g., new highway construction). The criteria are provided below, along with corresponding explanations that are taken verbatim from TCRP Report 35 (Cambridge Systematics et al. 1998).

1. **Validity**: Indicates the degree to which the method accurately measures and portrays the phenomenon under study. There are two types of validity:
    a. **Internal Validity**: The techniques and measures applied allow the effects of an action or event (e.g., a transit investment) to be unambiguously determined so as to allow one to accurately draw cause-effect inferences. This criterion essentially means that controls have been properly introduced to allow the unique effects of an action or event to be isolated and all confounding influences to be removed.
    b. **External Validity**: The findings are generalizable from the specific cases to a larger domain. This means the core findings in one location can reliably be applied to another location.
2. **Reliability**: Indicates the degree to which the method provides consistent and stable results when applied repeatedly to the same case or cases.
3. **Data and Resource Demands**: Indicates the degree to which the analysis requires significant amounts of data, time, skills, budget, and expertise to conduct the work. Related principles are parsimony and elegance. Parsimonious and elegant methods and study approaches aim to express relationships in as simple terms as possible, allowing the truly important elements of a relationship to be understood and minimizing the risks of mismeasurement, poor estimation, or error propagation.

4. **Transparency**: Indicates the degree to which the methods, assumptions, and results are understood and accessible to an audience beyond methodologists themselves (Cambridge Systematics et al. 1998).

The above criteria may help assess the quality of an analysis method used to estimate the economic impacts resulting from transportation investments. The four criteria above offer a basis for comparing different analysis methods and accentuating their different trade-offs.

NEEDS AND IMPROVING ECONOMIC IMPACT MODELS

Several factors related to economic impact analysis methods remain to be addressed through further research and development. Many of these needs and the shortcomings of current methods are listed below, along with the corresponding source from which each need or shortcoming was obtained:

NCHRP Synthesis 290 (Weisbrod 2000)

- Economic impact study results are not accepted universally, partly due "to insufficient attention to unique local and regional factors in the application of economic impact models." Also, inconsistency in economic impact analysis precludes acceptance of results.
- Inadequate data, complex analysis methods, and/or staff inexperience make economic impact analysis difficult.
- The link between transportation and economic development at the project corridor level and the facility level needs to be validated. Tracking an area's economic conditions before and after an implemented transportation project helps validate results from economic impact studies.
- A need exists to develop comprehensive, understandable, and cost-effective analysis tools that provide results consistent with results from other recognized methods and findings.

- Consistent definitions for economic development impact terminology need to be developed, along with staff training programs that promote proper and consistent assessment of economic development impacts by staff members.

Weisbrod 2006

- Measures of economic productivity benefits need to be improved and account for how the extent of impacts may vary by locale and industry.
- Commodity flows and international trade flows need to be represented better by improving the data sources that currently provide information in these areas.
- A need exists "for regional economic models to better establish the reasonableness of their assumptions about how workforce migration, wage rates and private investment change over time in response to transportation costs and other transportation project impacts."

Weisbrod 2008

- A need exists for "a general framework to help organize data and present results in a consistent manner."
- Some economic impact models do not consider "important transportation-related access impacts."
- Confusion may result when "economic growth impacts are used for benefit/cost analysis."
- The structure and underlying econometric equations of a model need validation.
- An issue exists in determining the accuracy of economic impact forecasts.
- Consequences exist when static transportation assignment models are linked with dynamic economic simulation models.

CONCLUSIONS

Various methods and tools are available for assessing the economic development impacts of proposed transportation projects. Market studies, case studies, and various survey-type methods provide a general sense of how transportation projects may affect a local economy. More advanced computational methods are available as well. Input-output (I-O) models track changes in the flows of money in an economy that result from a policy change or project. Because of its "static" nature, an I-O model must be used with other models to forecast impacts over time. Economic simulation models improve upon I-O models by incorporating I-O models and forecasting economic impacts over time. Two economic simulation models seem to be most prevalent: REMI-TranSight and TREDIS. TranSight can demonstrate how a transportation project affects economic development and employment, and economic benefits can be determined for both individuals and businesses. TREDIS is a web-based economic development impact analysis and benefit/cost analysis tool that can be used as a sketch planning tool or a comprehensive planning tool.

Economic impact analysis and associated methods and tools encounter questions and concerns about validity and accuracy. Furthermore, inadequate data sources, complex analysis methods, and staff inexperience contribute to the uneasiness that transportation agencies sometimes experience when considering whether or not to conduct an economic impact analysis. Comprehensive, understandable, and cost-effective analysis tools are needed to allay such apprehension. The TREDIS model addresses many of these aspects and is discussed in greater detail in Chapter 5.

Chapter 5: The Transportation Economic Development Impact System (TREDIS)

This chapter focuses on the economic impact analysis model called TREDIS, which was briefly described in the previous chapter. An overview of TREDIS is provided to give a clear understanding of the capabilities of and purposes for using TREDIS. The model's structure is described including how different elements of TREDIS work together to provide estimated economic impacts of a transportation project. The chapter concludes with descriptions of various applications of TREDIS.

THE TRANSPORTATION ECONOMIC DEVELOPMENT IMPACT SYSTEM (TREDIS)

TREDIS is a web-based economic impact and benefit/cost analysis tool that is specifically designed for transportation projects. The product was developed by Economic Development Research Group, Inc., and has been used by an increasing number of clients that includes metropolitan agencies, state DOTs, universities, and private sector companies. TREDIS can be used in a variety of applications including the following (TREDIS brochure; tredis.com):

- Estimating the economic impact of constructing and operating transportation facilities and services;
- Examining alternative strategies for managing transportation corridors;
- Performing multimodal freight system evaluations;
- Determining benefits and costs of alternative transportation investments; and,
- Evaluating economic benefits derived from improved multimodal access to consumer, producer, and labor markets.

The TREDIS framework consists of a modular structure, as depicted in Figure 5.1. Different modules serve different purposes, and each module can be used independently or in conjunction with other modules. The four key modules are the Travel Cost, Market Access, Economic Adjustment, and Benefit/Cost Modules. Each module is shown in Figure 5.1 and described in greater detail in subsequent subsections.

TREDIS requires the specification of a baseline scenario and at least one project scenario. The baseline scenario essentially represents existing infrastructure without implementation of any project. The project scenario represents infrastructure that has been altered by a transportation project. Differences in data values between the baseline scenario and the project scenario reflect how a transportation project influences various transportation-related measures such as travel times, travel costs, safety, and accessibility. For example, a capacity-expansion project may result in lower travel times and travel costs in the project scenario relative to the baseline scenario. These differences would be captured and used by the model to forecast economic impacts resulting from the implemented project. Figure 5.1 demonstrates this process. A transportation project leads to changes in travel characteristics such as VMT, VHT, accident rates, and reliability. These travel changes affect businesses by reducing operating costs and by expanding access to various markets, resulting in increased business income (i.e., a direct impact). Direct impacts stimulate demand for suppliers' services and products (i.e., indirect impacts), and induced impacts result as workers from the directly and indirectly impacted businesses spend additional income in the area. TREDIS captures the effects of these different impacts on changes in area jobs, income, and business revenues. Finally, costs, user benefits, and economic impacts can be disaggregated to demonstrate how a particular transportation project impacts various stakeholders such as households, businesses, and government entities.

TREDIS can account for road, rail, aviation, and marine modes and analyze impacts at a local, regional, and/or statewide level. TREDIS even includes bike and pedestrian modes. Various modes can be segmented according to passenger travel (e.g., personal and recreation trips, commute trips, or business trips) or freight travel, depending upon the focus of an impact analysis.

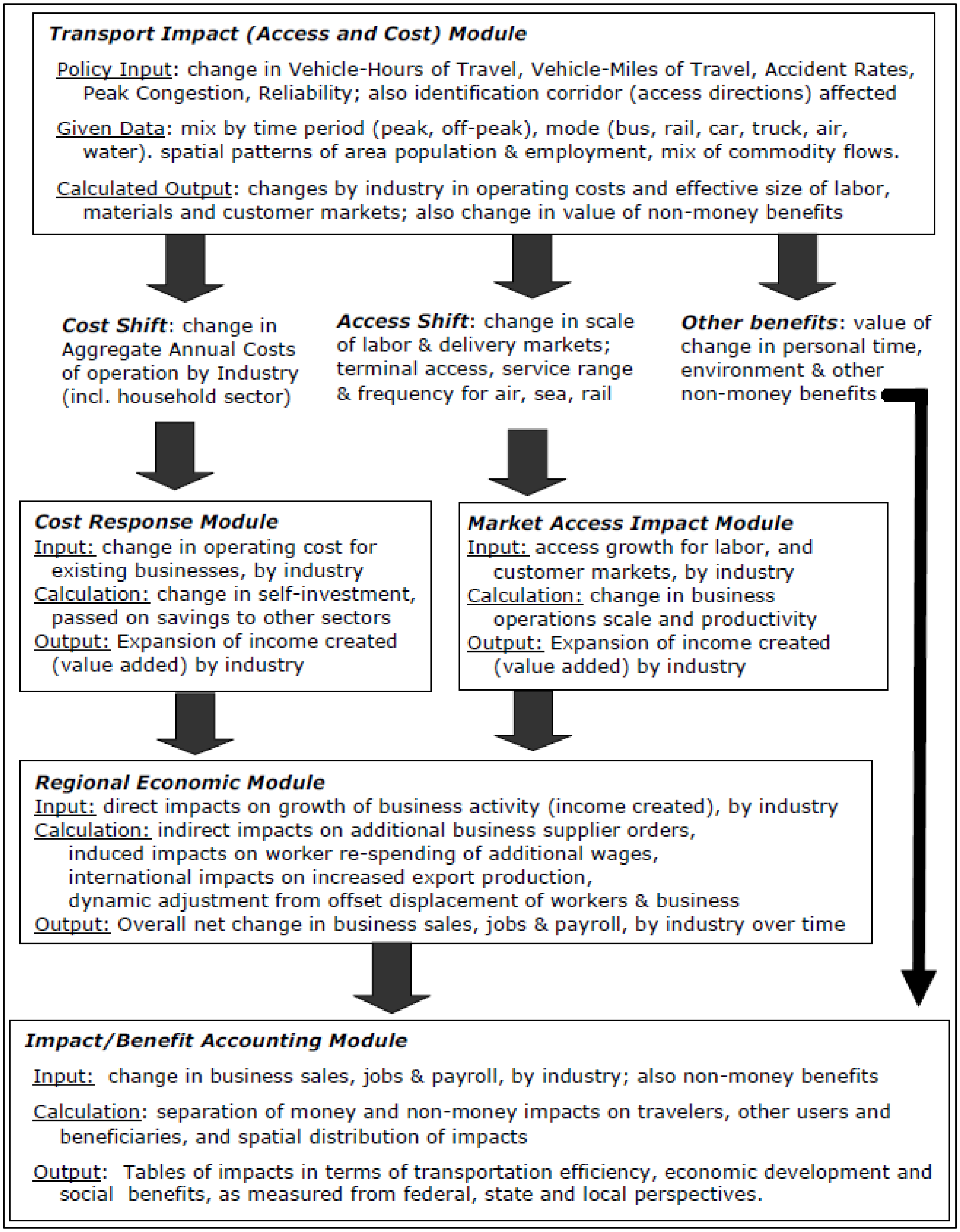

Figure 5.1- The modular structure of the TREDIS framework (Weisbrod 2006)

Elements of the TREDIS Model

TREDIS can be better understood by considering the model's inputs, calculations, and results. Each of these elements is discussed in the next subsections.

Analysis Inputs

The TREDIS web-based platform consists of four separate pages that serve distinct purposes. The "Project" page allows an analyst to define an individual project's characteristics including the name of the project, the transportation modes relevant to the project, the geographical areas influenced by the project, and the duration of project construction. Other inputs on this page include specifications for the project's operating period, travel growth rate, the discount rate, and the constant dollar year. Various default parameters (e.g., the money value of time for passengers and for shippers) are linked to this page, and these defaults can be manually changed if the analyst desires to do so.

The "Scenario" page consists of three broad input categories: Cost inputs, travel inputs, and other inputs. Cost inputs include startup construction costs, annual operations and maintenance (O&M) costs, and a section for cost and revenue sharing, which allows the analyst to specify how costs and revenues will be allocated between public and private entities. Travel inputs include data pertaining to traffic characteristics, accidents, and the commodity mix within the study area. A default commodity mix is used in TREDIS that is based on the average flows of a given mode within the State of the study region. Traffic characteristic data consist of several parameters including the number of vehicle trips, VMT, and VHT in the study region. Other inputs include information about access to local and regional markets, as well as drive times to terminals (e.g., intermodal rail facilities and airports) and international gateways (e.g., drive time to an airport with international flights).

The "Case" page allows the analyst to build alternative cases in which one project scenario is compared to a different project scenario. Required input for the "Case" page consists of naming a particular case and then selecting a pair of projects for comparison.

The “Report” page requires no inputs and provides reports and impact results based on the user-specified inputs from the three previous pages. Reports include summaries of project costs and benefit/cost results. Travel impacts, market access impacts, and economic impacts are also provided. Depending on the report or type of impact, results can be disaggregated by industry, mode, and/or year. Results also may be provided from the perspective of a study area, region, or nation.

The analyst can ignore various inputs by leaving zeros or blanks in those input fields. For example, an analyst may not have information concerning how many trips are made within or through the study region, so the analyst can leave the associated input fields blank. Inputs from a variety of sources may be used, including “peak traffic congestion models, spatial access models and intermodal terminal data in addition to highway network models that only measure annual average daily changes in travel times and distances” (Weisbrod 2006).

Analysis Calculations

The impacts of transportation projects are captured and processed through a series of modules, as shown previously in Figure 5.1. The modular structure facilitates the use of various models and information sources in TREDIS. Changes in transportation use and travel characteristics for different modes can be estimated by models or spreadsheet analysis methods. These results are then fed into TREDIS. Changes in user impacts and travel characteristics, as well as other data, are input into the Travel Cost and Market Access modules. The modular structure also facilities linking any GIS system with TREDIS so that changes in accessibility to various markets and intermodal facilities may be analyzed. TREDIS has a default GIS provided by ESRI, which “has been pre-populated with market and intermodal terminal data” (Weisbrod 2006). The output from the Travel Cost and Market Access modules is then fed as input into the Economic Adjustment module. TREDIS incorporates a default impact model by using either the Regional Dynamics (REDYN) model or a built-in elasticity impact model (Weisbrod 2006).

Analysis Results

As mentioned previously, the fourth page in TREDIS provides a range of options for viewing project impacts. Impacts may be distinguished according to a local, regional, or national perspective. Also, economic development impacts and benefit/cost analysis measures are differentiated, providing options for using the various measures depending upon the recipient audience or the intended purpose for using the results (Weisbrod 2006).

The Component Modules

As mentioned previously, the TREDIS framework is based on a modular structure that includes four key modules: The Travel Cost, Market Access, Economic Adjustment, and Benefit/Cost Modules. Two optional modules are also available, namely the Tax and Finance Module and the Freight and Trade Module. Each of the four key modules is reviewed, followed by a brief summary of the two optional modules.

Travel Cost Module

The Travel Cost Module determines dollar cost savings that accrue to businesses and households as a result of changes in traffic characteristics such as travel times, travel expenses, and accident rates. The module also can incorporate data related to congestion and to the distribution of trips that travel through, within, to, and from an area. Changes in traffic characteristics may result from changes in traffic speeds, travel conditions, route distances, and tolls/fares. The total savings derived from changes in traffic characteristics are allocated among various economic sectors based on the regional industry composition and the commodity mix by mode (tredis.com).

The inputs into TREDIS may be obtained from sketch planning methods, spreadsheets, or travel demand models. TREDIS has been supplied with data from several different models including CUBE Voyager, TransCAD, EMM2, TRANUS, TRIPS, and HERS (tredis.com).

The results from the Travel Cost Module essentially represent travel cost savings and values of non-monetary impacts that result because of the implementation of the project scenario relative to the baseline scenario. That is, resulting values reflect the differences in impacts between the project and baseline scenarios. Benefits are provided in terms of time, expense, access, safety, and environmental impacts. Benefits (including direct travel cost savings) also are provided for each mode, as well as by households and the various industry sectors (tredis.com).

Figure 5.2 below depicts the possible travel inputs, the assumed travel cost parameters, and how the module outputs of user and nonuser benefits are itemized. The travel cost assumptions are described in a TREDIS document about data sources, and the TREDIS default values and can be manually overridden by an analyst. Benefits may be categorized by user type (households and/or businesses), type of impact (safety, environmental, etc.), mode, and trip purpose (e.g., passenger car commuter trip).

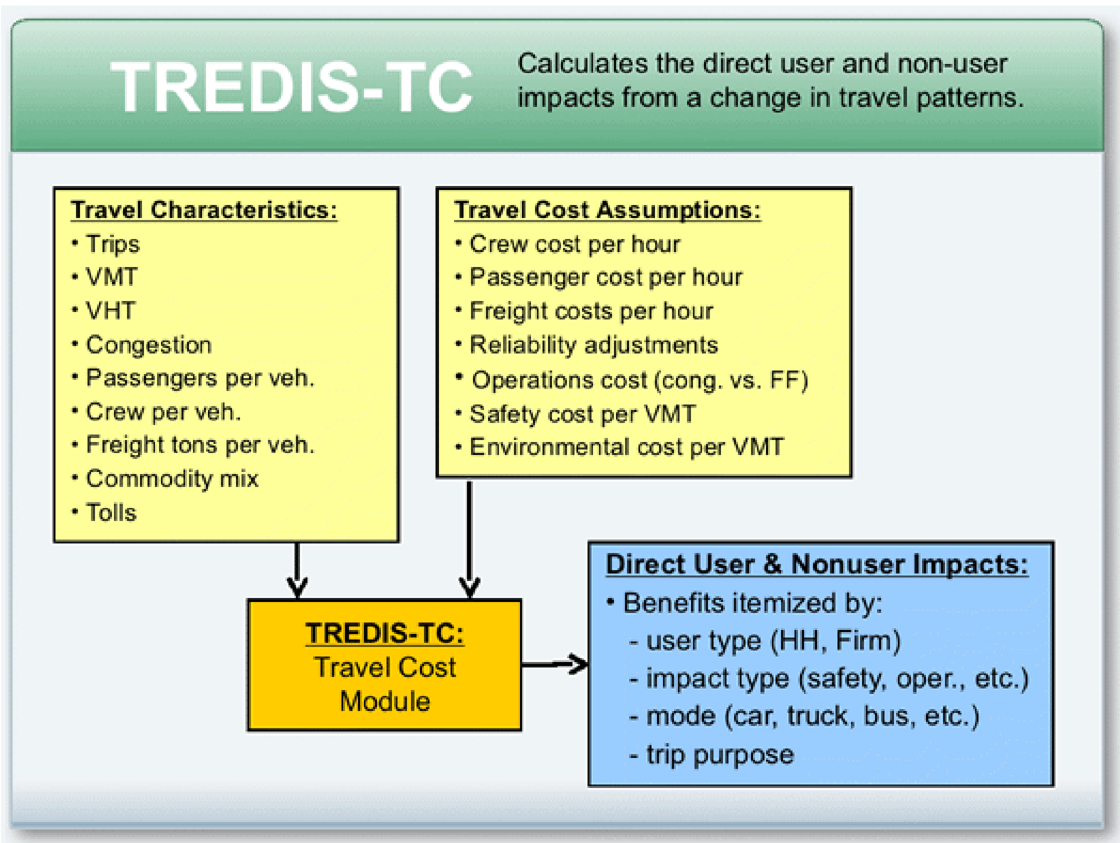

Figure 5.2- The Travel Cost Module (tredis.com)

Market Access Module

Using a geographic database loaded with spatial pattern information of populations and businesses, the Market Access Module estimates how transportation changes affect "business productivity, location pattern adjustments and economic growth over time" (tredis.com). The Module computes the value of improving connectivity and expanding market access. Connectivity is characterized by how well a transportation system's road network is linked to intermodal, air, and marine ports and international gateways. Market access refers to the accessibility of various markets including labor, supplier, and customer delivery markets. Effects on labor and delivery market expansion are computed for the various sectors in a given economy, and econometric equations are applied "to identify resulting impacts on industry agglomeration, supply chain dispersion and market scale economies," which affect productivity benefits and economic growth (tredis.com). Productivity benefits are accounted for in the Benefit-Cost Module, and economic growth is estimated in the Economic Adjustment Module.

TREDIS integrates EDR-LEAP, which is a web-based system that is an extension of the LEAP model. EDR-LEAP uses "GIS tracking of access patterns with USDOT highway network and intermodal terminal and port datasets, to calculate the travel time from any community in the US to rail, air and marine terminal/port facilities having regularly scheduled services" (Weisbrod 2008). The travel time results are used to evaluate the size of population markets that are "reachable" and to determine how industries reliant on intermodal connections and delivery market access may be affected by alternative transportation scenarios (Weisbrod 2008).

Figure 5.3 below shows the structure of the Market Access Module. Industry and regional data are dependent upon a region's unique economy and are supplied within the TREDIS model. Access data can be supplied by analysts in order to indicate access changes resulting from transportation improvements. Access data may be obtained by using sketch planning methods, travel demand models, or geographical information systems (tredis.com). Access variables include the following:

1. 40-minute labor market
2. 3-hour regional market
3. Drive time to intermodal facilities
4. Drive time to international gateways

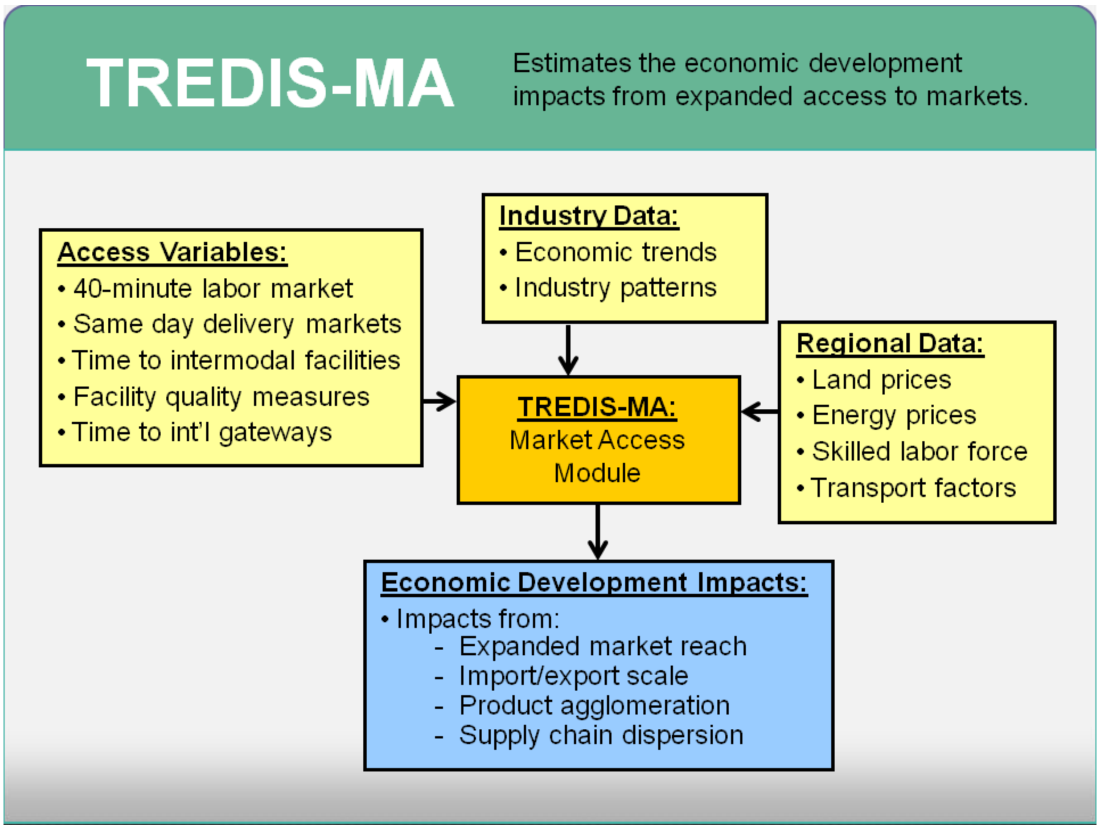

Figure 5.3- The Market Access Module (tredis.com)

Results from the Market Access Module include impacts from various markets' expansion and increased connectivity. Access benefits for road travel are provided in terms of the percent change in the coverage of the population for labor markets and for truck delivery markets. Access benefits for rail, air, and water travel are measured in terms of the "percent improvement in road access time to intermodal terminals and frequency/breadth of travel available at those terminals" (tredis.com). Benefits are disaggregated by industry sector and can be displayed by region and travel mode for a future target year (tredis.com).

Economic Adjustment Module

Using a dynamic regional economic impact model, the Economic Adjustment Module estimates long-term impacts on job and income growth over a period of time in the study region. A core forecasting model provides a baseline projection of a study region's economic growth over time, based on how demographics and the economy's structure are expected to change over time. Changes in direct transportation costs (i.e., cost, time, and safety), market access, and intermodal connectivity between the baseline and project scenarios are used to estimate the economic impacts on businesses. The Economic Adjustment Module also tracks indirect effects on suppliers, as well as the induced effects caused by the spending of increased worker income. Direct impacts from the Travel Cost and Market Access Modules are assigned to economic sectors, and adjustments are made for double-counting. Time-lag and spatial-lag effects on business responses to improvements are incorporated with construction spending and O&M spending in the economic model, which ultimately produces changes in employment, income, and business output. Figure 5.4 below displays the structure of the Economic Adjustment Module. Project data and results from the Travel Cost and Market Access Modules are fed into the economic module. The module uses this information and the baseline projection of the region's economy to estimate the net economic impacts for the various alternative scenarios (tredis.com).

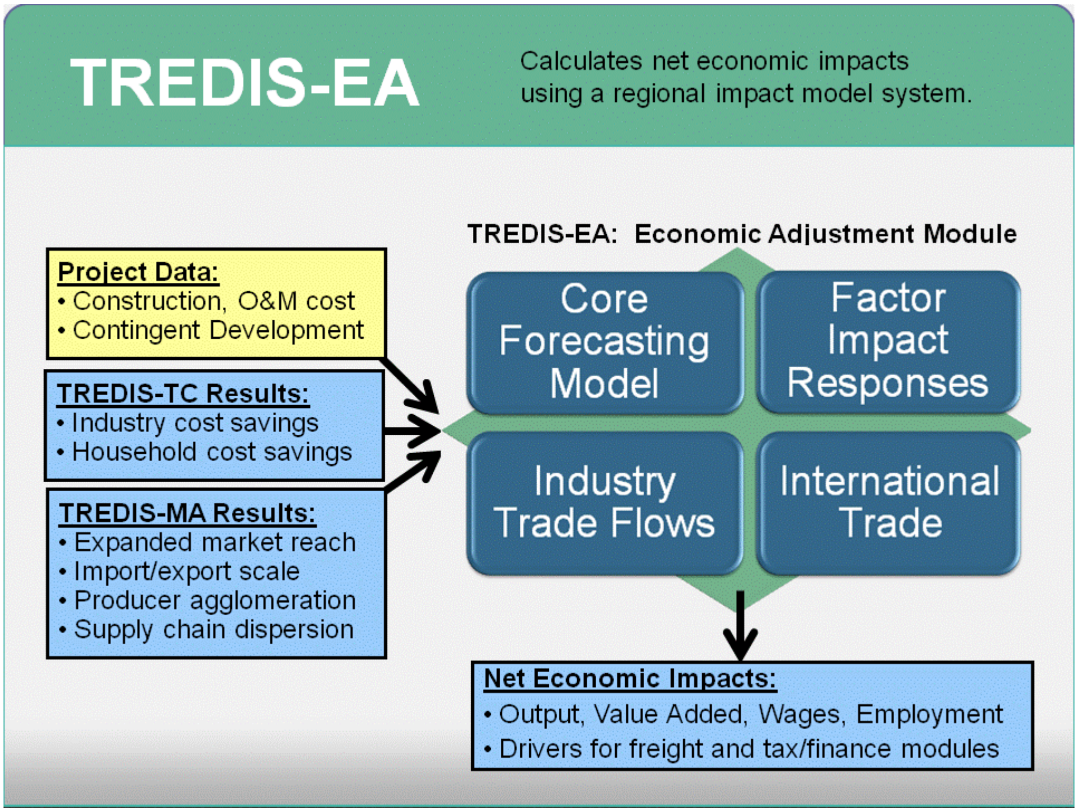

Figure 5.4- The Economic Adjustment Module (tredis.com)

Results of the Economic Adjustment Modules indicate how a transportation investment or improvement generates changes in employment, income, business output, and value added in a region. Economic impact results may be viewed by industry, year, and study region. Also, various geographical perspectives are available including local and state perspectives, and short-term and long-term effects can be disaggregated (tredis.com).

TREDIS typically uses the Dynamic Response Multi-Regional (DRMR) macroeconomic impact system to forecast economic impacts. DRMR relies on forecasting information from Moody's Analytics and on trade flow information from IMPLAN. TREDIS may be used with other models as well including REMI Policy Insight, Global Insight, REDYN, and RIMS-II (tredis.com).

Benefit-Cost Module

The Benefit-Cost Module provides benefit-cost analysis results by organizing information from the Travel Cost and Economic Adjustment Modules according to measures for economic impacts and economic benefits. A distinction is made between impacts that do and do not directly affect the flow of dollars in an economy. For instance, impacts on income and business sales directly affect the flow of money in an economy, whereas an impact such as household travel time savings has an economic value that does not directly impact the flow of dollars in the economy. The Benefit-Cost Module essentially groups benefits according to travel efficiency, cost savings, productivity, and social measures. Benefit cost ratios are obtained from different perspectives (local, state, and federal) by comparing the discounted present values of benefits and costs. Figure 5.5 below illustrates how the Benefit-Cost Module incorporates results from other modules and yields a net present value.

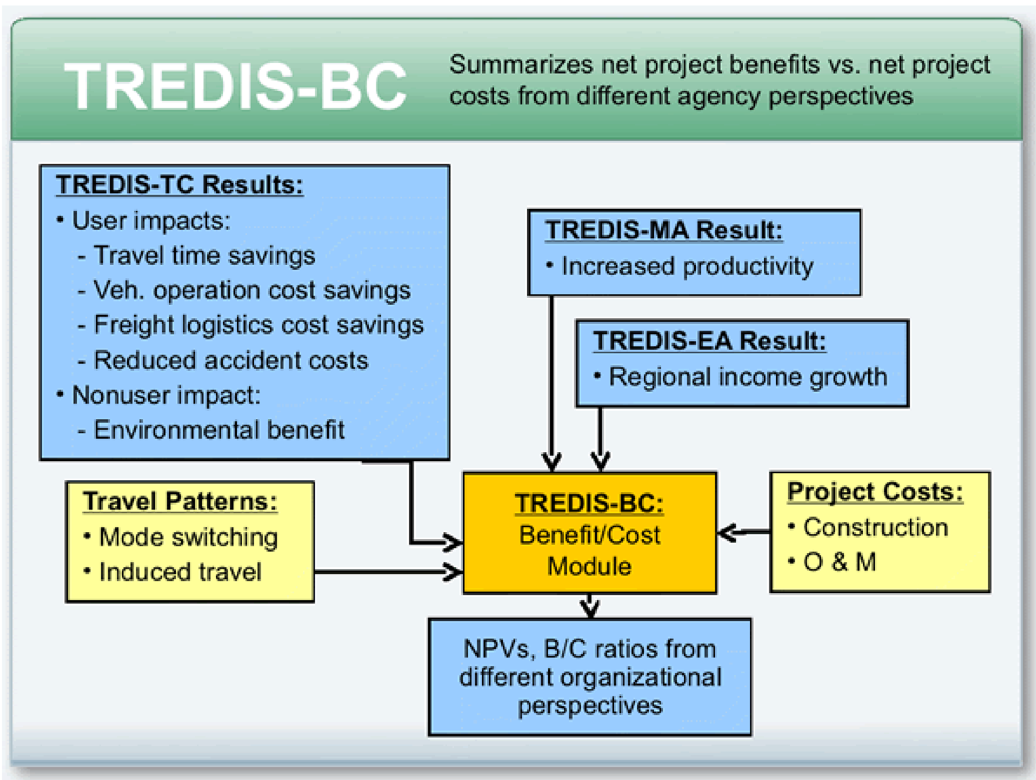

Figure 5.5- The Benefit-Cost Module (tredis.com)

Tax and Finance Module

The Tax and Finance Module accounts for transportation project costs and revenues that accrue to government entities and to private sector owners and operators. Changes in spending and investment in transportation can affect government revenues based on sales, income, motor fuel, and property taxes. The Tax and Finance Module can capture such effects on government revenues. The Module also may be used to assess alternative pricing strategies for roadway tolls, transit fares, fuel taxes, and infrastructure fees. Assessments may include which industries are most affected by price changes, as well as how industries' productivity, operating costs, and income are impacted. Another use includes assessing how public-private partnerships affect costs and revenues for both government and private sector partners. A "Revenue and Cost Sharing Report" is available for viewing results in terms of an entity's internal rate of return, payback period, and revenue/cost ratio. A "Revenue Report" is available which displays the types of impacts on various levels of government (i.e., the different tax revenue sources) and the taxes/fees paid by households and businesses (tredis.com).

Freight and Trade Module

The Freight and Trade Module is an optional component of TREDIS. Current economic and freight patterns are provided and displayed in terms of the volumes of goods moving in and out of a study region. These flows may be segmented according to mode, tonnage, value, industry, and origin/destination. The Module allows for assessment of the impact of freight movements on local income and employment. Further, the Module can assess how different transportation scenarios will impact freight shipping demand for various products and transportation modes. For instance, transportation projects or policies may affect the performance of a facility (e.g., travel speeds or capacity) or businesses' operating expenses to the point that freight shipping demand is altered for a particular product or transportation mode (tredis.com).

TREDIS APPLICATIONS

TREDIS has been applied in a variety of contexts. Applications of TREDIS generally fall under one of four categories:

1. Public Policy and Public Information
2. State and Regional Planning
3. Project Prioritization and Selection
4. Alternatives Analysis

Examples of studies and reports from each of the above categories are briefly summarized in order to provide a clear understanding of how TREDIS may be used in practice.

Public Policy and Public Information

Missouri Department of Economic Development

The Missouri Economic Research and Information Center (MERIC), which is the research arm of the Missouri Department of Economic Development, studied how Missouri's various transportation modes contributed to statewide economic impacts. The study also assessed the economic benefits resulting from investment in transportation infrastructure improvements. TREDIS was used to estimate economic impacts and to demonstrate the effects of policies intended "to reduce congestion, increase capacity and speed, and divert freight from congested to non-congested freight modes and routes" (tredis.com). Impacts were in terms of industry, transportation, safety, and environmental costs, which affected the gross regional product and the number of recurring jobs (tredis.com).

TREDIS was used in the rail freight component of the report to demonstrate how freight costs could be affected as a function of train speed. Figure 5.6 below displays some of the results obtained from the application of TREDIS. The base flow was taken as 50 mph, so the the different bars in the graph represent the reductions in freight costs as a result of some increase in train speed above 50 mph. It was estimated that an increase of 30 mph in train speed would reduce freight costs by almost 40 percent, which equated to an increase of more than 300 direct jobs (MERIC).

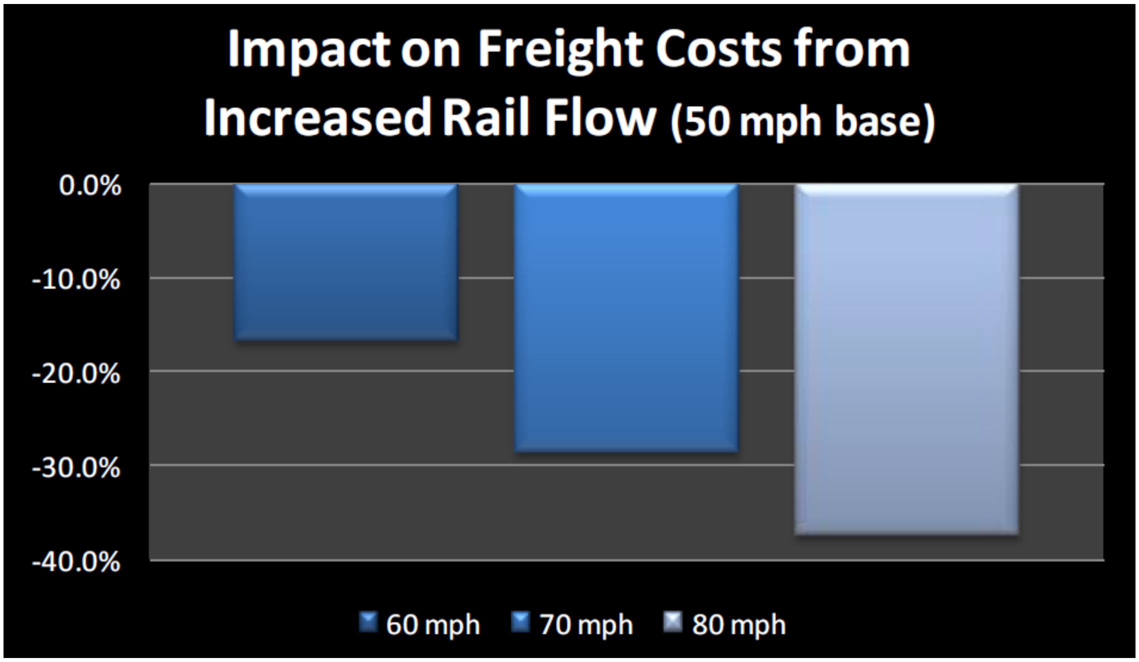

Figure 5.6- Impact of increased train speed on freight cost reduction (MERIC)

Cost of Congestion in Portland, Oregon

EDRG conducted a study for the Portland Business Alliance, Metro, the Port of Portland, and the Oregon DOT. The study was commissioned to evaluate the relationship between transportation investments and the economy and represents a first step toward addressing rising congestion problems in Portland, Oregon. Results from the study were meant to stimulate discussions concerning planning for and investing in Portland's metropolitan transportation system. Congestion problems led to a technology company's changing its last shipment departure time; a food company's opening a new regional distribution center in another area; and one company's increasing its inventories by 7 percent to 8 percent. It was noted that worsening congestion will negatively impact area businesses' competitiveness and could lead to loss of jobs, relocation of existing area businesses, and/or the attraction of fewer new businesses (EDRG 2005).

The study compared two transportation investment scenarios: The Planned Investment Scenario and the Improved System Scenario, which would double the amount of transportation investment over a 20-year period. It was found that the Improved System Scenario would result in much less congestion relative to the Planned Investment Scenario. Furthermore, the improved system investment would result in an annual benefit of $844 million by 2025, 2000 – 3000 annual construction jobs, and support 6,500 additional permanent jobs by 2025. Businesses would also experience additional sales, resulting in an annual value-added benefit of $426 million. Results also indicated that the benefit/cost ratio would be 2:1, meaning that $2 of benefit would occur for every dollar invested in transportation (EDRG 2005).

The economic impact analysis considered impacts on business operating and delivery costs, household expenses, and access to labor markets and product delivery markets. TREDIS was used to assess how future congestion scenarios would impact the population size within the commuting range of Portland and the size of the business base within the delivery range of the city. Also, the scenarios' effects on access to the airport, marine port, and intermodal rail facilities were calculated. TREDIS used these access effects to estimate how industry productivity and the region's competitiveness in attracting industries would be affected (EDRG 2005).

State and Regional Planning

Appalachian Regional Commission: Highway Program

The Appalachian Regional Commission (ARC) commissioned a study to assess the economic impacts, benefits, and costs associated with completing the Appalachian Development Highway System (ADHS), which is "the first highway system authorized by Congress for the purpose of stimulating economic development" (Cambridge et al. 2008). At the time of the study's conclusion, approximately 85 percent of the ADHS had been constructed, and completion of the remaining unfinished portions would integrate the Appalachian transportation network and connect the system to national markets and trade. Results from the study include estimates of travel and economic benefits over a short and long term, such as a benefit/cost analysis that evaluated "the expected economic return on investment of completing the ADHS to both the ARC region and the U.S." (Cambridge et al. 2008). The study also includes an assessment of potential economic development benefits resulting from improved market access to the labor force, suppliers, multimodal facilities, and consumers. It was estimated that increased market accessibility would result in a $2.1 billion annual gain in economic activity (i.e., value added) for the ARC region by 2035. Total economic impacts associated with completion of the ADHS were estimated to include the creation of 80,500 jobs by 2035 and $3.2 billion in increased annual wages for workers in the ARC region.

Completion of the ADHS would impact travel for users of the system. A travel demand model and GIS were used to determine changes in VMT and VHT and impacts on accessibility and connectivity resulting from the ADHS completion. These results were then used in TREDIS to estimate economic impacts in the ARC region. Analyses were performed to determine how travel time and cost savings accrued to businesses and households and how market access changes affected regional economic growth opportunities and competitiveness. A regional economic model within TREDIS used the results from changes in business costs and regional access changes to forecast long-term economic impacts. Calculated benefits and impacts were then compared to projected costs (Cambridge et al. 2008).

Chicago Metropolitan Agency for Planning (CMAP)

CMAP developed GOTO2040, which is the comprehensive regional plan for the metropolitan area of Chicago. The plan addresses a number of metropolitan issues including transportation and economic development. Within the transportation issue, several particular areas were addressed: Economic vitality, accessibility and mobility, and air quality. In considering economic vitality, CMAP staff used the agency's regional travel model with TREDIS to forecast economic impacts resulting from each of 53 major projects (e.g., road and rail transit) and for alternative project scenarios (tredis.com).

Virginia Department of Transportation (VDOT): Multimodal Plan

VTrans2035 is Virginia's long-range transportation planning process, which includes a focus on Virginia's economic vitality and the coordination of transportation and economic development activities. An economic impact analysis was conducted in order to measure and evaluate "the extent to which planned transportation investments will provide desired impacts on expanding Virginia's economic base by enhancing both passenger and freight movements" (EDRG et al. 2010). The analysis focused on impacts in terms of industry creation of jobs and income.

Impacts were assessed concerning how various transportation spending scenarios affected the capacity, use, and conditions of transportation facilities in Virginia. Traffic, congestion, and the growth of freight flows through ports were considered. Passenger and freight volumes, speeds, travel distances, and service reliability were also assessed under each spending scenario. The results from these analyses were fed into TREDIS, which was used to calculate long-term economic impacts resulting from multimodal transportation improvements. The TREDIS version used in the analysis was based on a model of Virginia's economy, the state's import and export freight flows, and the "ways in which different Virginia industries depend on transportation for workers, materials and product deliveries" (EDRG et al. 2010). Results indicated that $10.4 billion in capital investments would enable $81 billion in additional business output over 25 years. The additional average annual number of jobs created was estimated to be over 23,000 jobs. These figures represent differential effects between funding and not funding needed capital investments. In addition to the long-term economic impact analysis, short-term economic impacts were analyzed using TREDIS. Results indicated that expected capital and operations investments over six years and totaling $32.9 billion would support over $56 billion in business sales revenue and an annual average of over 78,000 jobs. As household incomes and net business revenues would rise, additional local and state tax revenue would increase by about $2.3 billion over the six-year period (EDRG et al. 2010).

Project Prioritization and Selection

North Carolina Department of Transportation (NCDOT)

NCDOT conducted a second prioritization process called P2.0 in order to score and rank various transportation-related projects in North Carolina. Approximately 1200 highway projects, more than 600 bicycle and pedestrian projects, and nearly 100 transit projects were scored based upon a project's meeting a need and aligning with local community priorities. Results from P2.0 serve as input into the next draft 10 Year Work Program crafted by NCDOT (which may be available in spring 2012). Stakeholder input expanded scoring criteria, leading to the inclusion of an economic impact component and a benefit/cost component for highway projects in the scoring process for "mobility projects" (NCDOT [a]; NCDOT [b]). Mobility projects include roadway widening, construction of new roadway, and upgrading interchanges or intersections. The scoring process for highway mobility projects consists of three tiers, namely statewide, regional, and subregional (e.g., county routes) tiers. Each tier has a unique scoring system in which data and local input are weighted differently. The statewide and regional tiers include an economic competitiveness component comprising 10 percent and 5 percent, respectively, of the overall project score. The statewide and regional tiers also include a benefit/cost component that comprises 20 percent and 15 percent, respectively, of the overall project score. The economic competitiveness score is based on output from TREDIS. VHT is the primary input into TREDIS, and output is in terms of "value added based on % change in NCDOT Division" (NCDOT [b]). The output characterizes the potential impact to the region over a 30-year period and includes information about the number of jobs created, increased wages, and increased productivity (NCDOT [b]).

Kansas Department of Transportation (KDOT)

The Kansas Department of Transportation (KDOT) developed and pilot tested a new approach for scoring potential highway projects. The program encompassed three project types: Preservation, modernization, and expansion. For expansion projects the scoring approach includes a strong emphasis on project engineering and incorporates a local/regional score component and an economic impact score. The engineering, local, and economic impact scores are weighted 50 percent, 25 percent, and 25 percent, respectively. The engineering score is based on how one project performs relative to other projects in areas such as impacts on congestion and on safety. The local score is based on perceived safety benefits, regional impact, system connectivity benefits, and extenuating costs and/or other factors. The economic impact score is based on a project's performance in creating or retaining jobs, expanding the gross regional product (GRP), and enhancing traveler benefits in terms of travel time, vehicle costs, and safety costs. The economic impact scoring system favors projects that generate or preserve a relatively high number of jobs and expand the GRP relative to project costs (KDOT).

KDOT used TREDIS to estimate economic impacts resulting from transportation projects, and results were used to inform the economic impact scoring of projects. Points were allotted to a project based upon the project's performance in (1) creating or retaining jobs by 2030 and (2) increasing safety benefits and the GRP by 2030 (KDOT).

Alternatives Analysis

Highway Corridor Improvements: I-95 Corridor Coalition

A study was performed for the I-95 Corridor Coalition, five Mid-Atlantic states (Delaware, Maryland, New Jersey, Pennsylvania, and Virginia), and three railroads (Amtrak, CSX, and Norfolk Southern) to assess how rail choke points affect the Mid-Atlantic region's economy and rail freight transportation. TREDIS was used to calculate economic benefits including changes in business output, value added, employment, and income. Changes in travel costs for truck and rail modes were estimated for the case in which Mid-Atlantic Rail Operations (MAROps) improvements were not made and no increase in rail mode share occurred. Shipping costs, which were based on travel costs per 1,000 ton-miles, increased for both truck and rail modes from 2008 to 2035. Three types of data were input into TREDIS (Cambridge Systematics 2009):

1. MAROps program costs;

2. Travel model information including market access data and various travel demand characteristics (e.g., vehicle trips, VMT, and VHT); and,
3. Economic value assumptions for crew costs, freight logistic costs, and vehicle cost factors related to vehicle operations and safety.

Highway Corridor Improvements: Indiana Department of Transportation (INDOT)

The states of Indiana, Missouri, Ohio, and Illinois formed the I-70 Corridor Coalition. FHWA provided the Coalition with matching funding "to conduct a two-phase feasibility study to determine the need, cost, risk, financing options and practicality to develop dedicated truck lanes (DTLs)" on an Interstate 70 (I-70) corridor (Wilbur Smith Associates 2010). The corridor extends 800 miles along I-70 from the Ohio/West Virginia state line to just west of Kansas City, Missouri. The first phase of the study provided the Coalition with an assessment as to whether the Coalition should continue examining the potential DTL project in greater detail, which Phase 2 would provide. The main conclusion from the Phase 1 report was that there existed "a business case for constructing, operating and maintaining dedicated truck lanes" along the defined I-70 Corridor (Wilbur Smith Associates 2010). As part of the Phase 1 study, an economic benefit analysis was conducted using TREDIS. Approximately 20 years of economic benefits were calculated for the counties adjacent to the 800-mile I-70 Corridor, assuming that DTLs were constructed by 2015. The analysis indicated that an additional $36 billion in total regional economic output through 2030 would occur, along with an additional 258,000 job years (Wilbur Smith Associates 2010).

Freight Intercity Rail Services: Chicago Freight Railroad Acquisition

EDRG conducted a study for Chicago Metropolis 2020 concerning the regional economic benefits resulting from Canadian National (CN) Railroad Company's acquisition of the Elgin Joliet and Eastern (EJ&E) Beltway. The acquisition would have allowed CN to move some of its traffic off of its five lines that entered the Chicago Terminal District and onto the EJ&E Beltway. The results of this potential traffic shift include alleviated congestion and reduced delay "in the core rail networks" while also placing more trains on the EJ&E (EDRG 2008). The study's purpose was to assess the regional economic impacts resulting from CN's diversion of some of its trains away from the core rail network. The economic impact study region included eight counties surrounding the area, and economic benefits to the nation were also assessed. National benefits were based on "productivity gains that flow from the portion of the transportation benefits that accrue to freight (rail and truck) customer destinations outside of the metro-area" (EDRG 2008).

The acquisition would result in "direct cost impacts related to freight logistics, rail freight services, driver/passenger time, and vehicle operations" (EDRG 2008). These direct cost impacts could affect business operating costs, productivity, regional competitiveness, and even household living costs. These secondary effects would impact the Chicago metropolitan economy in terms of changes in employment, income, gross domestic product, and/or business sales in the region. The study noted that TREDIS could track how the changes in travel time and costs affected business and household living costs in the area, which could lead to shifts in local spending patterns and business competitiveness. Changes in these latter aspects would influence business growth and investment, resulting in changes in employment and income. Results from the economic impact analysis indicated that business sales would increase by $211 million in 2015 as a result of the acquisition. 898 additional jobs would be created and supported by $56 million in compensation. The gross regional product, which is part of business sales, would increase by an estimated $89 million. The study also highlighted the industries that would realize the greatest direct transportation savings: Chemicals, computer and electronic products, electrical equipment and appliances, food products, and transportation equipment firms (EDRG 2008).

CONCLUSIONS

The TREDIS model is a comprehensive benefit/cost analysis and economic impact analysis tool. The model accounts not only for user benefits pertaining to travel time and travel cost savings, but also for the economic benefits that materialize when transportation improvements expand market accessibility. The modular structure of the model provides an understandable framework for assessing economic impacts. The travel cost module accounts for the travel impacts of a transportation project. The market access module captures the effects of expanded access to labor and consumer markets. The economic adjustment module forecasts the economic impacts of a transportation project over time. The benefit/cost module accounts for the project benefits and costs.

The TREDIS model has been applied in a number of areas including the following: Public policy, state and regional planning, project prioritization and selection, and alternatives analysis. Several public sector agencies and private sector entities have used TREDIS or commissioned studies that use TREDIS. The model has won an increasing number of clients, which is a sure indication of its growing acceptance in the field of economic impact analysis. Its rising popularity may be due to the model's comprehensiveness, ease of use, and relative cost-effectiveness.

Chapter 6: The Economic Impacts of an Interstate 10 Capacity Expansion Project

In this chapter the TREDIS model will be used to estimate the local economic impacts resulting from investment in a current highway project in San Antonio, Texas: An Interstate 10 (I-10) capacity expansion project (CSJ 0072-08-120). It should be noted that the economic impact forecasts and results in this chapter are based upon results obtained as part of an ongoing TxDOT interagency services contract. This contract consists in identifying major freight corridors (road and rail) in Texas and demonstrating the economic importance of improving these corridors. The TREDIS model will be used to estimate the economic impacts of investments in different freight-related road and rail projects throughout Texas. An economic impact analysis was conducted for the I-10 expansion project mentioned previously, and results from that analysis are used in this chapter.

Identification of Important Freight Highway Corridors

As part of the aforementioned TxDOT interagency services contract, several Texas roadways were identified as important freight highway corridors. All of the Texas Interstate Highways were included in this group, and other US routes were added following the recommendations provided by two TxDOT Planning and Programming Division employees. In all, 13 highways were identified as important to freight movements in Texas and are listed below in Table 6.1. The table also provides the population, employment, and business totals along each highway in order to demonstrate the relative consumer and labor market sizes that each highway serves. Table 6.1 indicates that I-10 serves the second highest total population of any major freight roadway in Texas, and I-10 also supports relatively high numbers of business establishments and jobs. Thus, I-10 is a critical corridor for freight movements based upon the amount of people and businesses that the roadway serves.

Table 6.1- Figures indicating relative importance of highways to freight movements (Sources: *U.S. Dept. of Labor and **U.S. Census Bureau)

Roadway	Population (est. July 2009)*	Total Employment*	Total Establishments**	Annual Payroll ($1,000)**
IH 10	7,803,211	3,394,281	162,355	145,164,906
IH 20	5,474,016	2,650,298	130,420	114,918,737
IH 27	551,681	239,825	13,558	6,332,368
IH 30	4,702,998	2,309,400	109,113	102,767,876
IH 35	9,651,976	4,270,272	209,793	169,987,292
IH 37	2,098,396	899,639	42,512	28,988,016
IH 40	179,023	98,524	5,044	2,811,365
IH 45	7,572,193	3,725,792	172,629	181,257,582
US 59	6,116,038	2,605,609	128,915	119,889,337
US 77	4,622,801	2,132,488	103,985	89,643,728
US 87	2,668,339	1,128,949	57,284	34,641,166
US 281	3,372,163	1,246,987	62,284	35,306,897
US 287	3,033,851	1,200,446	63,061	43,058,505

IDENTIFICATION OF HIGHWAY PROJECTS

Large infrastructure investments can have relatively large economic impacts in population centers, so highway projects near major population centers in Texas were considered for use in the economic impact analysis of the TxDOT project. Major population centers in Texas include the metropolitan areas of Austin, Dallas-Fort Worth, Houston, and San Antonio. Also, the type of highway project likely to positively impact freight movements consists of capacity expansion. Expanding highway capacity can reduce congestion, resulting in increased travel speeds, reduced travel times, and improved fuel efficiency. This report includes economic impact analysis results (specifically related to market access impacts) from a capacity-expansion project near the San Antonio metropolitan area.

Various sources were used to identify capacity expansion projects in the San Antonio area. The 2011 – 2014 Transportation Improvement Program (TIP) of the San Antonio-Bexar County MPO was reviewed in order to identify capacity expansion projects. A screening process was used to select possible projects. The selection criteria consisted of the following aspects:

- Projects had to be at least $25,000,000 in value.
- Projects must expand highway capacity.
- Projects had to occur on major roadways that essentially carry much freight.

Based upon the above criteria, selected projects included projects on Loop 1604, U.S. 281, and I-35. Another source for project information consisted of TxDOT's "Project Tracker" website tool, which lists various highway projects and corresponding project information for a given area. A capacity expansion project for I-10 was identified, and this project was studied using economic impact analysis. As listed previously, the CSJ number of the I-10 highway project is 0072-08-120.

DETAILED PROJECT INFORMATION

More detailed project information was obtained for the I-10 highway project, which had a dedicated project website. More information was obtained concerning project costs, limits, and scope of work. A summary of relevant project information is provided below. The economic impacts of investing in this particular highway project were assessed with the TREDIS model, and the results are provided later in this chapter.

CSJ 0072-08-120

Figure 6.1 shows the limits of CSJ 0072-08-120, which are from Loop 1604 (labeled "B") to 1.0 miles north of Huebner Road (labeled "A"). The project length is 2.54 miles along I-10. The official start date of the project was January 2, 2012, and work is expected to be completed by the summer of 2014. The scope of work involves adding one lane in each direction to the main lanes and making operational improvements along the corridor. The awarded contract bid was $35,968,285.40, and the cost of engineering to date is $2,265,617.61 (TxDOT fact sheet; TxDOT Project Tracker Tool). The goals of the project (in order of priority) include improving safety, relieving congestion, and promoting economic development.

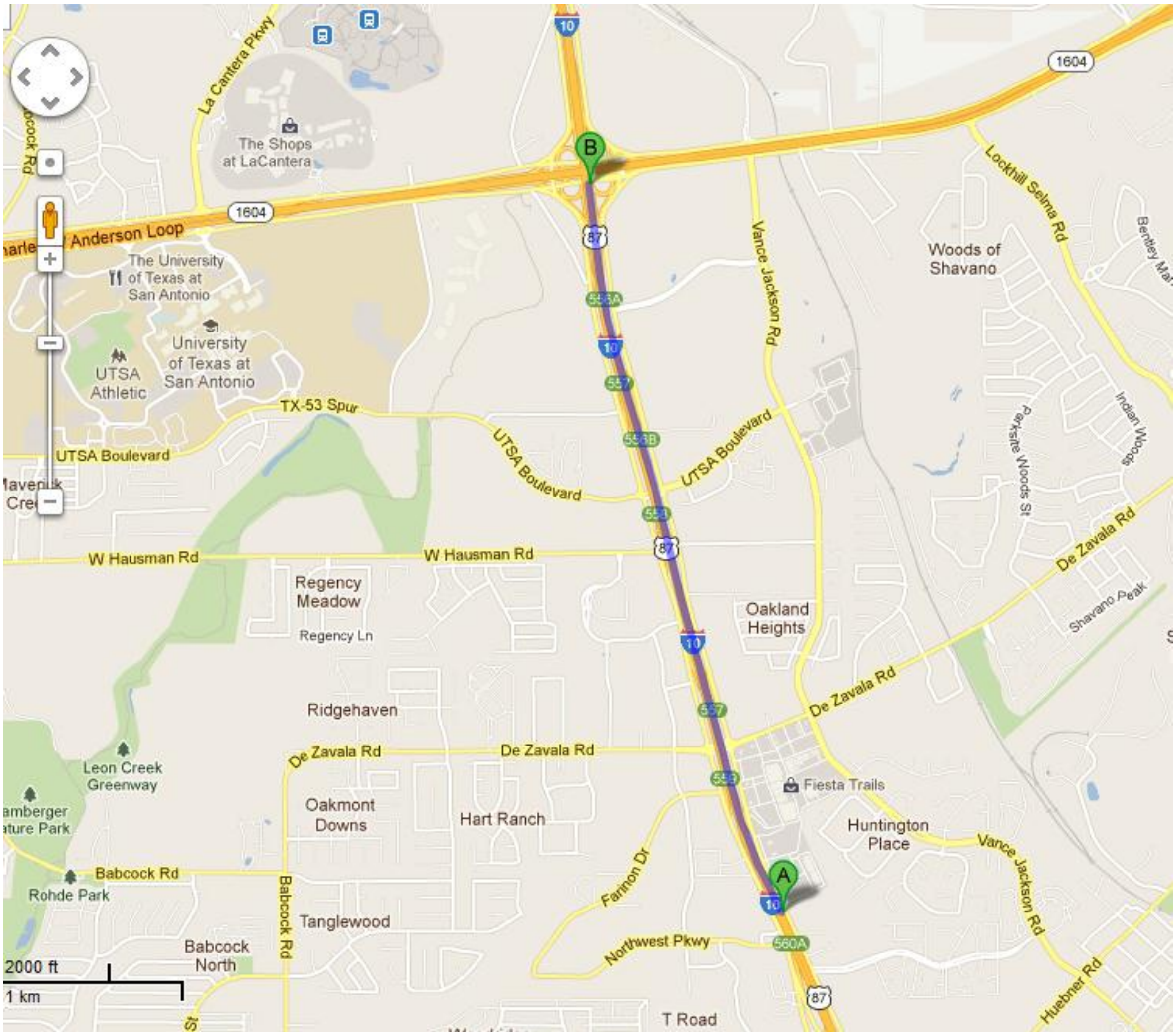

Figure 6.1- Project limits for CSJ 0072-08-120 (from Google Maps)

TREDIS MODEL CONFIGURATION AND DATA INPUT

As described in Chapter 5, the TREDIS model has four distinct pages with different functions: The Project, Scenario, Case, and Report pages. The first three pages require user-specified inputs, and the Report page provides the estimated impacts of a given project. The input process for the first three pages is discussed next.

Defining the Project

The available project information was used to define the I-10 highway project on the Project page in TREDIS. The project was named the "I-10 San Antonio Project". The mode and purpose combinations selected for analysis included truck freight and passenger cars for commute and personal/recreational trips. San Antonio is located in Bexar County, which was chosen as the study region. Kendall County, located to the northwest of Bexar County, was selected as a "linked area," which represents an area that is connected to and external to the study region. The time period on which input values are based was selected to be an annual period; that is, input values represent yearly values such as annual VMT and annual VHT. Based upon previously mentioned construction scheduling information, the construction period was chosen to begin in 2012 and end in 2014. Since the project began in January 2012 and is expected to last until the summer of 2014, total construction spending was allocated in the following way: 40 percent to 2012, 40 percent to 2013, and 20 percent to 2014 (since construction is expected to end mid-year). The "Project Phase-in Detail" function was used to allocate construction spending. The operational life of the facility was assumed to be 25 years, so the operation period ranged from 2014 to 2038. A constant dollar year of 2012 was selected, and an analysis year of 2035 was chosen, meaning that resulting outputs are provided for the year 2035. A travel growth rate of 2.18 percent and a discount rate of 3.65 percent were used. Justifications for these rates are provided in Appendix C.

Defining the Scenarios

The Scenario page consists of cost inputs, travel-related inputs, and market access inputs. The different input categories and the corresponding inputs are discussed below.

Cost Inputs

The startup construction costs include costs associated with right-of-way acquisition, engineering and design, and actual project construction. The previously mentioned contract bid amount (for construction) and engineering costs were used as inputs for the highway mode of the project scenario. The inputs are as follows:

- Engineering and Design: $2,265,617.61
- Project Construction: $35,968,285.40

Construction costs for the base scenario were assumed to be $0 since the no-build option does not involve construction. Also, since the project is a highway project, only costs associated with the road mode were input. Inputs for operations costs (e.g., for highway toll collection) were not specified. Inputs for annual roadway maintenance and rehabilitation costs are based on calculations shown in Appendix D and were input as follows:

- Annual Base Scenario M&R Costs: $251,349
- Annual Project Scenario M&R Costs: $335,132

TREDIS has a Cost & Revenue Sharing input option. All project costs are assumed to be borne by the public, and no toll revenue is to be generated by the I-10 project.

Travel Impacts of Projects

A major component of estimating the economic impacts of a transportation project in TREDIS involves the specification of how a given project impacts travel. Information concerning travel characteristics (e.g., traffic volumes, VMT, and VHT) and the changes in travel characteristics that result from transportation improvements can be obtained from sketch planning tools or travel demand models. The San Antonio-Bexar County MPO uses a travel demand model of the San Antonio metropolitan area for regional planning purposes. The modeling team of the MPO was approached about the possibility of modeling the travel impacts of the preceding I-10 highway project. The modeling team agreed to model how the I-10 highway expansion project would impact travel, and the modeling team was provided with a project schematic and a project fact sheet so that the highway expansion could be modeled correctly.

Using the available project schematic and project information, the modeling team simulated a 2035 “no-build” scenario and a 2035 “build” scenario on the MPO’s 2015 travel network. That is, the 2015 travel network was “loaded” with 2035 demographics and the traffic impacts were obtained for the no-build and build scenarios. The desired outputs from the travel demand model included vehicle volumes, VMT, and VHT for the no-build and build scenarios in Bexar County for the year 2035. The original output from the MPO travel demand model is provided in Appendix E. This data had to be “cleaned” in order for the data to be used in the TREDIS model. A spreadsheet in Appendix F shows how the raw output data from the MPO travel demand model was converted to input data used in TREDIS. The final travel characteristic values used in TREDIS are provided in Appendix G. It should be noted that the travel demand model outputs did not include the number of vehicle-trips, so the number of vehicle-trips was estimated by dividing the VMT (from the travel demand model output) by an average weighted trip distance of 7.12 miles. Appendix F includes the information used to determine the average trip distance.

TREDIS contains default accident rates concerning the number of fatalities per 100 million VMT, the number of personal injuries per 100 million VMT, and the number of accidents involving property damage per 100 million VMT. The default accident rates were maintained. Also, TREDIS contains default values for the relative commodity mix shipped by truck or rail for a given area. The default commodity mix values were maintained.

Market Access Impacts

TREDIS contains default values that characterize a region's access to consumer and labor markets, delivery markets, intermodal facilities, and international gateways. All market access default values for the base and project scenarios were maintained, except for the value of labor and consumer market size in the project scenario. The expansion of I-10 was expected to increase access to labor and consumer markets. This increased accessibility was estimated based upon the change in average travel speed along I-10 from the base scenario to the project scenario. The procedure for this estimation is shown in Appendix H. The market access default values and the calculated labor and consumer market size are provided in Appendix I. Note that no values were input as part of the Contingent Development option.

The Case Definition

The Case page consists of defining cases in which two scenarios are compared. Only one base scenario and one project scenario were specified, so one case ("Case 1") was created.

I-10 PROJECT IMPACTS

After the project was defined and the various cost, travel, and market access information was input into TREDIS, the local project impacts were estimated by running the TREDIS model. TREDIS presents project impacts in the following categories:

- Travel cost savings
- Market access impacts
- Economic impacts
- Benefit/cost results
- Tax impacts

The results corresponding to each impact category are presented and discussed in the following subsections.

Travel Cost Savings

The travel cost savings estimated by TREDIS indicated the differences in travel characteristics, safety, and travel cost savings between the base and project scenarios for Analysis Year 2035. Results estimated by TREDIS for travel cost savings were inconclusive. The model may not have been structured in such a way as to capture the economic impacts resulting from improvements to travel, safety, and the environment.

Market Access Impacts

The expansion of the labor/consumer market in the project scenario represented the only difference in market access characteristics between the base and project scenarios. Figure 6.3 shows the highway project's market access impacts in 2035, which occurred solely because of the expansion of the labor/consumer market. Access to other markets and facilities (e.g., intermodal or international gateway) was not affected by the expansion project. The improved market access was represented by a 0.4 percent increase in coverage of persons within a 40-minute drive time of the center of San Antonio. It was estimated that the expanded labor/consumer market access would increase the gross regional product (GRP) in 2035 by over \$19 million, of which over \$15 million could be attributed to business migration and nearly \$4 million could be attributed to enhanced labor productivity. The total estimated change in GRP represents about 0.025 percent of the current regional GRP. While the relative size of the market access impact to the total GRP may seem small, the estimated impact in absolute terms (i.e., $19 million) is not small.

Scenario	Labor/Consumer Market (population within a 40-minute drive time)
Base Scenario	636,265
Project Scenario	638,628
Change - Project vs Base	2,363
% Improvement - Project vs Base	0.4 %
Source of Impact	**GRP Impact from Improved Market Access ($)**
From Business Migration	15,378,939
From Labor Productivity	3,801,584
From International Exports	0
Total Change in GRP	19,180,523
Total Baseline Regional GRP	76,835,470,444
	Percent Change in Region's GRP ($)
From Business Migration	0.020%
From Labor Productivity	0.005%
From International Exports	0.000%
Total % Change in GRP	0.025%
	Implied Elasticity of GRP with Respect to Market Access Change
From Business Migration	0.054
From Labor Productivity	0.013
From International Exports	0.000
Total Implied Elasticity	0.067

Figure 6.3- Impacts of labor/consumer market access expansion on GRP in 2035

The allocation of the market access impacts is shown in Figure 6.4, which highlights the industries most affected by the I-10 project. The retail trade sector would benefit the most of any industry, receiving more than one-fifth of the value of the market access impacts. Other major beneficiaries include professional and technical services (e.g., law, accounting, and engineering services); government agencies (e.g., public administration and fire protection services); and the Postal Service and couriers. The labor/consumer market expansion impacts on all industries are provided in Appendix L.

NAICS	Industry	Gross Business Attraction from Market Access Improvement in Labor/Consumer Market ($ Value Added)	Percent of Total Business Attraction
441-454	Retail Trade	4,133,385	21.55%
541-551	Professional Scientific, Technical, Services	2,664,952	13.89%
920	Government & non NAICs	1,684,669	8.78%
491-493	Mail, package delivery & warehousing	1,209,443	6.31%
561	Administrative & Support Services	1,133,719	5.91%
324	Petroleum & Coal Products	1,006,089	5.25%
420	Wholesale Trade	967,066	5.04%
524	Insurance Carriers & Related Activities	785,613	4.10%
531	Real Estate	674,428	3.52%
621-624	Health Care & Social Services	671,650	3.50%
521-523	Monetary, Financial, & Credit Activity	570,081	2.97%
811-812	Repair, Maintenance, & Personal Services	560,579	2.92%
721-722	Accommodations, Eating & Drinking	380,772	1.99%
611	Educational Services	373,131	1.95%
481-487	Transportation	356,404	1.86%
513	Broadcasting	354,124	1.85%
711-713	Amusement & Recreation	298,777	1.56%
532	Rental & Leasing Services	259,606	1.35%
	Remaining Industries	1,096,035	5.71%
	Total	**19,180,523**	**100.00%**

Figure 6.4- Most affected industries in terms of value added for 2035

Economic Impacts

Figure 6.5 displays the estimated annual local economic impacts of the expansion project. Construction-related activities generate all estimated impacts in 2012 and 2013 and most of the economic impacts in 2014. The effects of market access on the economy begin in 2014, which was defined as the first operational year of the expanded roadway. The magnitude of the market access economic impacts slowly increases (in absolute terms) over the first five years of the operational life of the facility. Beginning in 2019, the economic impacts resulting from improved market access increase rapidly until 2023. After 2023, the effects of expanded market access on the economy remain fairly steady: An additional $48 million in business output, $31 million in value added, and $20 million in wage income are supported on an annual basis. The annual economic impacts are provided in Appendix M.

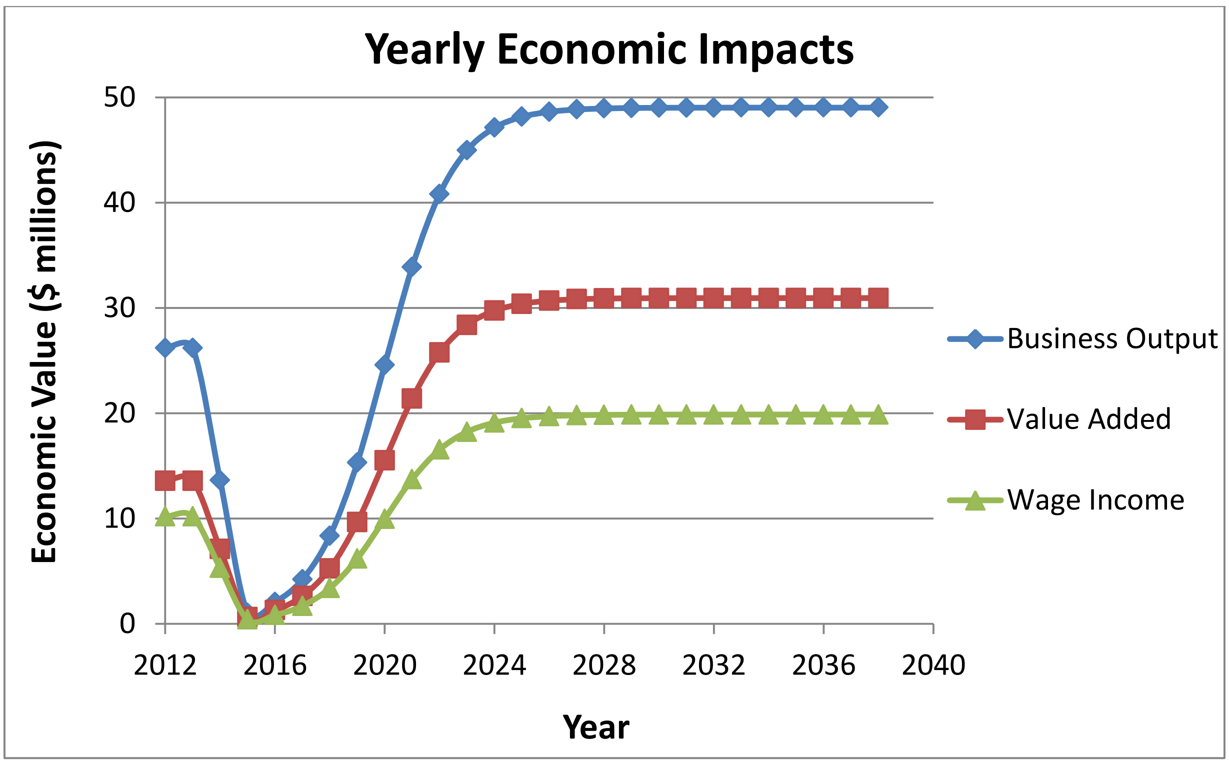

Figure 6.5- Economic impacts of the I-10 project over time

Construction impacts supported 217 jobs in 2012 and 2013; 110 jobs in 2014; and 1 job each year thereafter. In addition to these jobs, the effects of expanded market access generated even more jobs over time. Figure 6.6 shows the estimated annual number of jobs supported as a result of expanded market access into labor and consumer markets. The number of jobs created by the market access expansion slowly increases till 2018 before growing rapidly till 2022. After 2024, approximately 440 jobs are supported annually due to the market expansion.

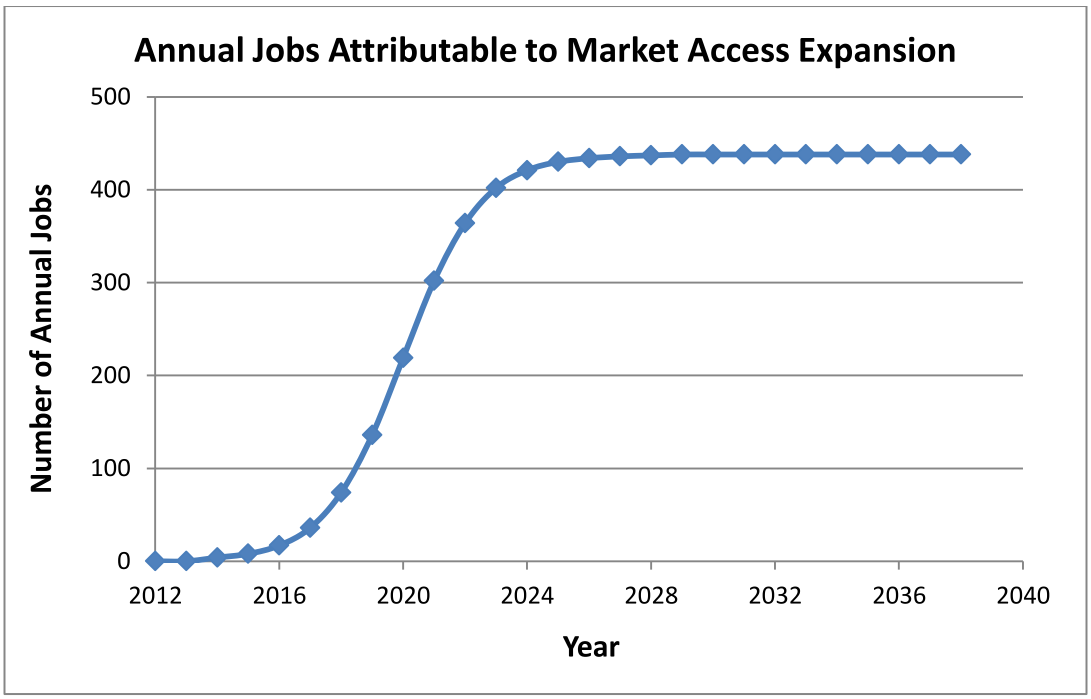

Figure 6.6- Annual jobs attributable to expansion of labor/consumer market access

Benefit/Cost Results

The present values of the local cost and benefit streams were determined to be $38.5 million and $41.0 million, respectively. The entire $41.0 million in benefits was attributed to business productivity, which resulted because of the market access expansion. The benefits and costs provide a total societal benefit/cost ratio of 1.07. Figure 6.7 shows the societal benefit and cost figures. Wider impact measures, such as additional gross regional product (GRP), also may be considered. The estimated impact/cost ratio for additional GRP was estimated to be 8.19 and is shown in Figure 6.7. The full benefit/cost results are provided in Appendix N.

Benefit Measure	Present Value of Benefit Stream ($ mil)	Present Value of Cost Stream ($ mil)	Net Present Value, $ mil (Benefits - Costs)	Benefit/Cost Ratio
Total Societal Benefit	41	38	3	1.07
Impact Measure	**Present Value of Impact Stream ($ mil)**	**Present Value of Cost Stream ($ mil)**	**Net Present Value, $ mil (Impacts - Costs)**	**Impact/Cost Ratio**
Add'l Gross Regional Product	315	38	277	8.19

Figure 6.7- Present Values of Project Benefit, Impact, and Cost Streams in Study Area

Tax Impacts

The total estimated tax impacts over the life of the project were estimated and are presented in Figure 6.8. Additional revenue from motor fuel taxes was not captured, which may be a limitation of the model and an underestimation of the project's tax impacts. The majority of estimated taxes and fees paid by households went to the federal government, while businesses paid approximately equal amounts of estimated taxes/fees to the federal government and to state and local governments. Relative to households, businesses would pay less federal taxes/fees and much more state and local government taxes/fees. State and local government sales tax revenue was not segmented by households and businesses, but a total of $19.3 million in sales tax revenue was projected.

REPORT T1: TAX IMPACTS

Analysis Year:	2035	Project:	I-10 San Antonio Project
Constant$ Year:	2012	Region:	All Regions
Base Scenario:	Base Scenario	Period:	All Periods
Project Scenario:	Project Scenario		

Tax/Fee Collector	Tax/Fee Description	Taxes/Fees Paid by:		Totals
		Households	Businesses	
Facility or Service Operator	Tolls & Fees	0	0	0
Federal Government	Motor Fuel Tax	0	0	0
	Income Profits	21,340,600	6,207,816	27,548,416
	Social Insurance Tax (FICA)	21,381,660	17,338,050	38,719,710
	Miscellaneous Fees & Taxes	0	9,384,023	9,384,023
	Total Federal Government	**42,722,260**	**32,929,889**	**75,652,149**
State and Local Government	Motor Fuel Tax	0	0	0
	Motor Vehicle License Fees	395,515	361,693	757,208
	Income/Profits	0	2,125,793	2,125,793
	Sales tax	not available	not available	19,309,360
	Property Tax	206,988	17,876,640	18,083,628
	Social Insurance Tax	191,548	475,781	667,329
	Miscellaneous Fees & Taxes	2,199,854	9,899,271	12,099,125
	Total State and Local Government	**2,993,905**	**30,739,178**	**53,042,443**
	Grand Totals for Federal, State and Local	45,716,165	63,669,067	128,694,592

Figure 6.8- Total tax impacts over all years (using an undiscounted sum of yearly values)

CONCLUSIONS

Project information, travel impacts, and market access impacts were used to model the economic impacts in TREDIS resulting from the expansion of I-10 in San Antonio. The project entails short-term and long-term costs and economic impacts. Short-term costs consist of construction costs for engineering/design ($2.3 million) and actual construction ($36.0 million). Long-term costs include expenditures for roadway maintenance and rehabilitation.

Short-term economic impacts were driven by project construction, which helped support more than 200 jobs and generate more than $25 million in business output in both 2012 and 2013. Long-term economic impacts were driven almost exclusively by the expansion of labor and consumer market access. Market access expansion generated an estimated $25 million in business output in 2020 and nearly $50 million in business output annually from 2024 onward. From 2025 and onward, improved market access is expected to support approximately 430 jobs annually. Labor and consumer market expansion led to an estimated $19 million in value added in 2035. Most of the value added benefit was derived from business migration, and the sectors that benefitted the most from the expansion project included retail trade, professional and technical services, and government. The total local, state, and federal government revenues generated over the lifetime of the project and facility were estimated to exceed $128 million. Clearly, the expansion of I-10 has positive economic impacts.

Chapter 7: Conclusions

Transportation professionals face difficult tasks in justifying and prioritizing transportation investments. Economic impact analysis can aid these efforts by estimating the economic impacts resulting from individual projects. Project impacts can be compared across a range of projects in order to accentuate the trade-offs among alternatives and better inform investment decisions. Various techniques are available to conduct economic impact analysis, including techniques reviewed in this paper. One of the reviewed techniques is the TREDIS economic impact model, which was used to estimate the local economic impacts resulting from a highway expansion project on I-10 in San Antonio beginning in 2012. Project information and market access impacts of the I-10 project were used to estimate the economic impacts, which included the following:

- The total local, state, and federal government revenues generated through taxes and fees over the life of the project and the facility exceeded $128 million.
- Project construction and spending annually supported more than 200 jobs and $25 million in business output in 2012 and 2013.
- The expansion of labor and consumer markets generated approximately $50 million in business revenue, $30 million in value added, $20 million in wage income, and supported approximately 430 jobs per year by 2025.

The labor and consumer market area is defined in TREDIS as the population within a 40-minute drive time of the population-weighted centroid of Bexar County. The expansion of these markets (i.e., the increase in population within the market area) resulted because of improvements to travel speed along I-10 from the base scenario to the project scenario. The estimated economic impacts resulting from expansion of the labor and consumer markets suggest that the I-10 expansion project would benefit the economy in Bexar County, particularly by increasing business revenues and supporting new jobs. Furthermore, the results obtained in this economic impact analysis demonstrate the usefulness of TREDIS in estimating project impacts. Through modeling efforts similar to the one used in this report, planners and engineers could apply TREDIS in order to estimate individual project impacts, compare impacts among project alternatives, and inform project selection decisions and programming activities.

A few observations were made concerning market access impacts over the course of this analysis. First, market access impacts are important, though they may not be accounted for in other economic impact tools and methods. After the end of the I-10 project's construction phase, almost all economic impacts were attributable to the expanded access into labor and consumer markets. Further, the degree of market expansion was relatively small (a 0.4 percent increase in population size from the population total within the original consumer and labor market), yet the overall estimated economic impacts were quite large (e.g., over 400 jobs supported annually by 2025). Economic impact analyses should account for important elements including market access changes and corresponding economic impacts. Second, greater economic impacts may be achieved through investments in projects that greatly increase market access. The I-10 project site is located on the outskirts of San Antonio, so market access expansion (away from downtown San Antonio) was confined to a rural area northwest of the city. Had the project site been closer to the center of San Antonio, the market access expansion likely would have been larger and led to greater economic impacts. Essentially, projects that expand market access into areas with greater populations will result in higher economic impacts. Third, a time lag may exist for the economic impacts attributable to market access expansion. Expansion of market access resulted in relatively minor economic impacts in the first five years following the completion of construction. However, between five and ten years after construction, economic impacts increased substantially and eventually plateaued after ten years. The effects of market access changes on the economy may not occur until several years after the completion of a project.

This study provides the estimated economic impacts of the I-10 expansion project resulting from construction activities, maintenance and rehabilitation work, and improved market access. This study did not include results for economic impacts resulting from travel cost savings (associated with improvements in travel, safety, and the environment), which generally could be large and could provide motivation for implementing a transportation project. Future economic impact analyses possibly could structure the TREDIS model in such a way as to capture the economic impacts associated with the aforementioned travel cost savings. Certain data inputs in the TREDIS model may be particularly relevant toward this endeavor, including the nature of the types of trips in an area (i.e., internal, incoming, outgoing, and through trips) and how congestion is affected by a transportation project. However, obtaining these kinds of data is challenging. Depending on the type of project(s) under consideration, assumptions will likely have to be made in order to conduct analyses with TREDIS that evaluate the economic impacts resulting from improvements in travel characteristics. One method that can be employed to counter limited data is sensitivity analysis, which allows for the input of a range of parameter/data values in order to assess what the range of possible outcomes may be. Inputs within TREDIS that may be useful to vary for the purpose of conducting sensitivity analyses include project cost figures, the level of congestion on a given piece of infrastructure before and after an improvement, and any pertinent market access inputs.

This study focused on the local impacts of the I-10 highway project. Local economic impacts are relevant to local planners, decision-makers, and citizens. Future study efforts could assess economic impacts from a broader regional perspective, such as the perspective of an entire state, which may increase support for regionally important projects because more stakeholders would be affected. Various approaches are available for assessing economic impacts from a regional perspective. One approach is to consider the economic impacts of a group of several potential projects located throughout a region. Within its long-range transportation plan, the Virginia Department of Transportation assessed the impacts of various spending scenarios on the capacity, usage, and conditions of transportation facilities in Virginia. Results from this assessment were used in TREDIS to estimate long-term economic impacts of multimodal investments. Other analyses with a regional focus may examine the economic impacts of projects along particular corridors. Study efforts in the previously mentioned TxDOT interagency services contract are likely to proceed in this direction. Texas has several current and potential major highway corridors that affect travel within the state and in the surrounding region. The economic impacts of proposed projects along these corridors could be assessed with TREDIS to demonstrate the importance of these highway corridors to the Texas economy and the surrounding regional economies. Several projects are currently underway or may be implemented over the next several years along I-35 in Texas. A corridor analysis of I-35 could assess how the travel impacts (i.e., changes in travel costs and travel times) of these projects stimulate the economies along the I-35 Corridor in terms of increased business revenues, aggregate income, and numbers of jobs. Potential future freight highway corridors may be examined as well. Two federally designated high-priority corridors in Texas include the Ports-to-Plains Corridor and U.S. Route 59. An economic impact analysis of the Ports-to-Plains Corridor could evaluate how upgrades to the existing highways of the Corridor would promote economic development in the counties along the Corridor in Texas. A case study of U.S. Route 59 (from Laredo to Houston) could assess how upgrading the existing facility to interstate highway standards would generate cost savings for businesses and affect the economy in the Houston area.

Other interesting topics to consider include improvements to critical border crossings and marine ports, which may decrease delay/congestion, reduce overall travel times, and thereby yield economic benefits to the various metropolitan areas in Texas. Case studies of the major Texas-Mexico truck border crossings (Laredo, El Paso, Hidalgo, and Brownsville) could be performed to capture the extent that truck border crossing improvements (e.g., reduced truck delay) lead to cost savings for businesses and economically impact major metropolitan areas in Texas including Austin, Dallas-Fort Worth, Houston, and San Antonio. Additionally, a case study could examine whether or not investments in alternative Texas truck border crossings (e.g., Del Rio and Eagle Pass) provide enough economic benefits to Texas to warrant such investments. Marine port improvements may also be studied. For example, a study may examine how improvements to the Port of Houston lead to economic benefits for San Antonio and Dallas-Fort Worth, which are linked to Houston by I-10 and I-45, respectively.

TREDIS has potential to provide meaningful economic and benefit/cost impacts of various types of transportation projects. While TREDIS may be used as a general sketch-planning tool, more rigorous economic impact modeling efforts will require more extensive and intensive data collection efforts. Efforts to estimate economic impacts with models such as TREDIS also necessitate careful consideration of how to structure analyses within such models. Furthermore, a great need exists to validate the results from economic impact tools and methodologies, including the results from this analysis. The I-10 highway project is currently underway and is expected to conclude in the summer of 2014. Future research could assess the actual local economic impacts that result from the I-10 project, compare the actual economic impacts with the projected impacts from this study, and evaluate the accuracy of TREDIS in estimating economic impacts.

Appendix A: TREDIS Pre-Loaded Data and TREDIS Inputs

PRE-LOADED DATA. TREDIS comes pre-loaded with an extensive database of information on current characteristics of your study area(s) and modes. This includes:

-> **Economy** - baseline measures

- mix of employment, wages, value added (GDP), and income, by industry
- domestic and international import, export and internal shipments, by commodity
- indicators of relative cost of doing business - labor, electricity, land/building values
- forecast (year-to-year change in employment and income by industry (option from Moody's Economy.com)

-> **Market Access and Connectivity** - baseline measures

- scale of labor and retail markets (population within 40 minute travel time)
- scale of same day truck delivery market (employment within 3-hour travel time)
- average road access time to commercial airports with scheduled domestic air service
- average road access time to commercial marine ports with scheduled freight service
- average road access time to public intermodal rail terminal
- average road access time to major international gateway airport

-> **Unit Values** - may be split by mode and/or trip purpose

- Unit value of passenger time savings (per traveler by mode)
- Unit value of vehicle operating cost savings (avg. per vehicle-mile or vehicle-hr)
- Unit value of cargo time savings (per ton, by mode and commodity class)
- Unit value of crash reduction (by type: mortality, injury, property damage)
- Unit value of emissions reduction (user supplied or average per vehicle-mile)
- Reliability Factors (congestion rating factor, logistics cost factor)
- Business Productivity (effective density/agglomeration scale factors)

USER INPUTS. All that is needed to run TREDIS is a scenario that represents some ***change*** in travel characteristics, defined in terms of at least one of the following items

-> **Available Modes** - sub-modes may be defined as desired (examples in parentheses)

- Cars (may split by trip purpose: work, commute or personal):
- Trucks (may split delivery vans, light trucks, heavy trucks, multiple trailer, etc.)

- Transit (may split by trip purpose or sub-mode: van, regular bus, BRT, light rail, etc.)
- Rail (may split freight, commuter rail, inter-city passenger, high speed rail, etc.)
- Marine (may split passenger ferry, car ferry, barge, freighter, cruise ship, etc.)
- Air (may split general aviation, air taxi/charter, freight, prop, regional jets, full size commercial airliners, jumbo jets, etc.),

-> **Modal Characteristics** - (change) for each available mode:

- Avg. Vehicle occupancy (passengers)
- Avg. Driver/crew size (commercial services)
- Avg. Cargo carried (tons)
- Avg. fare, toll, road user fee or freight fee
- Cargo mix (default or user-selected commodity mix)
- Operating costs/mile (or per km)
- Fuel economy (miles/gallon or per liter)
- Emission rates (various pollutants and CO, per mile or per km)

-> **Traffic Characteristics** - (change) may be split by mode, vehicle class, trip purpose, time period:

- Volume, speed or average trip distance
- Baseline traffic growth rate (annual rate)
- VMT vehicle miles traveled (or VKT vehicle kilometers traveled)
- VHT vehicle hours traveled
- Congestion levels (volume/capacity ratio, or percent of major routes congested)
- Reliability (time variability or buffer time)
- Safety (accident rates: mortality, injury, property damage)
- Induced travel

-> **Origin/Destination Patterns** - may be split by mode, vehicle class, trip purpose, time period:

- Fraction of trips internal to study area (local origin and destination)
- Fraction of trips with coming into the study area (outside origin, local destination)
- Fraction of trips leaving the study area (local origin, outside destination)
- Fraction of trips passing through the study area (outside origin and destination)

-> **Access Characteristics** (change) - for each county in the study area:

- Size of labor and shopper markets (population within 40 minute travel time)
- Size of same day truck delivery market (employment within 3-hour travel time)
- Average road access time to commercial airports (and activity scale of the airport)

- Average road access time to marine port
- Average road access time to an intermodal rail terminal
- Average road access time to international gateway airport

-> Policy, Program or Project Attributes (change) - may be split by mode, vehicle class, time period:

- Regulation or Restrictions on Use of Facility or Equipment (e.g., truck lanes, carpool lanes, bridge weight limits, airport runway limits, port vessel size limits)
- Charges for Use of Facility or Equipment: Tolls, Taxes, Fees (per vehicle, per trip, per mile, or per fuel unit; for specific facilities or areas)
- Cost of Constructing or Reconstructing Facility & Purchasing Equipment (total, over time, by type)
- Cost of Operating Facility & Equipment (total, allocation over time, budget elements)
- Public/private partnership roles (finance, operation, revenue collection)
- Contingent development (dependent on transport access investment)

*Source: Economic Development Research Group, Inc. "TREDIS Inputs."

Appendix B: TREDIS Outputs

TREDIS provides numerous results including project costs, benefits, and economic impacts. These results are presented in different tables. Each one of the key tables (indicated in bold font) is briefly described below.

Project Costs Summary: A breakdown of project costs by cost category and by mode.

Travel Cost Savings – By Cost Type: A breakdown of reductions and/or savings in travel-related aspects including vehicles trips, VMT, VHT, fatalities, crew costs, and freight costs. The reductions and savings are distributed according to modal purpose (e.g., passenger car commute, passenger car personal/recreational, truck freight, etc.).

Travel Cost Savings – By Industry: A breakdown of industry sector-specific cost savings according to modal purpose.

Market Access Impacts – By Source: A breakdown of how business migration, labor productivity, and international exports are affected by market access changes (i.e., changes in access to labor markets, consumer markets, intermodal facilities, and land/air gateways) in terms of the measure Gross Regional Product.

Market Access Impacts – by Industry: A breakdown of how industries are affected by market access changes in terms of the measure "value added".

Direct Project Impact Summary – By Industry: A breakdown of industry-specific cost savings according to travel cost savings, contingent development, and additional potential output from market access changes.

Total Economic Impacts – By Year: A breakdown of the annual economic impacts in terms of business output, value added, jobs, and wage income. The economic impacts are presented for each year over the course of the operation of the facility.

Total Economic Impacts – By Industry: A breakdown of economic impacts that occur for each industry in terms of business output, value added, jobs, and wage income.

Benefit/Cost Results – By Mode: A breakdown of traveler benefits by mode in terms of savings or improvements to vehicle operating costs, travel time, safety, and other areas. Shipper/logistic cost savings, business productivity, and social/environmental benefits are presented as well. Costs are shown for each mode, and benefits are shown from different perspectives (i.e., traveler, full user, and society).

Benefit/Cost Results – By Year: A breakdown of annual impacts on travel characteristics (trips, miles traveled, hours traveled) according to a vehicle, passenger, and freight perspective. The annual present value of the benefit stream and the project's net benefits are presented according to benefit category (traveler, shipper, business productivity, and social/environmental benefits).

Tax Impacts: A breakdown of federal and state/local government tax revenues by particular revenue generators (e.g., sales tax, property tax, motor fuel tax, etc.) and according to contributor (i.e., households and businesses).

Public/Private Cost and Revenue Sharing: A breakdown of project costs and revenues from the perspectives of government and the private sector.

Economic Flows: A breakdown of industry-specific commodity supply and demand flows in terms of the value of commodities. Supplied commodities are disaggregated by commodities that are consumed locally, shipped to the rest of the United States, and exported internationally. Demanded commodities are disaggregated by commodities that are produced locally, produced in the rest of the United States, and are imported from other countries. The net production or economic outflow- determined by the difference between supply and demand- indicates whether a region produces relatively more than the region demands (in terms of value).

Freight Dependency: A breakdown of how many jobs are supported by individual industries based on the net outflows (production) from the region.

<u>Outputs available for study regions that are also FAF Regions</u>

Supply Chain Dependence

Freight Summary

Domestic Mode Split

Trade Flow Patterns

*Source: The TREDIS model

Appendix C: Discount Rate and Travel Growth Rate in TREDIS

The Texas Comptroller's Office was contacted concerning an appropriate discount rate for use in the analysis of economic impacts resulting from I-10 expansion. A representative of the Comptroller's Office noted that discount rates provided by the Office of Management and Budget (OMB) are appropriate for such analyses. The table below shows the December 2011 discount rates put forth by the OMB in its Circular A-94 Appendix C, which is updated annually (OMB Circular). Since the assumed operational life of the facility was 25 years, a linear interpolation was made using the 20-year and 30-year discount rates in order to obtain an estimated 25-year discount rate of 3.65 percent.

Table 2- OMB discount rates (OMB Circular)

Nominal Interest Rates on Treasury Notes and Bonds of Specified Maturities (in percent)					
3-Year	5-Year	7-Year	10-Year	20-Year	30-Year
1.6	2.1	2.5	2.8	3.5	3.8

Through email correspondence, a TxDOT public information officer* provided the 2013 average daily traffic (ADT) and the 2033 ADT. The 2013 ADT is 224,600 vehicles per day (vpd), and the 2033 ADT is 345,800 vpd. The equation below was used to determine the travel growth rate (r) based upon the present (P) ADT and the anticipated future (F) ADT.

$$F = P * (1 + r)^n$$

$$345{,}800 = 224{,}600 * (1 + r)^{20}$$

$$r = 2.18\ \%$$

*Email Correspondence with Josh Donat, TxDOT Public Information Officer. April 26, 2012.

Appendix D: Calculation of Average Annual Maintenance Costs

Average annual maintenance costs for the base scenario and the project scenario were determined based upon maintenance and rehabilitation (M&R) unit costs provided by Dr. Zhanmin Zhang of The University of Texas at Austin. The unit costs are shown in the table below. Dr. Zhang noted that the unit costs were in 2008 dollars and could be converted to 2012 dollars by dividing the 2008 unit cost figures by 1.103. The type of M&R actions are listed with corresponding M&R unit costs for flexible and rigid pavements, along with the length of time when a particular action generally is implemented.

Maintenance and Rehabilitation Action Unit Costs in 2008 Dollars (Zhang)

M&R Action	Unit Cost (per mile per lane) for Flexible Pavements	Unit Cost (per mile per lane) for Rigid Pavements	Cycle Length (Years)
Needs Nothing	$0	$0	
Preventive Maintenance	$29,000	$36,000	7
Light Rehabilitation	$173,000	$60,000	10
Medium Rehabilitation	$237,000	$256,000	15
Heavy Rehabilitation	$442,000	$651,000	20

For the economic impact analysis in TREDIS, the I-10 highway facility was assumed to have an operational life of 25 years. Based on this assumption, the following M&R schedule was assumed for the operational life of the facility:

- Preventative maintenance at 7 years;
- Medium rehabilitation at 15 years;
- Preventative maintenance at 22 years.

For the existent six-lane facility (3 lanes in each direction) with flexible pavement and a project length of 2.54 miles, the above M&R schedule would correspond to the following costs in 2008 dollars:

- 6 lanes * 2.54 miles * $29,000/lane/mile = $441,960
- 6 lanes * 2.54 miles * $237,000/lane/mile = $3,611,880
- 6 lanes * 2.54 miles * $29,000/lane/mile = $441,960

Therefore, the total M&R costs over the operational life of the facility is estimated to be $4,495,800 in 2008 dollars; this value equates to $4,075,975 in 2012 dollars (using the 1.103 factor provided by Dr. Zhang). The total cost of $4,075,975 in 2012 dollars may be annualized over the 25-year life of the project by assuming the interest rate used in TREDIS (3.65 percent) and using the following formula (Watts and Chapman) for the annualized cost (A) given the present 2012 cost (P):

$$A = \frac{P*i*(1+i)^N}{(1+i)^N-1}$$

$$A = \frac{\$4{,}075{,}975*0.0365*(1+0.0365)^{25}}{(1+0.0365)^{25}-1}$$

A = $251,349

Thus, for the 6-lane existing facility, an average of $251,349 is expected to be spent per year on M&R activities. The alternative scenario consists of expansion to an 8-lane facility. The expected average annual M&R costs associated with the 8-lane facility may be determined by simply increasing the annual cost for the 6-lane facility by one-third (the area of maintained highway increases by one-third from a six-lane facility to an eight-lane facility). Therefore, the expected average annual M&R costs for the 8-lane facility is $335,132.

Appendix E: San Antonio-Bexar County MPO Travel Demand Model Summary Output

```
  2035 San Antonio         Selection: Bexar         Future Year

1     CUMULATIVE TABLE 2: Summary of Maximum Links
 ---------------------------------------------------------------------------------
 TransCad                           Maximum
 Name                                Value                  ( Link ID)
 --------                       ------------                ----------
 AB_Flow                            152,916                 ( 1963004)
 BA_Flow                            144,397                 ( 2220860)
 COUNT05                            120,291                 ( 2220860)
 TOT_CAP                            152,760                 ( 2214284)
 LANES                                    6                 ( 2733234)
 V/C Ratio                             5.33                 ( 3219750)

  2035 San Antonio         Selection: Bexar         Future Year

1     CUMULATIVE TABLE 3: Summary by Modeled VOLUMES
 ---------------------------------------------------------------------------------
 SUM OF CAPACITIES ON CAPACITY LINKS:                  240,673,500
 AVERAGE CAPACITY:                                          22,347
 TOTAL MODELED VOLUME ON Capacity LINKS:               200,162,703
 ROOT MEAN SQUARE ERROR:                                     9,387
 % ROOT MEAN SQUARE ERROR:                                   42.01
  ---------------------------------------------------------------------------------

  2035 San Antonio         Selection: Bexar         Future Year

1     CUMULATIVE TABLE 4: Summary by Modeled VMT
 ---------------------------------------------------------------------------------
 TOTAL CAPACITY VMT ON CAPACITY LINKS:                  74,150,415
 AVERAGE CAPACITY VMT:                                       6,885
 TOTAL MODELED VMT ON CAPACITY LINKS:                   62,142,326
  ---------------------------------------------------------------------------------
 PERCENT MODELED VMT OF CAPACITY VMT:  83.81

 2035 San Antonio         Selection: Bexar         Future Year

1     CUMULATIVE TABLE 5: VMT Summary
 ---------------------------------------------------------------------------------
 TOTAL MODELED VMT ON CAPACITYD LINKS:                  62,142,326
 TOTAL MODELED VMT ON NON-CAPACITY LINKS                         0
 TOTAL MODELED VMT ON ALL LINKS:                        62,142,326
 PERCENT OF MODELED VMT ON CAPACITY LINK                    100.00
 TOTAL MODELED VMT ON CENTROID CONNECTOR                 5,626,060
 TOTAL MODELED VMT ON EVERYTHING:                       67,768,386
  ---------------------------------------------------------------------------------

 2035 San Antonio         Selection: Bexar         Future Year

1     CUMULATIVE TABLE 6: VHT Summary
 ---------------------------------------------------------------------------------
 TOTAL VHT USING INPUT SPEEDS =                          2,008,486
 AVERAGE INPUT SPEED (VMT WEIGHTED) =                        33.56
 RESULTING ASSIGNED NETWORK SPEED (VMT WEIGHTED) =            0.00
 CAPACITY VMT =                                         74,150,415
 ASSIGNED VMT/CAPACITY VMT Percent =                         83.81 %
 Total number of Links =                                    10,770
```

Figure E1- San Antonio-Bexar County Travel Demand Model Summary Output: 2035 No-build Scenario

```
 2035 San Antonio         Selection: Bexar         Future Year

1     CUMULATIVE TABLE 2: Summary of Maximum Links
----------------------------------------------------------------------------------
TransCad                        Maximum
Name                             Value                 ( Link ID)
--------                    ------------               ----------
AB_Flow                         153,035                ( 1963004)
BA_Flow                         145,146                ( 2220860)
COUNT05                         120,291                ( 2220860)
TOT_CAP                         152,760                ( 2214284)
LANES                                 6                ( 2733234)
V/C Ratio                          5.35                ( 3219750)

 2035 San Antonio         Selection: Bexar         Future Year

1     CUMULATIVE TABLE 3: Summary by Modeled VOLUMES
----------------------------------------------------------------------------------
SUM OF CAPACITIES ON CAPACITY LINKS:              241,231,380
AVERAGE CAPACITY:                                      22,398
TOTAL MODELED VOLUME ON Capacity LINKS:           200,226,236
ROOT MEAN SQUARE ERROR:                                 9,445
% ROOT MEAN SQUARE ERROR:                               42.17
 ---------------------------------------------------------------------------------

 2035 San Antonio         Selection: Bexar         Future Year

1     CUMULATIVE TABLE 4: Summary by Modeled VMT
----------------------------------------------------------------------------------
TOTAL CAPACITY VMT ON CAPACITY LINKS:              74,400,114
AVERAGE CAPACITY VMT:                                   6,908
TOTAL MODELED VMT ON CAPACITY LINKS:               62,188,279
 ---------------------------------------------------------------------------------
PERCENT MODELED VMT OF CAPACITY VMT:  83.59

2035 San Antonio         Selection: Bexar         Future Year

1     CUMULATIVE TABLE 5: VMT Summary
----------------------------------------------------------------------------------
TOTAL MODELED VMT ON CAPACITYD LINKS:              62,188,279
TOTAL MODELED VMT ON NON-CAPACITY LINKS                     0
TOTAL MODELED VMT ON ALL LINKS:                    62,188,279
PERCENT OF MODELED VMT ON CAPACITY LINK                100.00
TOTAL MODELED VMT ON CENTROID CONNECTOR             5,626,315
TOTAL MODELED VMT ON EVERYTHING:                   67,814,593
 ---------------------------------------------------------------------------------

2035 San Antonio         Selection: Bexar         Future Year

1     CUMULATIVE TABLE 6: VHT Summary
----------------------------------------------------------------------------------
TOTAL VHT USING INPUT SPEEDS =                      2,008,997
AVERAGE INPUT SPEED (VMT WEIGHTED) =                    33.58
RESULTING ASSIGNED NETWORK SPEED (VMT WEIGHTED) =        0.00
CAPACITY VMT =                                     74,400,114
ASSIGNED VMT/CAPACITY VMT Percent =                     83.59 %
Total number of Links =                                10,770
----------------------------------------------------------------------------------
```

Figure E2- San Antonio-Bexar County Travel Demand Model Summary Output: 2035 Build Scenario

Appendix F: Annual Vehicle-trips, VMT, and VHT for Various Mode/Purpose Combinations

Figure E1 below shows the process by which the annual number of vehicle-trips, annual VMT, and annual VHT were computed for the no-build and build scenarios. The values in the boxed sections located to the right of the spreadsheet were used as inputs for the traffic characteristics in TREDIS. The values in the top half of the figure relate to truck traffic, and the values in the bottom half of the figure relate to passenger car traffic. The traffic characteristic values used in TREDIS are shown in Appendix F.

The third column of the spreadsheet in Figure E1 includes the raw data provided by the San Antonio-Bexar County travel demand model. Two figures from the travel demand model were used, namely the 24-hour weekday VMT and VHT. To determine the number of vehicle-trips, the VMT was divided by a computed average trip distance.

			Truck Data				
		24-Hour Weekday Raw Data	24-hour Weekday Truck	24-hour Weekend Truck	Annual Weekday Truck	Annual Weekend Truck	Annual Trucks
No-build Scenario	Vehicle Trips	8,727,855	374,051	294,752	97,627,290	30,654,221	128,281,511
	VMT	62,142,326	2,663,243	2,098,635	695,106,304	218,258,053	913,364,357
	VHT	2,008,486	86,078	67,829	22,466,351	7,054,262	29,520,612
Build Scenario	Vehicle Trips	8,734,309	374,328	294,970	97,699,483	30,676,889	128,376,372
	VMT	62,188,279	2,665,212	2,100,187	695,620,321	218,419,450	914,039,771
	VHT	2,008,997	86,100	67,847	22,472,066	7,056,057	29,528,123

			Passenger Data									
		24-Hour Weekday Raw Data	24-hour Weekday Passenger	24-hour Weekend Passenger	Annual Passenger Weekday	Annual Personal/Rec Weekday	Annual Commute Weekday	Annual Weekend	Annual Personal/Rec Weekend	Annual Commute Weekend	Annual Personal/Rec	Annual Commute
No-build Scenario	Vehicle Trips	8,727,855	8,353,804	6,582,797	2,180,342,807	1,504,654,571	675,688,236	684,610,934	615,191,385	69,419,549	2,119,845,956	745,107,784
	VMT	62,142,326	59,479,083	46,869,518	15,524,040,782	10,713,140,544	4,810,900,238	4,874,429,847	4,380,162,661	494,267,187	15,093,303,205	5,305,167,425
	VHT	2,008,486	1,922,408	1,514,858	501,748,495	346,256,637	155,491,859	157,545,183	141,570,101	15,975,082	487,826,738	171,466,940
Build Scenario	Vehicle Trips	8,734,309	8,359,981	6,587,665	2,181,955,126	1,505,767,233	676,187,894	685,117,190	615,646,307	69,470,883	2,121,413,539	745,658,777
	VMT	62,188,279	59,523,067	46,904,177	15,535,520,498	10,721,062,696	4,814,457,802	4,878,034,390	4,383,401,703	494,632,687	15,104,464,399	5,309,090,490
	VHT	2,008,997	1,922,897	1,515,243	501,876,151	346,344,731	155,531,419	157,585,265	141,606,120	15,979,146	487,950,851	171,510,565

Figure F1- Annual vehicle-trips, VMT, and VHT for various mode/purpose combinations

The average trip distance was computed as a weighted average of trip distances corresponding to various trip purposes, as shown in Figure E2 on the next page. The data for the 2005 trips and corresponding average trip lengths was provided by the San Antonio-Bexar County MPO travel demand modeler.

Trip Purpose	2005 Trips	2005 Trip Type	Resulting Average Trip Length (miles)	Total miles	
HBW	1,140,945	Person	10.27	11,717,505	
HBNW-Retail	1,232,550	Person	5.93	7,309,022	
HBNW-Other	1,048,384	Person	7.51	7,873,364	
HBNW-ED1	1,194,653	Person	4.66	5,567,083	
HBNW-ED2	121,041	Person	11.29	1,366,553	
NW-Airport	99,570	Person	16.49	1,641,909	
NHB	1,662,503	Person	6.44	10,706,519	
NHB-Special	507,500	Person	5.90	2,994,250	
TRUCK-Commercial	457,521	Vehicle	7.28	3,330,753	
External-local Commercial	42,527	Vehicle	21.56	916,882	
Totals	7,507,194			53,423,840	
		Average weighted trip distance:		7.12	miles

Figure F2- Calculation of average weighted trip distance (Trip information provided by the San Antonio-Bexar County MPO)

Appendix G: TREDIS Inputs for Traffic Characteristics

Scenario	Region	Period	Facility	Mode	Purpose	Period Veh-Trips	Period VMT	Period VHT
Base Scenario	Bexar County	Annual Period	Road	Passenger Car	Commute	745,107,784	5,305,167,425	171,466,940
Base Scenario	Bexar County	Annual Period	Road	Passenger Car	Personal/Rec	2,119,845,956	15,093,303,205	487,826,738
Base Scenario	Bexar County	Annual Period	Road	Truck Freight	Freight	128,281,511	913,364,357	29,520,612
Project Scenario	Bexar County	Annual Period	Road	Passenger Car	Commute	745,658,777	5,309,090,490	171,510,565
Project Scenario	Bexar County	Annual Period	Road	Passenger Car	Personal/Rec	2,121,413,539	15,104,464,399	487,950,851
Project Scenario	Bexar County	Annual Period	Road	Truck Freight	Freight	128,376,372	914,039,771	29,528,123

Figure G1- TREDIS Inputs for Traffic Characteristics

Appendix H: Market Access Impacts and Calculation of Average "Loaded" Travel Speed on I-10

To determine the market access impacts caused by the highway expansion on I-10, average travel speeds for the no-build scenario and build scenario were computed. As a result of an expansion project, such as the I-10 expansion project, travel speeds may increase along a route and thereby reduce travel times between two given points on the route. As travel times between locations are reduced, access is increased as businesses are able to travel farther in a given amount of time. That is, market access is expanded. TREDIS defines labor and consumer market access in terms of the total population within a 40-minute drive time of a metropolitan center. By determining the average travel speed on the I-10 roadway in the San Antonio area for the build and no-build scenario, one may assess the extent to which the labor and consumer market increases after implementation of a project. Figure H1 on the next page shows the default labor and consumer market size used in TREDIS for Bexar County, Texas. The red shaded area represents the area within a 40-minute drive time of the center of San Antonio. The yellow portion along I-10 represents the length of the project site that is located northwest of downtown San Antonio. The light blue circle in the upper left of the figure indicates the outer boundary of the labor and consumer market that runs along I-10. The boundary of the labor and consumer market along I-10 in Kendall County essentially ends just southwest of Comfort, Texas.

The methodology used to determine the market access impacts consists of three steps. First, the average travel speed along I-10 is computed for the no-build and build scenario. Second, the difference in average travel speed between the two scenarios is used to estimate the distance in which the 40-minute drive time is expanded under the build scenario. Lastly, the population residing in the expanded market area is added to the population total in the original market area. Discussion concerning the calculation of the average travel speeds for the no-build and build scenarios follows Figure H1 on the next page.

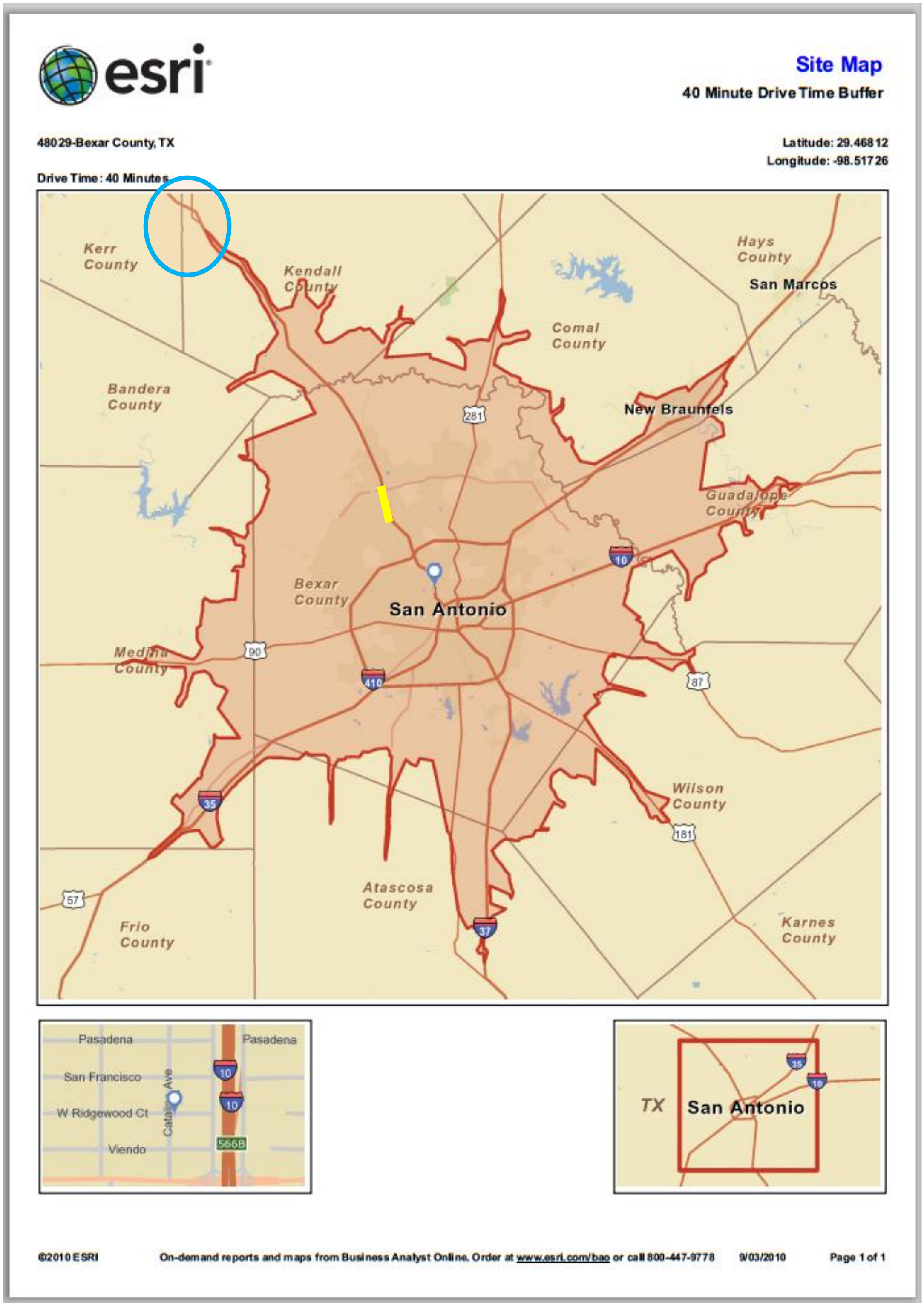

Figure H1- Labor and consumer market area (area within a 40-minute drive time of the center of San Antonio)

Step 1: Calculation of average travel speeds on I-10 for no-build and build scenarios

The average travel speeds on the I-10 facility were computed based on output speeds from the San Antonio-Bexar County travel demand model. The model contained different types of speeds including an average 24-hour weighted speed and a "loaded" speed. The loaded speed depends on the volume/capacity ratio, which causes the loaded speed to decrease as congestion increases. In the travel demand output files for the no-build (base) scenario and the build (project) scenario, the average weighted speeds were the same for each link regardless of the capacity expansion. However, the loaded travel speed on each link of the I-10 roadway network was different between the no-build scenario and the build scenario. The loaded travel speed was used to represent how the highway expansion may affect travel speeds on I-10.

A weighted travel speed (based on the loaded travel speed of each link) was computed for the no-build scenario and build scenario. The length of each link was multiplied by the loaded speed of each link, and the sum of this product was divided by the sum of the lengths of the links. The resulting value represented the weighted travel speed based on the loaded travel speed of each link. This operation was performed for both the no-build scenario and the build scenario. The values used in each calculation are shown in the following two tables. Essentially, the weighted travel speed along I-10 for the no-build scenario was determined to be 26.3 mi/hr, and the weighted travel speed along I-10 for the build scenario was determined to be 30.4 mi/hr. The capacity expansion led to an average increase of 4.1 mi/hr along I-10 based on the method used to determine the weighted travel speed for each scenario. It should be noted that links in both travel directions were used in the estimation of an average travel speed.

		2035 No-build Scenario	
ID	**Length (miles)**	**Speed_Loaded (mi/hr)**	**Length*Speed_Loaded (mi^2/hr)**
1769983	0.38	15.8	5.9
1770010	0.45	16.1	7.2
1708011	1.05	17.9	18.9
1706888	0.26	37.2	9.6
1706704	0.28	27.1	7.5
1706721	0.22	24.7	5.4
1707975	1.25	19.2	24.0
1718426	0.85	38.5	32.8
1706941	0.13	31.6	4.3
1706979	0.30	35.4	10.5
1707830	0.33	31.1	10.3
3219202	0.46	27.3	12.6
3219198	0.35	20.7	7.2
1718342	0.89	38.3	34.2
1708941	0.68	25.1	17.0
1710632	0.16	26.8	4.2
1710570	0.53	35.8	19.1
1711266	0.30	35.4	10.5
1711328	0.18	43.2	7.7
1711318	0.21	39.5	8.4
3219205	0.73	23.0	16.8
1708968	0.58	24.2	13.9
1693087	0.46	21.7	10.0
1692996	0.66	26.2	17.3
3219207	0.06	21.3	1.2
1709056	0.57	16.1	9.2
3219210	0.11	13.3	1.4
3219445	0.33	25.6	8.6
3219446	0.31	28.9	8.9
3219637	0.40	21.4	8.5
3219639	1.43	26.9	38.4
3219645	0.13	20.6	2.7
3221779	0.10	10.7	1.1
3221821	0.13	37.7	5.0
Totals	15.25		400.4
2035 No-build Scenario Average Travel Speed on IH 10:			**26.3** mi/hr

Figure H2- 2035 no-build scenario: Average loaded travel speed on I-10

2035 Build Scenario			
ID	Length (miles)	Speed_Loaded (mi/hr)	Length*Speed_Loaded (mi^2/hr)
1769983	0.38	15.6	5.9
1770010	0.45	16.1	7.2
1708011	1.05	17.7	18.7
1706888	0.26	36.8	9.5
1706704	0.28	25.9	7.2
1706721	0.22	23.2	5.1
1707975	1.25	18.8	23.6
1718426	0.85	43.7	37.3
1706941	0.13	31.2	4.2
1706979	0.30	35.0	10.4
1707830	0.33	30.8	10.3
3219202	0.46	33.8	15.6
3219198	0.35	28.0	9.7
1718342	0.89	43.8	39.1
1708941	0.68	34.0	23.1
1710632	0.16	37.9	6.0
1710570	0.53	40.4	21.6
1711266	0.30	40.3	11.9
1711328	0.18	44.5	7.9
1711318	0.21	42.3	9.0
3219205	0.73	31.5	22.9
1708968	0.58	33.0	19.0
1693087	0.46	30.6	14.1
1692996	0.66	21.8	14.4
3219207	0.06	29.5	1.7
1709056	0.57	26.0	14.8
3219210	0.11	23.7	2.5
3219445	0.33	31.7	10.6
3219446	0.31	34.7	10.7
3219637	0.40	28.5	11.4
3219639	1.43	33.8	48.3
3219645	0.13	28.1	3.7
3221779	0.10	7.6	0.8
3221821	0.13	42.1	5.6
Totals	15.25		463.6
2035 Build Scenario Average Travel Speed on IH 10:			**30.4** mi/hr

Figure H3- 2035 build scenario: Average loaded travel speed on I-10

Step 2: Determination of the expanded market area

The market area along I-10 northwest of San Antonio may expand at least a distance that is equivalent to the product of (1) the travel time reduction over the distance from the population-weighted centroid of Bexar County to the project site location and (2) the travel speed near the boundary of the market area. Since the boundary of the market area is located in a rural area, the travel speed is assumed to be near the speed limit. A travel speed of 65 mi/hr is assumed. The location of the population-weighted centroid mentioned in (1) is used, because TREDIS defines the boundaries of the labor/consumer market as the perimeter of a 40-minute drive from the population-weighted center of a given county. The distance described in (1) above was estimated by determining the approximate distance from the location of the population-weighted centroid of Bexar County (provided in the TREDIS model) to the project site location. The distance was estimated to be approximately 10 miles along I-10 (the centroid was located very near I-10). The travel time reduction over this stretch of I-10 may be computed by determining the difference in travel times over the 10-mile length under the no-build and build scenarios. The travel time over this stretch for each scenario is simply the length of 10 miles divided by the average travel speed over the length, which is assumed to be the average travel speed calculated in Step 1. Thus, the travel times for the no-build scenario (TT_{NB}) and the build scenario (TT_B) are computed as follows:

$$TT_{NB} = \frac{10\ miles}{26.3\ mi/hr} = 0.380228\ hr$$

$$TT_B = \frac{10\ miles}{30.4\ mi/hr} = 0.328947\ hr$$

The reduction in travel time over the project length is as follows:

$$TT_{NB} - TT_B = 0.051281\ hr$$

When this reduction in travel time is multiplied by the assumed travel speed at the market area boundary (i.e., 65 mi/hr), the distance by which the market area expands may be found:

$$Market\ area\ increase = 0.051281\ hr * 65\frac{mi}{hr} = 3.33\ miles$$

Thus, the market area will increase at the boundary by a distance of approximately 3.33 miles.

Step 3: Determination of population within newly expanded market area

The default market area boundary in TREDIS along I-10 northwest of San Antonio appeared to end just southwest of Comfort, TX. An increase of 3.33 miles of market access along I-10 expands access to Comfort. Since Comfort is not a large town, it is assumed that the increased market access area encompasses the population of Comfort, which was 2,363 in 2010 (U.S. Census Bureau). Thus, the figure of 2,363 is added to the default population total in TREDIS that defined the original market access area. The market access inputs are provided in Appendix I.

Appendix I: Market Access Inputs and TREDIS Market Access Default Values

Figure H1 below shows the default market access factors used in TREDIS. Figure H2 on the next page shows the Market Access inputs. The only value that was changed from the base scenario to the project scenario was the labor and consumer market size, which is represented by the population within a 40-minute drive time of the center of San Antonio.

REPORT 3a: DEFAULT MARKET ACCESS FACTORS			
Constant $ Year:	2012	Project:	I-10 San Antonio Project
		County/ Custom Region:	Bexar County, TX
Cost Factor		**Unit of Measure**	**Value**
Average Labor Cost		$ per year (retail sector)	25,758
Average Cost of Electricity		$ per kilowatt-hour	0.061
Average Total Tax Burden per Person		$ per person per year	523
Average Housing Cost		$ for a single family home	94,200
Average Rental Cost		$ per month	832
Market Size Factor		**Unit of Measure**	**Value**
Area Population		number	1,555,592
Population Density		people per square mile	1,248
Skilled Workers		% of labor force with bachelor's degree or higher	24.3
Population within 40 minute drive time		number	636,265
Employment within 180 minute drive time		number	3,043,273
Transportation Access/ Quality Factor	**Facility Name**	**Unit of Measure**	**Value**
Access to Commercial Airport	SAN ANTONIO INTL	average travel time (minutes)	18
Annual Operations at Commercial Airport	SAN ANTONIO INTL	takeoffs+landings per year	94,157
Access to Freight Marine Port	Victoria, TX	average travel time (minutes)	164
Access to Rail Intermodal Facility	SP San Antonio TOFC/ COFC	average travel time (minutes)	7
Access to International Land Border	Del Rio, Texas	average travel time (minutes)	144
Access to Airport with International Connections	GEORGE BUSH INTERCONTINENTAL ARPT/ HOUSTON	average travel time (minutes)	190
Other Factors		**Unit of Measure**	**Value**
Broadband Access		Relative measure (10=best bandwidth/ cost)	7
© 2012 Economic Development Research Group, Inc			

Figure I1- TREDIS default market access factors

Scenario	Region	Facility	Local Market Size (population within 40 minutes)	Regional Market Size (employment within 3 hours)	Activity Level (annual operations)	Average Drive Time to Terminal (minutes)	Average Drive Time to Int'l Gateway (minutes)
Base Scenario	Bexar County	Road	636,265	3,043,273			144.3
Base Scenario	Bexar County	Rail	0	0		7.3	
Base Scenario	Bexar County	Air			94,157	17.6	190.3
Base Scenario	Bexar County	Water				163.8	
Project Scenario	Bexar County	Road	638,628	3,043,273			144.3
Project Scenario	Bexar County	Rail	0	0		7.3	
Project Scenario	Bexar County	Air			94,157	17.6	190.3
Project Scenario	Bexar County	Water				163.8	

Figure I2- TREDIS Market Access inputs

Appendix J: Default Safety/Accident Data Inputs

Scenario	Region	Facility	Mode	Purpose	Fatality Accident per 100m VMT	Pers Injury Accident per 100m VMT	Prop Damage Accident per 100m VMT
Base Scenario	Bexar County	Road	Passenger Car	Commute	1.3	79	195
Base Scenario	Bexar County	Road	Passenger Car	Personal/Rec	1.3	79	195
Base Scenario	Bexar County	Road	Truck Freight	Freight	0.3	10.1	167
Project Scenario	Bexar County	Road	Passenger Car	Commute	1.3	79	195
Project Scenario	Bexar County	Road	Passenger Car	Personal/Rec	1.3	79	195
Project Scenario	Bexar County	Road	Truck Freight	Freight	0.3	10.1	167

Figure J1- TREDIS Default Safety/Accident Inputs

Appendix K: Default Industry Commodity Mix Table

System	Scenario	Region	Period	SCTG Code	Commodity Description	Pass Car-Commute Mix	Pass Car-Pers/Rec Mix	Truck-Freight Mix
SCTG	Base	Bexar County	Annual	01	Live animals/fish	0.01047384	0.01047384	0.01047384
SCTG	Base	Bexar County	Annual	02	Cereal grains	0.06499873	0.06499873	0.06499873
SCTG	Base	Bexar County	Annual	03	Other ag prods.	0.02041472	0.02041472	0.02041472
SCTG	Base	Bexar County	Annual	04	Animal feed	0.01618085	0.01618085	0.01618085
SCTG	Base	Bexar County	Annual	05	Meat/seafood	0.01194563	0.01194563	0.01194563
SCTG	Base	Bexar County	Annual	06	Milled grain prods.	0.00956736	0.00956736	0.00956736
SCTG	Base	Bexar County	Annual	07	Other foodstuffs	0.04064936	0.04064936	0.04064936
SCTG	Base	Bexar County	Annual	08	Alcoholic beverages	0.01187761	0.01187761	0.01187761
SCTG	Base	Bexar County	Annual	09	Tobacco prods.	0.00013644	0.00013644	0.00013644
SCTG	Base	Bexar County	Annual	10	Building stone	0.00273157	0.00273157	0.00273157
SCTG	Base	Bexar County	Annual	11	Natural sands	0.04503683	0.04503683	0.04503683
SCTG	Base	Bexar County	Annual	12	Gravel	0.07343799	0.07343799	0.07343799
SCTG	Base	Bexar County	Annual	13	Nonmetallic minerals	0.01047161	0.01047161	0.01047161
SCTG	Base	Bexar County	Annual	14	Metallic ores	0.00534293	0.00534293	0.00534293
SCTG	Base	Bexar County	Annual	15	Coal	0.03537216	0.03537216	0.03537216
SCTG	Base	Bexar County	Annual	16	Crude petroleum	0.00117909	0.00117909	0.00117909
SCTG	Base	Bexar County	Annual	17	Gasoline	0.0629834	0.0629834	0.0629834
SCTG	Base	Bexar County	Annual	18	Fuel oils	0.05211939	0.05211939	0.05211939
SCTG	Base	Bexar County	Annual	19	Coal-n.e.c.	0.05760277	0.05760277	0.05760277
SCTG	Base	Bexar County	Annual	20	Basic chemicals	0.04668686	0.04668686	0.04668686
SCTG	Base	Bexar County	Annual	21	Pharmaceuticals	0.00165308	0.00165308	0.00165308
SCTG	Base	Bexar County	Annual	22	Fertilizers	0.00976743	0.00976743	0.00976743
SCTG	Base	Bexar County	Annual	23	Chemical prods.	0.01642744	0.01642744	0.01642744
SCTG	Base	Bexar County	Annual	24	Plastics/rubber	0.02278843	0.02278843	0.02278843
SCTG	Base	Bexar County	Annual	25	Logs	0.01382366	0.01382366	0.01382366
SCTG	Base	Bexar County	Annual	26	Wood prods.	0.01910462	0.01910462	0.01910462
SCTG	Base	Bexar County	Annual	27	Newsprint/paper	0.00656097	0.00656097	0.00656097
SCTG	Base	Bexar County	Annual	28	Paper articles	0.00664116	0.00664116	0.00664116
SCTG	Base	Bexar County	Annual	29	Printed prods.	0.00205281	0.00205281	0.00205281
SCTG	Base	Bexar County	Annual	30	Textiles/leather	0.00447412	0.00447412	0.00447412
SCTG	Base	Bexar County	Annual	31	Nonmetal min. prods.	0.10990076	0.10990076	0.10990076
SCTG	Base	Bexar County	Annual	32	Base metals	0.02609986	0.02609986	0.02609986
SCTG	Base	Bexar County	Annual	33	Articles-base metal	0.02176038	0.02176038	0.02176038
SCTG	Base	Bexar County	Annual	34	Machinery	0.01741014	0.01741014	0.01741014
SCTG	Base	Bexar County	Annual	35	Electronics	0.00975578	0.00975578	0.00975578
SCTG	Base	Bexar County	Annual	36	Motorized vehicles	0.0116162	0.0116162	0.0116162
SCTG	Base	Bexar County	Annual	37	Transport equip.	0.00095827	0.00095827	0.00095827
SCTG	Base	Bexar County	Annual	38	Precision instruments	0.00077339	0.00077339	0.00077339
SCTG	Base	Bexar County	Annual	39	Furniture	0.00408908	0.00408908	0.00408908
SCTG	Base	Bexar County	Annual	40	Misc. mfg. prods.	0.00999398	0.00999398	0.00999398
SCTG	Base	Bexar County	Annual	41	Waste/scrap	0.06486826	0.06486826	0.06486826
SCTG	Base	Bexar County	Annual	43	Mixed freight	0.02933805	0.02933805	0.02933805
SCTG	Base	Bexar County	Annual	99	Unknown	0.01093298	0.01093298	0.01093298
SCTG	Base	Bexar County	Annual	Custom1	(open)	0	0	0
SCTG	Base	Bexar County	Annual	Custom2	(open)	0	0	0
SCTG	Base	Bexar County	Annual	Custom3	(open)	0	0	0
SCTG	Base	Bexar County	Annual	Custom4	(open)	0	0	0
SCTG	Base	Bexar County	Annual	Custom5	(open)	0	0	0
SCTG	Base	Bexar County	Annual	Custom6	(open)	0	0	0
SCTG	Base	Bexar County	Annual	Custom7	(open)	0	0	0
SCTG	Base	Bexar County	Annual	Custom8	(open)	0	0	0
SCTG	Base	Bexar County	Annual	Custom9	(open)	0	0	0
SCTG	Base	Bexar County	Annual	Custom10	(open)	0	0	0
SCTG	Base	Bexar County	Annual	Custom11	(open)	0	0	0
SCTG	Base	Bexar County	Annual	Custom12	(open)	0	0	0

Figure K1- TREDIS Default Commodity Mix Table: Base Scenario

System	Scenario	Region	Period	SCTG Code	Commodity Description	Pass Car-Commute Mix	Pass Car-Pers/Rec Mix	Truck-Freight Mix
SCTG	Project	Bexar County	Annual	01	Live animals/fish	0.01047384	0.01047384	0.01047384
SCTG	Project	Bexar County	Annual	02	Cereal grains	0.06499873	0.06499873	0.06499873
SCTG	Project	Bexar County	Annual	03	Other ag prods.	0.02041472	0.02041472	0.02041472
SCTG	Project	Bexar County	Annual	04	Animal feed	0.01618085	0.01618085	0.01618085
SCTG	Project	Bexar County	Annual	05	Meat/seafood	0.01194563	0.01194563	0.01194563
SCTG	Project	Bexar County	Annual	06	Milled grain prods.	0.00956736	0.00956736	0.00956736
SCTG	Project	Bexar County	Annual	07	Other foodstuffs	0.04064936	0.04064936	0.04064936
SCTG	Project	Bexar County	Annual	08	Alcoholic beverages	0.01187761	0.01187761	0.01187761
SCTG	Project	Bexar County	Annual	09	Tobacco prods.	0.00013644	0.00013644	0.00013644
SCTG	Project	Bexar County	Annual	10	Building stone	0.00273157	0.00273157	0.00273157
SCTG	Project	Bexar County	Annual	11	Natural sands	0.04503683	0.04503683	0.04503683
SCTG	Project	Bexar County	Annual	12	Gravel	0.07343799	0.07343799	0.07343799
SCTG	Project	Bexar County	Annual	13	Nonmetallic minerals	0.01047161	0.01047161	0.01047161
SCTG	Project	Bexar County	Annual	14	Metallic ores	0.00534293	0.00534293	0.00534293
SCTG	Project	Bexar County	Annual	15	Coal	0.03537216	0.03537216	0.03537216
SCTG	Project	Bexar County	Annual	16	Crude petroleum	0.00117909	0.00117909	0.00117909
SCTG	Project	Bexar County	Annual	17	Gasoline	0.0629834	0.0629834	0.0629834
SCTG	Project	Bexar County	Annual	18	Fuel oils	0.05211939	0.05211939	0.05211939
SCTG	Project	Bexar County	Annual	19	Coal-n.e.c.	0.05760277	0.05760277	0.05760277
SCTG	Project	Bexar County	Annual	20	Basic chemicals	0.04668686	0.04668686	0.04668686
SCTG	Project	Bexar County	Annual	21	Pharmaceuticals	0.00165308	0.00165308	0.00165308
SCTG	Project	Bexar County	Annual	22	Fertilizers	0.00976743	0.00976743	0.00976743
SCTG	Project	Bexar County	Annual	23	Chemical prods.	0.01642744	0.01642744	0.01642744
SCTG	Project	Bexar County	Annual	24	Plastics/rubber	0.02278843	0.02278843	0.02278843
SCTG	Project	Bexar County	Annual	25	Logs	0.01382366	0.01382366	0.01382366
SCTG	Project	Bexar County	Annual	26	Wood prods.	0.01910462	0.01910462	0.01910462
SCTG	Project	Bexar County	Annual	27	Newsprint/paper	0.00656097	0.00656097	0.00656097
SCTG	Project	Bexar County	Annual	28	Paper articles	0.00664116	0.00664116	0.00664116
SCTG	Project	Bexar County	Annual	29	Printed prods.	0.00205281	0.00205281	0.00205281
SCTG	Project	Bexar County	Annual	30	Textiles/leather	0.00447412	0.00447412	0.00447412
SCTG	Project	Bexar County	Annual	31	Nonmetal min. prods.	0.10990076	0.10990076	0.10990076
SCTG	Project	Bexar County	Annual	32	Base metals	0.02609986	0.02609986	0.02609986
SCTG	Project	Bexar County	Annual	33	Articles-base metal	0.02176038	0.02176038	0.02176038
SCTG	Project	Bexar County	Annual	34	Machinery	0.01741014	0.01741014	0.01741014
SCTG	Project	Bexar County	Annual	35	Electronics	0.00975578	0.00975578	0.00975578
SCTG	Project	Bexar County	Annual	36	Motorized vehicles	0.0116162	0.0116162	0.0116162
SCTG	Project	Bexar County	Annual	37	Transport equip.	0.00095827	0.00095827	0.00095827
SCTG	Project	Bexar County	Annual	38	Precision instruments	0.00077339	0.00077339	0.00077339
SCTG	Project	Bexar County	Annual	39	Furniture	0.00408908	0.00408908	0.00408908
SCTG	Project	Bexar County	Annual	40	Misc. mfg. prods.	0.00999398	0.00999398	0.00999398
SCTG	Project	Bexar County	Annual	41	Waste/scrap	0.06486826	0.06486826	0.06486826
SCTG	Project	Bexar County	Annual	43	Mixed freight	0.02933805	0.02933805	0.02933805
SCTG	Project	Bexar County	Annual	99	Unknown	0.01093298	0.01093298	0.01093298
SCTG	Project	Bexar County	Annual	Custom1	(open)	0	0	0
SCTG	Project	Bexar County	Annual	Custom2	(open)	0	0	0
SCTG	Project	Bexar County	Annual	Custom3	(open)	0	0	0
SCTG	Project	Bexar County	Annual	Custom4	(open)	0	0	0
SCTG	Project	Bexar County	Annual	Custom5	(open)	0	0	0
SCTG	Project	Bexar County	Annual	Custom6	(open)	0	0	0
SCTG	Project	Bexar County	Annual	Custom7	(open)	0	0	0
SCTG	Project	Bexar County	Annual	Custom8	(open)	0	0	0
SCTG	Project	Bexar County	Annual	Custom9	(open)	0	0	0
SCTG	Project	Bexar County	Annual	Custom10	(open)	0	0	0
SCTG	Project	Bexar County	Annual	Custom11	(open)	0	0	0
SCTG	Project	Bexar County	Annual	Custom12	(open)	0	0	0

Figure K2- TREDIS Default Commodity Mix Table: Project Scenario

Appendix L: Gross Business Attraction from Labor/Consumer Market Access Expansion

NAICS	Industry	Gross Business Attraction from Market Access Improvement in Labor/Consumer Market ($ Value Added)	Percent of Total Business Attraction
111	Crop Production	0	0.00%
112	Animal Production	0	0.00%
113	Forestry & Logging	0	0.00%
114	Fishing, Hunting & Trapping	0	0.00%
115	Support for Agriculture & Forestry	0	0.00%
211	Oil & Gas Extraction	0	0.00%
212-213	Mining & Support Activities	0	0.00%
221	Utilities	33980	0.18%
230	Construction	51467	0.27%
311	Food Products	32784	0.17%
312	Beverage & Tobacco Products	9560	0.05%
313	Textile Mills	14	0.00%
314	Textile Product Mills	1778	0.01%
315	Apparel Manufacturing	549	0.00%
316	Leather & Allied Products	857	0.00%
321	Wood Products	0	0.00%
322	Paper Manufacturing	0	0.00%
323	Printing & Related Support Activities	61890	0.32%
324	Petroleum & Coal Products	1006089	5.25%
325	Chemical Manufacturing	11767	0.06%
326	Plastics & Rubber Products	1593	0.01%
327	Nonmetallic Mineral Products	10899	0.06%
331	Primary Metal Manufacturing	2244	0.01%
332	Fabricated Metal Products	31274	0.16%
333	Machinery Manufacturing	31573	0.16%
334	Computer & Electronic Products	165407	0.86%
335	Electric Equipment, Appliances, etc.	0	0.00%
336	Transportation Equipment	36928	0.19%
337	Furniture & Related Products	9395	0.05%
339	Miscellaneous Manufacturing	45827	0.24%
420	Wholesale Trade	967066	5.04%
441-454	Retail Trade	4133385	21.55%
481-487	Transportation	356404	1.86%
491-493	Mail, package delivery & warehousing	1209443	6.31%
511	Publishing Industries (except Internet)	124136	0.65%
512	Motion Picture & Sound Recording	42350	0.22%
513	Broadcasting	354124	1.85%
514	Internet & data process svcs	177318	0.92%
521-523	Monetary, Financial, & Credit Activity	570081	2.97%
524	Insurance Carriers & Related Activities	785613	4.10%
525	Funds, Trusts, & Other Financial Vehicles	16418	0.09%
531	Real Estate	674428	3.52%
532	Rental & Leasing Services	259606	1.35%
533	Lessors of Nonfinancial Intangible Assets	140959	0.73%
541-551	Professional Scientific, Technical, Services	2664952	13.89%
561	Administrative & Support Services	1133719	5.91%
562	Waste Management & Remediation	14543	0.08%
611	Educational Services	373131	1.95%
621-624	Health Care & Social Services	671650	3.50%
711-713	Amusement & Recreation	298777	1.56%
721-722	Accommodations, Eating & Drinking	380772	1.99%
811-812	Repair, Maintenance, & Personal Services	560579	2.92%
813	Religious, Civic, Professional, Organizations	40523	0.21%
920	Government & non NAICs	1684669	8.78%
	Total Change in Value Added ($):	19,180,523	100.00%
	Baseline Value Added ($):		
	Percent Change in Value Added:	0.025 %	

Figure L1- Gross Business Attraction due to Labor/Consumer Market Access Expansion

Appendix M: Economic Impacts by Year

REPORT 4b: TOTAL ECONOMIC IMPACTS - BY YEAR					
	Analysis Year:	2035	Project:	I-10 San Antonio Project	
	Constant $ Year:	2012	Region:	All Regions	
	Base Scenario:	Base Scenario	Period:	All Periods	
	Project Scenario:	Project Scenario	Impact Type:	Total Impacts	
Count	Year	Business Output ($ mil.)	Value Added ($ mil.)	Jobs	Wage Income ($ mil.)
0	2012	26.182	13.572	217	10.185
1	2013	26.182	13.572	217	10.185
2	2014	13.633	7.111	114	5.309
3	2015	1.022	0.628	9	0.411
4	2016	2.058	1.282	18	0.831
5	2017	4.209	2.64	37	1.704
6	2018	8.355	5.258	75	3.385
7	2019	15.299	9.643	137	6.201
8	2020	24.585	15.507	220	9.967
9	2021	33.872	21.371	303	13.733
10	2022	40.816	25.755	365	16.549
11	2023	44.962	28.373	403	18.23
12	2024	47.113	29.732	422	19.102
13	2025	48.148	30.385	431	19.522
14	2026	48.629	30.689	435	19.717
15	2027	48.847	30.827	437	19.806
16	2028	48.946	30.889	438	19.846
17	2029	48.991	30.918	439	19.864
18	2030	49.011	30.93	439	19.872
19	2031	49.020	30.936	439	19.876
20	2032	49.024	30.939	439	19.877
21	2033	49.026	30.94	439	19.878
22	2034	49.027	30.94	439	19.878
23	2035	49.027	30.94	439	19.879
24	2036	49.027	30.941	439	19.879
25	2037	49.027	30.941	439	19.879
26	2038	49.028	30.941	439	19.879
	Sum of Impact for all Years	973.068	606.6		393.443

Figure M1- Total Economic Impacts by Year

REPORT 4b: TOTAL ECONOMIC IMPACTS - BY YEAR					
	Analysis Year:	2035	Project:	I-10 San Antonio Project	
	Constant $ Year:	2012	Region:	All Regions	
	Base Scenario:	Base Scenario	Period:	All Periods	
	Project Scenario:	Project Scenario	Impact Type:	Construction Impacts	
Count	Year	Business Output ($ mil.)	Value Added ($ mil.)	Jobs	Wage Income ($ mil.)
0	2012	26.182	13.572	217	10.185
1	2013	26.182	13.572	217	10.185
2	2014	13.234	6.859	110	5.147
3	2015	0.143	0.073	1	0.055
4	2016	0.143	0.073	1	0.055
5	2017	0.143	0.073	1	0.055
6	2018	0.143	0.073	1	0.055
7	2019	0.143	0.073	1	0.055
8	2020	0.143	0.073	1	0.055
9	2021	0.143	0.073	1	0.055
10	2022	0.143	0.073	1	0.055
11	2023	0.143	0.073	1	0.055
12	2024	0.143	0.073	1	0.055
13	2025	0.143	0.073	1	0.055
14	2026	0.143	0.073	1	0.055
15	2027	0.143	0.073	1	0.055
16	2028	0.143	0.073	1	0.055
17	2029	0.143	0.073	1	0.055
18	2030	0.143	0.073	1	0.055
19	2031	0.143	0.073	1	0.055
20	2032	0.143	0.073	1	0.055
21	2033	0.143	0.073	1	0.055
22	2034	0.143	0.073	1	0.055
23	2035	0.143	0.073	1	0.055
24	2036	0.143	0.073	1	0.055
25	2037	0.143	0.073	1	0.055
26	2038	0.143	0.073	1	0.055
	Sum of Impact for all Years	69.035	35.759		26.835

Figure M2- Construction Economic Impacts by Year

REPORT 4b: TOTAL ECONOMIC IMPACTS - BY YEAR					
Analysis Year:	2035		Project:	I-10 San Antonio Project	
Constant $ Year:	2012		Region:	All Regions	
Base Scenario:	Base Scenario		Period:	All Periods	
Project Scenario:	Project Scenario		Impact Type:	Market Access	
Count	**Year**	**Business Output ($ mil.)**	**Value Added ($ mil.)**	**Jobs**	**Wage Income ($ mil.)**
0	2012	0	0	0	0
1	2013	0	0	0	0
2	2014	0.399	0.252	4	0.162
3	2015	0.879	0.555	8	0.357
4	2016	1.915	1.209	17	0.776
5	2017	4.066	2.567	36	1.649
6	2018	8.212	5.185	74	3.33
7	2019	15.155	9.57	136	6.146
8	2020	24.442	15.434	219	9.912
9	2021	33.729	21.298	302	13.678
10	2022	40.673	25.682	364	16.494
11	2023	44.819	28.3	402	18.175
12	2024	46.97	29.659	421	19.047
13	2025	48.005	30.312	430	19.467
14	2026	48.485	30.615	434	19.662
15	2027	48.704	30.754	436	19.751
16	2028	48.803	30.816	437	19.791
17	2029	48.848	30.844	438	19.809
18	2030	48.868	30.857	438	19.817
19	2031	48.877	30.863	438	19.821
20	2032	48.881	30.865	438	19.823
21	2033	48.883	30.867	438	19.823
22	2034	48.884	30.867	438	19.824
23	2035	48.884	30.867	438	19.824
24	2036	48.884	30.867	438	19.824
25	2037	48.884	30.867	438	19.824
26	2038	48.884	30.867	438	19.824
	Sum of Impact for all Years	904.034	570.841		366.608

Figure M3- Market Access Economic Impacts by Year

Appendix N: Project Benefits and Costs

REPORT 5a: BENEFIT/COST RESULTS - BY MODE (STUDY AREA PERSPECTIVE)			
Analysis Year:	2035	Project:	I-10 San Antonio Project
Constant $ Year:	2012	Region:	Study Area
Base Scenario:	Base Scenario	Period:	All Periods
Project Scenario:	Project Scenario		

Present Value of Benefit Stream ($m 2012 Const dollars)

Mode	(A) Traveler Benefits ($)		(B) Traveler Benefits (non-$)			(C) Shipper/ Logistics Cost ($)	(D) Business Productivity ($)	(E) Social/ Environ. (non-$)
	Vehicle Operating Costs	Time & Reliability Costs	Value of Personal Time & Reliability	Safety Cost	Additional Consumer Surplus			
Pass Car - Commute	0.0	0.0	0.0	0.0	0.0	0.0	–	–
Pass Car - Pers/Rec	0.0	0.0	0.0	0.0	0.0	0.0	–	–
Truck - Freight	0.0	0.0	0.0	0.0	0.0	0.0	–	–
Project Totals	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**41.0**	**0.0**

Present Value of Cost Stream ($m 2012 Const dollars)

Facility Type	Startup Costs	Annual O&M Costs	Residual Value	Net Total Costs
Road	37.2	1.3	0.0	38.5
Rail	0.0	0.0	0.0	0.0
Air	0.0	0.0	0.0	0.0
Marine	0.0	0.0	0.0	0.0
Total for All Facilities	**37.2**	**1.3**	**0.0**	**38.5**

Efficiency Measures

Benefit Measure	Benefit Definition	Present Value of Benefit Stream ($ mil)	Present Value of Cost Stream ($ mil)	Net Present Value, $ mil (Benefits - Costs)	Benefit/Cost Ratio
Traveler Benefit	A+B	0	38	-38	0.00
Full User Benefit	A+B+C	0	38	-38	0.00
Total Societal Benefit	A+B+C+D+E	41	38	3	1.07

Wider Measures

Impact Measure	Impact Definition	Present Value of Impact Stream ($ mil)	Present Value of Cost Stream ($ mil)	Net Present Value, $ mil (Impacts - Costs)	Impact/Cost Ratio
Add'l Gross Regional Product	GRP	315	38	277	8.19
GRP plus Traveler non-$ Benefit	GRP+B	315	38	277	8.19
GRP plus Total non-$ Benefit	GRP+B+E	315	38	277	8.19

Figure N1- Project Benefits, Costs, and Impacts over the Project Life

Appendix O: Other Default Values Used in the Analysis

Facility	Mode	Purpose	Crew Cost Factor ($/hr per crew member)	Passenger Cost Factor ($/hr per occupant)	Freight Logistics Factor ($/hr per ton)	Buffer Time Cost Factor ($/hr per veh-trip)
Road	Passenger Car	Commute	0	22.48728653	0	22.48728653
Road	Passenger Car	Personal/Rec	0	11.24364326	0	11.24364326
Road	Truck Freight	Freight	26.0607119	0	1.591081594	62.33857685

Figure O1- Time Value Factors

Facility	Mode	Purpose	Cost Unit	Vehicle Operating Cost $/mile (Free Flow)	Vehicle Operating Cost $/mile (Congested)	Vehicle Operating Cost $/hour (Congested or Idle)	$ per Fatalities Accident	$ per Pers Injury Accident	$ per Prop Damage Accident	Environmental Cost $/mile (Free Flow)	Environmental Cost $/mile (Congested)	Environmental Cost $/hour (Congested or Idle)
Road	Passenger Car	Commute	Per Vehicle	0.423745455	0.484351515	1.513598485	6297097.579	87655.598	3316.4714	0.027	0.029892857	0.092571429
Road	Passenger Car	Personal/Rec	Per Vehicle	0.423745455	0.484351515	1.513598485	6297097.579	87655.598	3316.4714	0.027	0.029892857	0.092571429
Road	Truck Freight	Freight	Per Vehicle	1.225995974	1.500166249	4.623800081	6297097.579	87655.598	3316.4714	0.053	0.0675	0.208285714

Figure O2- Per Vehicle Cost Factors

Commodity SCTG Code	Short Description	Long Description	Cost Per Hour (relative to avg)
01	Live animals/fish	Live animals and live fish	1.5
02	Cereal grains	Cereal grains	0.53
03	Other ag prods.	Other agricultural products	0.83
04	Animal feed	Animal feed and products of animal origin, n.e.c.	0.68
05	Meat/seafood	Meat, fish, seafood, and their preparations	1.87
06	Milled grain prods.	Milled grain products and preparations, bakery products	0.91
07	Other foodstuffs	Other prepared foodstuffs and fats and oils	1.01
08	Alcoholic beverages	Alcoholic beverages	1.38
09	Tobacco prods.	Tobacco products	1.5
10	Building stone	Monumental or building stone	1.42
11	Natural sands	Natural sands	0.18
12	Gravel	Gravel and crushed stone	0.14
13	Nonmetallic minerals	Nonmetallic minerals n.e.c.	0.39
14	Metallic ores	Metallic ores and concentrates	0.18
15	Coal	Coal	0.3
16	Crude petroleum	Crude Petroleum	0.5
17	Gasoline	Gasoline and aviation turbine fuel	0.71
18	Fuel oils	Fuel oils	0.58
19	Coal-n.e.c.	Coal and petroleum products, n.e.c.	0.63
20	Basic chemicals	Basic chemicals	0.89
21	Pharmaceuticals	Pharmaceutical products	5
22	Fertilizers	Fertilizers	0.48
23	Chemical prods.	Chemical products and preparations, n.e.c.	1.78
24	Plastics/rubber	Plastics and rubber	1.59
25	Logs	Logs and other wood in the rough	0.89
26	Wood prods.	Wood products	0.99
27	Newsprint/paper	Pulp, newsprint, paper, and paperboard	1.24
28	Paper articles	Paper or paperboard articles	1.28
29	Printed prods.	Printed products	1.03
30	Textiles/leather	Textiles, leather, and articles of textiles or leather	1.98
31	Nonmetal min. prods.	Nonmetallic mineral products	0.65
32	Base metals	Base metal in primary or semi-finished forms and in finished basic shape	1.05
33	Articles-base metal	Articles of base metal	1.35
34	Machinery	Machinery	3.93
35	Electronics	Electronic and other electrical equipment and components and office equ	3.93
36	Motorized vehicles	Motorized and other vehicles (including parts)	4.28
37	Transport equip.	Transportation equipment, n.e.c.	1.69
38	Precision instruments	Precision instruments and apparatus	5
39	Furniture	Furniture, mattresses and mattress supports, lamps, lighting fittings, and	1.76
40	Misc. mfg. prods.	Miscellaneous manufactured products	2.71
41	Waste/scrap	Waste and scrap	1
43	Mixed freight	Mixed freight	1
99	Unknown	Commodity unknown	1
Custom1	(open)	(open)	1

Figure O3- Commodity Value Factors

Facility Type	Road	Rail	Air	Marine
Right-of-Way (paving, rails)	20	15	30	40
Transport Structures (bridges)	30	40	40	40
Terminal Bldgs & Equipment	40	40	50	40
Vehicles	15	25	20	30
© 2012 Economic Development Research Group, Inc				

Figure O4- Useful Life Inputs

Facility	Mode	Purpose	Average Fuel Consumption gal/mile (Free Flow)	Average Fuel Consumption gal/mile (Congested)	Average Fuel Consumption gal/hour (Congested or	State Fuel Tax Rate $/gal	Federal Fuel Tax Rate $/gal
Road	Passenger Car	Commute	0.048214286	0.096428571	0.289285714	0.2	0.184
Road	Passenger Car	Personal/Rec	0.048214286	0.096428571	0.289285714	0.2	0.184
Road	Truck Freight	Freight	0.096428571	0.192857143	0.578571429	0.2	0.244
© 2012 Economic Development Research Group, Inc							

Figure O5- Fuel Tax Inputs

- Note that all factors in the default table for "Industry Forecasts" (over all years and across all industries) were 1.

References

Adams, John S., and Barbara J. VanDrasek. "Transportation as Catalyst for Community Economic Development." SAFETEA-LU SEC. 1925 Community Enhancement Study. University of Minnesota, Center for Transportation Studies, Minneapolis, MN. December 2007.

Alam, Jobair B., Saiyid H. Sikder, and Konstadinos G. Goulias. "Assessing the Time Lag Between Transportation Investment and Economic Development by the Data Envelopment Approach." Transportation Research Record: Journal of the Transportation Research Board 1932 (2005): 79 – 88.

Attaran, Kazem, and Philippe Auclair. "Highway Stock and Private-Sector Productivity." Transportation Research Record: Journal of the Transportation Research Board 1274 (1990).

Beemiller, Richard M. "Hybrid Approach to Estimating Economic Impacts Using the Regional Input-Output Modeling System (RIMS II)." Transportation Research Record: Journal of the Transportation Research Board 1274 (1990).

Bell, Michael, and Eran Feitelson. "Bottlenecks and Flexibility: Key Concepts for Identifying Economic Development Impacts of Transportation Services." Transportation Research Record: Journal of the Transportation Research Board 1274 (1990).

Burke, Dock, David Luskin, Duane Rosa, and Tina Collier. "Transportation and the Texas Economy: Some Interim Results." Texas Transportation Institute and Texas A&M University. June 2005.

Cambridge Systematics, Inc. "Mid-Atlantic Rail Operations Phase II Study: Final Report." December 2009.

Cambridge Systematics, Inc., Economic Development Research Group, Inc., and HDR Decision Economics. "Economic Impact Study of Completing the Appalachian Development Highway System." June 2008. 18 Feb. 2012 <http://www.arc.gov/assets/research_reports/EconomicImpactStudyofCompletingADHS.pdf>.

Cambridge Systematics, Inc., Economic Development Research Group, Inc., and Boston Logistics Group, Inc. "Guide to Quantifying the Economic Impacts of Federal Investments in Large-Scale Freight Transportation Projects." August 2006.

Cambridge Systematics, Inc. “Economic Benefits of Transportation Investment.” NCHRP Project 8-36, Task 22 Demonstrating Positive Benefits of Transportation Investment. January 2002.

Cambridge Systematics, Inc., and Economic Development Research Group, Inc. “Transportation Improvements Grow Wisconsin’s Economy: The Economic Benefits of Transportation Investments.” February 2003.

Cambridge Systematics, Inc., Robert Cervero, and David Aschauer. “Economic Impact Analysis of Transit Investments: Guidebook for Practitioners.” Transit Cooperative Research Program Report 35. Transportation Research Board. Washington, D.C., 1998. 29 Apr. 2012 <http://onlinepubs.trb.org/onlinepubs/tcrp/tcrp_rpt_35.pdf>.

Chandra, Amitabh, and Eric Thompson. “Does public infrastructure affect economic activity? Evidence from the rural interstate highway system.” Regional Science and Urban Economics 30 (2000): 457 – 490.

Data Resources, Inc. (DRI). “Documentation of the DRI Model of the U.S. Economy.” December 1993.

Drew, Donald R. “System Dynamics Modeling of Development Induced by Transportation Investment.” Transportation Research Record: Journal of the Transportation Research Board 1274 (1990).

Drew, Donald R. “Conference Summary.” Transportation Research Record: Journal of the Transportation Research Board 1274 (1990).

Economic Development Research Group, Inc. “TREDIS Technical Document: Travel Cost Module Version 3.6.4.” 2011.

Economic Development Research Group, Inc. “The Cost of Congestion to the Economy of the Portland Region.” December 2005. 18 Feb. 2012 <http://www.portlandalliance.com/pdf/Congestion_Report.pdf>.

Economic Development Research Group, Inc., Delcan Corporation, and Cambridge Systematics, Inc. “Virginia’s Long-Range Multimodal Transportation Plan: Economic Impact of Transportation Investments in Virginia.” January 2010. 18 Feb. 2012 <http://www.vtrans.org/resources/VDOT-Econ-Impact-Final-01-20-2010.pdf>.

Economic Development Research Group, Inc. “The Regional Economic Benefits from CN’s Acquisition of the EJ&E.” November 2008. 20 Feb. 2012 <http://www.chicagometropolis2020.org/PDFs/RegionalEconomicBenefitsfromCNAcquisitionoftheEJandE-Fullreport.pdf>.

Economic Development Research Group, Inc. TREDIS brochure. 2010. 9 Mar. 2012 <http://tredis.com/attachments/-01_TREDIS%20-%20Management%20Level%20Brochure.pdf>.

Economic Development Research Group, Inc. “TREDIS Inputs.” 19 Mar. 2012 <http://tredis.com/product-info/capabilities/tredis-inputs.html>.

Forkenbrock, David J. “Putting Transportation and Economic Development into Perspective.” Transportation Research Record: Journal of the Transportation Research Board 1274 (1990).

Hartgen, David T., Alfred W. Stuart, Wayne A. Walcott, and James W. Clay. “Role of Transportation in Manufacturer’ Satisfaction with Locations.” Transportation Research Record: Journal of the Transportation Research Board 1274 (1990).

Horowitz, Alan J., Xia Jin, and Yi Zhu. “An Evaluation of the Business Attraction Module in Montana’s Highway Economic Analysis Tool.” Midwest Regional University Transportation Center, University of Wisconsin, Madison. November 2007.

IMPLAN. MIG, Inc. 12 Apr. 2012 <implan.com>.

Jarzab, James T. “Economic Impacts and Transportation Projects.” Journal of Transportation Engineering 112 (1986): 276 – 286.

Kansas Department of Transportation. “Kansas Department of Transportation Briefing Paper: Expanded Highway Project Selection Process.” January 2010.

Kreis, Doug, Brian Howell, and Lenahan O’Connell. “Early State Benefit Cost Analysis for Estimating Economic Impacts.” University of Kentucky, Kentucky Transportation Center. June 2006.

Lahr, Michael L., and Vyacheslav Khoroshevskiy. “R/ECON I-O: New features in commercial-grade software that estimates economic impacts.” Rutgers University, Center for Urban Policy Research. 5 Jan. 2012

<http://www.casos.cs.cmu.edu/events/conferences/2003/proceedings/NAACSOS_PAPERS_DAY3/Lahr,Khoroshevskiy_Michael,Vyacheslav_s2_d3.pdf>.

Litman, Todd. "Evaluating Transportation Economic Development Impacts: Understanding How Transport Policy and Planning Decisions Affect Employment, Incomes, Productivity, Competitiveness, Property Values and Tax Revenues." Victoria Transport Policy Institute. August 2010.

Lombard, Paulus C. "The relationship between highway infrastructure and regional economic development." Ph.D. dissertation. Purdue University, 1991.

Lynch, Tim. "Analyzing the Economic Impact of Transportation Projects Using RIMS II, IMPLAN, and REMI." Florida State University, Institute for Science and Public Affairs. October 2010.

McNamara, Kevin T. "Recruiting Manufacturing Firms as a Community Development Strategy." EC-659. Purdue University, Cooperative Extension Service. West Lafayette, IN. 28 Feb. 2012 <http://www.ces.purdue.edu/extmedia/EC/EC-659.html>.

Brite, Tony. "Missouri Freight Transportation: Economy on the Move- Rail Freight." Missouri Economic Research and Information Center, Missouri Department of Economic Development. 10 Feb. 2012 <http://www.missourieconomy.org/pdfs/rail.pdf>.

Miller, Ronald E., and Peter D. Blair. *Input-Output Analysis: Foundations and Extensions*. 2nd Ed. Cambridge, UK: Cambridge University Press, 2009. eBook.

North Carolina Department of Transportation. "Strategic Prioritization Process." 10 Fe. 2012 <http://www.ncdot.org/performance/reform/prioritization/>.

---. Strategic Planning Office. "Prioritization 2.0 Presentation" January 2012. 10 Feb. 2012 <http://www.ncdot.org/performance/reform/prioritization/>.

Oregon Department of Transportation. "Immediate Opportunity Fund Policy Guidelines." March 2004. 29 Feb. 2012 <http://www.oregon.gov/ODOT/TD/EA/reports/Immediate_Opportunity_Fund.pdf?ga=t>.

Perera, Max H. "Framework for Classifying and Evaluating Economic Impacts Caused by a Transportation Improvement." Transportation Research Record: Journal of the Transportation Research Board 1274 (1990).

Regional Economic Models, Inc. “What does REMI say?” 13 Mar. 2012 <http://www.remi.com/download/documentation/remi/information/REMI_Brochure.pdf>.

Regional Economic Models, Inc. “Getting Started with TranSight. Version 3.1.” 13 Mar. 2012 < http://www.remi.com/products/transight>.

Schultz, Grant G. et al. “Assessing the Economic Impacts of Transportation Improvement Projects.” Report No. UT-06.03. Brigham Young University, Dept. of Civil and Environmental Engineering. March 2006.

Schultz, Grant G., Jeremy E. Searle, and Mitsuru Saito. “Understanding the Economics of Transportation in Utah.” Report No. UT-10.21. Brigham Young University, Dept. of Civil and Environmental Engineering. December 2010.

Seskin, Samuel N. “Comprehensive Framework for Highway Economic Impact Assessment: Methods and Results.” Transportation Research Record: Journal of the Transportation Research Board 1274 (1990).

Stephanedes, Yorgos J. “Distributional Effects of State Highway Investment on Local and Regional Development.” Transportation Research Record: Journal of the Transportation Research Board 1274 (1990).

Texas Department of Transportation. “I-10 Huebner Road project Fact Sheet.” 2 May 2012 <https://ftp.dot.state.tx.us/pub/txdot-info/sat/ih10/fact_sheet.pdf>.

---. TxDOT Project Tracker Tool. “Project Detail.” 2 May 2012 <http://apps.dot.state.tx.us/apps/project_tracker/projectdetails.htm?projid=007208120&dist=San%20Antonio>.

Transportation Research Board. Highway Capacity Manual 2010. Transportation Research Board of the National Academies, Washington, D.C., 2010.

Transportation Research Record No. 1274, Foreword. Transportation Research Record: Journal of the Transportation Research Board 1274 (1990).

TREDIS. TREDIS Software Group, Division of Economic Development Research Group, Inc. 12 Apr. 2012 <tredis.com>.

United States. Census Bureau. “County Business Patterns: 2008.” 30 Apr. 2012 <http://www.census.gov/econ/cbp/>.

---. Department of Labor, Bureau of Labor Statistics. Quarterly Census of Employment and Wages: 3rd Quarter of 2010. 30 Apr. 2012 <http://www.tracer2.com/publication.asp?PUBLICATIONID=%20%20%20%20%20%20%20%20%20%20%20%201981>.

---. Federal Highway Administration. "TEA-21: A SUMMARY - Rebuilding America's Infrastructure." 12 Apr. 2012 <http://www.fhwa.dot.gov/tea21/suminfra.htm#ncpabip>.

---. ---. "SAFETEA-LU: Fact Sheets on Highway Provisions." 12 Apr. 2012 <http://www.fhwa.dot.gov/safetealu/factsheets/corridors.htm>.

---. ---. "A Summary of Highway Provisions in SAFETEA-LU." August 2005. 12 Apr. 2012 < http://www.fhwa.dot.gov/safetealu/summary.htm>.

---. Office of Management and Budget. "Circular A-94 Appendix C: Revised December 2011." 2 May 2012 <http://www.whitehouse.gov/omb/circulars_a094/a94_appx-c>.

---. Research and Innovative Technology Administration, Bureau of Transportation Statistics. "Table 1-40: U.S. Passenger Miles." 12 Apr. 2012 <http://www.bts.gov/publications/national_transportation_statistics/html/table_01_35.html>.

Watts, Jr., John M., and Robert E. Chapman. "Chapter 7: Engineering Economics." 26 Apr. 2012 <http://www.fire.nist.gov/bfrlpubs/build02/PDF/b02155.pdf>.

Weisbrod, Glen. "Models to predict the economic development impact of transportation projects: historical experience and new applications." The Annals of Regional Science. Vol. 42, Issue 3. September 2008.

Weisbrod, Glen, and Burton Weisbrod. "Measuring Economic Impacts of Projects and Programs." Economic Development Research Group. April 1997.

Weisbrod, Glen. "Current Practices for Assessing Economic Development Impacts from Transportation Investments: A Synthesis of Highway Practice." NCHRP Synthesis 290. Transportation Research Board. Washington, D.C., 2000.

Weisbrod, Glen. "Evolution of Methods for Assessing Economic Development Impacts of Proposed Transportation Projects." Paper was prepared for presentation at the 3rd International Conference on Transportation and Economic Development (TED2006). March 2006.

Wilbur Smith Associates et al. "I-70 Dedicated Truck Lanes Feasibility Study: Phase I Report." June 2010. 20 Feb. 2012 <http://www.infrastructureaustralia.gov.au/publications/files/PR_2010_Dedicated_Truck_Lanes_Feasibility_Study-Phase_I_Report.pdf>.

Vita

Stephen Daniel Evans was born in and grew up in Birmingham, Alabama. He attended Vestavia Hills High School before enrolling at Auburn University. After obtaining the degree of Bachelor of Civil Engineering from Auburn, Daniel attended The University of Texas at Austin where he studied transportation engineering.

Email address: sdanielevans@gmail.com

This thesis was typed by the author.