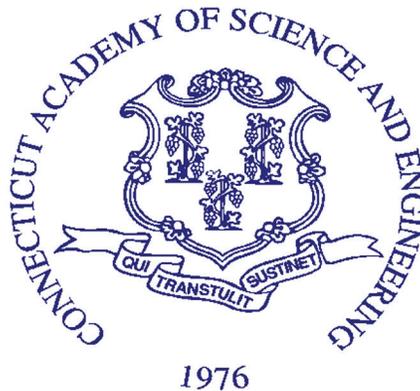


**ANALYZING THE
ECONOMIC IMPACTS OF
TRANSPORTATION PROJECTS**

SEPTEMBER 2013

A REPORT BY

**THE CONNECTICUT
ACADEMY OF SCIENCE
AND ENGINEERING**



FOR

THE

**CONNECTICUT DEPARTMENT OF
TRANSPORTATION**

ANALYZING THE ECONOMIC IMPACTS OF TRANSPORTATION PROJECTS

A REPORT BY

THE CONNECTICUT ACADEMY
OF SCIENCE AND ENGINEERING

ORIGIN OF INQUIRY:	THE CONNECTICUT DEPARTMENT OF TRANSPORTATION
DATE INQUIRY ESTABLISHED:	SEPTEMBER 1, 2012
DATE RESPONSE RELEASED:	SEPTEMBER 13, 2013

This study was initiated at the request of the Connecticut Department of Transportation on September 1, 2012. The project was conducted by an Academy Study Committee with the support of Karthik Konduri, PhD, Study Manager and Nicholas Lownes, PhD, Study Advisor. The content of this report lies within the province of the Academy's Transportation Systems and Economic Development Technical Boards. The report has been reviewed by Academy Members Sten A. Caspersson and Herbert S. Levinson, PE. Martha Sherman, the Academy's Managing Editor, edited the report. The report is hereby released with the approval of the Academy Council.

Richard H. Strauss
Executive Director

Disclaimer

The contents of this report reflect the views of the authors who are responsible for the facts and accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the Connecticut Department of Transportation. The report does not constitute a standard, specification, or regulation.

The US Government and the Connecticut Department of Transportation do not endorse products or manufacturers.

ANALYZING THE ECONOMIC IMPACTS OF TRANSPORTATION PROJECTS

Technical Report Documentation Page

1. Report No. CT-2279-F-13-13	2. Government Accession No.	3. Recipients Catalog No.	
4. Title and Subtitle Analyzing the Economic Impacts of Transportation Projects		5. Report Date September 2013	
		6. Performing Organization Code SPR-2279	
7. Author(s) Karthik Konduri, Study Manager Nicholas Lownes, Study Advisor Jamie Angueira, Research Assistant		8. Performing Organization Report No. CT-2279-F-13-13	
9. Performing Organization Name and Address Connecticut Academy of Science & Engineering 805 Brook Street, Building 4-CERC Rocky Hill, CT 06067-3405		10. Work Unit No. (TRIS)	
		11. Contract or Grant No. CT Study No. SPR-2279	
12. Sponsoring Agency Name and Address Connecticut Department of Transportation 2800 Berlin Turnpike Newington, CT 06131-7546		13. Type of Report and Period Covered Final Report September 2012 - September 2013	
		14. Sponsoring Agency Code SPR-2279	
15. Supplementary Notes Partners: Connecticut Department of Transportation: Bureau of Engineering and Construction and Bureau of Policy and Planning; Connecticut Academy of Science and Engineering; Connecticut Transportation Institute, UCONN. Prepared in cooperation with USDOT, Federal Highway Administration.			
16. Abstract: The main goal of the study is to explore methods, approaches and analytical software tools for analyzing economic activity that results from large-scale transportation investments in Connecticut. The primary conclusion is that the transportation system and users of transportation infrastructure interact with the economy in complex ways, causing economic impacts. Therefore, in order to effectively analyze the economic impact of transportation projects, ConnDOT should consider: establishing the role of economic impact analysis in the state's strategic transportation planning process; adopting an objective, independent and consistent process for conducting economic impact analyses that incorporates the state's regional, economic and political considerations; building capacity of ConnDOT staff including their understanding of economic impact analysis and the tools used to conduct such analyses for use in the strategic planning process and to support and manage analysts that conduct the analyses; utilizing analysts well versed in the principles of transportation planning/engineering and economic theory, and knowledgeable about the interrelations between the two for the purpose of ensuring validity of the results; establishing a partnership with an organization or consultant with the capacity to conduct economic analyses to achieve consistency in analyses over time; selecting an economic analysis software model to analyze the economic impact of transportation projects. Of the models considered in this study, currently REMI TranSight and TREDIS are recommended for ConnDOT's consideration; and customizing and communicating the results of the analyses in meaningful terms for various audiences (e.g., decision makers, stakeholders and the public).			
17. Key Words Economic Impact Analysis; Economic Development; Estimating and Evaluating Economic Impacts of Transportation Projects		18. Distribution Statement No restrictions. This document is available to the public through the National Technical Information Service, Springfield, VA 22161	
19. Security Classif. (Of this report) Unclassified	20. Security Classif. (Of this page) Unclassified	21. No. of Pages 162	20. Price N/A

Form DOT F 1700.7 (8-72)

Reproduction of completed page authorized

**MEMBERS OF THE STUDY COMMITTEE ON
ANALYZING THE ECONOMIC IMPACTS OF
TRANSPORTATION PROJECTS**

Joseph (Yossi) Berechman, PhD
Chairman, Department of Economics
The City College, The City University of New York

Alison Premo Black, PhD
Vice President of Policy and Chief Economist
Managing Director of Research and Education
American Road and Transportation Builders Association

Terry Clower, PhD
Director, Center for Economic Development and Research
University of North Texas

John Fischer
Consultant, Transportation Policy

A. George Foyt, ScD (*Academy Member*)
Manager of Electronics Research
United Technologies Research Center (ret.)

John N. Ivan, PhD (*Academy Member*)
Professor and Associate Department Head
Department of Civil & Environmental Engineering
University of Connecticut

Todd Litman
Founder and Executive Director
Victoria Transport Policy Institute

Alan Pisarski
Writer, Analyst, Consultant on Transportation Policy

Joshua L. Schank, PhD
President and CEO, Eno Center for Transportation

Martin Seifert (*Academy Member*)
President, Nufern, Inc.

Martin Wachs, PhD
Senior Principal Researcher, RAND Corporation

Shirley Ybarra
Senior Transportation Policy Analyst, Reason Foundation

RESEARCH TEAM

CONNECTICUT TRANSPORTATION INSTITUTE, UCONN

STUDY MANAGER

Karthik Konduri, Assistant Professor
Department of Civil and Environmental Engineering, UConn

STUDY ADVISOR

Nicholas E. Lownes, PhD, PE, Assistant Professor
Department of Civil and Environmental Engineering & Director,
Center for Transportation & Livable Systems, UConn

RESEARCH ASSISTANT

Jamie Angueira, Research Assistant, UConn

CONNECTICUT ECONOMIC RESOURCE CENTER

STUDY CONSULTANTS

Dale Shannon, Senior Economist/Consultant

Alissa K. DeJonge, Vice President of Research
Carmel Ford, Research Analyst

ACADEMY PROJECT STAFF

Richard H. Strauss, Executive Director
Terri Clark, Associate Director
Ann G. Bertini, Assistant Director for Programs

TABLE OF CONTENTS

TABLE OF CONTENTS	vii
KEY DEFINITIONS	ix
LIST OF ACRONYMS.....	xi
EXECUTIVE SUMMARY.....	xiii
1.0 INTRODUCTION	1
1.1 Need for analyzing economic impacts of transportation investments .	1
1.2 Study considerations	2
1.3 Project objectives.....	4
2.0 CHARACTERIZING ECONOMIC IMPACTS DUE TO TRANSPORTATION INVESTMENTS.....	7
2.1 Dimensions of the Transportation System and Economic Impacts.....	7
2.2 Processes Characterizing Economic Impacts Due to Transportation Investments	8
2.3 Economic Development Due to Transportation Investments.....	8
2.4 Transportation Investments as a Facilitator of Economic Development Impacts.....	12
2.5 Measures of Economic Impacts	13
2.6 Summary.....	16
3.0 METHODOLOGIES FOR CONDUCTING ECONOMIC IMPACT ANALYSES OF TRANSPORTATION INVESTMENTS.....	19
3.1 Purpose of Economic Impact Analysis.....	19
3.2 Estimating and Evaluating Economic Impacts of Transportation Investments	20
3.3 Methodologies for Estimating Economic Impacts of Transportation Investments.....	22
3.4 Methodologies for Evaluating Economic Impacts of Transportation Investments.....	32
3.5 Other Considerations for Analyzing Economic Impacts of Transportation Investments	39
3.6 Summary.....	42

4.0 REVIEW OF CANDIDATE SOFTWARE FOR ANALYZING ECONOMIC IMPACTS DUE TO TRANSPORTATION INVESTMENTS	49
4.1. Models Selected for this Review: REMI TranSight and TREDIS®	52
4.2. Overview of Model Methodology	55
4.3. Similarities Between TranSight and TREDIS	58
4.4. Differences Between TranSight and TREDIS	62
4.5. Perspectives from Other Models	78
4.6. Summary	80
5.0 REVIEW OF THE STATE OF PRATICE FOR ANALYZING ECONOMIC IMPACTS	83
5.1 State of Practice in United States	83
5.2 State of Practice in States with Established Economic Impact Analysis Procedures	84
5.3 State of Practice in States without Established Economic Impact Analysis Procedures	88
5.4 State of Practice in Connecticut.....	90
5.5 Summary	97
6.0 SUMMARY OF FINDINGS AND RECOMMENDATIONS	103
6.1 Need for Analyzing Economic Impacts Due to Transportation Investments	103
6.2 Characterizing Economic Impacts of Transportation Investments	103
6.3 Analyzing Economic Impacts.....	106
6.4 Implementation Strategy	111
APPENDICES	
Appendix A: Model Overviews	115
Appendix B: Comparison Between the Parameters in REMI TranSight and TREDIS models	123
Appendix C: Regional Planning Agencies Focus Group Session Pre-Survey	126
Appendix D: Connecticut General Assembly Transportation Committee: Focus Group Session Questions.....	129
Appendix E: Regional Planning Agencies and Key ConnDOT Staff: Focus Group Session Guide.....	130
Appendix F: Summary of Projects Reviewed	132
Appendix G: Study Committee Meetings and Guest Speakers	138

KEY DEFINITIONS

Economic Activity – Refers to the production, distribution and consumption of goods and services by businesses and end users.

Economic Impacts – Indicates a change in an item or an entity and includes both positive impacts (benefits) and negative impacts (costs). For example, whenever the phrase “economic impacts” is used in the report, it refers to both the positive and negative economic impacts that are realized due to the transportation investment. Economic impacts caused by transportation investments include shorter-term economic activities that result from construction of transportation projects and longer-term economic activities caused by improvement in connectivity, mobility, accessibility, and reliability of the transportation system.

Economic Development – The growth of jobs, wealth, tax base, and well-being of a neighborhood, city, region or state. A program results in economic development when the following conditions are realized:

- Increase in employment and wages that will result in the economic well-being of individuals and households in the region.
- Additional employment choices and opportunities for upward mobility so that individuals are satisfied and others may migrate into the region.
- Improved quality of life and well-being of individuals and households by offering them opportunities to engage in activities.
- Sustaining the above conditions over a long-term.

Economic Development Impacts – A subset of “economic impacts” that result in economic development. All transportation investments bring about economic impacts, but not all transportation investments result in economic development impacts.

Estimating Economic Impacts – Analysis aimed at quantifying the economic impacts due to a transportation investment by measuring the change in economic indicators with and without the transportation investment.

Evaluating Economic Impacts – Analysis aimed at quantifying the net value (or net return) of economic impacts due to a transportation investment by comparing the full range of benefits and costs. In evaluating economic impacts, values of economic benefits and costs are obtained by “estimating economic impacts.”

LIST OF ACRONYMS

AASHTO	American Association of State Highway and Transportation Officials
BCA	Benefit-Cost Analysis
BCR	Benefit-Cost Ratio
BEA	Bureau of Economic Analysis
CBA	Cost-Benefit Analysis
CBO	Congressional Budget Office
CEA	Chumra Economics and Analytics
CEA	Cost-Effectiveness Analysis
CEO	Council of Elected Officials
CGE	Computable General Equilibrium
COG	Council of Governments
CRC	Columbia River Crossing
CS	Cambridge Systematics
CUA	Cost-Utility Analysis
DfT	Department for Transport
DRT	Durham Region Transit
EDRG	Economic Development Resource Group, Inc.
EIA	Economic Impact Analysis
EOHED	Executive Office of Housing and Economic Development
EOT	Executive Office of Transportation
ERA	Economics Research Associate
FHWA	Federal Highway Administration
GAO	Government Accountability Office
GDI	Gross Domestic Income
GDP	Gross Domestic Product
GIS	Geographic Information System
GRP	Gross Regional Product
HEAT	Highway Economic Analysis Tool
HEEM	Highway Economic Evaluation Model
HERS-ST	Highway Economic Requirements System – State Version
IDT	Indicator Development Team
IMPLAN	Impact Analysis for Planning
INDOT	Indiana Department of Transportation
IO	Input-Output
ITS	Intelligent Transportation Systems
KDOT	Kansas Department of Transportation
LCCA	Life-Cycle Cost Analysis
LCP	Least Cost Planning
LEAP	Local Economic Assessment Package
L RTP	Long-Range Transportation Plan
MAP-21	Moving Ahead for Progress in the 21st Century Act
MARTA	Metropolitan Atlanta Rapid Transit Authority
MCIBAS	Major Corridor Investment-Benefit System
MDOT	Michigan Department of Transportation

LIST OF ACRONYMS (CONTINUED)

MI-BEST	Michigan Benefit Estimation System for Transportation
MPO	Metropolitan Planning Organization
MTO	Ministry of Transportation, Ontario
NCDOT	North Carolina Department of Transportation
NHHS	New Haven - Hartford - Springfield Rail Program
NPV	Net Present Value
ODOT	Oregon Department of Transportation
PECAS	Production, Exchange, and Consumption Allocation System
PRISM	Parsons Brinckerhoff Regional Infrastructure Scenario Model
REIMHS	Regional Economic Impact Model for Highway Systems
REM	Regional Economic Model
REMI	Regional Economic Model, Inc.
RIMS	Regional Input-Output Modeling System
RPA	Regional Planning Agency
RPO	Regional Planning Organization
RTA	Regional Transportation Authority
RUBMRIO	Random-Utility-Based Multiregional Input-Output
SACTRA	Standing Advisory Committee on Trunk Road Appraisal
SAM	Social Accounting Matrix
SCR	South Coast Rail
SHRP	Strategic Highway Research Program
STEAM	Surface Transportation Efficiency Analysis Model
STIP	Statewide Transportation Improvement Program
TCRP	Transit Cooperative Research Program
TDM	Travel Demand Management
TEIM	Travel Economic Impact Model
TELUM	Transportation Economic and Land Use Model
TELUS	Transportation Land Use System
TEMS	Transportation Economics & Management Systems, Inc.
TIGER	Transportation Investment Generating Economic Recovery
T-PICS	Transportation Project Impact Case Studies
TRB	Transportation Research Board
TREDIS	Transportation Economic Development Impact System
TRENDS	Transportation Revenue Estimator and Needs Determination System
TTI	Texas Transportation Institute
TxDOT	Texas Department of Transportation
USGPO	United States Government Printing Office
USDOT	United States Department of Transportation
WHO	World Health Organization

EXECUTIVE SUMMARY

This study, “Analyzing the Economic Impacts of Transportation Projects,” was conducted on behalf of the Connecticut Department of Transportation (ConnDOT) by the Connecticut Academy of Science and Engineering (CASE). The main goal of the study is to explore methods, approaches and analytical software tools for analyzing economic activity that results from large-scale transportation investments in Connecticut.

BACKGROUND

Transportation investments are traditionally motivated by transportation-related considerations including the need to improve safety, alleviate congestion, enhance mobility and accessibility, and increase reliability of transportation networks. In addition, transportation investments are also aimed at promoting *economic activity* and bringing about *economic development* in a region.

- Economic activity refers to the production, distribution and consumption of goods and services by businesses and end users.
- Economic development refers to a sustained longer-term change in economic activity leading to an improvement in the jobs, wealth, tax base, and well-being in a neighborhood, city, region or state.

The interactions between transportation investments and economic activity have long been recognized. However, estimating and evaluating the economic impacts of such investments for project selection, programming and prioritization have grown in interest among transportation agencies in recent years for the following reasons, among others:

- A decline in the availability of funding for transportation projects has led to increased competition for limited federal and state resources.
- A paradigm shift in implementing transportation projects from seeking funding to obtaining financing, resulting in an increased need for transportation agencies to justify the economic value of transportation projects in comparison with other priorities for competing bonding or other financing.
- A growing call at the federal and state levels for funding/financing projects based on performance-based criteria, such as the potential for investment in a program or project to result in economic development.
- Investing in transportation to promote economic development of a region.

OBJECTIVES

This study provides a synthesis of the literature on economic impact analysis and includes the following objectives:

- Review the state-of-art and state-of-practice for analyzing the economic impacts of transportation investments.
- Identify methods for analyzing the economic value/benefits of transportation projects and explore approaches that can be adapted for evaluating alternative transportation projects.
- Identify and provide an assessment of candidate software modeling tools for analyzing the economic impacts of transportation investments.

BRIEF STATEMENT OF PRIMARY CONCLUSION

The transportation system and users of transportation infrastructure interact with the economy in complex ways, causing economic impacts. Therefore, in order to effectively analyze the economic impact of transportation projects, ConnDOT should consider the following:

- Establishing the role of economic impact analysis in the state's strategic transportation planning process.
- Adopting an objective, independent and consistent process for conducting economic impact analyses that incorporates the state's regional, economic and political considerations.
- Building capacity of ConnDOT staff including their understanding of economic impact analysis and the tools used to conduct such analyses for use in the strategic planning process and to support and manage analysts that conduct the analyses.
- Utilizing analysts well versed in the principles of transportation planning/engineering and economic theory, and knowledgeable about the interrelations between the two for the purpose of ensuring validity of the results.
- Establishing a partnership with an organization or consultant with the capacity to conduct economic analyses to achieve consistency in analyses over time.
- Selecting an economic analysis software model to analyze the economic impact of transportation projects. Of the models considered in this study, currently REMI TranSight and TREDIS are recommended for ConnDOT's consideration.
- Customizing and communicating the results of the analyses in meaningful terms for various audiences (e.g., decision makers, stakeholders and the public).

SUMMARY OF FINDINGS AND RECOMMENDATIONS

A summary of the study's findings and suggested recommendations follows.

Characterizing Economic Impacts of Transportation Investments

Transportation investments contribute to economic activity in two significant ways:

- Creation of economic activity from the spending of money in the construction of transportation projects. This type of economic activity is short lived and temporary. Economic activity related to project construction needs to be put in the perspective of the state's annual total transportation investment program.
- Improvements in the connectivity, mobility, accessibility, and reliability of the transportation system interact in complex ways also resulting in economic activities. These economic activities are realized in the longer term and are more long-lasting. A subset of these economic activities that positively influence jobs, wealth, tax base and well-being are referred to as economic development impacts.

As noted, all transportation investments bring about economic activity, but not all transportation investments result in economic development of a region. A transportation system facilitates the economic development activity in a region by influencing the movement of people, activities, goods, and services. However, the transportation system is not the only factor causing economic development in a region. There needs to be a confluence of other favorable factors including economy, land use, policy, legal structures such as property rights, labor, education, taxation, quality of life factors and other non-transportation-related infrastructure for the economic development impacts to be realized from a transportation investment.

Analyzing Economic Impacts of Transportation Investments

Two types of interrelated analyses are often conducted to analyze economic impacts from transportation investments. These consist of those for *estimating* economic impacts, and those for *evaluating* economic impacts:

- Regional economic models (REMs) are the most comprehensive for estimation.
- Benefit-cost analyses (BCAs) are the most comprehensive for evaluation.

ESTIMATING ECONOMIC IMPACTS

Analyses aimed at estimating economic impacts attempt to answer the question : What is the overall impact on the regional economy from the proposed transportation project? This type of analysis employs methods and approaches that estimate changes in economic indicators by modeling the economy with and without a transportation investment.

Regional economic models (REMs) are the most comprehensive and most commonly used for analysis of large-scale transportation investments. REMs can accurately capture the flow of goods and services across different industries and sectors. This approach can incorporate a wide range of economic impacts, including the following:

- Direct economic impacts that are realized from the impact of the transportation improvement to the economic efficiency of travel choices of end users (e.g., households and businesses).
- Indirect economic impacts that are needed to support the direct economic impacts to end users affected by the transportation investment.

- Induced economic impacts that result from the additional income afforded by households and wealth accumulated by businesses due to the direct and indirect impacts. They also include additional economic activity resulting from market access changes, including increased competitiveness and attractiveness of the region and changes in the structure of the regional economy.

Therefore, it is recommended that a REM be used to estimate the economic impacts due to transportation investments.

EVALUATING ECONOMIC IMPACTS

Analyses aimed at evaluating economic impacts attempt to answer the question: What are the overall costs compared with the benefits over the life cycle of a transportation project? This type of analysis uses techniques to evaluate the net value/outcome/return of the different economic activities by considering the benefits and costs of a project.

Benefit-cost analysis (BCA) is widely used for evaluating transportation investments because it captures the costs and most direct benefits in evaluating the value of a transportation investment to the society at large. This methodology can also be used to compare alternative transportation investments and to objectively use the analysis results in the transportation planning process. Additionally, BCA can be used to compare alternative staging and implementations schedules for a project.

BCA is an appropriate methodology for evaluating the value or return of a transportation investment. Typically, only direct economic impacts of transportation investments are included in the calculation of benefits of a BCA. The indirect economic impacts are often ignored as manifestations of the direct economic impacts, and induced impacts are not considered due to the difficulty associated with measuring them and uncertainty associated with realizing the impacts. While it may be appropriate to ignore the indirect impacts in a BCA, a comprehensive BCA must include the induced impacts when calculating the benefits. The induced impacts are generally produced as estimates from REMs.

REMs and BCAs offer different insights into a project. Therefore, it is recommended that both of these analytical tools be used so that the potential economic impacts due to a transportation investment can be comprehensively analyzed.

Candidate Tools

Eighteen different analytical tools for analyzing economic impacts of transportation investments were reviewed. This review included models that estimate economic impacts (REMs) and those that are used to evaluate the economic impacts (BCAs). Based on criteria related to functionality, capability, and applicability, REMI TranSight and TREDIS were selected for a detailed review. Several features of these models make them useful for analyzing the economic impacts of transportation investments. Both models incorporate a REM and can be utilized to conduct BCA.

Model selection criteria and general requirements that were used for this study's detailed review of candidate models will be useful to ConnDOT's consideration of models to evaluate for its use. See Section 6.3.4 (Candidate Tools) of this report for the criteria used in this review

and key features of the selected models. In general, it is suggested that the analytical tool accommodate the state of Connecticut including surrounding regions as appropriate, and be designed for use in estimating and evaluating the economic impacts of transportation projects. REMI TranSight and TREDIS modeling tools are recommended for ConnDOT's consideration because both are fully developed and are capable of comprehensively analyzing the economic impacts of transportation investments.

Considerations for Conducting Economic Impact Analysis

It is recommended that analysts who are well versed in the principles of transportation planning/engineering and economic theory, and knowledgeable about the interplay between the two be utilized to conduct the economic impact analyses of transportation projects. It is also noted that economic considerations are only one aspect of the transportation planning process. The other considerations include

- the role and identification of other favorable conditions (e.g., special development zones/zoning regulations) so that appropriate non-transportation-related policy decisions can be made to realize potential economic impacts from transportation investments;
- the local economic and social context and considerations so that appropriate assumptions are made in applying models and interpreting the results; and
- how the measures of economic activity are represented and derived in the model. This will enable the analysts to identify and/or avoid common measurement issues.

Implementation Strategy

Review of the state of the practice in the United States and inputs from the focus group sessions were used to identify key considerations for the selection, adoption and implementation of economic analysis models in Connecticut. The research indicated that economic impact analysis is increasingly incorporated as part of transportation planning efforts in some states. It was also observed that transportation planning efforts in these states have been successful in achieving both transportation and non-transportation objectives, including economic development strategic goals.

Based on this review it is recommended that ConnDOT adopt an objective, independent, and consistent process for conducting economic impact analysis of transportation projects. Further, it is recommended that economic impact analysis be incorporated into the strategic planning, long-range capital investment program planning, and asset management practices at ConnDOT. Transportation-related measures provide the foundation for project selection, prioritization and programming. However, economic analysis that identifies the economic development potential of a project or projects is useful in determining the overall value of a project for the state.

The transportation investment decision making process should incorporate a multi-criteria evaluation procedure that takes into consideration transportation-related criteria, as well as non-transportation-related criteria including economic impacts and land use impacts, among others, when applicable.

ConnDOT should select a statewide economic model that integrates with existing modeling platforms and analytical tools that are used for making transportation investment decisions and evaluating land use impacts. Selection and use of a statewide economic model will ensure consistency and continuity in the application of the model for analyzing economic impacts of transportation projects and/or alternatives and can be applied for the purposes of long-range transportation planning and capital project programming.

The expertise necessary to conduct economic impact analyses requires a working knowledge of economic analysis and modeling. Familiarity with the Connecticut's economy and the region would provide a valuable foundation for assessing the economic development potential for Connecticut's transportation investments. Consideration should be given to partnering with an organization or consultant with the capacity to conduct the analyses to achieve consistency.

Also, ConnDOT staff needs to be familiar with the economic analysis methodology for the purposes of overseeing the work of others and for applying the results of the economic analyses in the overall transportation investment decision making process.

The following additional implementation recommendations are suggested for conducting and reporting results of economic impact analyses for Connecticut's transportation investments:

- Transparency in conducting and applying the results of economic analysis for project selection decision making is necessary.
- Consistency throughout the project analysis and project selection process is critical for successful implementation over time.
- Communication is needed throughout the economic analysis process between ConnDOT staff and economic analysis analysts, as well as with stakeholders and policymakers at all levels, as appropriate, and the general public.
- Performance measures need to be identified for use in project selection. The metrics need to be customized for ConnDOT staff and various audiences (e.g., decision makers, stakeholders and the public). This will help ensure the results of analyses are effectively conveyed in terms that are meaningful for each audience's use in understanding the value of transportation investments for their purposes.
- The economic analysis models and methodologies used must be appropriate for the type and size of project or projects being considered. Projects and alternatives should be evaluated on the basis of the issues they are intended to solve and projected performance metrics as provided in the analyses.

1.0 INTRODUCTION

This study was conducted for the Connecticut Department of Transportation (ConnDOT) by the Connecticut Academy of Science and Engineering (CASE). The main goal of the study is to explore methods, approaches and analytical software tools for analyzing economic activity that results from large-scale transportation investments in Connecticut. Further, the focus of the study is to explore ways to go beyond shorter-term, construction-related economic activity analysis for the purpose of capturing the longer-term economic development activity that results from transportation investments.

1.1 NEED FOR ANALYZING ECONOMIC IMPACTS OF TRANSPORTATION INVESTMENTS

Investments in transportation are traditionally motivated by the need to

- alleviate congestion;
- maintain state of good repair and/or operations;
- promote sustainable mobility patterns;
- provide mobility options across different socio-economic and demographic groups;
- increase accessibility to markets, jobs, suppliers;
- improve quality of life and well-being of end users;
- minimize disruptive impacts and ensure reliability; and
- increase traffic safety among other transportation-related considerations.

In addition to transportation-related considerations, transportation investments are also motivated by interest in creating economic activity and bringing about economic development in a region. Economic impacts refer to a change in activity in the form of production, distribution and consumption of goods and services by businesses and end users. Economic development refers to a sustained longer-term change in the economic activity leading to an improvement in the jobs, wealth, tax base, and well-being in a neighborhood, city, region or state. A more detailed discussion of economic development is presented in Chapter 2. Investing in transportation for the purpose of promoting economic activity is not new — from waterway investments in colonial times, to railroads, to the development of interstate highway systems that partly led to the growth of the trucking industry (Weisbrod 2000, Iacono and Levinson 2013). More recent examples of using transportation investments to bring about economic impacts include the American Recovery and Reinvestment Act of 2009, which was intended to create shorter-term job growth (USGPO 2009). Additionally, a report published by the US Department of Treasury notes the potential economic development impacts of infrastructure investments (Treasury 2012).

The interactions between transportation investments and economic impacts have long been recognized, and there is extensive empirical evidence on the subject (Radopoulou et al. 2011, Shatz et al. 2011, EDRG 2013). With the changing landscape of funding, regulatory review, project evaluation criteria, and public education, it is no longer sufficient for transportation agencies to only qualitatively justify the potential economic impacts due to transportation investments. It is increasingly important to quantitatively analyze the economic impacts of transportation investments so informed decisions can be made by transportation agencies and justifications can be provided to various stakeholders on the economic value of such investments (Weisbrod 2000; Vozzolo 2012).

1.2 STUDY CONSIDERATIONS

Extensive literature has been published on the topic of the economic impact analysis of transportation investments, and the literature varies in both the depth and detail of the review of economic impacts of transportation investments (Weisbrod 2000, Poor et al. 2008, Weisbrod and Reno 2009, Kockelman et al. 2013).

This study provides a synthesis of the literature; explores the best practices; and identifies methods, approaches and software implementations for analyzing economic impacts of transportation investments, while recognizing the considerations associated with the review of transportation projects by ConnDOT.

1.2.1 Effective programs and policies to meet larger goals of the region

There is a paradigm shift in transportation agencies across the nation in how transportation projects are planned, programmed and executed. The economic value of transportation investments is seen as a key aspect of the project planning process and is tied to project prioritization and selection as well as reporting to the General Assembly. While the main goal of transportation investments is to address present and future transportation challenges, there is a renewed emphasis on making informed decisions based on an understanding of the overall economic impact of transportation investments. Further, the economic value of such investments can be used as one of the many justifications provided to various stakeholders of transportation investments. In this regard, not only is the shorter-term economic impact related to construction-phase of the transportation project of interest, but the longer-term economic activities that potentially benefit a local community, the region, and the state as well.

1.2.2 Changing landscape of funding

The landscape of funding transportation initiatives is constantly changing, with increased justification needed to support investments. According to a recent report by the Congressional Budget Office, total government spending between 2008 and 2011 was approximately \$200 billion a year on surface transportation infrastructure projects. While the federal government spent about \$50 billion a year, local transportation agencies spent \$150 billion a year on surface transportation projects and additional private sector investments on privately owned railroads in United States were \$12 billion in capital expenditures. The report notes that if the current funding levels persist, an additional \$13 billion per year would be needed to maintain and operate existing highway and transit infrastructure. An additional \$83 billion per year will

be needed to support projects where the potential return on the investment is positive (i.e., greater than one). The report also proposes a shift from seeking funds to obtaining financing for infrastructure projects (CBO 2012, TRB 2011, Mathur 2012). For example, the report proposes establishing infrastructure banks that would institute “a number of criteria, including their costs and benefits” in selecting and financing infrastructure projects (CBO 2012). This shift is also echoed in the long-term federal highway authorization for supporting transportation infrastructure funding titled, “Moving Ahead for Progress in the 21st Century Act” (MAP-21). Map-21 identifies the creation of jobs and supporting economic growth as a key goal of transportation investments (FHWA 2012). As Vozollo (2012) notes, project justification in the New Starts program under MAP-21 will involve a multi-criterion rating system wherein projects will be evaluated based on mobility improvements, land use implications, environmental benefits, economic development effects, congestion relief, and cost effectiveness.

The increased need for justifying transportation infrastructure investments and interest in seeking alternative ways of funding transportation projects is currently based on a number of factors, such as budget deficits and an uncertain economic climate. There are limited resources available for funding initiatives at federal, state and local levels, and a number of competing needs. The resources that are available must be allocated to projects and initiatives that will provide the greatest benefit. Therefore, there is a growing need for understanding the economic impacts that result from transportation investments so that the limited resources can be efficiently allocated among competing needs. More importantly, not all investments in transportation initiatives will yield positive economic impacts; therefore, an understanding of the economic impacts will allow for the selection of transportation initiatives that offer positive economic value and provide the greatest return on the investment. ConnDOT also has to consider and program major transportation projects that each compete for the limited resources that are available. Hence, there is a need for selecting and using an economic impact analysis tool to identify transportation investments that provide the most value.

1.2.3 Evaluate alternative transportation investments

The types of projects typically considered by ConnDOT vary in purpose from maintenance and operation activities, to capacity expansion initiatives, and to the introduction of new modal alternatives. Examples of major competing transportation projects in Connecticut include the rehabilitation and expansion of Interstate 84 (I-84) in Danbury and Waterbury. I-84 is a major interstate corridor connecting New York and Connecticut and serves as a major link for truck traffic, business travel and tourism. The section of I-84 passing through Danbury and Waterbury suffers from major congestion and will require significant maintenance and repair to operate at acceptable levels. The estimated cost to widen the section of I-84 in Danbury is approximately \$800 million, and the estimated cost to widen and replace the 50-year-old viaduct section of I-84 in Waterbury is approximately \$2-3 billion.

While this serves as an example of a major highway expansion and maintenance project under consideration by ConnDOT, the New Haven-Hartford-Springfield commuter rail project is an example of a transportation initiative that will introduce a new modal alternative to metropolitan regions in Connecticut and Massachusetts. This initiative holds promise for significant changes to the economy and development in the region and expectations for changing the way people access the New York and Boston metropolitan areas. The estimated cost of the project is \$670 million.

The examples mentioned comprise significant investments and have the potential to bring about major development and change in the areas affected directly by the initiatives and to the state at large. However, as noted earlier, funding is limited in today's economic climate, and there is a need to be able to evaluate the economic impact of projects with transportation goals varying from maintenance and rehabilitation, to capacity expansion, to new modal alternatives.

1.3 PROJECT OBJECTIVES

This study identifies approaches/methods/implementations for analyzing economic impacts that result from transportation investments, and specifically economic impact analysis tools that can be tailored for Connecticut's application. These tools will need to address the new planning paradigm for transportation infrastructure investment, the changing landscape of funding, and the need to analyze various multi-modal transportation investment alternatives.

The study has the following objectives:

- Review the state-of-practice for analyzing economic impacts of transportation investments.
- Identify methods for analyzing the economic value/benefits of transportation projects and explore approaches that can be adapted for evaluating alternative transportation projects.
- Identify and provide an assessment of candidate software modeling tools for analyzing the economic impacts of transportation investments for ConnDOT's use. Further, the assessment includes a discussion about the applicability of the tools for evaluating the economic development potential from major transportation initiatives

The balance of the report is organized as follows:

- Chapter 2 discusses the connection between transportation investments and the economy.
- Chapter 3 presents methods and approaches for conducting economic impact analysis of transportation investments.
- Chapter 4 contains a review of the candidate software for conducting economic impact analysis of transportation investments,
- Chapter 5 provides a review of the state of practice for conducting economic impact analysis.
- Chapter 6 includes the study recommendations and concluding remarks.

REFERENCES

- CBO (2012) Infrastructure Banks and Surface Transportation. Congressional Budget Office: Non-Partisan Analysis for the US Congress. (Website: <http://www.hdrinc.com/about-hdr/knowledge-center/white-papers/2012-interim-guidance-on-map-21-fixed-guideway-capital-inves>, Accessed: April 16, 2013)
- EDRG (2013) Transportation Project Impact Case Studies. A product of the US Strategic Highway Research Program (SHRP 2), project C03, "Impact of Transportation Capacity on Economic Development and Land Use" developed by Economic Development Resource Group, Inc. (Website: <http://transportationforcommunities.com/t-pics/>, Accessed: April 16, 2013)
- FHWA (2012) Moving Ahead for Progress in the 21st Century Act: A Summary of Highway Provisions. Federal Highway Administration, Office of Policy and Governmental Affairs, July 12, 2012.
- Iacono, M. and Levinson, D. (2013) Case Studies of Transportation Investment to Identify the Impacts on the Local and State Economy. Minnesota Department of Transportation, Research Services, Office of Planning Analysis, Research and Innovation.
- Kockelman, K., Chen, D., and Nichols, B. (2013) The Economics of Transportation Systems: A Reference for Practitioners. TxDOT Project 0-6628: Economic Consideration in Transportation System Development and Operations.
- Poor, A., Lindquist, K., and Wendt, M. (2008) Transportation's Link to the Economy: Synthesis. Prepared for Jerry Lenzi, Washington Department of Transportation.
- Mathur, S. (2012) A Decision-Support Framework for Using Value Capture to Fund Public Transit: Lessons from Project-Specific Analyses. A publication of Mineta Transportation Institute, College of Business, San Jose State University, San Jose, CA.
- Radopoulou, S., Melibaeva, S., Huang, T., and Sussman, J. (2011) Literature Review of Papers Relevant to the Topic of Development Impacts and Economic Evaluation Methods of High-Speed Rail (HSR). Engineering Systems Division, Massachusetts Institute of Technology, ESD-WP-2010-07.
- Shatz, H.J., Kitchens, K.E., Rosenbloom, S. and Wachs, M. (2011) Highway Infrastructure and the Economy: Implications for Federal Policy. RAND Corporation. (Website: http://www.rand.org/content/dam/rand/pubs/monographs/2011/RAND_MG1049.pdf, Accessed: April 16, 2013)
- TRB (2011) Leading in Lean Times: Findings from the Transportation Research Board's 2011 State Partnership Visits Program. (Website: <http://onlinepubs.trb.org/onlinepubs/trnews/trnews278statevisits.pdf>, Accessed: April 16, 2013)
- Treasury (2012) A New Economic Analysis of Infrastructure Investment: A Report Prepared by the Department of the Treasury with the Council of Economic Advisers.
- USGPO (2009) American Recovery and Reinvestment Act of 2009. U.S. Government Printing Office.

- Vozzolo, D. (2012) Interim Guidance on MAP-21 Fixed Guideway Capital Investment Program. White Paper, HDR Inc. (Website: http://www.hdrinc.com/sites/all/files/content/white-papers/white-paper-images/5088-interim-guidance-on-map-21-fixed-guideway-capital-investment-program_0.pdf, Accessed April 16, 2013).
- Weisbrod, G. (2000) Procedures for Assessing Economic Development Impacts from Transportation Investments. National Cooperative Highway Research Program, Synthesis of Highway Practice, Synthesis Report 290.
- Weisbrod, G., and Reno, A. (2009) Economic Impact of Public Transportation Investment. Prepared for the American Public Transportation Association. (Website: http://www.apta.com/resources/reportsandpublications/Documents/economic_impact_of_public_transportation_investment.pdf, Accessed: April 16, 2013).

2.0 CHARACTERIZING ECONOMIC IMPACTS DUE TO TRANSPORTATION INVESTMENTS

Transportation investments are often targeted at making improvements to existing transportation facilities (e.g., a project adding lanes to improve capacity or a project aimed at maintaining and rehabilitating an existing bridge to prevent a shutdown) or for adding new elements to existing transportation infrastructure (e.g., a project introducing a new commuter rail mode into a region or a project aimed at adding a roadway providing a connection to a new commercial or residential development). It is through these changes that transportation investments impact the transportation system's performance and affect end users of the system by affecting mobility, accessibility, reliability, quality, and travel costs and thus the region's economy (Weisbrod 2008).

This chapter focuses on the ways in which transportation investments affect a region's economic activity and subsequently influence economic development.

- Section 2.1 describes the economic development impacts that result from transportation investments.
- Section 2.2 describes the primary users who are affected by transportation investments.
- Section 2.3 includes a discussion of the different ways in which transportation investments affect end users and their economic activities in a region and describes various economic impacts, based on the type of impact, of transportation investments.
- Section 2.4 identifies other necessary conditions for realizing economic development impacts resulting from transportation investments.
- Section 2.5 identifies measures that are used to quantify economic impacts of transportation investments and presents some common measurement issues.
- Section 2.6 provides a summary of the findings.

2.1 ECONOMIC DEVELOPMENT DUE TO TRANSPORTATION INVESTMENTS

Every transportation investment may bring about economic activity by affecting the movement of people, goods, and services. However, not every investment may bring about economic development in a region. Economic development refers to the improvement in the jobs, wealth, tax base, and well-being in a neighborhood, city, region or state. Programs aimed at economic development are typically motivated by a combination of the following goals (Weisbrod 2000):

- Improve employment levels and increase wages thereby increase the economic well-being of individuals and households
- Offer a spectrum of employment choices that enables individuals to seek jobs with higher satisfaction and to pursue opportunities with upward mobility

- Improve the quality of life and well-being of individuals and households by offering opportunities for discretionary (shopping, entertainment, leisure) and maintenance (hospital, meals, day-care) types of activities
- Sustain jobs and income levels

In an effort to realize these economic development goals, economic development programs are developed to expand existing businesses, retain current industries, promote new startups and attract new businesses into a region. Within this context, an efficient transportation system is an important consideration for facilitating economic development by providing for the effective movement of people, goods, and services.

2.2 DIMENSIONS OF THE TRANSPORTATION SYSTEM AND ECONOMIC IMPACTS

In accurately characterizing economic impacts resulting from transportation investments, it is first necessary to identify the end users and define the built environment where the transportation infrastructure and economic transactions occur. The primary end users of the transportation system are households and businesses (or industries).

Households engage in travel to meet their daily activity needs such as commuting, chauffeuring, shopping, seeking entertainment and dining. Businesses rely on the transportation system for serving their customers, acquiring goods and services from other businesses and having employees commute to work.

At least three distinct layers of the urban environment influence the economic impacts of transportation investment:

- Geography (or space) defines the location of end users – households, and businesses
- Transportation infrastructure connects various locations and destinations
- Activities and transactions between the end users result in the economic activity

2.3 PROCESSES CHARACTERIZING ECONOMIC IMPACTS DUE TO TRANSPORTATION INVESTMENTS

Transportation investments can bring about economic activity by improving mobility, increasing accessibility, alleviating costs, and increasing reliability. Each of these impacts interacts in complex ways resulting in economic activity, as follows (SACTRA 1999, Weisbrod 2008):

- Improved mobility leads to new trade between locations; reduced travel time and travel costs lead to a decrease in operating costs, positively impacting productivity.
- Accessibility improvements lead to larger consumer markets, leading to growth of companies, and larger labor pools lead to productivity gains. Accessibility improvements also provide faster and more efficient access to resources, which in turn positively impacts productivity, allowing for expansion of industries and economies of scale in production and distribution.

- Improving reliability reduces the uncertainty and risk associated with transportation networks in supply chain logistics. This in turn creates economic activity by increasing efficiency (e.g., promoting just-in-time delivery type paradigms) and reducing operating costs (e.g., eliminating the need for warehousing facilities). An efficient transportation system also increases the competitiveness of a region and attracts new businesses.
- Operating at a more disaggregate scale (neighborhood, local), transportation investments also affect land use patterns of households and businesses by influencing real estate prices and affecting wages (Kockelman et al. 2013). Table 2.1 provides an overview of the economic impacts due to transportation investments by type of impact.

TABLE 2.1: ECONOMIC IMPACTS DUE TO TRANSPORTATION INVESTMENTS
 (ADAPTED FROM RODRIQUE AND NOTTEBOOM, 2013)

Impacts on Transportation Supply	Impacts on Transportation Demand	Microeconomic Impacts	Macroeconomic Impacts
<ul style="list-style-type: none"> • Income from transport operations (fares and wages) • Access to wider distribution markets and niches 	<ul style="list-style-type: none"> • Improved accessibility • Time and cost savings • Productivity gains • Division of labor • Access to wider range of suppliers and consumers • Economies of scale 	<ul style="list-style-type: none"> • Rent income • Lower price of commodities • Higher supply of commodities 	<ul style="list-style-type: none"> • Formation of distribution networks • Attraction and accumulation of economic activities • Increased competitiveness • Growth of consumption • Fulfilling of mobility needs

The impacts of transportation investments on economic activity in a region can be classified based on the linkage between the transportation impact and economic activity, as follows:

- **Direct Impacts:** This set of impacts is also referred to as the primary impacts. The impacts that are realized due to the transportation investment are referred to as the direct impacts. These impacts result from improvement to the economic efficiency of end users including households and businesses (industries) and their travel choices. For example, reduction in operating costs will result in efficiency and lead to business growth
- **Indirect Impacts:** These impacts, also known as secondary impacts, refer to economic activity that is needed to support direct economic impacts to end users affected by the transportation investment. Indirect impacts are an estimate of the level of economic activity of regional businesses and households to provide the inputs necessary to meet the direct impacts

- **Induced Impacts:** This set of economic impacts results from the additional income earned by employees due to direct and indirect impacts as they spend their earnings in the region. The term induced impacts can also include tertiary economic effects that result from the development of new infrastructure due to attractiveness and competitiveness of the region (e.g., the development of a new shopping center resulting from increased access in an area; this will subsequently result in expenditures, jobs and other economic activity) and longer-term perpetuity effects that result from changes to the economic structure in the region due to shift in population, workforce, labor, costs and prices (e.g., In Memphis, Tennessee, investments in highways, airports, and warehousing facilities over a long period has contributed to the creation of an economy that is primarily supported by the shipping and manufacturing industry). Induced impacts often refer to economic activity resulting in economic development in a region. (Weisbord 2000, Kockelman et al. 2013, Rodrigue and Notteboom 2013)

The sum of all effects provides the total impact of the transportation investment on the economic activity in a region. The ratio of total impact to the direct impact is referred to as the economic multiplier (Weisbord 2000). Multiplier effects include direct, indirect and induced impacts. However, the definition of multiplier effects is not consistent and can take various shapes and forms (Butler and Kiernan 1993). Therefore, there is a clear need to define and quantify these impacts to avoid ambiguity.

Figure 2.1 shows the linkages between transportation investments and economic activity in a region as proposed by Weisbord (2000). The figure also notes the economic development impacts that can result from transportation investments. The linkages in the figure are limited to the direct impact, indirect impacts and induced impacts in the form of surplus consumer expenditures. However, the figure does not accommodate the tertiary and perpetuity economic development impacts that can potentially be realized from transportation investments.

Figure 2.2 shows the linkages across transportation investments, economic activity, and economic development activity as proposed by Bannister and Berechman (2000). Unlike Figure 2.1, Figure 2.2 clearly identifies potential tertiary and perpetuity economic development impacts due to transportation investments. There are a number of other approaches to characterizing the linkages between transportation investment and economic activity (Weisbord and Weisbord 1997, Weisbord 2008). These approaches vary in the types of impacts captured and may differ in the linkages specified to realize the economic impacts, but they have the same overarching themes, as follows:

- Transportation investments lead to mobility, accessibility, connectivity and reliability improvements. These improvements lead to three main activities:
 - o Influence on travel costs
 - o Impact on location patterns of end users (including households and businesses) to improve their economic efficiencies
 - o Impact on economic activity
- In realizing economic development there must be the presence of an underlying latent need. This is particularly true for the tertiary and perpetuity impacts that will only be

realized when other favorable conditions exist. Weisbrod (2000) echoes this sentiment when mentioning that economic development impacts in the form of multiplier effects will only be realized and should be measured only when “the study area is a region with idle or underutilized workers and resources, or a region with a potential ability to attract more workers or resources to it.” Bannister and Berechman also note that to realize the economic development impacts, there is the need for “allocative positive externalities in specific markets, which are amenable to improved accessibility.” The authors define allocative externalities as the presence of a market with latent needs that consume resources that would become available once an investment in transportation is made. For example, in a knowledge economy whose growth is hindered by poor accessibility, transportation investment will likely realize economic development impacts compared to another knowledge economy that doesn’t suffer from poor accessibility. Further, the authors note that “the scale, spatial and temporal distribution of these externalities will affect the magnitude and scope of economic development, given the transport investment.”

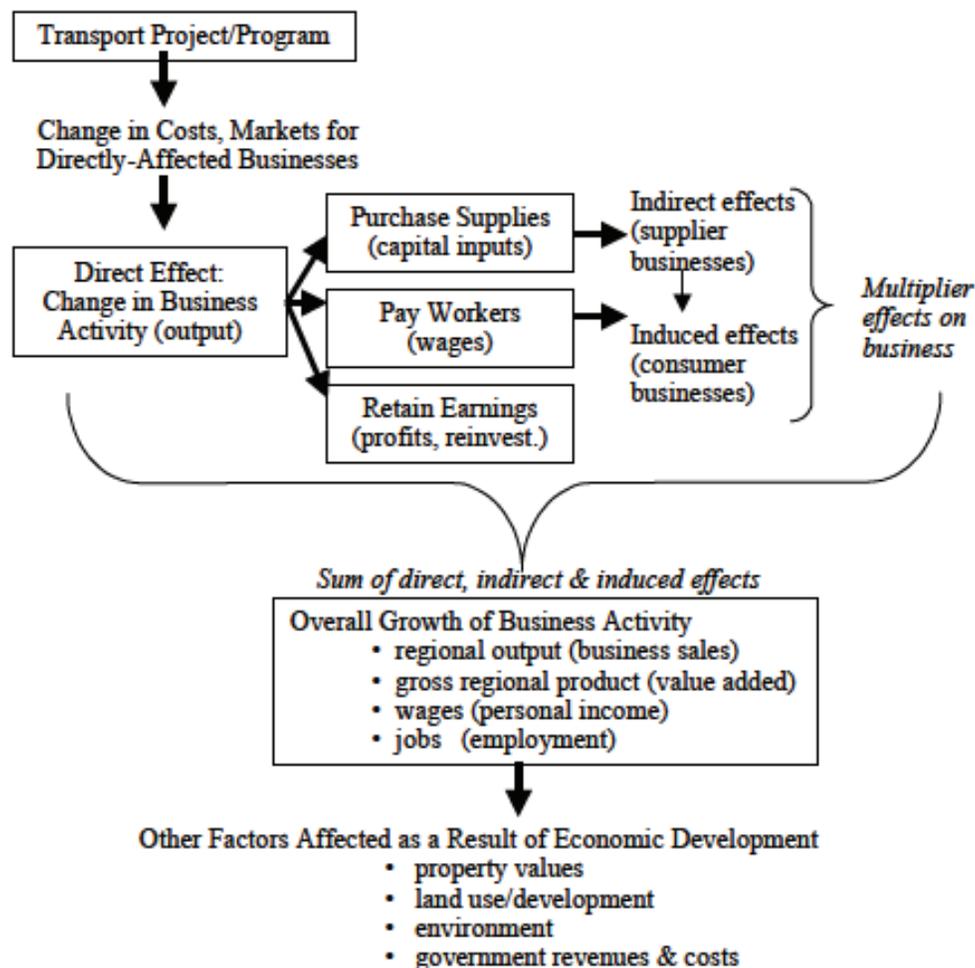


FIGURE 2.1: A FLOWCHART IDENTIFYING THE ECONOMIC IMPACTS DUE TO TRANSPORTATION INVESTMENTS (WEISBROD 2000)

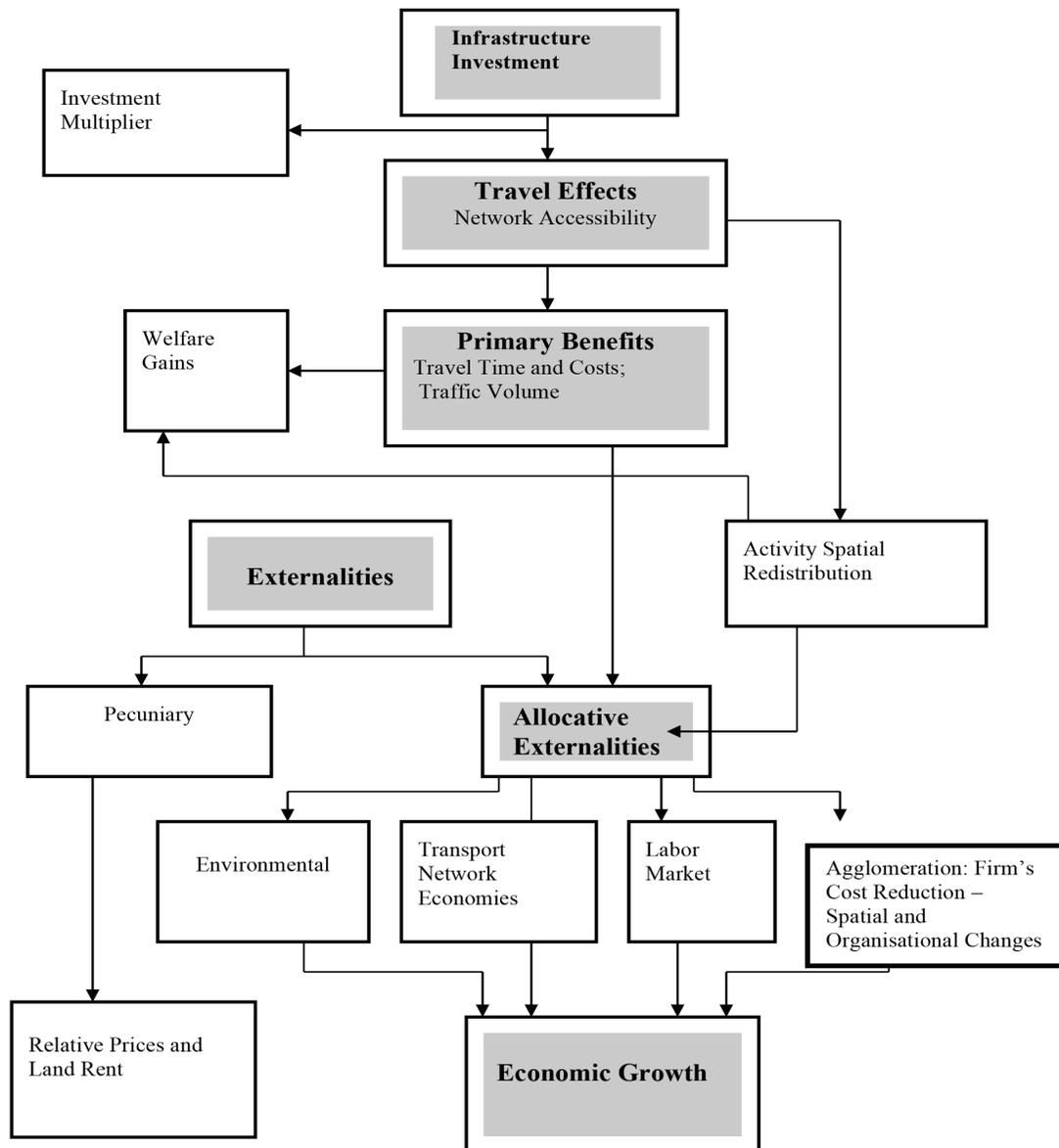


FIGURE 2.2: FRAMEWORK SPECIFYING THE LINKAGES BETWEEN TRANSPORTATION INVESTMENTS AND ECONOMIC IMPACTS (BANNISTER AND BERECHMAN 2000)

2.4 TRANSPORTATION INVESTMENTS AS A FACILITATOR OF ECONOMIC DEVELOPMENT

As noted in Section 2.1, all transportation investments cause economic impacts, but other favorable conditions should exist for transportation investments to bring about economic development. Transportation infrastructure investments facilitate economic development in regions that suffer from poor accessibility, mobility, and connectivity. However, as transportation infrastructure matures, and system level improvements to accessibility, mobility, and connectivity become marginal, then additional transportation investments

yield diminishing economic development returns (Iacono and Levinson 2013, Kockelman 2013). In such systems, transportation investment alone is not sufficient to facilitate economic development; there should be confluence of a number of other factors. Through an extensive literature review, Iacono and Levinson (2013), observed a number of factors in addition to transportation investments including, “policy climate, human capital and education, taxation and regulatory regimes, quality of life factors, and other types of non-transportation infrastructure such as sewer and water systems, schools and telecommunication systems” as affecting economic development. Bannister and Berechman (2000) also note that while transportation can facilitate economic development, it is not a necessary and sufficient condition that guarantees economic development. Further, they note that

“there is plenty of evidence showing long-term regional economic development despite the lack of any significant transport investment. Apparently, many other forces, ranging from a sharp rise in international trade, technological innovations, and human capital betterment to successful local economic policies, can all support growth. Hence, in general, transport development serves as a growth supporter and not as a growth generator. By and large, within a region with a reasonable level of transport accessibility, development is achieved by an assortment of forces and policies, not necessarily transport related.”

Wornum, et al. (2005) comprises a study conducted for the Montana Department of Transportation on the economic impacts of reconfiguring two-lane highways in the state. The report also notes the need for other favorable conditions to stimulate economic development including labor pool, economic development programs, quality of life, non-transportation infrastructure, and the tax and regulatory environment.

2.5 MEASURES OF ECONOMIC IMPACTS

In quantifying the economic impacts of transportation investments, change in a number of economic indicators is measured. Weisbrod (2000) identified the following as typical measures to evaluate transportation investments. These measures were compiled from a survey of transportation departments in US states and Canadian provinces, transportation planning agencies and other transport agencies outside the United States:

- Economic Indicators
 - o employment
 - o business dislocations
 - o tourism spending
 - o personal income
 - o business sales output
 - o value added (Gross Regional Product)
 - o property values and development
 - o business productivity
 - o industry composition

- Other Indicators
 - o travel time and expense
 - o safety/accident factors
 - o environmental impacts
 - o quality of life/other

2.5.1 Common Measurement Issues

The relevance of the measures used for economic impact analysis can be observed from their widespread use by transportation agencies in the United States and worldwide. However, concern about the approaches used for measuring these impacts is appropriate. All approaches are based on critical assumptions and apply complex methodologies in developing estimates of the effects of a transportation project on the regional economy. Both the assumptions and the methodologies are developed from an effort to practically apply economic theory that at times is still being refined and tested by the economic community. In addition, incorrect specification of the data in the model can lead to incorrect inferences regarding the value of a transportation investment. Analyses that attempt to utilize these measures to justify transportation investments need to address these concerns, as follows:

- Generative, Redistributive and Transfer Impacts: Transportation investments can potentially lead to positive economic impacts. However, depending on the scale and extent of analysis, the observed change in an economic indicator may be qualified as generative, redistributive or a transfer of economic activity. Report 35 of the Transit Cooperative Research Program, “Economic Impact Analysis of Transit Investments: Guidebook for Practitioners,” defines these impacts as follows:
 - o Generative impacts are net positive changes in the economic activity in a region.
 - o Redistributive impacts result from locational shift in economic activity within a region.
 - o Transfer impacts result from a shift from “one entity to another” (TCRP 1998).

For example, the report classifies changes in economic indicators due to transit investments as generative, redistributive, or transfer as shown in Table 2.2. Whether an economic impact can be qualified as generative or redistributive depends significantly on the spatial resolution of the analysis and the extent of the analysis area. Therefore, it is very important to define the goals of a transportation investment and to apply the correct regional specification that is associated with those goals. Further, clearly defining the resolution of the analysis and extent of the analysis geography will help ensure that impact analyses and subsequent alternative comparisons are carried out accurately. It is the presence of generative impacts that causes economic development in a region.

TABLE 2.2: BREAKDOWN OF ECONOMIC IMPACTS DUE TO TRANSIT INVESTMENTS (TCRP 1998)

Generative Impacts	Redistributive Impacts	Transfer Impacts
<ul style="list-style-type: none"> • 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 facility costs 	<ul style="list-style-type: none"> • Land development (e.g., clustered development around transit stations) • Employment and income growth due to land development • Increased economic activity within corridor 	<ul style="list-style-type: none"> • Employment and income growth related to system construction, operation, or maintenance • Joint-development income to local agencies • Property tax impacts

- *Double Counting:* As indicated in Section 2.2, a number of economic impact indicators are utilized by transportation agencies to analyze the economic effects of transportation investments. It is important to understand that the measures are interrelated in ways described in the frameworks presented in Figure 2.1 and Figure 2.2. Often these measures are different manifestations of the same basic economic activity. For example, the growth of a company due to reduced operating costs can be measured in terms of increased profits, increased worker wages, new investments in property and equipment, higher taxes, and increases in employment. The dollar measures from these different activities are not necessarily additive, and it is important to clearly understand the underlying frameworks and the processes used in specifying economic activities in order to conduct an accurate analysis of transportation investment impacts on the economy.
- *Separating Impact from Benefit:* Most economic impact analyses are conducted for the purpose of either estimating the economic impacts or evaluating the value, or benefit, of economic impacts. There is a very subtle but important difference between estimating and evaluating economic impacts. The former is used to identify the change or difference in an economic indicator with and without a transportation investment, whereas the latter is used to show the net benefit or value of the change in an economic indicator. For example, a transportation investment may lead to an addition of 100 jobs due to various economic impacts. However, let us say that 25 of the new jobs were filled by individuals at the same wage rate as they had at their previous positions. In a study aimed at estimating economic impacts, a positive impact of 100 jobs will be reported

whereas in an analysis aimed at evaluating the net value or benefit, a positive impact of only 75 jobs will be reported. It is the latter (i.e., benefit or value) that should be utilized for justifying transportation investments and not the former (i.e., change in an economic indicator).

2.6 SUMMARY

In addition to addressing existing transportation related issues and challenges, transportation investments can also bring about economic activity in a region. Transportation investments spur economic activity by primarily affecting the mobility, accessibility, connectivity, and reliability of the transportation facilities. The direct transportation impacts in turn enhance economic activity by reducing costs, improving quality and quantity of labor pools, increasing size of consumer markets, raising efficiency, improving productivity, increasing competitiveness, enabling growth and altering locational patterns, among others. A number of steps are involved in accurately characterizing the economic impacts of transportation investments. The following are some key considerations for conducting a valid economic impact analysis.

- All transportation investments bring about economic activity. However, not all transportation investments create economic development. This is because transportation investments are neither a necessary nor a sufficient condition, but a facilitator of economic development impacts.
 - Transportation investments are not a necessary condition because there are a number of programs where economic development is achieved without investing in transportation.
 - Transportation investments are not a sufficient condition because there has to be presence of a number of other favorable conditions, including policies, programs, market conditions, and other types of non-transportation infrastructure considerations to realize the full range of economic development impacts, in particular the longer-term tertiary and perpetuity impacts.
- It is important to clearly understand the dimensions of economic impacts and the processes underlying the influence of transportation investments on economic development activity in order to conduct a valid economic impact analysis.
- Increased awareness of dimensions and processes used in conducting an economic analysis, combined with a clear purpose of the analysis (estimating versus evaluation), will help avoid common errors in the use of economic measures.

REFERENCES

- Banister and Berechman (2000) The Economic Development Effects of Transportation Investments. Paper for presentation at the TRANS-TALK Workshop, Brussels, November 2000.
- Butler, S. and Kiernan, L. (1993) Estimating the Regional Economic Significance of Airports, Office of Airport Planning and Programming, Federal Aviation Administration.
- Butler, S. and Kiernan, L. (1993) Estimating the Regional Economic Significance of Airports. Office of Airport Planning and Programming, Federal Aviation Administration.
- Kockelman, K., Chen, D., and Nichols, B. (2013) The Economics of Transportation Systems: A Reference for Practitioners. TxDOT Project 0-6628: Economic Consideration in Transportation System Development and Operations.
- Levinson (2010) Economic Development Impacts of High-Speed Rail. University of Minnesota: Nexus Research Group, Working Paper No. 72. (Website: <http://nexus.umn.edu/Papers/EconomicDevelopmentImpactsOfHSR.pdf>, Accessed: July 26, 2013).
- Radopoulou, S., Melibaeva, S., Huang, T., and Sussman, J. (2011) Literature Review of Papers Relevant to the Topic of Development Impacts and Economic Evaluation Methods of High-Speed Rail (HSR). Engineering Systems Division, Massachusetts Institute of Technology, ESD-WP-2010-07.
- Rodrigue, J-P, and Notteboom (2013) The Geography of Transport Systems. Routledge, New York.
- Standing Advisory Committee on Trunk Road Appraisal (SACTRA) (1999) Transport and the Economy: Full Report. (Website: http://webarchive.nationalarchives.gov.uk/20050301192906/http://dft.gov.uk/stellent/groups/dft_econappr/documents/pdf/dft_econappr_pdf_022512.pdf, Accessed: August 5, 2013)
- TCRP (1998) Economic Impact Analysis of Transit Investments: Guidebook for Practitioners. Prepared by Cambridge Systematics with Robert Cervero and David Aschauer, Transit Cooperative Research Program, Transportation Research Board, Washington DC.
- Weisbrod, G. (2008) Models to Predict the Economic Development Impact of Transportation Projects: Historical Experience and New Applications. *Annals of Regional Science*, 52, pp. 519-543.
- Weisbrod, G. and Weisbrod, B. (1997) Assessing the Economic Impact of Transportation Projects: How to Choose the Appropriate Technique for Your Project. Transportation Research Circular, Number 477, Transportation Research Board, Washington DC.
- Wornum, C., Hodge, D., Weisbord, G., Colby, J., Lynch, T., Payne, R., Benson, M., and Ang-Olson, J. (2005) Montana Highway Reconfiguration Study. Prepared for Montana Department of Transportation by Cambridge Systematics with Economic Development Research Group, ICF Consulting, and Short Elliott Hendrickson, Inc.

3.0 METHODOLOGIES FOR CONDUCTING ECONOMIC IMPACT ANALYSES OF TRANSPORTATION INVESTMENTS

Several analytical techniques and modeling approaches are utilized to study the economic impacts of transportation investments. The analysis methods vary widely in their complexity, rigor, theoretical foundations, and coverage of economic impact processes. Further, depending on the analysis technique and the model system utilized, the economic impacts will vary in their spatial resolution and extent, from a microscopic scale of neighborhood to a macroscopic scale of region, state, and even a nation. The different analysis techniques and modeling tools are representations of the economic system and they seek to provide answers to the following fundamental questions:

- What are the impacts?
- Who is affected?
- When will the impacts be realized?
- What is the spatial distribution of these effects?

This chapter provides an overview of methods for analyzing the economic impacts of transportation investments, including the following:

- Typical objectives of economic analyses, with a clear distinction made between studies aimed at estimating economic impacts and others aimed at evaluating the economic value of transportation investments
- Different approaches that are used for estimating economic impacts
- Procedures for evaluating the value of economic impacts
- Other key analytical considerations for accurately analyzing economic impacts
- Concluding remarks

3.1 PURPOSE OF ECONOMIC IMPACT ANALYSIS

The key purpose of conducting an analysis is to analyze the full range of potential economic implications that could occur from a proposed set of transportation investments. The choice of the analysis method for analyzing the economic effects of a proposed transportation project on a region or the nation should be based on an understanding of the purpose of transportation investment. Historically transportation projects have been undertaken with the following motivations (Weisbrod 2008, Levinson 2013):

- Enable new trade between locations
- Reduce travel times and costs
- Reduce uncertainty and risk, diminishing loss and improving reliability
- Expand markets and allow economies of scale in production and distribution
- Increase productivity from increased access to a variety of resources

Analyzing the potential impacts on a region from a specific transportation project depends to an extent on the issues that the project is designed to address, including its size and complexity. This dependence will influence the types of procedures or tools used for analyzing the project's potential contribution. For some transportation projects, the monetary returns to businesses and households from changes in travel time, expenses, risk costs, and reliability of scheduling will be included in the analysis. Additionally, business factors associated with costs, such as the ability to schedule travel time and arrival times that minimize costs as well as reduce spoilage or loss rates, will be important factors to consider. If these business factors are included, then a set of additional factors related to the effect of economic changes to the region's industrial structure caused by changes in market accessibility must be added to the analyses. These factors may include: improved access to industrial inputs; access to intermodal facilities; cargo capacities; and hourly, daily, and seasonal variations that will result from the completion of the proposed transportation project. For a large transportation project or set of projects, the impacts that are likely to result from the agglomeration effects associated with dynamic changes in the region's industrial structure will also need to be considered.

The analysis of significant transportation projects should also address the project's impact on the region's overall cost competitiveness. This analysis should be in terms of the improvement to the region's long-term economic efficiency through the changes to reliability of the transportation network and the impact on the region due to the changes in household well-being. The changes in household well-being could include costs savings that result from improved transportation options that reduce the need to own and operate motor vehicles, including reduced parking costs.

3.2 ESTIMATING AND EVALUATING ECONOMIC IMPACTS OF TRANSPORTATION INVESTMENTS

Economic impact analyses often have two key motivations: 1) to "estimate" economic impacts; and 2) to "evaluate" the value of economic impacts. These motivations appear related and the analysis types have been used interchangeably in literature. However, as previously noted, there is a very subtle but important difference that has implications for the method selected and the type of analysis conducted (Weisbrod 2000, Kockelman et al. 2013, US Department of Transportation [USDOT] 2003).

An analysis that is conducted to estimate economic impacts is limited to quantifying the changes in the region as measured by the change in economic indicators due to a transportation investment. While the estimate of economic impacts may take into account both positive and negative effects, these effects are related to the overall change on the economy. Comparatively, an economic analysis that evaluates the impact of a transportation project considers a full range of benefits that

result from the investment and compares them with the costs of the transportation project from the perspective of the government, public agency, or organizations considering the activity.

A variety of methodologies with varying levels of sophistication are used for the purpose of estimating the economic impacts of transportation investments (refer to Section 3.3). These studies are often referred to as an Economic Impact Analysis (EIA). Additionally, a common approach that is used to evaluate the value of transportation investments is Benefit-Cost Analysis (BCA), also referred to as Cost-Benefit Analysis (refer to Section 3.4.).

There are some common factors used in both analyses (see Table 3.1.). BCA that is used to evaluate economic impacts of transportation investments is traditionally limited to direct effects, whereas EIA that is used to estimate economic impacts considers not only the direct effects, but also the indirect and induced (including tertiary and perpetuity; see Section 2.1) impacts of transportation investments. There are a number of reasons for only including direct impacts in analysis that are used to evaluate transportation investments:

- It is assumed that the indirect, and induced (including tertiary, and perpetuity) impacts are different manifestations of the direct effects and need not be considered independently. According to the Economic Analysis Primer of the USDOT, “economists generally hold that the direct benefits and costs of transportation improvements measured using BCA are converted into wider, indirect, economic impacts through the operation of the marketplace. These converted, indirect effects are assumed to have the same net monetary value as the BCA-measured direct effects” (USDOT 2003). However, recent literature on benefits to include in a BCA posits that there are other positive net benefits from the broader- and longer-term effects of transportation investments beyond the direct effects. These effects occur due to the induced economic processes, which are not accounted for by just using the direct benefits. Therefore, it is recommended that BCA applications that are conducted with the full range of benefits will avoid underestimating the potential benefits of transportation investments (Vickerman 2007).
- The factors considered in evaluating economic impacts are limited also because of measurement issues (See Section 2.5.1), especially regarding indirect, tertiary and perpetuity impacts (Weisbrod 2000, Kockelman et al. 2013).

TABLE 3.1: FACTORS TYPICALLY CONSIDERED IN BCA AND EIA
 (ADAPTED FROM DRT 2009, KOCKELMAN ET AL., 2013)

Form of Impact	Counted in BCA	Counted in EIA
Business cost savings	Yes	Yes
Business-related and household out-of-pocket cost savings	Yes	Yes
Personal and household out-of-pocket cost savings	Yes	Yes
Personal and household time savings that do not result in actual out-of-pocket costs	Yes	No
Other benefits that do not result in an actual economic transaction	Yes	No
Attraction (relocation) of business activity into the area	No	Yes
Income generated by off-highway businesses and their suppliers	No	Yes

Economic impact analyses conducted with each of the two referenced motivations have a different but important role in justifying the need for transportation investments.

- BCA provides an objective approach to selecting alternatives that provide the most return on the transportation investment.
- EIA is used to estimate regional changes on economic indicators, such as productivity, employment patterns, personal income, business sales, tourism, and to some extent industry locational patterns. Further, EIA can disaggregate the positive and negative impacts in the presentation of the full impacts of the transportation project to different decision makers, stakeholders, and project proponents (USDOT 2003, Weisbrod 2010).

3.3 METHODOLOGIES FOR ESTIMATING ECONOMIC IMPACTS OF TRANSPORTATION INVESTMENTS

Weisbrod (2000) identifies a number of analytical techniques and modeling approaches utilized by transportation agencies to estimate the economic impacts of transportation investments. The analysis method selected depends on the purpose of the analysis, scope of the project, complexity of economic impacts that need to be captured, and the scale of the investment (Weisbrod 2000, USDOT 2003). The analysis approaches vary in their complexity, sophistication, and economic rigor from simple surveys and interviews, to market studies, to case study approaches, to regional economic models and, hybrid models (Weisbrod 2000, Sinha and Labi 2007). Table 3.2 provides an overview of the features of various analysis approaches used for the estimation of economic impacts. This table also provides implementations of the different features. The approaches listed above differ in the combination of feature implementations; this subsequently influences their capability, functionality, and applicability for estimating economic impacts. For example, with regard to the economic theory on which the approaches are based, surveys are empirical in nature, whereas the regional economic models are founded on economic theory.

Regional economic models (REMs) are by far the most comprehensive and commonly used approach for estimating economic impacts of large-scale transportation investments. REMs have been used by various transportation agencies in the United States and elsewhere to support investments, to satisfy requirements of a regulatory review, to educate the public on the impacts of transportation investments, and to evaluate the post-project impact of transportation investments (Weisbrod 2000).

As noted in Chapter 1, the main emphasis of this study is to analyze the economic impacts of large-scale transportation investments and understand the implications of these investment decisions on the economic activity in a region, state and nation. Therefore, the review of analysis methods in this section will focus on REMs that are appropriate for such analysis. In most REM implementations, the following three methodologies are widely used (Weisbrod 1997, Weisbrod 2000, Charney and Vest 2003, Wells 2012, Kockelman et al. 2013):

- Input-Output (IO) models
- Computable General Equilibrium (CGE) models
- Econometric models

The discussion of these modeling approaches in the following sections is limited to a high-level overview. The references in this chapter are recommended for a more detailed description of the modeling approaches, theoretical underpinnings, and the mathematical formulations.

TABLE 3.2: FEATURES OF MODELS FOR ESTIMATING ECONOMIC IMPACTS
 (ADAPTED FROM KOCKELMAN ET AL.; 2013)

Feature	Types of Implementation
Economic Principles	Theoretical: Tests theories and uses simulated data <i>Or</i> Empirical (Applied): Uses real-world data to solve real-world problems
Methodology	Microeconomic: Study of individual businesses and industries at the disaggregated level <i>Or</i> Macroeconomic: Study of interactions of economic entities at the aggregate level
Ability to Capture Temporal Dynamics	Static: One time period <i>Or</i> Dynamic: Multiple time periods, with future periods affected by previous periods
Applicability for Forecasting	Myopic: Multiple time periods solved one at a time, thus not allowing economic behavior that can look ahead into the future <i>Or</i> Forward-Looking: Multiple time periods are solved for, simultaneously allowing economic behavior to consider future changes
Variability	Deterministic: Predetermined equations with values fixed and no error terms <i>Or</i> Stochastic: Equations with uncertain parameters and calibrated error terms
Model Application	Calibrated: Equation parameters selected based on limited data and judgment <i>Or</i> Estimated: Statistical methods used to estimate parameters with standard derivations for equations
Framework	Integrated: Predictive system consists of multiple model equations applied simultaneously with feedbacks <i>Or</i> Sequential: System consists of separate sub-models

3.3.1 IO Models

3.3.1.1 BACKGROUND

The origins of IO modeling can be traced back to the seminal work of Wassily Leontief (Leontief 1951), who was awarded the Nobel Prize for his contribution to the field of input-output economics in 1973 (Sargento 2009). IO models are primarily used to study and estimate the impacts from a change to the activity of one sector on other sectors in the regional economy and to model the flow of transactions across economies throughout the world. This is achieved by representing the flow of goods and services across the different sectors and subsequently the consumption of outputs by the world. Specifically, as Sargento points out, the input-output transaction table created provides a snapshot of “*estimates of an important set of macroeconomic aggregates (production, demand components, value added, and trade flows) and disaggregates them among the different industries and products*” (Sargento 2008). The IO model is not only capable of capturing the impacts of changing inputs (e.g., government investments, household expenditures, and business investment), but is also applicable for studying the impacts of changing supply (e.g., a transportation improvement reducing the cost of operations for businesses and subsequently allowing for increased business spending) (Kockelman et al. 2013).

Initially, IO modeling was developed for analyzing national economies and for studying the flow of goods and services across nations. However, growing interest in estimating economic impacts at a much more disaggregated spatial scale (e.g., states, regions, and counties) led to the development of regional IO models. The different regional IO model implementations vary in their treatment of the following key considerations: 1) the number of regions; 2) specification of the interregional linkages; 3) detail of industry and sectors; and 4) trade coefficients (Sargento 2008).

3.3.1.2 METHODOLOGY

A transaction table forms the basis of IO modeling (Kockelman et al. 2013, Horowitz and Planting 2009). As noted, the table consists of a detailed snapshot of the transactions (flow of goods and services) between producers and consumers. The table also lists the demand for the goods and services for consumption by the outside world (Horowitz and Planting, 2009).

Table 3.3 provides an example of a transaction table, also referred to as a “use table.” Transactions are represented by cells in the table, and they show the value of different commodities consumed by the various industries and final users in the outside world. A row in the transaction table represents commodities used in production and the columns represent the consumers, including industries and final users. The table also includes rows representing three components of value-added by industry, including employee compensation, taxes generated and operating surplus or profits. Further, the table includes two subtotal rows:

1. The *Total Value Added* row represents the Gross Domestic Product (GDP) from an industry and is equal to the sum of the three components of value added.
2. The *Total Intermediate* row represents the sum of commodities consumed as intermediates by the different industries to produce goods and services for eventual consumption.

The overall row total (*Total Industry Output*) represents the commodity’s output and the overall column total (*Total Commodity*) represents the total output by industry.

The transactions in the table can be classified into these three major categories (Horowitz and Planting 2009).

- **Intermediate Transactions** represent the flow of goods and services (transactions) between industries for the production of commodities (highlighted in gray).
- **Final Transactions** represent the flow of goods and services between industries that produce the commodities and the end users. A cell in the final transaction section (Final Uses (GDP) represents the amount expended by the end users to consume the commodity. There are six categories of final transactions: 1) personal consumption expenditures; 2) private fixed investments; 3) change in private inventories; 4) exports of goods and services; 5) import of goods and services; and 6) government consumption expenditures and gross. The six final use transaction categories together comprise the Gross Domestic Product (GDP).
- **Value-Added Transactions** represent the transactions adding up to the Gross Domestic Income (GDI) of an economy. The table includes three main types of transactions: 1) compensation of employees; 2) taxes on production and imports less subsidies; and 3) gross operating surplus. Note that the GDP and GDI across industries should generate the same value.

After a transaction table is built, an IO model can be used to conduct two types of analysis.

- The model can study the effects of changes to final use components. For example, a transportation improvement can lead to additional retail revenues due to personal consumption expenditures shifting from travel costs. It could also lead to increases in private fixed investments due to a reduction in business operating costs. Once these estimates are determined, the IO model can be applied to study the impacts of changes in final demand on the economy. The net change from the initial activity to the total impact is estimated using multipliers.
- IO models can be used to understand the economic activity in different sectors that is required to meet the demands (goods and services) of one sector. For example, how much output (goods and services) should be produced by the different sectors to produce a certain number of cars by the automotive industry?

Typically, multipliers are estimated and then applied to understand the impact of changes in final demand or to obtain the output requirement to meet a certain demand of an industry. As defined in Chapter 2, the sum of all effects provides the total impact of the transportation investment on the economic activity in a region. The ratio of total impact to the direct impact is referred to as the economic multiplier (Weisbrod 2000)

ANALYZING THE ECONOMIC IMPACTS OF TRANSPORTATION PROJECTS
 METHODOLOGIES FOR CONDUCTING
 ECONOMIC IMPACT ANALYSES OF TRANSPORTATION INVESTMENTS

TABLE 3.3: USE PORTION OF THE TRANSACTION TABLE SHOWING THE COMMODITIES
 CONSUMED BY INDUSTRIES (ADAPTED FROM HOROWITZ AND PLANTING, 2009)

		Total Final Uses (GDP)		Total Intermediate		Industries		Total Commodity	
Commodities	Agriculture, forestry, fishing, and hunting								
	Mineral products								
	Utilities								
	Construction								
	Manufacturing								
	Wholesale trade								
	Retail trade								
	Transportation and warehousing								
	Information								
	Finance, insurance, real estate, rental and leasing								
	Professional and business services								
	Educational services, health care, and social assistance								
	Arts, entertainment, recreation, accommodation, and food services								
	Other services, except government								
	Government								
	Other								
	Scrap, used, second-hand goods								
	Total intermediate								
	Value Added								
	Compensation of employees								
Taxes on production and imports, less subsidies									
Gross operating surplus									
Total Value Added									
Total Industry Output									

Figure 3.1 shows the steps involved in conducting the two types of analysis using an IO model. The IO analysis begins with the setting up of a set of linear equations that represent the flow of goods and services across sectors as shown in the “Input-Output Analysis” block of the figure.

- Y represents the vector of outputs by industry to be produced.
- I is an identity matrix.
- A is a matrix of IO technical coefficients.
- X represents the vector of output by sector needed to produce the demand of outputs as indicated in Y .

The matrix of technical coefficients is derived from the transactions table. The $(I-A)^{-1}$ matrix is also referred to as the Leontief inverse matrix and forms the basis for all types of analysis using an IO model. The Leontief inverse matrix multiplied by the demand vector Y produces the demand by industry needed to satisfy the demand Y . The same inverse matrix can also be utilized to produce the multipliers, which can then be used to estimate the total output across sectors and to estimate the change in final transactions across sectors caused in response to change in final transactions in a particular sector.

As noted earlier, IO models were initially designed to study national economies and the approach was later applied to study regional economies. The large amount of data required to develop IO models was a primary reason for the slow progress in applying the methodology to the study of regional economies. Five main data items must be available to successfully run the model at any geographic level:

- Sales by industries to all other industries domestically
- Imports by industry in the nation
- Exports by industry to other nations
- Consumption patterns of households
- Consumption behaviors of governments

Additionally, the level of industry disaggregation can greatly increase the data requirements. While data at the national level for imports and exports are often readily available, even at the industry level the inter-industry sales flows are difficult to obtain. Likewise, although consumption patterns of goods and services by households may be easy to obtain, an increase in the detailed use of these goods and services (commodities) disaggregated by industry may require significant survey work and estimation procedures. The challenges for successfully building an IO model are exaggerated further when moving from a national to a regional IO Model, as available data for successfully specifying and running a regional IO model may be difficult to acquire. (Charney and Vest 2003)

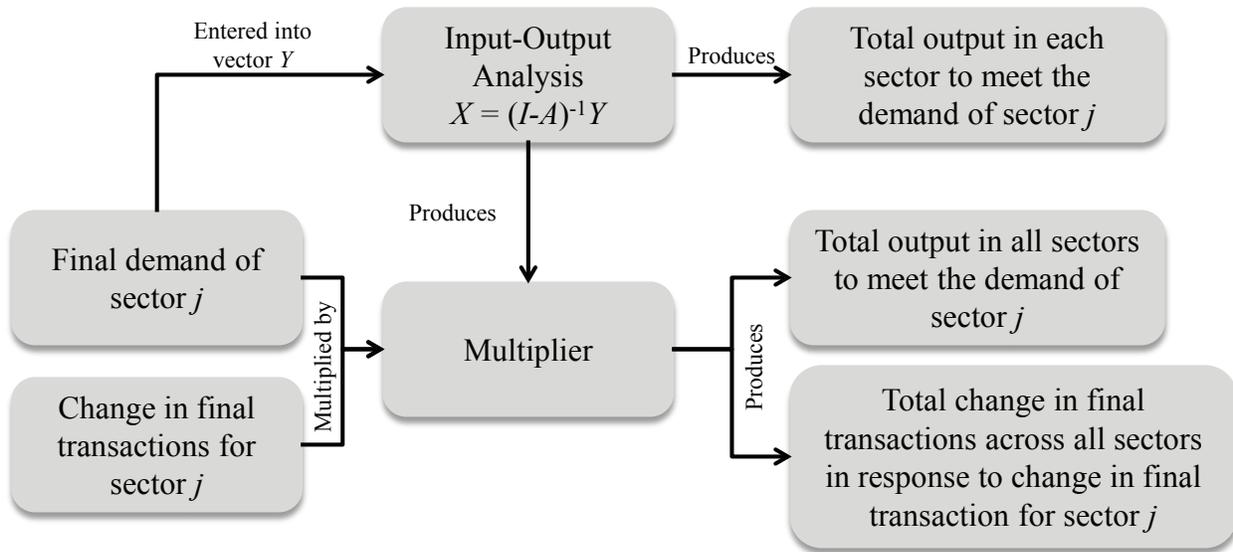


FIGURE 3.1: FRAMEWORK FOR ESTIMATING THE ECONOMIC IMPACTS USING AN INPUT-OUTPUT MODEL (ADAPTED FROM KOCKELMAN ET AL. 2013)

3.3.1.3 LIMITATIONS

The IO approach is widely used to estimate the economic activity resulting from changes to the status quo. The methodology uses the linkages between industries to capture the changes in the economic activity across the different industry sectors. However, some key limitations include (Kockelman et al. 2013, Fatemi 2013):

- IO analysis assumes constant returns to scale, i.e., if inputs required to produce goods by an industry are all increased by a certain proportion, then the outputs produced by the industry will also increase by the same proportion. However, this assumption is not true in the real world where industries exhibit increasing or decreasing returns to scale.
- IO analysis also does not incorporate financial markets and monetary policy information and as a result cannot include conditions in the economy that affect economic activity. For example, this type of analysis does not recognize the influence of government policies, interest rates, and taxes.
- IO models also make assumptions about the input goods that are required to produce products. The approach assumes the presence of unlimited resources of raw goods. Further, the raw goods are assumed to be at a constant price, which fails to recognize the impact of growing and falling demand on the prices of raw goods.

3.3.2 Computable General Equilibrium Models

3.3.2.1 BACKGROUND

The CGE models build on the IO approach developed by Wassily Leontief, addressing its limitations by including constant returns to scale, knowledge about markets, and pricing. CGE

models are large systems of simultaneous equations that are typically more complex than the IO model. In the field of economics, these models are often referred to as black boxes based on their complexity (Wing 2004). The basis of any CGE model is the households, firms, and governments (known as players), their actions, and the market conditions leading to economic activity.

Figure 3.2 shows the circular flow of payments, goods and services between different players and the markets of an economy. The different players and their markets are interconnected and act simultaneously to create equilibrium conditions, while seeking their individual objectives. These objectives may include firms seeking profit maximization, households maximizing utility, and governments supporting economic activity and/or economic development, among others. The *dashed lines* in the figure represent the flow of payments and the *solid lines* represent the flow of goods and services. (Kockelman et al. 2013, Wing 2004, Bess and Ambargis 2011)

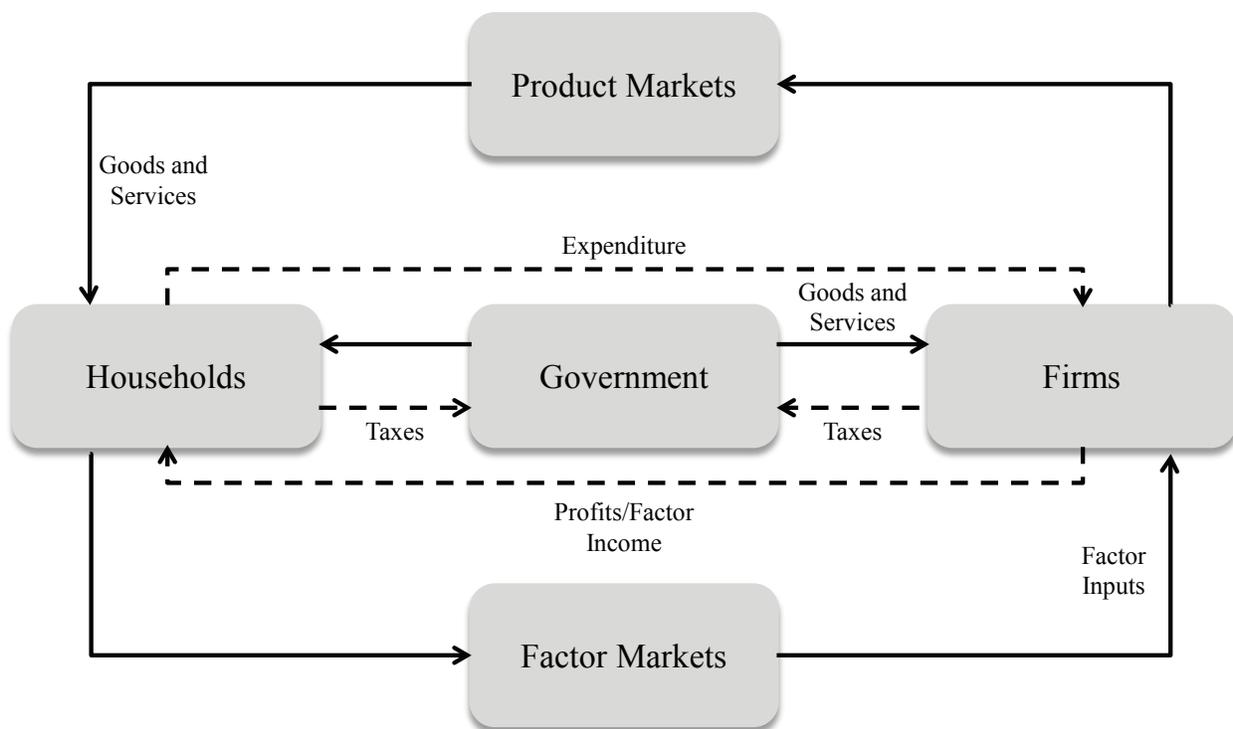


FIGURE 3.2: CIRCULAR FLOWS IN THE CGE MODEL (ADAPTED FROM WING 2004)

The equilibrium concept of the model enables the following two key properties that ensure accountability of the different players and consistency of their actions:

1. Conservation of product ensures that there is a balance between the production and consumption of commodities.
2. Conservation of value ensures that there is a balance between all expenses and incomes.

The conservation properties have some important implications and comprise an accurate representation of a real-world economy and economic activity by ensuring that *“neither product nor value can appear out of nowhere: each activity’s production or endowment must be matched by others’ uses, and each activity’s income must be balanced by others’ expenditures”* (Wing 2004). The

general equilibrium feature of the model ensures that the interactions across all players and markets are represented accurately. To a lesser degree, the partial-equilibrium model only includes the interactions across a subset of players and markets where the information and actions of the excluded players and markets are assumed to be constant (Kockelman et al. 2013). CGE models can be further classified into static and dynamic equilibrium models based on their ability to capture the temporal dimension of economic activity.

3.3.2.2 METHODOLOGY

A CGE model has two components. The first component is an accounting matrix that represents the interdependencies of the different players and the circular flow of actions, which subsequently leads to economic activity. For example, the use matrix, such as the one shown in Table 3.3, is a sample of an accounting matrix used in most CGE modeling. The use matrix is also referred to as Social Accounting Matrix (SAM). The second component is a set of equations that represent the economic theory that defines the economic objectives of various players and describes the economic actions of the players in achieving their objectives.

There are three widely recognized theoretical formulations of general equilibrium:

1. Walras general equilibrium
2. Arrow-Debreu general equilibrium
3. Macroeconomic equilibrium.

The Walras and Arrow-Debreu formulations take a bottom-up approach to defining equilibrium, whereas the Macroeconomic formulation takes a top-down approach. The economy according to the Walras general equilibrium formulation is a competitive one with prices derived from firms trying to maximize profits, individuals attempting to maximize their utility subject to budget constraints, and markets clearing goods. The Arrow-Debreu formulation builds on the Walras's general equilibrium by proving the existence of the economy as proposed by Walras and establishing the conditions at which the Walras economy will exist. The Macroeconomic equilibrium approach to CGE is based on the balancing of the different parameters of the economy, including investment, savings, government spending, taxes, imports, and exports. (Mamuneas and Nadiri 2006, Kockelman et al. 2013)

The basis of the CGE model is the overlay of the accounting matrix with the system of equations that define that economic theory for firm and household behaviors. As with IO models, CGE models are designed to estimate the effects on an economy from a change in prices or a modification of the demand for goods in an industry across multiple sectors. Typically, a base case equilibrium that establishes prices and levels of economic activity across markets is estimated initially for the region using the model. A perturbation to the region's economy is then applied and the model estimates a scenario in which some of the prices and/or demand for goods in a target industry or industries have been exogenously specified. The model then estimates a new equilibrium for the economy under the scenario of interest. Prices and levels of activity derived by the new scenario can then be compared against the base case values to evaluate an impact on the economy from a new scenario.

CGE models that incorporate temporal dynamics can ensure that *"consumers maximize their lifelong utility, subject to a lifetime inter-temporal budget constraint that equalizes the present value of consumer*

income and expenditure,” while accurately capturing the tradeoffs between *“consumption today and consumption over their lifetimes.”* Further, CGE models also capture the temporal dynamics of the investment decisions of the different players. For example, *“households may choose to invest today so they can make bequests to their children in the future.”* CGE models that capture temporal dynamics are appropriate for forecasting, as well as for conducting impact studies. (Wing 2004)

A CGE model requires more data items such as property, plant, and equipment, quantity and prices, than the IO model, which results in CGE models having a more aggregate industry classification structure. The limited number of industry sectors in the CGE approach therefore reduces the need for specifying the numeric values of the different parameters in a model’s formulation, but diminishes the overall accuracy and usefulness of the model.

3.3.2.3 LIMITATIONS

The CGE approach overcomes some of the limitations of the IO model, including: 1) constant returns to scale; 2) limited information about market conditions; and 3) price responses due to changing demand for the inputs and for final products. However, there are a number of limitations, including the following (Charney and Vest 2003, Kockelman et al. 2013):

- The theoretical foundations that represent the objectives of the different players and their economic activity are unclear and there is debate about the best formulation for specifying this activity.
- The industry classification used in CGE models is often coarser than that used for IO models due to data limitations and the need for specifying additional parameters.
- Parameterizing and calibrating the CGE model requires a number of assumptions that could affect the sensitivity and validity of the results.

3.3.3 *Econometric Models*

3.3.3.1 BACKGROUND

The IO and CGE are the most commonly used approaches in regional economic models. An econometric approach is another way to model the regional economy. This approach also uses a system of equations to represent the various processes characterizing an economy. The econometric approach utilizes regression analysis with a variety of estimation routines on cross-sectional and time series data to estimate parameters in the model formulation. The main difference from the other two approaches to regional economic modeling is the type of data needed and the estimation methods utilized in the framework. Further, limitations of the econometric approach, as compared to the IO and CGE approaches, include the following:

- Econometric model formulation does not always ensure consistency in the economic activity (i.e., sum of production is equal to the sum of consumption and budgetary balance).
- General equilibrium principles in a CGE approach used to represent the objectives and actions of the different players, including firms, households, and governments among others, are not easily included in the econometric models. (Bellu and Pansini 2009, Charney and Vest 2003)

Econometric models can take various shapes and forms depending on the detail of the processes represented in the analysis. Some implementations of econometric models incorporate IO models in their structure. In fact, Charney and Vest (2003) note that there is *“little difference between a detailed econometric model designed for impact analysis and a CGE model in which every parameter is estimated econometrically.”*

Econometric models typically use information from a large number of regions over time or from the specific region being studied, and provide parameters that can be used to estimate what would happen to the economy of the region once a set of proposed changes are implemented in the region. Thus, in effect the model observes what happens when similar changes have happened across a wide spectrum of data that incorporate information from a large number of measures, and estimates the impact on the region from a specified activity of a given size. Therefore, econometric models are suited for forecasting (i.e., economic effects into the future) because of the type of data used to estimate the model parameters in the framework.

3.3.3.2 LIMITATIONS

The econometric framework for modeling regional economies includes the following limitations (Bellu and Pansini 2009, Charney and Vest 2003):

- Typically, the structure of the framework does not allow for modeling the flow of goods and services across industries and sectors, which is a main feature of the IO and CGE approach to modeling the economy.
- The framework is better suited for forecasting macro-level effects and not for modeling micro-level impacts. However, the econometric model frameworks can take any structure, with its detail enhanced based on needs.
- A misspecified model may lead to incorrect inferences. For example, if unique features of the region being studied are not specified in the model, then the results may not be accurate.

3.4 METHODOLOGIES FOR EVALUATING ECONOMIC IMPACTS OF TRANSPORTATION INVESTMENTS

The focus of this section is on methodologies that are used to evaluate transportation investments by capturing the value of the costs and benefits. Based on the definition of the “value” of transportation investment, several methodologies have been defined in literature as follows:

- *BCA*: This methodology is used to evaluate alternative transportation initiatives and/or alternatives within an initiative by comparing the monetized values of the full range of benefits against associated costs. BCA is typically used when evaluating program(s) to determine their value (i.e., benefits outweigh costs) to society at large. Further, this approach can be implemented to compare multiple projects by first identifying the projects that offer a positive return and then selecting the project that offers the highest return on the investment cost. (USDOT 2003, HM Treasury 2011, Kockelman 2013, Mason 2010)
- *Cost-effectiveness Analysis (CEA)*: Similar to BCA, CEA also evaluates transportation projects and/or compares alternatives by comparing the full range of benefits against

the associated costs. However, there are two key differences between BCA and CEA. First, benefits are not monetized in CEA and typically measures of cost associated with a unit of one type of benefit are generated for comparative analysis. Second, in CEAs the measures generated are often limited to a primary benefit from the transportation project, although separate CEA benefit measures can be generated for each of the benefits associated with a transportation project.

However, the CEA measure used in the analysis accounts for only a single benefit at a time and it does not comprehensively account for the full range of benefits associated with a transportation project, unlike the BCA, which comprehensively considers the full range of benefits. Typically, CEA is applied when a program is known to offer a positive value to the society and a choice needs to be made among many competing alternatives. (Cellini and Kee 2010, Mason 2010).

- *Cost-utility Analysis (CUA)*: The cost-utility analysis is a specific type of CEA wherein benefits are expressed in terms of change to the years of life of beneficiaries. This type of analysis generally is conducted for evaluating policies with one of the primary benefits related to enhancing health and promoting longevity. (WHO 2003, Mason 2010)
- *Life-cycle Cost Analysis (LCCA)*: This type of analysis can be used to identify the lowest cost alternative for a transportation investment under consideration by applying a discount rate to the full range of costs incurred by implementation of the alternative. This approach assumes that the benefits associated with the different alternatives are identical (USDOT 2003). LCCA cannot be used on its own to analyze the value of a transportation initiative. It is generally applied once a decision to invest in a transportation initiative is made to identify the lowest cost alternative and best staging plan to build the project.

The methodology selected for evaluating the economic impacts of transportation investments will depend, in part, on the stage in the transportation planning process the project is in and the key questions that need to be addressed.

The BCA methodology is the focus for evaluating transportation investments, as the other methodologies identified are special cases of a BCA, with differences being in the consideration of benefits (i.e., definition and enumeration) and in assumptions made about quantifying the benefits. For example:

- Cost-effectiveness analysis considers a benefit at a time without monetizing the benefit.
- Cost-utility analysis is a special case of a cost-effectiveness analysis and is mostly applied to analyze health-related policies where the primary benefit is a change in years of life.
- Life-cycle cost analysis is a special case of a BCA where the benefits associated with different projects and/or alternatives are the same.

3.4.1 *Benefit-Cost Analysis*

3.4.1.1 BACKGROUND

The use of BCA for evaluating economic impacts in the United States dates back to the 1930s during the great economic depression when the approach was used to evaluate public works programs (Boardman, et.al, 2006, Hufschmidt 2000). Currently, this approach is used across various disciplines with different objectives. Both developed and developing nations utilize it to evaluate projects, programs, initiatives and public policies to spur economic activity and promote economic development. In the transportation field, BCA has been used to study the economic impacts of transportation projects to answer the following questions, such as:

- Should an investment be made in a certain transportation project or initiative?
- Which transportation projects and initiatives should be implemented given limited resources?
- What should be the timeline for implementing a project and staging the various project tasks?

BCA is an objective-based framework that is used to evaluate transportation projects. This approach is used to consider the full range of benefits and costs associated with a project or initiative to the society at large. Benefits are monetized to present day values by applying discount rates and compared against costs, which also are converted to present day values. BCA can be used to evaluate different transportation projects and to compare various alternatives for a given project. BCA also has the functionality to capture the timing of various tasks and events in the life cycle of a project. As a result, measures from a BCA analysis can be utilized to program (establish the timeline for implementation) projects that offer the most economic value. Additionally, for a given project, BCA provides a systematic approach to identify staging plans for the various tasks of the project such that the plans are economically effective.

The BCA approach is also referred to as the cost-benefit analysis (CBA). The difference between the two is in the measure that results from the analyses; BCA provides a “bang for buck” type measure and CBA provides a “buck per bang” type measure (Mason 2010). However, the usage of the measure and the eventual decision making process remains the same irrespective of the variant of benefit-cost analysis that is used. In comparing benefits to costs, the following measures are widely used (USDOT 2003):

- *Net present value (NPV)*: This measure is defined as the difference in the benefits and costs discounted (by the cost of money) to present day values. This measure yields a positive value if the stream of benefits outweighs the stream of costs over the specified time frame, and a negative value if the costs associated with a project are higher than the potential benefits.
- *Benefit-cost ratio (BCR)*: This measure is defined as the ratio of the benefits and costs discounted to present day values. A BCR value of greater than one indicates that the project benefits outweigh the project costs, and a value less than one indicates that the potential project benefits are smaller than the project costs and that the project may not offer any positive value.

When comparing multiple projects, a project that yields the highest BCR is selected when the projects are not mutually exclusive. However, if the projects are mutually exclusive, then an incremental BCA should be conducted (Kockelman 2013). When utilizing the NPV to compare projects, a project that yields the highest NPV offers the greatest economic impact. However, it may not always be the selected alternative, as other factors are considered in the final selection of an alternative such as political climate, funding and financing availability, and potential risk. BCA provides measures of economic value, while a number of other value-type considerations can inform the final selection of a transportation project, including financial, environmental, social, and welfare value.

3.4.1.2 METHODOLOGY

Table 3.4 lists the steps involved in a BCA as depicted by three different references on the topic.

Cost-Benefit Analysis: Concepts and Practice <i>(Adapted from Boardman et al. 2006)</i>	Economic Analysis Primer <i>(Adapted from USDOT 2003)</i>	The Economics of Transportation Systems: A Reference for Practitioners <i>(Adapted from Kockelman et al. 2013)</i>
<ol style="list-style-type: none"> 1. Specify the set of alternative projects 2. Decide whose benefits and costs count 3. Identify the impact categories, catalogue them, and select measurement indicators 4. Predict the impacts quantitatively over the life of the project 5. Monetize all impacts 6. Discount benefits and costs to obtain present values 7. Compute the net present value of each alternative 8. Perform sensitivity analysis 9. Make a recommendation 	<ol style="list-style-type: none"> 1. Establish objectives 2. Identify constraints and specify assumptions 3. Define base case and identify alternatives 4. Set analysis period 5. Define the level of effort for screening alternatives 6. Analyze traffic effects 7. Estimate benefits and costs relative to base case 8. Evaluate risk 9. Compare net benefits and rank alternatives 10. Make recommendations 	<ol style="list-style-type: none"> 1. Identify project needs 2. Identify project constraints 3. Define the base case 4. Identify alternatives 5. Define a time period 6. Define work scope 7. Analyze alternative traffic effects 8. Estimate benefits and costs 9. Evaluate risk 10. Conduct sensitivity analysis 11. Find benefit/cost ratio

TABLE 3.4: TYPICAL STEPS INVOLVED IN A BENEFIT-COST ANALYSIS

The steps from the first reference are more generic and can be used to evaluate programs, policies, projects and initiatives across any domain. The latter two sources list steps that are more specific to evaluating transportation projects and alternatives. While there are differences in approaches, the BCA process can be summarized in the following five steps:

1. **Defining the Problem:** Identify project objectives, enumerate the project alternatives and establish the assumptions and constraints. It is also important to identify the base case (or a no investment scenario) against which the comparisons will be made in assessing the net benefits and costs of the project alternatives.
2. **Identifying the Benefits and Costs:** Identify the full range of benefits and costs metrics and define the timeline from inception to build-out of the project or alternative projects and the baseline.
3. **Quantifying the Benefits and Costs:** Monetize the benefits for each of the alternative projects using appropriate procedures and analytical tools and convert the benefits and costs into present day values, while recognizing the project timeline and timing of benefits and costs.
4. **Comparing the Benefits and Costs:** Compute the NPV and the BCR that compares the benefits and costs for each project alternative and rank the alternatives. Another key consideration in comparing alternatives is to acknowledge the uncertainty associated with the benefits and evaluate the risk. An extension of BCA would be a sensitivity analysis. This type of analysis is useful in dealing with uncertainty by identifying the contribution of benefit and cost items and making appropriate selection and programming decisions.
5. **Recommending a Project:** In the last step, information from the analysis is used to make a recommendation for further analysis or for final decision making.

Although a BCA may seem to be unbiased, differing results can be obtained based on the analyst's choices in classifying and enumerating the costs and benefits within the model. In the context of conducting a BCA, Boardman et al. (2006) identified three types of individuals with differing views of what constitute benefits and costs:

- Analysts hold a view of benefits and costs in a BCA true to its definition by considering the full range of benefits and costs and taking a very wide societal view in the evaluation of project alternatives.
- Guardians are individuals with a budgetary orientation who view benefits and costs from a revenue standpoint, with benefits as revenue inflows to their budget and cost as a revenue outflow. Such a viewpoint of benefits and costs will potentially lead to ignoring the non-revenue based societal benefits of alternative projects. For example, guardians may ignore the potential for time savings from a transportation improvement project and may fail to include the potential cost savings from improved safety conditions in the benefits calculation. Additionally, costs associated with a right-of-way may be ignored if the land is owned by the government. Thus, guardians are likely to underestimate the benefits or exaggerate the costs of transportation investments.

- Spenders are individuals who invest in public policies, programs and initiatives to promote welfare, create jobs, and improve the quality of life. Spenders view the positive impacts derived from the investment and the improvements for constituents that result from implementation of the program as benefits. As a result, spenders will include travel cost savings and cost savings due to safety improvements, along with payments to construction workers in defining the benefits. This approach has the potential for incorrectly favoring capital-intensive projects.

Therefore, the approach taken even in a relatively straightforward BCA for evaluating transportation investments can affect the results and recommendations.

To overcome some of the issues associated with varying points of view, the USDOT’s Economic Analysis Primer provides guidance on the categories of benefits and costs that should be considered in a typical BCA for transportation investments (see Table 3.5). The benefit and cost categories identified are all related to the direct economic impacts of the transportation investment. According to the primer, BCA is limited to only direct economic impacts based on the viewpoint that economists hold that *“the direct benefits and costs of transportation improvements measured using BCA are converted into wider, indirect, economic impacts through the operation of the marketplace. These converted, indirect effects are assumed to have the same net monetary value as the BCA-measured direct effects”* (USDOT 2003). A preference for the more narrow view of benefits in a BCA is partly due to the risk, uncertainty and difficulty associated with estimating the more long-term and downstream indirect and induced economic impacts of transportation investments.

TABLE 3.5: CATEGORIES OF BENEFITS AND COSTS TO INCLUDE IN A BENEFIT-COST ANALYSIS OF TRANSPORTATION INVESTMENTS (ADAPTED FROM USDOT, 2003)

Agency Costs	User Costs/ Benefits Associated with Work Zones	User Costs/ Benefits Associated with Facility Operations	Costs/Benefits Associated with Externalities (<i>nonuser impacts, if applicable</i>)
<ul style="list-style-type: none"> • Design and engineering • Land acquisition • Construction • Reconstruction/rehabilitation • Preservation/routine maintenance • Mitigation (e.g., noise barriers) 	<ul style="list-style-type: none"> • Delay • Crashes • Vehicle operating costs 	<ul style="list-style-type: none"> • Travel time and delay • Crashes • Vehicle operating costs 	<ul style="list-style-type: none"> • Emissions • Noise • Other impacts

However, recent literature on BCA cites empirical evidence on the presence of the indirect and induced economic impacts of transportation investments (Iacono and Levinson 2013). These economic impacts are also termed as wider economic benefits because they are broader in their scope and realized in the longer term, after the build-out of a project. The wider economic benefits also result from agglomeration economies (increases in returns from industry clustering), increased competitiveness, and improved labor supply (DfT 2005, Vickerman 2007). From this perspective, this increase in economic activity also represents net benefits, with the implication that any valid BCA should include them. Thus, a BCA conducted should be inclusive of all impacts resulting from the transportation investment.

3.4.1.3 LIMITATIONS

The following are some limitations of the BCA approach:

- Conducting a BCA is only one of several considerations that contribute to a transportation investment decision. Other considerations in the decision making process for the selection, programming and execution of a transportation investment include financial, political, environmental, social, and welfare impacts and value of the investment in these areas. As Mason (2010) noted in his presentation to the Saskatchewan Chapter of the Canadian Evaluation Society,

“cost-benefit and cost-effectiveness analysis are decision aids; they are not the decision. These methods can help organize and may reveal both hidden benefits and hidden costs, but the outputs from this method must not be the only input into a policy decision. Any decision on a program, policy, or investment will always involve questions of ethics, intrinsic values, political considerations, etc.”
- The monetizing of costs and benefits is not always straightforward, especially the non-revenue based benefits and costs, such as the societal and welfare impacts. The challenge with monetizing also occurs when dealing with a baseline scenario in which there will be a decline in the transportation network quality due to the lack of investment and an increase in costs to all users of the network.
- BCA assumes that the numbers included in the analysis are definite. However, many benefits and costs are often uncertain. This is particularly true for the wider economic benefits that require a confluence of other favorable conditions for the benefits to be realized. Therefore, the analyst must be cautious when the benefits considered are associated with greater uncertainties. A thorough sensitivity analysis can be conducted to ensure that the benefits with greater certainty drive the choice of the alternative.
- In Section 3.4.1.2, different types of assessors of benefits and costs were identified, along with the potential for biases. As noted, the “analysts” hold a very idealistic view of benefits and costs by holding true to the definition of benefits and costs in a BCA. Rarely, if ever, is a BCA conducted by this ideal group of assessors due to a number of reasons including political agendas and personal opinions. More often than not a BCA will be subject to some degree of bias. Therefore, the question is not if there is a bias, but how the bias affects the analysis.

3.5 OTHER CONSIDERATIONS FOR ANALYZING ECONOMIC IMPACTS OF TRANSPORTATION INVESTMENTS

This chapter has provided an overview of methodologies and approaches for estimating economic impacts and for evaluating the value of transportation investment projects. The focus has been on the economic impacts resulting from the transportation investments. However, transportation investments impact a regional economy primarily by affecting accessibility, mobility, connectivity and reliability of the transportation infrastructure. Through direct changes to the transportation infrastructure and its performance, transportation investments indirectly impact the economy by affecting location choices, travel behaviors, and economic transactions of households and businesses.

Changes to economic transactions can be incorporated into an economic model that implements the methods and approaches previously referenced, but the economic model requires that changes in location choices and travel behaviors need to be provided as inputs for modeling the economic impacts associated with the transportation investment. Also, to accurately capture the economic impacts, changes to location choices and travel behaviors need to be accurately specified in the model or the analysis may be inaccurate and inferences will be erroneous.

Land use and transportation models are the analytical tools used for analyzing location choices and travel behavior changes, respectively, in response to a transportation investment. Further, there are complex spatial and temporal interactions between the location choices, travel behaviors and economic transactions to consider. These interactions need to be accounted for through an integration of the economic, land use, and transportation models under a single unifying framework, with appropriate linkages to conduct valid analyses.

In this section, brief overviews of the economic, transportation and land use models are presented. Further, the need for an integrated modeling framework is discussed to capture the linkages across the component model systems (economic model, land use model, transportation model).

3.5.1 Economic Model

The economic model includes the economic transactions of different groups, including households and businesses, in an effort to mimic the economy. The outputs from an economic model include various measures of economic activity. A detailed discussion of the different types of economic models was presented earlier in this chapter. These models can incorporate all aspects of changes in travel behaviors. They are developed in various geographic dimensions to analyze the impacts and can capture the interactions among the economies within a state across counties. With some loss of accuracy due to estimation procedures, models can even be developed that can estimate economic impacts at the zip code level.

3.5.2 Land Use Model

A land use model captures the location choices of various decision makers, including households, businesses, developers and governments. Decision makers and the types of choices they have include

- households: where to live;
- individuals: where to work, go to school/college, among other fixed activity location choices, and where to pursue activities to meet their daily needs;
- businesses: where to locate offices and setup warehouses and facilities;
- developers: development and redevelopment decisions about types of buildings and facilities to construct; and
- governments: zoning policies and land use regulations to meet larger strategic goals of the region.

The location decisions and land use choices of the different decision makers comprise the shape of the regional form and the layout of the built environment that are captured in a land use model. The outputs from a land use model include geographical location choices of decision makers, the land use, and accessibility indices at a fine spatial detail (Waddell 2002, Waddell et al. 2003).

3.5.3 Transportation Model

A transportation model focuses on the travel decisions of households and businesses in a region. The model has two subcomponents:

1. *Travel Demand Model*: This model estimates the demand for travel. The activity-travel patterns of households and businesses in a region are simulated. The outputs include where, when, for how long, with whom, and the mode decisions for household and business trips.
2. *Network Supply Model*: This model uses travel demand and simulates conditions on the transportation network. For each trip, this model identifies the route taken and the movement of vehicles at a fine spatial and temporal resolution. The outputs from this model include traffic conditions on roadway links and transportation accessibility measures.

3.5.4 Linkages Across Economic, Land Use and Transportation Models

In the context of economic impacts of transportation investments, there are three important components, and linkages across these components, of a region and its built environment as follows (See Figure 3.3):

- **The Economy**: the current economy and existing economic conditions influence the type of location choices. The location choices of households and businesses are influenced by economic conditions (i.e., where to locate is affected by wealth available to businesses, and incomes of individuals). For example, additional income may enable individuals to own houses in lieu of renting apartments. The economy also impacts land use of a region by influencing development and redevelopment decisions of developers. These choices by households, businesses and developers in turn affect the type of economic activity by influencing the accessibility that decision makers have with the various markets for housing, goods and services, and final demand expenditures. For example, the location of individuals affects the size of consumer markets and magnitude of

labor pools, which also could affect the productivity, competitiveness, and efficiency of businesses and ultimately the economic activity in a region.

- **Land Use:** the level of accessibility and mobility provided by the existing transportation system may influence location choices. For example, the introduction of a new roadway connector may make an empty parcel of land more conducive for development. The transportation system is also in turn affected by the location choices of the different groups in a region. For example, where households and businesses locate will affect how far individuals travel to access opportunities and how far businesses have to locate or how far they have to travel to provide goods and services.
- **Transportation Network:** transportation conditions and activity-travel patterns influence economic transactions of households and businesses. For example, a congested corridor will increase travel costs for distribution for a business in the transport industry. Economic conditions will in turn affect the amount of travel by individuals to engage in activities. For instance, a vibrant economy with more disposable income will lead to more activity and travel pursuits.

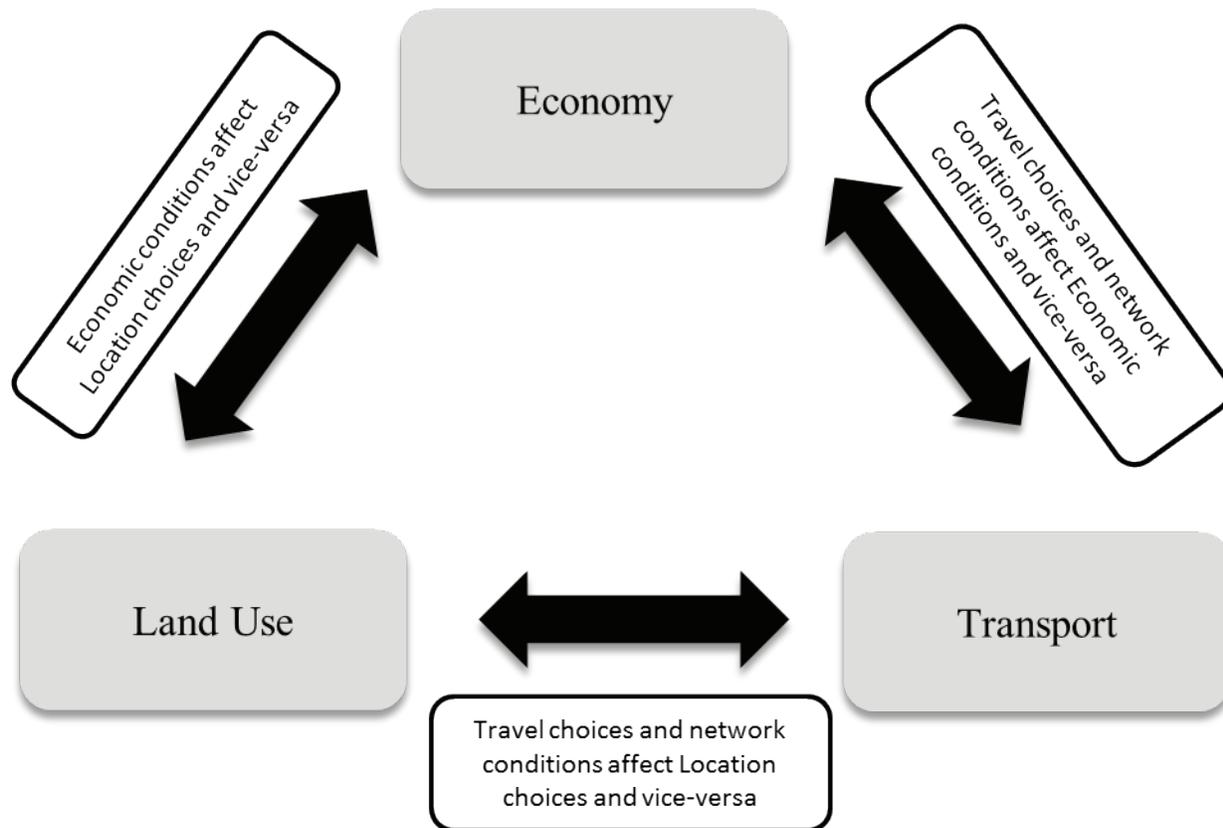


FIGURE 3.3: OVERVIEW OF THE LINKAGES ACROSS ECONOMY, LAND USE AND TRANSPORTATION SYSTEM IN A REGION

As noted, there are important bi-directional linkages between these three dimensions in a region. Therefore, an economic transaction, land use, or transport analysis of a policy or project should not only include the analytical tool selected for the respective choice, but should also

recognize the linkages and capture the cascading impacts so that the analysis conducted is as accurate as possible. This holistic approach to considering the full range of choices is even more important as the focus shifts from capacity-oriented policies to a new transportation planning paradigm that incorporates smarter-growth type concepts and seeks to implement sustainability-type initiatives (Litman 2013), such as

- transportation interaction, transit- and pedestrian-oriented developments;
- zoning restrictions;
- mixed use development incentives;
- implementation of intelligent transportation systems (ITS);
- impacts of a range of travel demand management (TDM) strategies; and
- transportation control measures (TCM), such as variable pricing initiatives, social equity and environmental justice in the context of special populations, transportation and public health (obesity), and the effect of telecommunications on travel behavior (e.g., e-commerce, telecommuting)

These concepts are more behaviorally oriented. Further, the impacts are not limited to just the transportation system. They are realized through complex interactions and cascading impacts across the economy, land use, and transportation systems. Hence, there is a need for a comprehensive set of analytical tools to conduct a valid analysis of the full range of economic impacts from a transportation investment or an entire shift in a transportation policy.

3.6 SUMMARY

The following is a summary of the key points regarding approaches that are used for analyzing the economic impacts of transportation investments:

- Two types of analyses can be conducted to analyze the economic impacts of transportation investments. These types of analyses are not independent and they address related questions about economic activity.
 - An analysis conducted for the purpose of estimating economic impacts involves quantifying a change in measures or indicators of economic activity due to a transportation project or initiative. This type of analysis addresses the question: What are the changes in economic activity indicators of the regional economy from the proposed activity?
 - An analysis conducted for the purpose of evaluating economic impacts compares the full range of benefits against all the costs to quantify the net value of the project. This analysis aims at answering the question: What is the net value of a project by comparing the overall costs and benefits over the full life cycle of a project?

There is a subtle, but important, difference between the two that has important implications for the type of analysis utilized and for the kinds of outputs that result from such an analysis. These two types of analyses should be conducted as part of any planning process to select, program, and execute a transportation project.

- *Estimating Economic Impacts:* Several methodologies can be used to estimate the economic impacts of transportation investments. These methodologies vary in complexity and economic rigor, from simple meta-analysis modeling to complex regional economic modeling (REM) founded on economic theory. REMs are capable of modeling the economy by capturing the flow of goods and services across the different industries and sectors. REMs are widely used for large-scale transportation investments because of their ability to holistically model the various transactions and processes in an economy.

Three methodologies form the foundation of most REMs: IO; CGE; and Econometric modeling. These methodologies vary in their assumptions about the groups in the economy, their objectives and their economic transactions; and in their ability to capture temporal dynamics, with all having the functionality to model the economy and economic activity.

- *Evaluating Economic Impacts:* Methodologies that are used to evaluate the economic impacts of transportation investments include BCA, CEA, CUA, and LCCA. However, these approaches are all special cases of the broader BCA, with assumptions being made about the nature of the benefits and costs considered in the analysis. Therefore, the BCA methodology is the focus for evaluating transportation investments.

The BCA comprises a systematic approach for quantifying the value of a transportation investment. The analysis involves comparing the full range of benefits monetized to present value and compared against all the costs incurred by the investment to produce a single metric of value, either NPV or as a BCR. Either metric can be objectively used to compare multiple transportation projects or multiple alternatives for a transportation initiative. BCA also has the functionality to capture the timing of benefits or costs over a project's lifecycle. Therefore, BCA can be used in the planning stages to justify a project and also in the engineering stage to select a staging and implementation schedule for various project tasks that offers the greatest value, such as comparing construction schedules to identify the lowest-cost alternative.

- In the context of analyzing economic impacts, the terms estimating the economic impacts of transportation investments (using REMs) and evaluating the economic impacts (using BCA) have been loosely used in the transportation arena. Both approaches are economic analyses that are conducted to study the impacts of transportation investments, but they are not the same and traditionally, the models are implemented independently.

However, with the recent recognition that the longer-term economic benefits (that are caused due to the indirect and induced impacts of transportation investments) should also be considered in a BCA, a potential connection between the two types of analysis has been established. REMs provide a measure of the wider economic benefits, including agglomeration, competitiveness, and improved labor supply, that can then be used to conduct a BCA with a more comprehensive accounting of the potential benefits of transportation investments.

- The methodologies discussed are utilized for analyzing the economic impacts due to transportation investments. However, a number of other considerations are also used to inform the final selection of a transportation investment. Therefore, a systematic

decision making process needs to be established for selection, programming and execution of transportation investments. Further, the role of economic impact analysis in the decision making process should be established. This will ensure that the analyses conducted are objective, independent, unbiased, and consistent across transportation projects and alternatives.

In the context of evaluating transportation projects, a number of other concepts are also used, including Value for Money. Value for Money refers to a decision making mechanism that attempts to provide an objective, independent and consistent decision-making process for transportation project selection and delivery. The approach incorporates three major considerations: economy, efficiency, and effectiveness. A recent variant of this concept includes equity as an additional consideration.

- A number of considerations are utilized to select a transportation investment including financial, political, environmental, social, and welfare impacts. As Mason noted in his presentation to the Saskatchewan Chapter of the Canadian Evaluation Society, “*cost-benefit and cost-effectiveness analysis are decision aids; they are not the decision. These methods can help organize and may reveal both hidden benefits and hidden costs, but the outputs from this method must not be the only input into a policy decision.*” Therefore, in addition to listing the various steps for conducting an analysis, the decision making mechanism should incorporate a multi-criteria approach that addresses the considerations important to the different stakeholders and their audiences, including constituents and end users.
- Lastly, as with any analysis technique, a thorough understanding of the mechanisms and processes that drive economic activity due to transportation investments is required for the application of an appropriate analysis technique, both for estimating the changes in economic activity and also for evaluating the value of economic impacts. In this context, it is also important to consider other analytical tools, including land use and transportation models, to accurately model and comprehensively capture the full range of impacts associated with transportation investments on the economic activity in a region.

REFERENCES

- Ackerman, F. (2008) Critique of Cost-Benefit Analysis, and Alternative Approaches to Decision-Making. A Report to Friends of the Earth England, Wales and Northern Ireland. (Website: http://www.foe.co.uk/resource/reports/policy_appraisal.pdf, Accessed: May 5, 2013)
- Ackerman, F., Gallagher, K., and Nadal, A. (2001) The Limits of Economic Modeling in the FTAA Environmental Review. Globalization and Sustainable Development Program Background Paper, Global Development and Environmental Institute, Tufts University, Medford, MA (Website: http://www.ase.tufts.edu/gdae/publications/articles_reports/USTRComments&Summary.pdf, Accessed: May 5, 2013)
- Bellu, L.G., and Pansini, R.V. (2009) Quantitative Socio-Economic Policy Impact Analysis: A Methodological Introduction. EASYPol Resources for Policy Making, Module 068, Food and Agricultural Organization of the United States, FAO. (Website: http://www.fao.org/docs/up/easypol/774/quant_socio-economic_pia_068en.pdf, Accessed: May 5, 2013)

- Bess, R., and Ambargis, Z.O. (2011) Input-Output Models for Impact Analysis: Suggestions for Practitioners Using RIMS II Multipliers. Presented at the 50th Southern Regional Science Association Conference, New Orleans, Louisiana, March 23-27, 2011.
- Bhattarai, K. (2008) Static and Dynamic Applied General Equilibrium Tax and Trade Policy Models of the UK Economy. Serials Publications, New Delhi.
- Boardman, A.A., Greenberg, D.H., Vining, A.R., And Weimer, D.L. (2006) Cost-Benefit Analysis: Concepts and Practice. Third Edition, Prentice Hall, Upper Saddle River, N.J.
- Cellini, S.R., and Kee, J.E. (2010) Cost-Effectiveness and Cost-Benefit Analysis. Handbook of Practical Program Evaluation. (Website: <http://home.gwu.edu/~scellini/CelliniKee21.pdf>, Accessed: May 5, 2013)
- Charney, A.H., and Vest, M.J. (2003) Modeling Practices and Their Ability to Assess Tax/Expenditure Economic Impacts. Paper prepared for presentation at the AUBER Conference, New Orleans, October 2003. (Website: <http://ebr.eller.arizona.edu/research/TaxModelingPractices.pdf>, Accessed: May 5, 2013)
- DfT (Department for Transport (2005) Transport, Wider Economic Benefits, and Impacts on GDP. Discussion Paper, Published by the Department of Transport, United Kingdom. (Website: <http://webarchive.nationalarchives.gov.uk/+http://www.dft.gov.uk/pgr/economics/rdg/webia/webmethodology/sportwidereconomicbenefi3137.pdf>, Accessed: May 5, 2013)
- Durham Region Transit (DRT) (2009) Literature Review of Benefit Cost and Economic Impact Analysis, Regional Municipality of Durham, Economic Development Research, <http://www.durham.ca/pdf/transit/DRTLTTTS/Appendices/AppendixPCostBenEconAnalysis.pdf>
- Fatemi, A.S. (2013) Input-Output Economics. (Website: <http://lid01.econ.unipr.it/DOCENTI/MESSORI/docs/files/input-oputput.doc>, Accessed: May 5, 2013)
- Horowitz, K.J., and Planting, M.A. (2009) Concepts and Methods of the Input-Output Accounts. Bureau of Economic Analysis, US Department of Commerce. (Website: http://www.bea.gov/papers/pdf/IOmanual_092906.pdf, Accessed: May 5, 2013)
- Hufschmidt, M.M. (2000) Reflections On a Century of Water Science and Policy - Benefit-Cost Analysis: 1933-1985. Journal of Contemporary Water Research and Education, 116, pp. 42-49. (Website: <http://opensiuc.lib.siu.edu/cgi/viewcontent.cgi?article=1196&context=jcwre>, Accessed: May 5, 2013)
- HM Treasury (2011) The Green Book: Appraisal and Evaluation in Central Government. Treasury Guidance, London UK. (Website: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/179349/green_book_complete.pdf, Accessed: May 5, 2013)
- Iacono, M. and Levinson, D. (2013) Case Studies of Transportation Investment to Identify the Impacts on the Local and State Economy. Minnesota Department of Transportation, Research Services, Office of Planning Analysis, Research and Innovation.

- Jackson, P. (2012) Value for Money and International Development: Deconstructing Myths to Promote a More Constructive Discussion. Development Assistance Committee, The Organization for Economic Co-operation and Development (OECD). (Website: <http://www.oecd.org/dac/effectiveness/49652541.pdf>, Accessed: May 5, 2013)
- Kockelman, K., Chen, D., and Nichols, B. (2013) The Economics of Transportation Systems: A Reference for Practitioners. TxDOT Project 0-6628: Economic Consideration in Transportation System Development and Operations.
- Leontief, W.W. (1951) Input-Output Economics. Scientific American, p. 15-21.
- Levinson, D. (2010) Economic Development Impacts of High-Speed Rail. Working Papers, University of Minnesota: Nexus Research Group, 72.
- Litman, T. (2013) The New Transportation Planning Paradigm. ITE Journal, Vo. 83, No. 6, pp. 20-28. <http://www.vtpi.org/paradigm.pdf>
- Mamuneas, T.P. and Nadiri, M. I. (2006) Production, Consumption, and the Rates of Return to Highway Infrastructure Capital. (Website: Report prepared for U.S. Department of Transportation, Federal Highway Administration, Accessed: August 8, 2013)
- Mason, G. (2010) Value for Money: Cost-Benefit and Cost-Effectiveness Analysis. Presentation to the Saskatchewan Chapter of Canadian Evaluation Society, September 22, 2010. (Website: http://gregorymason.ca/wp-content/uploads/2010/08/CEA_CBA_Nuts-and-Boltsv1_Regina_V2.ppt, Accessed: May 5, 2013)
- Sargento, A.L.M. (2009) Introducing Input-Output Analysis at the Regional Level: Basic Notions and Specific Issues. Discussion Paper, Regional Economics Applications Laboratory, University of Illinois. (Website: <http://www.real.illinois.edu/d-paper/09/09-t-4.pdf>, Accessed: May 5, 2013)
- Sinha, K.S. and Labi, S. (2007) Transportation Decision Making: Principles of Project Evaluation and Programming. John Wiley & Sons Inc.
- USDOT (2003) Economic Analysis Primer. Federal Highway Administration, US Department of Transportation.
- Vickerman, R. (2007) Recent Evolution of Research Into the Wider Economic Benefits of Transport Infrastructure Investments. Discussion Paper 2007-9, Joint Transport Research Center, International Transport Forum. (Website: <http://www.internationaltransportforum.org/jtrc/discussionpapers/DiscussionPaper9.pdf>, Accessed: May 5, 2013)
- Waddell, P. (2000) A Behavioral Simulation Model for Metropolitan Policy Analysis and Planning: Residential Location and Housing Market Components of UrbanSim. Environment and Planning B, 27(2), pp. 247-263.
- Waddell, P., A. Borning, M. Noth, N. Freier, M. Becke, G. Ulfarsson (2003) UrbanSim: A Simulation System for Land Use and Transportation. Networks and Spatial Economics, 3, pp. 43-67.

- Weisbrod, G. (1997) Assessing the Economic Impacts of Transportation Projects: How to Choose an Appropriate Technique for Your Project. Transportation Research Circular, 477. (Website: <http://onlinepubs.trb.org/onlinepubs/circulars/circular477.pdf>, Accessed: May 5, 2013)
- Weisbrod, G. (2000) Procedures for Assessing Economic Development Impacts from Transportation Investments. National Cooperative Highway Research Program, Synthesis of Highway Practice. (Website: <http://www.edrgroup.com/pdf/synth290.pdf>, Accessed: May 5, 2013)
- Weisbrod, G. (2008) Models to Predict the Economic Development Impact of Transportation Projects: Historical Experience and New Applications. Annals of Regional Science, 52, pp. 519-543.
- Weisbrod, G. (2010) Being Clear About Benefit/Cost Analysis (BCA) and Economic Impact Analysis (EIA), Economic Development Research Group, Workshop on Benefit/Cost Analysis for Transportation Infrastructure, USDOT, May 17, 2010.
- Wells, J. (2012) Economic Value of Transportation Projects. Presentation to the Economic Value Study Committee, Connecticut Academy of Science and Engineering. http://www.dotdata.ct.gov/media/mainpsa.aspx?url=mms://159.247.0.209/mediapoint/case/11_09_12/part4.wmv?sami=http://www.ct.gov/dot/lib/dot/documents/dconndot/none.smi&name= John V. Wells
- WHO World Health Organization (2003) Introduction to Drug Utilization Research. World Health Organization. (Website: <http://apps.who.int/medicinedocs/pdf/s4876e/s4876e.pdf>, Accessed: May 5, 2013)
- Wing, I.S. (2004) Computable General Equilibrium Models and Their Use in Economy-Wide Policy Analysis. MIT Joint Program on the Science and Policy of Global Change, Technical Note No. 6.

4.0 REVIEW OF CANDIDATE SOFTWARE FOR ANALYZING ECONOMIC IMPACTS FROM TRANSPORTATION INVESTMENTS

Two distinct modeling frameworks developed to analyze economic impacts from transportation projects were identified in Chapter 3.

An estimation framework provides estimates of the extent of the impact from a transportation project on a regional economy using either regional economic models or outputs from regional models such as multipliers. REMs estimate a set of impacts that start from a specified set of activities and over time ripple across the regional economy affecting businesses, households and governments.

An evaluation framework provides a structure to compare the costs associated with the construction of the transportation project with the benefits that will accrue to the society from the use of the project once it is completed. The basic form of this framework is a traditional BCA that compares the costs with the benefits from the direct changes observed in the use of the transportation network. A more advanced application of this framework would include the benefits estimated by a REM, which would more fully account for the interaction of the transportation network with the regional economy.

A number of different implementations of these modeling approaches are available and have been reviewed in various papers (Weisbrod 2008, Ellis et al. 2012). As previously noted, a focus of this report is to review various software implementations available for analyzing economic impacts and to identify the best candidate or candidates for use by ConnDOT. Table 4.1 presents an overview of 26 different models that can be used to provide analysis of transportation projects and identifies the capabilities of these models in five major categories:

- General type of transportation project proposed, including new construction, upgrading an existing facility or maintaining an existing facility
- Regional scale of the project
- Types of transportation-specific factors that will need to be included
- Economic measures that the model is capable of working with
- Ability to account for non-economic impacts, such as changes to social well-being and environmental quality of the impacted area

ANALYZING THE ECONOMIC IMPACTS OF TRANSPORTATION PROJECTS
 REVIEW OF CANDIDATE SOFTWARE FOR ANALYZING ECONOMIC IMPACTS FROM
 TRANSPORTATION INVESTMENT

**TABLE 4.1: A REVIEW OF MODELS FOR ANALYZING THE ECONOMIC IMPACTS OF
 TRANSPORTATION INVESTMENTS**

Criteria / Software	REMI-TransSight	TREDIS	IMPLAN	TELU/ TELUM	TRENDS (Texas)	RIMS II	REIMHS	RUBMRIO	PECAS	PRISM	AASHTO Redbook	HEEM-III	MicroBENCOST	HERS-ST	HEAT	STEAM	TEIM	LEAP
Analysis Method Used																		
Input - Output	X	X	X	X		X	X	X	X	X								
General Equilibrium	X																	
Benefits Costs	X	X									X	X	X	X	X	X		
Land Use				X					X									
Other																	X	X
Transport Project Types Geographic Scale																		
Does New Transportation Projects	X	X		X		X				X								
Does Expanding existing Projects	X	X		X		X				X								
Maintenance and operations	X	X		X		X				X								
Transit Component	X	X	X	X						X								
Includes Travel Demand Data																		
Geography Scale																		
National dimension	X	X	X							X								
State(s)	X	X	X		X	X				X								
County(ies)	X	X	X		X	X				X								
Sub-county - Corridor/Zip Codes	Possible	X	X							X								
Regional geographic interaction	X	Partial	X							X								
Economic Factors																		
Output (Sales and inventory change)	X	X	X	X	X	X	X			X					X			
Employment	X	X	X	X	X	X	X	X	X	X					X		X	X
Flow of Labor	X							X										
Income	X	X	X	X	X	X	X		X	X					X			X
Value Added	X	X	X			X				X								
Productivity Change	X	X	X	X					X	X	X	X	X					
Fiscal Impacts	X	X	X	X	X	X				X				X		X	X	
Tourism Spending	X					X									X		X	
Resource Management				X				X	X									
Flow of goods	X							X										
Population	X			X	X				X									X
Social Benefits	X	X	X							X								
Transportation Factors																		
Performance: VHT, VMT, Speeds, Flow	X	X		X	X			X		X	X	X	X	X		X		
Charges: tolls, fares, fuel prices, taxes	X	X			X					X	X	X	X	X		X		
Operating costs	X	X		X						X				X	X	X		
Accessibility / Connectivity	X	X		X						X				X	X	X		
Time Saved	X	X		X	X					X	X	X	X	X	X	X		
Safety	X	X								X	X	X	X	X		X		
Environmental Factors - Emission	X	X								X			X	X		X		
Freight Flow	X	X								X				X				
Land Use Component																		
Long-Term Forecast of Changes in Land Use				X					X									

The software models summarized in Table 4.1 are complex and each approach offers unique perspectives on the estimates of economic activity that would be associated with transportation investments. In addition to the complexity of the software, the economic principles applied in the methodology require the analyst to have at least a good understanding of how the economic concepts are applied in the model. Although the focus and application of economic theory varies by model, at a minimum all of the models require a broad enough understanding of the economics of the activities of a proposed transportation project for those activities to be appropriately interpreted in the model. These economic factors even reach into changes that occur due to government activity, such as how government revenues will change due to the investments and how households and businesses will respond to the requirements of revenues for the projects. Failing to correctly specify in the model the economic activity associated with the transportation investment projects, misspecifying the activity, ignoring parameters that may need to be specified by the analyst, or selecting inappropriate methodological approaches within the software models can lead to inaccurate estimates from the model, and reduce public confidence in the results.

The empty cells shown in Table 4.1 indicate that the given model does not address a specific dimension, which highlights the fact that no single model addresses all the potential questions associated with an analysis of a regional transportation project. Thus, the analyst needs to be aware broadly of the capabilities and the limitations of the available models and select the model or models for a given analysis that can most completely address the questions associated with the specific transportation project being reviewed, and the intended audiences/stakeholders.

In addition to potential errors that could result from the analyst's unfamiliarity with the economics associated with models and the jargon used in explaining the modeling software, the assumptions used to determine the possible baseline(s) and the long-term effects of a specific project are important and can significantly affect the estimated results. Therefore, often a broad number of assumptions need to be fully considered in developing the most appropriate approach to correctly specifying the model. The questions that are associated with these assumptions include:

- What types of responses might occur in neighboring regions due to the proposed changes to the specified region's transportation structure?
- Will there be changes in the economy that the model cannot incorporate and should therefore be exogenously specified?
- Are there aspects of the transportation project that the model will incorrectly estimate?
- What is the true baseline once required maintenance or costs are taken into account?

An analyst who is aware of the assumptions in the model, its capability to correctly specify the interactions within the economy of the region and with the proposed transportation project, can use the model as a tool to aid in proposing alternative transportation solutions. Further, models like these can be used to explore the economic impacts that would occur due to new modes of transportation and make informed decisions about the regional transportation infrastructure. The analyst can also explore solutions that have been applied in other regions that may have had similar transportation pressures, geographic factors, and industrial structures, using the model in conjunction with other statistical techniques.

In summary, for a best practice use of a complex economic model, the analyst will need a clear understanding of the assumptions applied within the model, an awareness of the factors that are beyond the model, and the presence of other information associated with the transportation project and the regional economy that is likely to impact the region if the transportation project were completed.

4.1. MODELS SELECTED FOR THIS REVIEW: REMI TRANSIGHT AND TREDIS®

The level of complexity and the specific factors of each of the various models reviewed and the type of output and reports they provide vary widely. There were a number of factors that determined which models would be reviewed for this study, including

- ability to provide economic impact analysis for a region;
- flexibility in the selection of specific regions within Connecticut for modeling;
- awareness of the unique industry and household profiles of the specified region;
- ability to incorporate wider economic benefits including agglomeration, competitiveness, and improved labor supply caused by changes to market access experienced by businesses, and households;
- ability to simulate annual economic activity;
- inclusion of data from a transportation demand model into the economic impacts;
- provision for inputs and outputs of annual activity for construction and use;
- fully supported with help staff;
- significant number of academic or professional peer reviews and articles on the model; and
- known credibility in the public sector as a strong transportation modeling software.

Based on these factors, TranSight (REMI 2013) and TREDIS (TREDIS 2013) were selected for a detailed review in this report.

Both TranSight and TREDIS are comprehensive economic models that can be utilized to conduct economic impact analyses of transportation investments. The models are fully calibrated to the region's economy and the analyst can adjust parameters of the economy to specify local industry structures and household behaviors. Both models are capable of examining transportation investment projects from a variety of perspectives, including understanding the changes in economic activity due to transportation investments (i.e., estimation-type studies) and also for evaluating the economic value of transportation projects (i.e., evaluation-type studies).

Finally, in addressing the accuracy and reasonableness of these models, TranSight and TREDIS are economic models rather than engineering models. These models provide estimates of the changes to a regional economy due to transportation projects by taking into account the effects of similar projects and activity that is historically similar and projecting estimates of the changes

in a regional economy based on economic conditions in a larger region, as well as the nation and rest of the world.

The projected estimates are based on well-defined parameters and equations that take into account the effects of policy decisions made by businesses, households, and all levels of government. Thus, because of the multitude of dimensions and factors being taken into the model's specifications, these models provide valuable estimates of projected human activity rather than a mathematical summation of a known set of factors.

The analyst working with these models needs to leverage their strengths and acknowledge their weaknesses. Their strengths include the ability to provide estimates that take into account the known changes in the transportation networks and to the regional economy and the likely response to these changes as the activity ripples through the economy, and the ability to provide consistent estimates of the effects on that economy due to a variety of transportation projects. These estimates, which incorporate a complex model of the region's economy, could not be developed without this type of regional economic model. Although the results from these models could be compared with the actual estimates of the effects from a project that has been accomplished, the information acquired from conducting the analysis would most likely provide valuable insights about where the region under or over performed relative to expectations by industry sector, policy specifications, and household activity, rather than providing an examination into how accurate the specific model was.

Additionally, from a practitioner's perspective, the accuracy of a model being applied to a specific region is likely to be viewed as only marginally relevant. Practitioners who use these models are more likely to consider recent historical¹ use of these models and whether or not these models represent accepted industry standards in the field.

Table 4.2 presents a brief summary of the types of analyses or concepts the models are capable of performing. It should be noted that, in addition to the concepts identified in the table, the two models are capable of evaluating transportation investment projects from any economic perspective. This statement is made with the caveat that while many other models are capable of capturing some large scale economic changes, such as industry level agglomerations and changes in population movements, they do not include a level of geographical awareness or spatial detail sufficient to provide the kind of assessment of changes to location patterns and land use that a land use model would typically incorporate.

1. The first use of the TranSight model's predecessor, REMI, was in the estimation of the impact of Interstate 90 on the Massachusetts economy in the 1970s. Although TREDIS has been developed more recently, both models receive consistent use in the field and this use leads to continued refinement and re-specification of equations.

TABLE 4.2: SUMMARY OF TYPES OF FUNCTIONALITY AND CAPABILITIES OF
 TRANSPARENT AND TREDIS

Inputs and Results Available for:	TranSight	TREDIS
Benefit-Cost Analysis	Immediately Available	Immediately Available
Value for Money Principles	Yes	Yes
Broad Regional Economic Impacts	Immediately Available	Immediately Available
General Economic Development	Yes	Yes
Quantitative Ranking Systems	Yes	Yes
Smart Growth Concepts	Yes	Yes
Sustainable Development	Yes	Yes
Any Multi-Modal Structure	Yes	Yes
Vehicle Ownership Savings	Yes	Yes

The “yes” associated with TranSight or TREDIS indicates that data are available within the model to easily address the typical types of questions or analyses for the concepts identified. One example of the usefulness of these models is how they would incorporate the relatively new principles associated with a value for money type of analysis, previously described in Chapter 3. Either of these models could easily be specified to include impacts in industries that are assumed to be the result of the specified transportation impacts. In addition, either model can be used to provide a value for money analysis, as well as for any of the other approaches noted.

To fully examine the returns to a society (regional economy) from a transportation project and thus be able to compare its efficiency and effectiveness with other potential projects, an analysis that incorporated the full impacts on the economy, rather than just the immediately observable costs and benefits of a given project, would need to be considered. Both TranSight and TREDIS are capable of providing consistent and balanced estimates of the net effects of all the economic activities that would be associated with a number of different transportation projects. Additionally, because both are consistent and fully developed models, their results could be used to compare transportation projects with other types of economic projects. The models can thus be incorporated in quantitative systems for ranking transportation investment-related economic development efforts and include rankings for other economic development projects as well, even if the other projects did not explicitly include transportation investments. As a result, these quantitative type ranking systems can provide a unique, objective perspective that can facilitate broad policy discussions, more specific goal setting and even encourage results-based accountability measures for projects and within government agencies.

While the above discussion identifies only a subset of the analysis types and transportation project categories, the inputs and outputs provided by either of these models can easily be applied to any quantitative analysis of the economic impacts of a transportation project.

4.2. OVERVIEW OF MODEL METHODOLOGY

4.2.1 *REMI TranSight (TranSight)*

The general framework that the TranSight model has been developed around is built from a strong background in economic theory. In applying this theory to the modeling methods, TranSight includes

- a regional industry input-output framework to structure the initial activity;
- a computable general equilibrium economic theory to comprehensively account for the activity noted;
- a set of econometric models to provide regional information in specified parameters; and
- the principles of the new economic geography² to estimate the regional interactions.

The specific theories from each of these perspectives are combined within the TranSight model and serve as the basis for the estimation routines. TranSight has been developed as an extension of the original REMI model to easily incorporate into the basic model all appropriate transportation project information. As a result, the TranSight model can include the metrics from a region's transportation demand model, industrial requirements dependent on market access, labor demand flows, and pollution externalities as it estimates the net impacts on the regional economy from specified changes in any or all of these transportation measures.

The core of the TranSight model is an industry input-output algorithm. This approach anchors the region's economy on industry-to-industry input-output relationships. These relationships are built on the production functions or estimates of the goods and services an industry uses and the commodities that each industry makes or supplies. The model includes estimates of the share of these commodities that remain in the region relative to those that are exported from the region. With this information, the model can estimate the effects of a change in an industry on the other industries in the region. Thus, an industry strongly connected to other industries in the region would have a larger impact on the region than a change that affects an industry weakly connected, if the other aspects of both industries are the same.

Economic equilibrium occurs in a region when supply and demand are balanced. Therefore, a CGE model is based on the assumption that a change in production in the region will initially disturb the region's equilibrium of supply and demand and thus perturb prices. Over time, the region's economy will rebalance the supply and demand of goods through the relative prices observed within the region and in the rest of the world for all goods and services. TranSight captures the price fluctuations and estimates the overall impact on the economy and on households for the region as supply and demand move back into equilibrium. Since households respond to these changes by changing buying patterns and by moving into or out of the region, TranSight incorporates into its estimation routines wage and consumer spending patterns as

2. Economists developed enough computing power and mathematics skills to add a spatial dimension to Economic Geography Theory. For more information about this "New Economic Geography," see Krugman, Paul, "What's New About the New Economic Geography," Oxford Review of Economic Policy, Vol. 14, No. 2, http://www.uni-miskolc.hu/~euint/20031002zzz20031231/EcoGeo_2008_article2.pdf

well as migration. Thus, TranSight provides a full set of estimates for changes in the region's demographics over the long term, as the population responds to wage and price changes. CGE principles also include estimating government activity. Thus, TranSight incorporates governmental revenues and expenditures in balancing supply and demand over time and provides a full set of estimates of that activity, as well as a comprehensive set of inputs to model that activity. Finally, general equilibrium principles mean that changes to an economy are modeled such that the result of the region's industrial competitiveness, profits, and capital investments is dependent on the market structure by ensuring a balance between the supply of goods and services in a region with the demand for those goods and services. As a result of the need to find the equilibrium for a large number of transactions in the model, TranSight provides for a large number and wide variety of inputs and outputs a large number of measurements associated with any impact analysis.

Econometric principles are applied to estimate the underlying equations and parameters associated with the equations in the input-output framework. In TranSight, the advanced statistical techniques are extended to estimate the response time associated with specific characteristics of the region, including the industry structure and its demographic profile. This temporal dimension can improve the understanding of the financial effects associated with the costs of funding a project and the possible rates of return from the timing associated with an investment. This dimension of TranSight thus makes possible the examination of different policy recommendations, as well as different production schedules within the model. Econometric techniques can also be applied in estimating regional purchase coefficients, labor and market access factors, and other regional parameters that are required in the various equations.

Finally, TranSight uses new economic geography principles to capture the important spatial dimension of the economy. These dimensions include a concept of market accessibility within the region and its connection to other regions. Within this framework, the transportation network, specifically transportation costs, capture important factors that affect the region's overall productivity. This market accessibility will enhance labor market access and can create regional industry agglomerations, with the net result being an increase of productivity and a competitive advantage for the region.

4.2.2 Transportation Economic Development Impact System (TREDIS)

The TREDIS model is also based on a regional industry input-output structure. TREDIS incorporates the relationships of up to 440 industries in the region (the TranSight model is based on the relationships among 70 unique industries). This additional industry detail used by TREDIS is likely to reduce the size of the error associated with the assumption that the average values observed for a larger industry are the same as the values for a more detailed industry within that larger industry structure.

As with TranSight, TREDIS also uses new economic geography principles in estimating the efficiencies of a region's transportation network as it interacts with the industry and household structures. In part, it is the inter-industry linkages that create demand for the flow of goods and services within the region and the requirement of goods and services from outside the region. Households interact with these activities by providing labor and by purchasing some of the goods and services provided by the regional industries. These factors together can support the creation of industry agglomerations that depend on unique inputs and specialized

labor to contribute to a region's economic competitiveness. In TREDIS, the region's industrial competitiveness is also determined by the location of international borders, regional air, water, and inter-modal rail hubs and activity levels at those hubs.

TREDIS also applies econometric principles in many of the same ways as TranSight uses data to determine parameters for cross-sectional and trend estimation procedures. However, TREDIS's approach leverages more extensive industry detail, which should increase its accuracy. TREDIS's partial equilibrium approach also focuses on resolving impact estimates within the specific industry and household structure, rather than expanding the analysis of the estimates to include the principles of CGE theory. This means that the full analysis provided by TREDIS is narrower in scope, but more focused, as it includes additional detailed market access information, such as

- local labor market structure and distance;
- regional markets for delivery of intermediate and final goods and services;
- domestic airport access;
- international airport access;
- intermodal rail facility access;
- major seaport access; and
- distance to an active international land border crossing.

New economic geography theory is also applied in TREDIS, although from a different approach than is taken by TranSight. TREDIS focuses on the profile of the specific geography studied. Based on that geography's industry and household profiles and the geographic measures associated with market access, as previously noted, TREDIS estimates the contributions associated with these factors and incorporates these estimates on regional changes that can be observed in the economic impact.

As TREDIS is a partial equilibrium model, it approaches the evaluation of a proposed transportation project in a step-wise econometric fashion. Essentially, TREDIS isolates the relevant behavioral responses to changes in the transportation system, including project spending, travel characteristics (leading to travel costs), and accessibility, and then estimates the magnitude of the response with empirical (statistical) relationships. These behavioral responses primarily include household spending behavior, business investment behavior, business location behavior, and aggregate productivity gains through agglomeration. These responses utilize as much detail as possible from a travel demand model, including trip purposes, commodity utilization for freight modes, and detailed flow characteristics (including travel time variability).

The more restricted step-wise econometric approach means there are not as many measures of economic and demographic activity estimated in TREDIS as in the TranSight CGE model. This keeps the TREDIS results more narrowly focused on the regional economic impacts in the industries (as producers and consumers) and households (as consumers and income earners). The results do not include estimates on the impacts of a region from population migrations associated with jobs and wage adjustments and long-term capital investments that CGE models incorporate to appropriately balance supply and demand over time.

4.3. SIMILARITIES BETWEEN TRANSIGHT AND TREDIS

4.3.1 *Methodological*

Both TREDIS and TranSight share a number of basic features and methodologies. Their basic approach is built from publicly available regional economic data that has been unsuppressed to provide estimates for all industries. These estimates allow the models to incorporate the unique industry mix of a region as the basis for the region's interaction with the rest of the world. This interaction with the rest of the world includes foreign and domestic exports and imports used for production of goods and services within the region. In the region, this interaction is specified in the industry-level production functions through regional purchase coefficients (the relative share of each input used in production). These metrics identify the share of each input provided locally and the share provided from outside the region. This IO approach provides the basis for both models, although the TranSight model extends the estimation procedure with additional components that are discussed later in this chapter.

In application, an IO model begins with a set of user-defined economic activities in a region and includes information regarding how these activities will interact with the larger economy. These activities in both models can include

- changes to industry output;
- household income;
- prices of inputs used; and
- industry or institutional spending patterns.

The first activity observed is usually classified as the direct activity; that is the activity that directly impacts the economy. In transportation demand modeling, the changes in the flow of people, goods, and services are converted into values and applied to the correct industries, commodities, and institutions, and are also included as direct activities. For the development of transportation projects, these values are associated with the appropriate industries that will observe changes in output due to the construction, maintenance and operation phases of the project or with the region's households. For each project, the initial activity will require inputs from local and non-local industries that are estimated through the production functions of that industry or group of industries specified with the direct effect. The indirect effects that are the result of these estimates are regional economic activity of the industries that are needed to fulfill the initially observed direct activity. The economic activity from the direct and indirect effects then ripple out further in the economy as households spend the wages and salaries paid to the workers, who provide the labor associated with the increased output from the direct and indirect effects. These expenditures buy the goods and services required for the households within the region. This estimate of the purchases of goods and services by households is the induced effect and completes the impacts observed in an input-output model.

As noted previously, both TranSight and TREDIS include the approach taken by economic IO models of incorporating information and estimate impacts, including information on households and other "institutions." Institutional information includes governments that

serve as purchasers of final demand and provide goods and services (labor and government production and services) to industries and to the other institutions in the region.

Both models apply methodologies that commingle the industry and institutional data, as noted, with transportation-related data. The transportation data used by both models include all aspects associated with the development and construction phases of a transportation project and the use of transportation infrastructure by businesses and households. This use is initially specified in travel demand models that have data on vehicle miles traveled; vehicle hours traveled; vehicle trips per time period; and costs associated with pollutants, accidents, and travel times. These travel demand models are usually developed by statewide or region-wide transportation departments and are used for a variety of purposes. The data from these travel demand models serve as inputs into both TranSight and TREDIS that provide information to the model that is used to estimate the changes to the regional economy due to shifts in the use of the transportation network as businesses and households shift their transportation preferences. These changes in preferences reflect changes in market access and thus the costs that companies absorb due to the transportation of goods used for inputs and the transport of their output to the market and the costs households observe commuting to work, traveling to markets and as tourists. This economic activity is included in both models as initial direct impacts.

Although to some extent their approaches are different, both models utilize econometric techniques to incorporate current economic theory and the most recent available data into estimating parameters that are used within the models.

Finally, both models are dynamic in time and provide estimates of the impacts from a start year until a specified ending time.

4.3.2 Inputs and Parameters

The geographies both models use include states and counties, and each can be developed to work at the zip code level. Additionally, states, counties, zip codes and geographic groups can be combined to identify a metropolitan area or a regional corridor that would be of interest for a specific transportation project. This capability also can be used to join multiple states into one larger region, if required.

Both models also allow the analyst to review the regional economic data used by the industrial sector and some parameters associated with households. The analyst can alter any metrics associated with an existing industry or add a new industry; specify its production function and regional purchases, employment, wages, output and value added metrics; and then rebalance the model. These changes might be required when an industry affected by the activity is critical and known to have significantly different measures than those of the larger industries to which the specified industry belongs. Moreover, there may be a reason to alter a measure within the model due to information available to the analyst that indicates that the regional data is different from that specified in the model or that it will be at some point during the time frame being considered in the analysis.

TREDIS and TranSight are capable of providing industry impacts independent of a specific transportation activity. As noted, modeling this type of activity might be necessary even within a transportation project, when it is known that a given project will either create or eliminate a

business(es) or might possibly create an entirely new industry in the region. Again, TREDIS provides 440 unique industry sectors to select for an impact analysis, while TranSight includes 70 industry sectors. This feature makes it relatively simple to include the dynamics of transit-oriented development into the analysis performed by the model.

However, the challenge of modeling often extends beyond noting an impact and assigning it to a specific industry. This is especially true in modeling transit-oriented development activities. Various economic dimensions need to be specified across multiple industries and even estimated for their direct effects due to changes in household consumption preferences before they are assigned to the appropriate sectors or household groupings in the model. Thus, using a REM can greatly enhance an analysis of a transit-oriented development project or a multimodal structure. The mapping of the relevant economic data from a transit-oriented development or multimodal project will require the development of methodologies to establish estimations of direct impacts likely to occur given the planned investment for the project. These estimations may require the use of surveys, land use models, and other modeling techniques as parts of the process before direct impact data can be applied to the economic impact model.

Both models easily incorporate the effects from one-time initial direct activity due to construction factors. Although they differ in how the inputs are made available, both provide options to allow the analyst to distribute the initial construction costs among the various activities, such as planning and design, land purchases, and various types of construction. As an option, both models provide an estimation routine that distributes construction costs among the various activities noted according to historically observed parameters for the specific type of transportation project. In both models, all potential impacts associated with construction of the project, including funding sources, can be specified and reported on separately from other impacts.

Travel demand variables can be entered into the models, either manually by entering a value for each variable or by uploading data from structured spreadsheets or other standard file formats. The models include matrices for travel demand measures by year for the baseline and changes due to the proposed transportation activity for the following:

- Changes in vehicle miles
- Changes in time spent during trips
- Changes in vehicle trips
- Accident occurrence by three types of severity
- Cost of accidents by three types of severity
- Fuel usage rates
- Fuel costs, including pretax, federal taxes, and state taxes

These metrics are available for both highway and public transit projects. The models include automobiles and trucks as modes of transportation within the highway category, and for public transit projects, passenger trains and buses. For each mode, there are default values associated with vehicle occupancy, accident rates and costs, fuel use and costs, purpose of trips, emission

rates and costs, and leisure time. Both models allow default values to be changed by the analyst. There are also differences between the two models on the travel modes and in other features associated with the travel demand components, which will be reviewed later in this chapter.

Finally, both models provide ways for the analyst to input large sets of data associated with a specific transportation project or regional industry. Additionally, both have available or will develop procedures to assist or automate linking the output from a regional transportation demand model into the regional economic impact model.

4.3.3 Reporting Results

The models build their reports partially from a baseline set of data for all of the measures that potentially might be affected by any sort of an economic impact. This baseline provides the default level of economic activity in a region, assuming things remain at the status quo. The baseline can be adjusted to reflect economic activity known by the analyst, but not available to the model.

Once the impacts are specified and estimated by the models, both models will provide a variety of reports. These include a full report of benefits and costs associated with the proposed transportation project. These reports are independent of the economic impact estimates, as they provide the accepted standard of accounting-based BCA. These benefits and costs reports include detailed values for the total benefits, including emissions, safety, vehicle operating costs, transportation infrastructure/maintenance costs, travel time savings, and other benefits. Total costs in the reports include design and construction, land acquisitions and custom costs. For the BCA, the models include the present value of the project as estimated over the project's life and determined by the discount rate set by the user. It must be noted that the BCA included in these models considers only the direct impacts when estimating the benefits and costs, while this report has expanded the concept of benefits and costs to incorporate the benefits estimated from a REM.

Both models also report the economic results from the full impact analysis in tabular and graphical forms. These reports are available for the entire region based on the NPV of the activity. At this level of analysis, both models provide the ability to view the specified measure in graphic form as a pie chart, with the distribution of the activity among the various industry sectors. Additionally, the models can report the annual flow of economic activity in total and relative to the base line as shown in Figure 4.1. This annual activity can be presented for all industries or for a specific industry sector. Although TREDIS works with 440 industries, it provides detailed reporting on only 86 industry sectors, while TranSight provides reports for all 70 industry sectors that are included in its model. For either model, the level of industry detail reported is more than enough to address most questions.

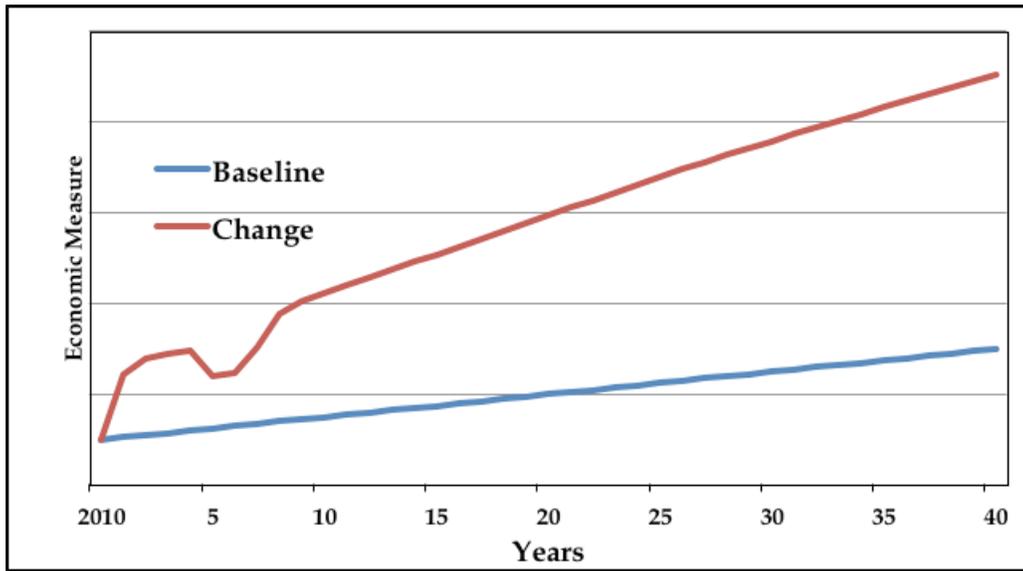


FIGURE 4.1: CONCEPTUAL CHART COMPARING THE BASELINE AND CHANGE
 DUE TO ECONOMIC ACTIVITY

4.4 DIFFERENCES BETWEEN TRANSIGHT AND TREDIS

Given all the similarities noted, it might be assumed that the models approach the analysis of transportation projects from similar methodological or theoretical perspectives. However, this is not the case. The different methodological approaches taken by the models result from different inputs used to model transportation projects and different variables used to measure the effects of the impacts on the region. From the analyst’s perspective the differences between the two have implications for the application, effort involved, and reports generated. Overall, while there are more differences than cited in this review, this report highlights the key differences and unique features in each model.

4.4.1 Methodological

The most basic difference between the models is that TREDIS employs a partial equilibrium model and, due to that approach, it maintains a focus throughout the estimation procedure on the basic assumptions of an IO model. Alternatively, TranSight starts with the structure of the IO model and then moves to a CGE model. This approach uses a much broader range of information based on the economic principles of a classical free market economic theory based on balancing demand with supply over time. The regional solution seeks a new equilibrium based on adjusting prices, including the price of labor, and can include changes across a wide array of metrics. These metrics might include demographic changes from migration, industry employment levels, and labor force participation rates to changes in capital investments made by households and businesses, government services and revenue requirements to changes in household spending levels and patterns. The initial data in the TranSight model, as well as the estimations from economic impact analysis, include a full spectrum of demographic measures. The net result of these differences is that TREDIS is more likely to accurately estimate the

impacts for a more limited set of metrics and remains focused on primarily addressing questions related to the economics of the impacts by industry for the specified geographies. However, TranSight moves from the tight framework of the traditional IO structure to estimate a much broader set of regional changes.

Additionally, the differences in the theoretical approach of each model translate to an entirely different “feel” in the use of each model’s software. This difference permeates all steps associated with the use of each model, from structuring the direct effects to adding transportation-related data, and on to examining the results in the various reports, tables and graphics. The input screens for TREDIS are sequential, compartmentalized and the model reflects its methodological underpinnings with a more granular and controlled feel to the software. Comparatively, TranSight seems to encourage thinking broadly about the entire economy, with input screens that flow across a multitude of variables and through multiple years. Result screens for specific variables or groups of related variables are available immediately after the model has been run, in either tabular or graphic form, for literally hundreds of variables.

The methodological similarities and differences are summarized in Table 4.3. One conclusion of these differences is shown in the “User Background” section in the table. As TranSight is based on the more economically complex CGE model and has the ability to provide impacts into the model using many relatively advanced economic concepts, an analyst using it should be very familiar with economic concepts. An analyst using TREDIS will need some familiarity with economic principles, especially those concepts involved in economic impact analysis, but will not need the same level of economic knowledge as that required for TranSight. Both models are fairly intuitive and with limited training, an analyst should be able to develop comprehensive analyses using them.

TABLE 4.3: SUMMARY OF THE METHODOLOGICAL DIFFERENCES BETWEEN
 TRANSGHIGHT AND TREDIS

Basic Methodology	TranSight	TREDIS
Input / Output	Yes (70 Industries)	Yes (440 industries)
New Economic Geography	Yes (Regions interact within model)	Yes (Econometrics)
Econometrics	Yes	Yes
General Equilibrium	Yes	No
Partial Equilibrium	No	Yes
Impacts (Direct Indirect Induced)	Yes	Yes
Additional Modeling Notes		
General Equilibrium Solution	Yes	No
Step-wise Econometric	No	Yes
Demographics (Migration / wages)	Yes	No
Land, Housing and Other Capital	Yes	No
Geography		
State	Yes	Yes
County	Yes	Yes
Sub-county	Yes (on request +\$)	Yes (on request +\$)
Visual Maps	Yes	No
Demographics		
Age	Yes (Detailed groups)	General Summary
Race / Ethnicity	Yes	No
Gender	Yes	No
Labor Force Participation	Yes	No
User Background		
Economics	(Masters+)	Familiarity with Economic Principles
Transportation	Familiarity with Economic Principles	Familiarity with Economic Principles

4.4.2 Inputs and Parameters

TREDIS applies econometric principles in many of the same ways as TranSight uses data sets to determine parameters for cross-sectional and trend estimation procedures. However, TREDIS’s approach leverages more industry detail and remains focused on resolving estimates within specific industry markets rather than expanding to the overall principles of general equilibrium theory. This approach means that TREDIS has more detailed industry and market access information, but it also limits the dimensions that the model can incorporate as inputs or parameters in estimating an impact. Although TREDIS allows the analyst to change a large number of metrics within the model, thus affecting the overall economic impact, only a few

metrics directly feed into the model estimation. These metrics include changes in employment, output, household incomes, and industry production functions (the changes in goods and services required as inputs in production).

TranSight includes the ability to estimate economic impacts from the same activities identified in TREDIS and extends the ability to specify direct effects into a large set of metrics associated with CGE routines embedded in the model. As a result, there are 185 input metrics available in TranSight.

TREDIS 4.0, the latest release, is available on the internet, while TranSight is a stand-alone product that is installed on a personal computer or network server. This means that working with TREDIS requires internet access and that data computations are performed on the TREDIS webserver. Additionally, all output reports initially are built on the server. These reports can be downloaded and data input tables can be copied and pasted from the web browser into a spreadsheet and back again with ease. There is no noticeable time delay associated with setting up inputs in TREDIS, although after all the inputs have been specified by the analyst, the calculations that the software then goes through to “build” the regional IO model for the impact analysis may take up to one minute. After the model is built, the reports compiled on the TREDIS server usually build in 30-60 seconds. While the time required to build a regional IO model and receive reports may be a bit of a hindrance for an analyst, it also means the model can be built and results obtained from virtually any computer regardless of space requirements, as long as a connection to the internet and access to Microsoft’s Internet Explorer is available. Moreover, having the process completely on the TREDIS server allows for a TREDIS analyst to quickly and easily review a user’s model to provide guidance, if needed. Finally, because the model resides on a server, maintenance and upgrades do not require the end user to download any components or install any upgrades.

The speed at which TranSight runs will depend on the capacity of the computer on which it is installed and the network connections between that server and the user, as applicable. As part of this study, a demonstration model was downloaded from the REMI site and tested on a recently purchased (2012 built) computer. On average, calculations were completed for all three regions in the demonstration model within five to ten seconds. Setting up the inputs associated with these calculations would take a comparable amount of time in both models, although TranSight has a convenient “fill or calculate” utility that can generate impacts across a specified series of years without exporting or importing the data. The reports that provided estimates from the TranSight model were generated nearly instantly.

The backbone of the TREDIS 4.0 input structure is a series of sequential templates. These templates are very useful for new analysts as they familiarize themselves with the structure and layout of the software. The basic structure of the template (see Figure 4.2 for an example of a template screen) follows a logical input procedure:

1. Project Control: create a new project, group projects and view projects modeled
2. Analysis Type
 - a. Prioritize and Select: sketch out general numbers among various projects
 - b. Vision Plan: long-range summary overview with limited details
 - c. Public Policy: Address service type needs, evaluate tolling and public/private options for ongoing operations.
 - d. TRANSEARCH – Freight: Targeted freight analysis utilizing <http://www.transearch.com/data>
 - e. Alternative Analysis: significant detail, including engineering information, is available
 - f. Single Project: provides estimates to support funding and regulatory approval
 - g. Existing Facility: provides impacts on the economy from established transportation infrastructure, such as airports, marine ports, and train and bus terminals
 - h. Asset Management: provides estimates of values associated with maintenance of existing transportation infrastructure
 - i. Advanced Mode: full options for custom analysis
3. Modes: select modes of transportation associated with project
 - a. Add custom mode or modes
 - b. Specify time/value factors associated with travel demand model
 - c. Specify per vehicle cost factors
 - d. Specify fuel use and costs and fuel taxes
4. Project Timing: multiple periods possible
 - a. Project start and end years for construction
 - b. Operations start and end years for use
 - c. Analysis year
 - d. Discount rate
 - e. Constant dollar year
 - f. Travel growth rate
5. Study Regions: based on geography purchased for model
 - a. Affected counties
 - b. Linked counties
 - c. Build the model

6. Alternatives: specify names of impact(s) of specific projects
7. Costs: specify costs associated with building the transportation project
 - a. Cost and revenue sharing: public private and total expenditures for the project
8. Travel Characteristics: specify transportation demand associated with project
 - a. By mode vehicle factors
 - b. By mode accident rates and values
 - c. By mode commodity mix details
 - d. Travel costs override
 - e. Phase in override: percent by year
9. Market Access: market sizes for 40 minutes and 3 hours, activity level for air travel, travel time to terminal, travel time to international gateway
 - a. Industry detail: add additional impacts by output or employment
 - b. Industry detail phase-in: percent by year
10. Results: reports
 - a. Summary Report
 - b. Economic Impact
 - c. BCA
 - d. Financial Analysis
 - e. Performance Metrics
 - f. Household and Land Use
 - g. Freight Flows
 - h. Grant Application
 - i. Tracing / Validation
 - j. Trip Balancing Table

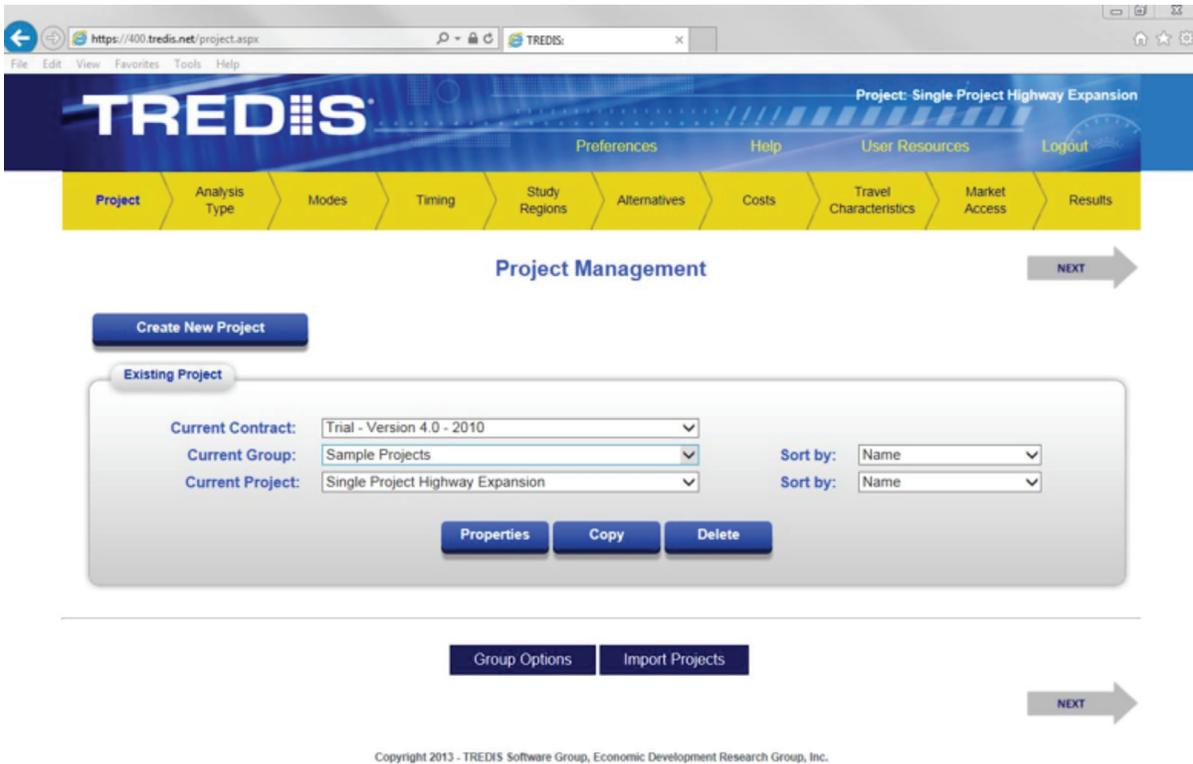


FIGURE 4.2: AN ILLUSTRATION OF THE TREDIS SEQUENTIAL TEMPLATE STRUCTURE:
PROJECT MANAGEMENT SCREEN

The template's major steps, identified by numbers in the outline, are shown as the yellow directional pentagons in Figure 4.2. When the analyst begins work on a project, in the project management section, only the corresponding "Project" pentagon is highlighted in yellow. All other steps in the template are greyed out to indicate that they are inactive and have not been completed. As the analyst works through the steps, the completed steps change color to yellow highlighting as shown in the figure. Once a step has been addressed by the analyst, it becomes active (highlighted in yellow), and from then on for that project, the step can be accessed at any time to make changes.

TranSight presents a much broader conceptual framework in its graphic user interface. This object-oriented interface reflects the model's theoretical framework. Thus, as shown in Figure 4.3, the theoretical context is evident upon opening the workbook screen, which shows a flow chart of the model and the alternative scenarios developed. Clicking on an object in this screen, such as the "Regional Simulation 1" rectangle, takes the analyst directly to the object to review or specify the inputs that define the project.

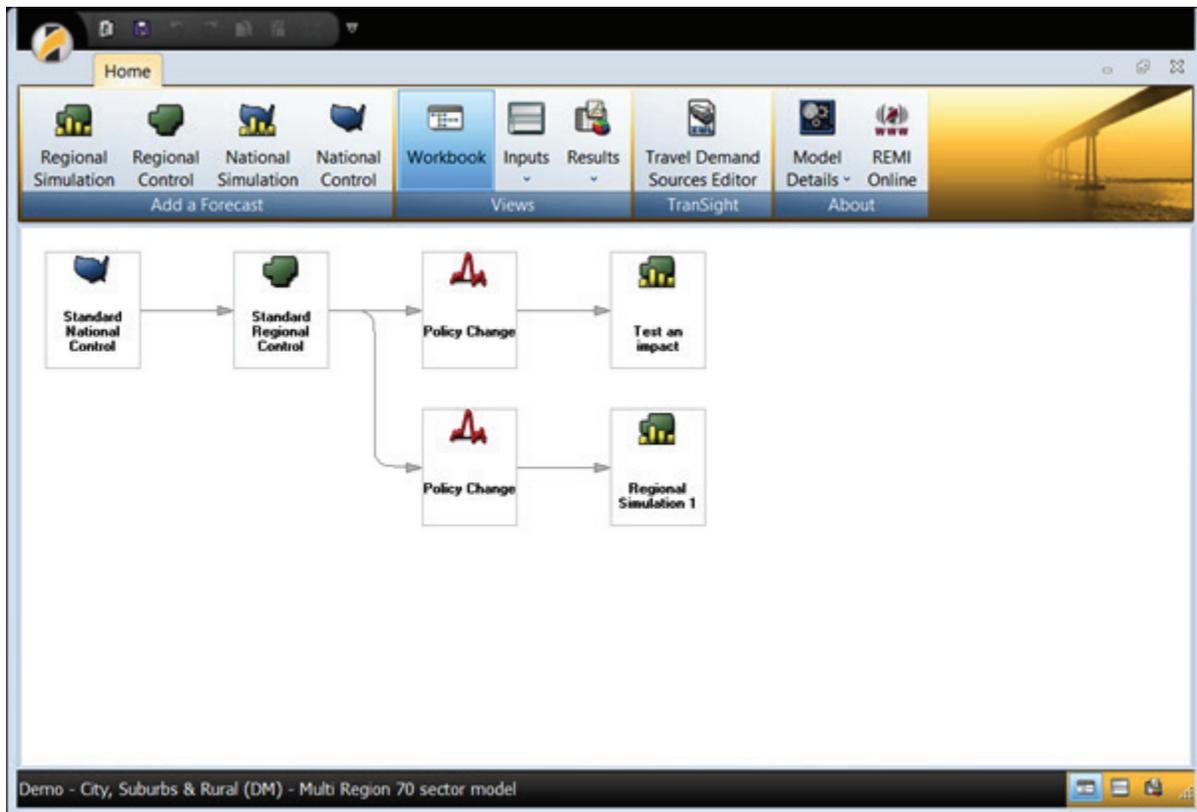


FIGURE 4.3: TRANsIGHT'S WORKBOOK HOME SCREEN

To develop a new regional simulation, TranSight's term for an impact analysis, the user clicks on the "Regional Simulation" button in the "Add a Forecast" group shown in Figure 4.3. Once selected, the Simulation Tools screen with an Insert tab would appear. TranSight is structured using the same "ribbon" principles as recent versions of Microsoft Office (2008 and onwards), in which ribbons change depending on the activities the user is likely to need. In the Simulation Tools Insert screen, there are 19 options grouped into six categories: Travel Demand Inputs, Transportation, Blueprints, Scenarios, Lists, and Tools.

The "Parameters" button within the "Travel Demand Inputs" group opens a screen that allows the user to set travel demand-related parameters (Figure 4.4). Included are the general parameters for emissions costs, leisure time value; parameters for highway activity, including non-fuel operating costs, vehicle occupancy, emission rates, accident rates, vehicle values, fuel costs, fuel rates; and the parameters for transit activity, including vehicle occupancy, emission rates, and accident rates. Both highway and transit activities have an advanced parameter setting that allows the analyst to specify weights associated with the appropriate modes of transportation for the region, the dimensions for transportation, accessibility and commuting, and how these dimensions will interact with the modes.

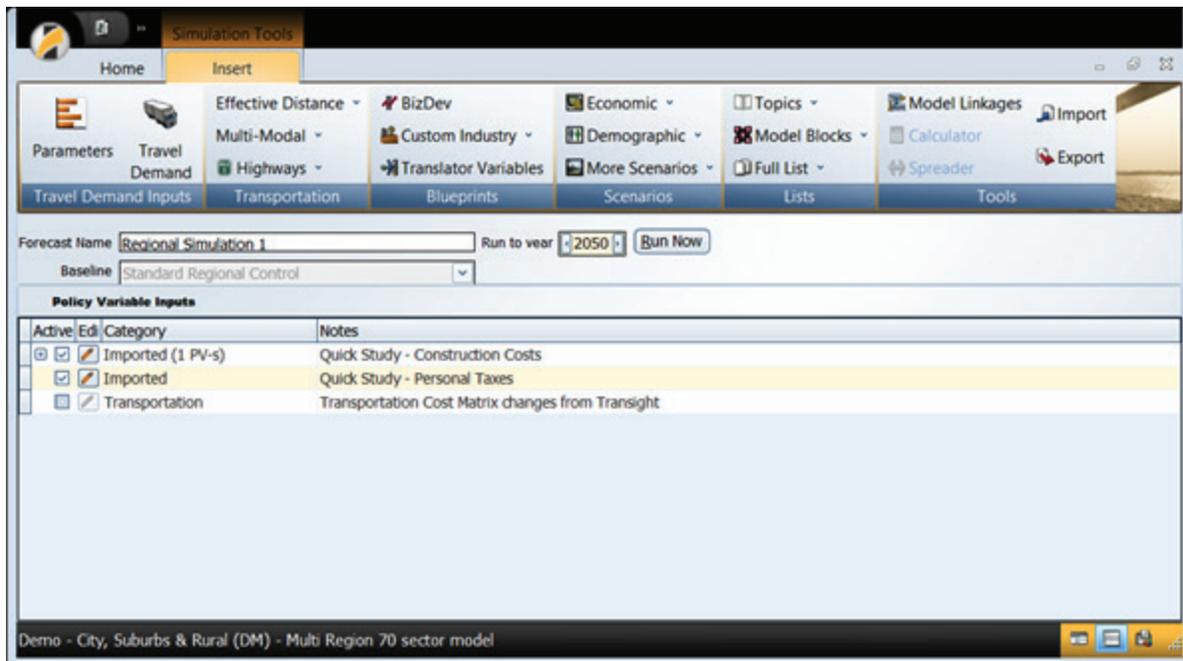


FIGURE 4.4: TRANSIGHT’S MODELING INPUTS SCREEN

The “Travel Demand” button shown in Figure 4.4 opens a form in which highway and transit vehicle miles travelled, vehicle hours travelled, and the number of trips can be set for the modes of transportation affected by the transportation project. The specific data structures include:

- The baseline and the changes to the baseline in vehicle trips due to the transportation project. These metrics include vehicle miles traveled, vehicle hours traveled, number of roadway trips, transit miles traveled, transit hours traveled and number of transit trips.
- General changes associated with emission costs and the value of leisure time.
- Highway changes associated with non-fuel operating costs, vehicle occupancy, emission rates, accident rates, accident costs, fuel costs and fuel rates.
- Transit changes including vehicle occupancy, emission rates, accident rates and accident values.

Within this framework, most of the data items associated with the roadway or transit trips are set by the analyst using data from the region’s travel demand model. Most of the other data items have default values based on national averages, but can be adjusted by the analyst.

The “Effective Distance” button in the “Transportation” group allows the analyst to set parameters associated with new economic geography theory. These parameters will affect the model’s estimations of the changes in costs projected due to the implementation of the proposed transportation project. These changes can be specified for commuting, accessibility and transportation costs between any of the regions specified in the model and for each year.

The “Multi-Modal” and the “Highway” buttons within the “Transportation” group present a set of functions that are most similar to the “Modes” templates in TREDIS. The “Multi-Modal” button opens a form to specify values associated with air, rail, boat and highway transportation modes. Additionally, the “Multi-Modal” button has access to a form that can be used to alter information on expected changes in market access, business costs and international trade. The options available with the “Highways” button are all associated with specifying parameters related to highway projects and include a “Quick Highway Study” form. Both the “Multi-Modal” and “Highway” buttons include options to specify values associated with design and construction costs, maintenance and operations costs, and government funding for the specified project.

TREDIS provides estimates based on a more classical IO approach and has a larger industry structure and thus may offer a more accurate set of estimates for a specified activity than TranSight for the limited set of metrics it works with in its approach. However, it should be assumed that the overall capability of either model to provide useful estimates for large-scale transportation projects will be dependent on the ability and understanding of the analyst. It is likely that either model will provide accurate estimates, if the analyst’s methods and assumptions are specified correctly and are approached with objectivity. Both models offer opportunities that allow the analyst to adjust parameters in ways that can have a significant effect on the overall result of the analysis.

A second observation is that TranSight is a more expansive model and because it is built as an extension of REMI’s CGE model, requires the analyst to be more familiar with the economics associated with the base REMI model than would be necessary with TREDIS.

As noted previously, the TranSight model is built with additional transportation-related components from the basic 70-industry sector REMI model. Because it is built on the REMI model, it has all the variables specified in that REMI model. Table 4.4 shows a summary of the non-transportation specific variables that are available as options to specify a simulation or as measures for either the baseline or the impacts from the simulation. Note that some data concepts in this table are counted multiple times. For example, employment as an input variable can be counted as an absolute value, a percent of a regional total for all industries, or as values estimated from two other measures, such as earnings per employee (see Appendix B for a detailed table of all non-transportation specific REMI variables).

TABLE 4.4: VARIABLES AND MEASURES AVAILABLE IN REMI

Type (not including transportation inputs)	Count
Total (input variables and measures in model)	424
Input Variables (Direct effects and policy changes)	185
Consumption / Consumer Purchases	75
Industrial Sectors / Commodities	70
Occupations	94

While variables shown in Table 4.4 and listed in detail in Appendix A may be useful in evaluating transportation projects, they are not related specifically to the transportation metrics

used in close parallel by both models. As noted in the methodological review, the theoretical approaches taken by TranSight and TREDIS are so different that a table that compares the two models has only limited usefulness.

However, this does not mean that aspects of the models are not comparable. The one dimension directly comparable is the number of industries. TREDIS has 440 industrial sectors, while TranSight has a more aggregated set of 70 industries. Some of the other dimensions, such as consumption, consumer purchases and occupations, cannot be compared because they are not directly present in TREDIS. Changes to consumer purchases due to impacts are modeled in the induced effects within the TREDIS model, but are not reported by commodity type. The information on occupations within the region is embedded within the industry structure and industry wage averages only. The 185 input variables in the REMI TranSight model match measures that are directly available in TREDIS, such as employment, output, and wages. However an analyst working with TREDIS would need to develop a methodology to address many of the non-transportation specific input variables that can be directly specified in TranSight. While estimates for these measures may not be necessary for the analysis being conducted, if they are required, the development of the methodology and the data sets could take a considerable amount of time. The benefits of developing a set of methods and data independent from the model are that the analyst would know the methodology applied, the assumptions used, and could develop estimates using the most current data available.

An overview of transportation-specific metrics (See Table 4.5) confirms that both models incorporate all the relevant aspects from a travel demand model, although each has certain unique features.

- The current TREDIS model works with a 2010 - 2042 time frame, while the TranSight model works with a 50-year time frame from 2010 - 2060. Both time frames may be too short for the full life of some transportation projects and too long to realistically suggest that they can assume the relevant economic parameters beyond 20 years. However, the value of the extended time frames is that they provide a useful baseline for comparing benefits and costs of a project, as well as for comparing multiple projects.
- There is a vehicle speed matrix available for mode of transportation (but not public transit) that allows the analyst to change vehicle fuel consumption and vehicle emission output in TranSight, but not in TREDIS. TREDIS has estimated parameters for emissions and fuel consumption, but the speed matrix is embedded in the TREDIS estimates and is not available for manipulation by the analyst.
- A difference that is only partly observable in Table 4.5 is that TREDIS is set up so that the structure of the inputs is more consistent and possibly more intuitive than the TranSight structure, especially for analysts not familiar with the software. The TREDIS software sequentially presents screens, each of which gathers the information needed to define the parameters of the model and then the transportation demand data. The screens include a visible dimension for each vehicle type, or mode, that has been selected earlier and do not include the vehicle types that were not selected earlier in the "Modes" sequence of screens. While TREDIS takes the analyst through a step-wise sequence of gathering information needed to build the model and estimate the impacts, TranSight has designed its input screens on the economics of the data relationships and then on how the data will be used in the simulation. Thus, even when vehicle types are

noted as an available dimension to a data type, the matrix that TranSight presents the analyst with is usually for one specific mode of transportation, with the other modes being available in a dropdown box on the screen that provides the data for a different mode. As noted previously, the Simulation Tools Insert screen modes are also divided by group into multi-modal and highway.

In addition to the different approach the two models take to gather travel demand data, the models also approach the specific travel modes differently. Table 4.5 shows that TREDIS breaks out modes of travel demand in much more detail and has more modes available than TranSight. Again, this breakout is a result of TREDIS's more granular, user-friendly and direct approach. Thus, TREDIS allows the user to specify the modes of transportation that will be involved in the project and ignore modes not involved after the second step of the input structure. To specify those modes by significant detail, TranSight works with more general modes and requires the analyst to adjust the various transportation parameters based on the analyst's preferred methodology.

The detailed modes of transportation available in TREDIS, but not directly available in TranSight, include various uses for bikes and walking, and multiple modes associated with aircraft and marine ships. The light rail option is not directly available in TREDIS, but as could be done for any transportation mode not available in TranSight, the analyst could specify the specific parameters associated with the light rail mode for the region. Moreover, TREDIS provides the opportunity for the analyst to create a new mode name and that mode will be available throughout the rest of the project, which makes identifying the various metrics entered for specific modes by the analyst and the final report tables with results by mode more user-friendly and understandable.

ANALYZING THE ECONOMIC IMPACTS OF TRANSPORTATION PROJECTS
 REVIEW OF CANDIDATE SOFTWARE FOR ANALYZING ECONOMIC IMPACTS FROM
 TRANSPORTATION INVESTMENT

TABLE 4.5: MODES OF TRANSPORTATION AVAILABLE IN TRANSGHIGHT AND TREDIS

Mode	TranSight	TREDIS
Car Passenger (Summary)	Yes	Yes
Business	as %	Yes
Personal	as %	Yes
Commute	as %	Yes
Freight		Yes
Truck (Summary)	Yes	Yes
Truck - Light/Medium Duty		Yes
Truck - Tractor Trailer		Yes
Bike/Ped (Pedestrian)		Yes
Business		Yes
Personal		Yes
Commute		Yes
Bike/Ped (Bike)		Yes
Business		Yes
Personal		Yes
Commute		Yes
Bus Passenger Bus (Summary)	Yes	Yes
Business		Yes
Personal		Yes
Commute		Yes
Aircraft (Summary)	multimodal	Yes
Air Taxi		Yes
Business		Yes
Personal		Yes
Commute		Yes
Freight		Yes
Commercial Jet		Yes
Business		Yes
Personal		Yes
Commute		Yes
Freight		Yes
General Aviation		Yes
Business		Yes
Personal		Yes
Commute		Yes
Freight		Yes

TABLE 4.5 (CONT.): MODES OF TRANSPORTATION AVAILABLE IN TRANSTIGHT AND TREDIS

Mode	TranSight	TREDIS
Jumbo Jet		Yes
Business		Yes
Personal		Yes
Commute		Yes
Freight		Yes
Regional Jet		Yes
Business		Yes
Personal		Yes
Commute		Yes
Freight		Yes
Ship Cruise (Personal)	multimodal	Yes
Ship Marine Freight	multimodal	Yes
Ship Passenger Ferry (Summary)	multimodal	Yes
Business		Yes
Personal		Yes
Commute		Yes
Train Freight Rail	multimodal	Yes
Train Passenger Rail (Summary)	Yes	Yes
Business	as %	Yes
Personal	as %	Yes
Commute	as %	Yes
Train Light Rail	Yes	

A brief summary of the similarities and differences in inputs, parameters and user interactions between the two models is presented in Table 4.6 on the following page.

ANALYZING THE ECONOMIC IMPACTS OF TRANSPORTATION PROJECTS
 REVIEW OF CANDIDATE SOFTWARE FOR ANALYZING ECONOMIC IMPACTS FROM
 TRANSPORTATION INVESTMENT

TABLE 4.6: SUMMARY OF THE SIMILARITIES AND DIFFERENCES IN INPUTS, PARAMETERS,
 AND USER INTERACTIONS BETWEEN TRANSGHIGHT AND TREDIS

Summary Parameters	TranSight	TREDIS
Time Span	2010 to 2060	2010 to 2042
Vehicle Speed Matrix	0 to 80	Fixed in model
Web-based	No	Yes
Response Speed	Fast	Slower Web dependent
Input Metrics (non-transportation)	185	7 (not including industry dimension)
Cost	\$43,000 to \$88,000	\$19,000
Model Graphical User Interface		
Template Steps (User friendly)	No	Yes
General Objects	Yes	Optional
Specification of Inputs		
Import from Spreadsheets	Yes	Yes
Calculate or Fill Sequentially	Yes	Yes
Modes of Transportation		
Bike	No (could build)	Yes
Pedestrian	No (could build)	Yes
Truck	Yes	Yes
Bus	Yes	Yes
Car	Yes	Yes
Light Rail	Yes	No (could build)
Rail	No (could build)	Yes
Freight Rail	No (could build)	Yes
Air	Yes	Yes
Water/Ship	No (could build)	Yes
Commutation	Yes	Yes
Transportation Demand		
Accidents	Yes	Yes (by type of vehicle)
Time Costs	Yes	Yes (by type of vehicle)
Pollution	Yes	Yes (by type of vehicle)
Fuel Costs	Yes	Yes (by type of vehicle)
Vehicle Occupancy	Yes	Yes (by type of vehicle)
Trips	Yes	Yes (by type of vehicle)
Congestion	Yes	Yes (by type of vehicle)
Trip Directions	Yes	Yes (by type of vehicle)
Vehicle Storage	Not explicit	Yes (by type of vehicle)
State Registration Costs	Not explicit	Yes (by type of vehicle)
Terminal (<i>fuel sales</i>)	Not explicit	Yes (by type of vehicle)
Toll Charges	Not explicit	Yes (by type of vehicle)

A key point made from comparing the two models is that each includes the necessary tools for conducting a variety of economic analyses that estimate the economic value of transportation investments. The model systems are dynamic enough in their structure to accept additional parameters, such as modes of transportation or industries not already specified in their default structures. However, an analysis of transportation investments may require the use of other analytical tools, such as land use models, additional demographic models or other advanced methodological approaches. These additional analytical tools enhance the analysis by both refining the inputs that define the direct activity and providing the ability to examine the impacts from additional perspectives.

4.4.3 Reporting Results

The reports that are provided by both models have some similarities that reflect both the basic goals and the specific frameworks of the models. Thus both models provide summary reports on the economic impacts on a regional economy over time by various measures using employment, output, value added, employee wages, and domestic and international exports, with the functionality to show most of this data by industry sector and by commodity. TranSight and TREDIS can present the data in tables or graphically show trends over time, and aggregate distributions of the trends in pie charts. TranSight also has the capability to graph detailed industry and commodity impacts over time.

Reports that address a specific framework include BCA that incorporate the basic costs of the development of the project and the maintenance costs and the directly measured benefits from the travel demand model. The NPV from these measures is calculated to provide both the total current dollar return from the investment and the BCA ratio.

As TranSight provides a general equilibrium solution for how much of an impact a transportation project could have, it offers a number of additional measures not necessary for the partial equilibrium solution TREDIS provides. Thus, TranSight includes reports with yearly values for the demographic variables of population by race, age for the existing population in the region, migration in and out of the region, labor force and the participation rate, economic reports for 94 different occupations, national and regional capital stocks, including residential capital stock, and consumer consumption for 75 different consumption categories.

Both models also provide data on relevant financial information for a project. Additionally, TREDIS provides a dedicated report for public, private, and total investments and the returns on those investments over time.

The TREDIS model includes the United States for its BCA and estimates of economic impacts for the nation.

The overall impressions provided from the reports that these models provide are very different. The TranSight reports present a tremendous amount of information in a logical way, but take the data provided and turn it into a critical analysis that will take a considerable amount of effort to review. The impressive feature of the TranSight model is that it provides estimates for just about any metric the analyst would want to consider.

While there are a number of different TREDIS reports, there are not as many as with TranSight and the analyst does not have the ability to review the data results as quickly and easily. How-

ever, the reports that TREDIS provides are thorough, have been developed thoughtfully to move the analyst closer to addressing the core issues, and are comprehensive given TREDIS's structure. Table 4.7 compares the report capabilities of the two models.

TABLE 4.7: COMPARISON OF THE REPORTING CAPABILITIES BETWEEN
 TRANSSIGHT AND TREDIS

Reports	TranSight	TREDIS
Transportation Oriented	Yes	Yes
General Structure	Trends-Line Graphs (Visual)	Comparative - output oriented
Exportable Spreadsheet Structures	Yes	Yes
Graphics	Trends and pie charts	Trends and pie charts
Available metrics		
Occupations	Yes (94)	No
Consumer Consumption	Yes (75)	No
Industries	70 + Aggregates	86 reported (440 run model)
Other Metrics (<i>non-transportation</i>)	185	About 10 (all major ones)
Additional Analysis		
Benefit-Cost Analysis	Yes	Yes
Financial Analysis	Yes	Yes

4.5 PERSPECTIVES FROM OTHER MODELS

While the TranSight and TREDIS modeling tools are comprehensive in their capabilities, functionality and applicability, initial exploration of other software used for economic impact analysis identified some useful aspects that are not available in these models.

One perspective that is not available in either model is the ability to generate views of the actual geographic location of the transportation projects. The ability to see on a map the location of an existing or potential transportation project and quickly review relevant factors associated with that specific project can be very useful, especially when comparing multiple projects or when a number of potential projects are being reviewed within a larger framework. The ability to link seamlessly into a geographic information system (GIS) view of a project is a feature included in the TELUS/TELUM group of models developed by New Jersey's Science and Technology University. TELUS (Transportation Land Use System) is a fully integrated information-management and decision support system. TELUM (Transportation Economic and Land Use Model) is an integrated interactive software package that can evaluate the change in land use associated with changes in a transportation network. TELUS's GIS component allows the analyst to identify parts of a transportation network associated with a specific alternative for a transportation project or to present in a mapping framework a new transportation project. Once these projects are identified, the mapping system within the TELUS software can be used to query information about a specific project.

In addition to this visual GIS backbone, TELUS is designed to share projects among Metropolitan Planning Organizations (MPOs) and state departments of transportation (DOT). This sharing of information allows additions to be made from either a MPO or DOT that can then be shared with interested parties. This would enhance the project planning process when a consortium of government and private organizations were required to interact on a project.

TELUS also has a project scoring module, which offers the analyst the ability to analyze a proposed transportation project and compare that project to others using a group of appropriate metrics. TELUS includes a developed set of 57 metrics that are weighted and divided into eight categories that the model defaults to when evaluating a number of different projects. Additionally, the model allows an organization conducting a large-scale analysis with different projects to adjust the weights of any of the metrics, delete or create new metrics, modify categories with which the metrics are associated, and rename the metrics.

TELUS also has modules that provide support for the management of transportation projects including tracking the status of the projects, from initial planning through design and construction. Also included is a log that records all activity on a specific project that occurs within the TELUS software and charts the planned and actual schedules of each project, along with obligated and allocated funds. TELUS also provides the ability to document the extent to which each project meets planning objectives. Within this framework, TELUS can scan all projects and calculate the percentage of projects and total dollars allocated to meet a specified objective.

In summary, while the TELUS software program was not selected for a full review, the rich administrative features and its ability to visually identify projects by geography are important perspectives to consider as possible options for evaluating a transportation project³.

The geographic dimension presented in TELUS also suggests the potential to address economic impacts at a level more detailed than state and county, especially within Connecticut, with 169 municipalities and multiple transportation regions and corridors. Both TREDIS and TranSight are able to develop geographic regions at the zip code level. Additionally, the TREDIS model does not at this time link geographies to show the effects of an impact in one geography on the other geographies within the model.

The economic interactions among various geographies can provide valuable insights and this interaction can be explored in the IMPLAN model, developed by the IMPLAN Group LLC. IMPLAN uses a partial equilibrium solution similar to TREDIS. However, IMPLAN does not have any of the transportation demand parameters, which allow the user to easily model the effects of a transportation project on a regional economy. Moreover, IMPLAN does not have a dynamic time horizon, meaning that an impact is measured to occur in one time period, usually a year. However, despite these limitations, the application of the new economic geography in evaluating impacts that occur across regions would be a valuable function.

The IMPLAN model is structured so that estimates for the flow of 440 goods and services from one geography to another are included in an impact analysis. This flow between geographies is estimated for four different modes of transportation, including boat, truck, rail and air. Additionally, this flow is spatially aware, including distance costs between geographies. Thus,

3. The TELUS model was not reviewed because it did not appear to function appropriately when it was initially being tested. Additionally, concerns over user support and limited reviews of the product were also noted.

once a multi-regional model is built and impacts estimated in the standard reports provided, the model is capable of showing estimates of the distribution of the impacts in each of the regions included in the model for each of the industries. Some degree of accuracy is sacrificed for regions built at the zip code level. However, such a build would allow the analyst to develop standardized repeatable impacts for a transportation corridor and the other geographies in a county or state, or the estimates of impacts in a city due to a project and those that would accrue to other geographies as specified by the user.

The review of IMPLAN and TELUS suggests that these models have additional useful features that are not supported by the TREDIS and TranSight models. These features can be supplanted using additional tools and/or interfaces to TREDIS or TranSight, which then will allow for a thorough analysis of economic impacts of transportation investments. Therefore, given the current level of development and computer capabilities, it may be useful to invest in more than one software program and to develop the capacity to use each program or model for its design purpose.

4.6 SUMMARY

It is important to recognize that models are blind. It is the analyst who must be aware of the factors that limit the models and work within those limitations to convey what the models estimate. The “accuracy” of these models is dependent on the actual economic, social and political activity that occurs in the region due to the transportation project. Thus, the actual response observed from the project depends on policy decisions and effective leveraging of the new investments by households, industries, regional political organizations, state agencies, and responses in neighboring regions and beyond. Both models work within a clearly specified set of parameters and structured methodology that can provide for transparency throughout the analysis and reporting process.

A critically important aspect of any model-based analysis that uses these models is the development of an appropriate baseline. As noted, both models provide an initial default baseline. However, it may be appropriate to alter this initial baseline with known information about changes in future levels of investment activities associated with maintaining a status quo in the transportation infrastructure being addressed for a given project. That is, historically allocated funds associated with a given transportation structure may not be appropriate to allow that structure to remain in a steady state into the future.

During the analysis process it may become evident that a proposed project may have an agglomeration effect beyond what could be estimated by the model given the model’s default set of parameters. Observing this potential, the analyst may need to consider various adjustments to parameters that would reflect these potential changes. It also may be necessary to expand the analysis by identifying new industries or altered industrial structures and incorporate multiple scenarios to allow an analysis to include high- and low-impact estimates. In this chapter, a number of the features have been identified that make TranSight and TREDIS useful models. At their core, both models incorporate a large array of information related to the regional economy and to the transportation network that provides for the movement of goods, services, and people into, out of and within the region using a variety of modes. Using this information with a well developed, methodically consistent and transparent approach can provide estimates of the economic impacts that are most likely to occur as changes in the transportation infrastructure cascade across the region’s economy.

To take full advantage of these models for an evaluation of a transportation project or a comparison of transportation projects, the models need to be embedded into a larger policy framework with a clearly outlined process structured to determine how the value for a given project(s) will be measured. Additionally, this framework needs to stipulate that the entire process should have a transparent methodology and that all phases of the analysis project should be implemented with objectivity. Within this framework, the model(s) used for estimating economic parameters needs to be based on acceptable, publicly available data sets and the economics within the model's methodology needs to be based on published empirical tests. Moreover, the results of the models need to be replicable to analysts who may wish to confirm the process. It is critical that the transparency of the process also fully incorporate an approach in which the general public, stakeholders, and policy makers are presented with understandable and relevant reports that clearly provide information relevant for decision making.

Finally, the role of the analyst is an important consideration in the effective use of the selected model or models. The analyst needs to have thorough understanding of the model(s) and familiarity with the unique features of Connecticut's economy, including political influences and the dimensions of the state's demographics for use of the model(s) in Connecticut.

Finally, the role of the analyst is an important consideration in the effective use of the selected model or models. The analyst needs to have a thorough understanding of the model(s) and its interactions with the unique features of Connecticut's economy, including political influences and the dimensions of the state's demographics for use of the model(s) in Connecticut.

REFERENCES

- Ellis, D., Glover, B., and Norboge, N. (2012) Refining a Methodology for Determining the Economic Impacts of Transportation Improvements. University Transportation Center for Mobility, Texas Transportation Institute, The Texas A&M University. (Website: http://utcm.tamu.edu/publications/final_reports/Ellis_11-00-68.pdf, Accessed April 14, 2013).
- REMI (Regional Economic Model, Inc.) (2013) (Website: <http://www.remi.com/>, Accessed: May 27, 2013)
- TREDIS (Transportation Economic Development Impact System) (2013) (Website: <http://tredis.com/>, Accessed: May 27, 2013)
- Weisbrod, G. (2008) Models to Predict the Economic Development Impact of Transportation Projects: Historical Experience and New Applications. *Annals of Regional Science*, 52, pp. 519-543.

5. REVIEW OF STATE OF THE PRACTICE FOR ANALYZING ECONOMIC IMPACTS

A review of the state of the practice for analyzing economic impacts was conducted for guidance in identifying economic impact analysis analytical tool(s) best suited for use in Connecticut. Existing literature, surveys, and case studies regarding the state of the practices in selected states were reviewed. Further, to understand the state of the practice for analyzing the economic impacts due to transportation projects in Connecticut, focus group sessions and interviews with various stakeholders directly involved with transportation planning in the state were conducted.

This chapter includes a review of the following:

- Information gathered from surveys of US states
- States that have established economic impact analysis procedures as part of their transportation planning process
- States that do not have established economic impact analysis procedures, using example studies from major transportation investments
- State of Practice in Connecticut

5.1 STATE OF PRACTICE IN UNITED STATES

The linkage between transportation investments and economic activity has long been acknowledged. However, only recently has there been an increased emphasis on quantifying and using the economic activity potential of transportation projects for evaluating, justifying and selecting projects in the transportation planning process. According to a study conducted by the Texas Department of Transportation in 2004, only 16 out of the 26 states that responded indicated that they have conducted a study analyzing the economic impacts of transportation projects (Burke et al. 2005).

More recently, the 2010 US Government Accountability Office conducted a study, "Statewide Transportation Planning: Surveys of State Departments of Transportation and Regional Planning Organizations." This study provided an understanding of the state of the practice of economic analysis for the development of long-range statewide transportation plans (LRTP) and statewide transportation improvement program (STIP) in the states. One of the questions raised in the study was whether the states "conducted economic analysis for individual projects (e.g., benefit-cost analysis, cost-effectiveness analysis, and economic-impact analysis)." Out of the 50 states, 28 states indicated that they have performed economic analysis in the development of LRTP, STIP or both. However, only 11 states indicated that results from the economic analysis were of "very great importance" or "great importance" in the development of the STIP. Other factors cited as more important included funding availability, political agendas and public support (GAO 2010a, GAO 2010b, Eno report).

The limited use of economic analysis and its result in the transportation planning process is also related to the lack of a regulatory framework requiring the need for economic analysis in the selection, programming and execution of transportation projects. However, recent federal initiatives indicate the federal government's interest in using economic analysis to determine the value of transportation projects. For example, the Transportation Investment Generating Economic Recovery (TIGER) grant program awards funds competitively to transportation initiatives where the project benefits outweigh the project costs (GAO 2010a). Additionally, the more recent federal MAP 21 legislation, also indicates increased reliance on a performance-based transportation planning paradigm, with economic impact playing a significant role in project evaluation by USDOT (Vozzolo 2012).

5.2 STATE OF PRACTICE IN STATES WITH ESTABLISHED ECONOMIC IMPACT ANALYSIS PROCEDURES

As previously noted from a review of the GAO 2010 study, only 11 states used results from economic impact analysis for selecting, programming and executing transportation projects. The GAO survey did not link the survey responses with these states. Therefore, it was difficult to identify all the states where economic impact analysis played a significant role in the transportation planning process from the GAO study results. However, based on a literature scan, states that have established, or are in the process of incorporating, economic impact analysis for transportation project evaluation and selection were identified (Ellis et al 2012, Eno 2012).

The states reviewed include Indiana, Kansas, Michigan, North Carolina, Oregon and Texas. The first four states were selected based on the maturity of their economic impact analysis procedures and processes, and success stories of their use of economic impact analysis for justifying transportation projects. Further, the state of practice at these four states has been reviewed in literature as case studies based on their maturity and success (Ellis et al. 2012, Eno 2012). Additionally, Oregon and Texas were selected because these states have more recently incorporated or are in the process of incorporating economic impact analysis as part of their transportation planning process. The review of practice in these states will be particularly relevant for ConnDOT's use in considering the role of economic impact analysis in their transportation project selection process.

5.2.1 *Indiana*

Indiana Department of Transportation (INDOT) planned to expand US-31 and improve it to Interstate standards, but because of the high cost of the project, the department was interested in evaluating the benefits of the project to justify its selection. As a result, the benefits of the project benefits, including the economic development impacts of the transportation improvements to the highway corridor, were identified and then compared to the cost of the project to ensure that the investment provided a positive economic value.

INDOT developed an analytical tool called the Major Corridor Investment-Benefit System (MCIBAS) to conduct this analysis. This system includes a travel demand model, a BCA system and a regional economic model system (REMI TranSight).

Positive attributes included in the decision making framework for transportation project evaluation and selection based on INDOT's experience are as follows (Ellis et al. 2012, Eno 2012, INDOT 2013):

- INDOT's program considers broader- and longer-term economic processes in addition to the economic processes considered in a regional economic model implementation.
- BCA considers the full range of benefits, including long-term economic impact in evaluating transportation projects.
- MCIBAS comprises a comprehensive analytical tool integrating a travel demand model system (capturing transportation impacts) with a regional economic model (representing the economic activity), while also accounting for the interdependencies across the model systems.

With regard to the outcomes of the analysis framework, the selected projects achieved their transportation goals by reducing travel times and improving overall travel efficiency, as was initially desired. The transportation projects also contributed to strengthening future economic growth and made the region more competitive, as was predicted before project implementation. The success of the analysis conducted on initial transportation projects prompted INDOT to use the tool more widely for other projects.

5.2.2 Kansas

In 2003, the Kansas Department of Transportation (KDOT) went through a paradigm shift in their transportation planning process under the leadership of the state's secretary of transportation. This effort included renewed emphasis on public outreach and engagement in the evaluation and selection of transportation projects. KDOT's project selection process utilized a methodology developed by the department that combined engineering judgment with economic criteria, and consultation with the public. The TREDIS model was used to generate outputs about total jobs and gross regional product for each project, and forecasts were developed for the period through 2030.

In 2008, KDOT initiated development of a long-range transportation plan to establish project selection criteria. This plan incorporated an economic analysis factor into the project selection decision making process. KDOT realized that their transportation planning process at the time did not adequately address the economic growth potential. Also, there was renewed focus on acknowledging the linkage between transportation investments and economic development potential, and including that in the transportation planning process. KDOT's project prioritization program focused on the selection of highway projects. Each project was scored, and ranked based on potential gross state product, direct and indirect employment, and traveler benefits. Efforts to obtain public input included the posting of project rankings online, and conducting public outreach meetings throughout the state.

KDOT's project selection program considered several qualities in developing a decision making framework for transportation project evaluation and selection (Ellis et al. 2012, Eno 2012):

- The program heavily emphasized transparency (both in its design process and its prioritization approach with the community), public outreach and public engagement. This approach also promoted communication and collaboration between the department and local communities throughout the entire decision making process.
- The structure of the project selection process was flexible and adjustments were made to the selection criteria to fit the public's interests, where appropriate.

- The economic impact scoring criteria was innovative and proved to be effective.
- Transportation project ranking utilized a multi-criterion approach. The multi-criterion formula attributed a 25% weight to the economic impacts and included long-term economic activity resulting from the transportation project considered.

The project selection criterion addressed the call for the renewed focus on the economic development potential including business and industry competitiveness among other long-term economic impacts. Even though the short-term economic activity (e.g., construction jobs and construction-related economic activity) was considered, the focus for project ranking and selection was long-term economic growth. The selected projects have yielded the predicted transportation performance benefits; however, the anticipated economic benefits are yet to be seen.

5.2.3 Michigan

Michigan Department of Transportation (MDOT) worked with the University of Michigan to create a comprehensive methodology to analyze the economic benefits of the department's transportation plan. This effort was part of MDOT's public outreach efforts to convey the value of projects proposed in the department's long-range transportation plan. This effort led to the development of MI-BEST, an economic analysis tool that combined a travel demand model with a regional economic model (REMI TranSight). The output measures reported by MI-BEST include the gross state product, employment data by industry and cumulative income effects. In assessing the economic benefit, build and no-build scenarios were compared. Further, the scenarios were evaluated under different funding options and project alternatives were ranked. The results of this process were then posted online and publicly accessible.

A key attribute of the approach adopted by MDOT was detailed data-driven economic analysis. The approach realistically analyzed different funding scenarios that would be useful during the decision making process. MDOT's approach provided for the selection of projects that offered the most value from competing options, especially when funding was limited. Also, stakeholder participation was emphasized by involving local stakeholders and local communities in the process. Additionally, outreach efforts were utilized for engaging the general public.

A significant achievement of this program was its use in guiding MDOT's project selection decision making process through the great recession. MDOT maintained its focus on long-term jobs and investment alternatives that were shown to have the potential to promote economic growth in the state. The department was not influenced by the appeal of shorter-term construction jobs.

MDOT's alternative funding scenarios approach should be adopted as a transportation planning practice to purposely "plan for the best but prepare for the worst." The projects implemented resulted in an increase in connectivity in the state, and subsequently travel times were reduced. (Ellis et al. 2012, Eno 2012)

5.2.4 North Carolina

North Carolina Department of Transportation (NCDOT) created a program, Strategic Prioritization Process 1.0, to enhance their project selection and prioritization mechanism. The goal was to go beyond traditional engineering considerations and include additional factors for project selection. Like most states, the primary motivation for a project has been to address safety, mobility, or infrastructure health.

In 2011, NCDOT released Prioritization 2.0 that incorporated new elements and updated project selection criteria. This system includes economic competitiveness as one of the criteria used to prioritize projects. This review criterion was added to the project selection process in response to the public's interest in having transportation projects help to create positive economic impacts for the state. In a survey, the public stated that job creation, increased wages, and other economic impacts should be considered in the state's transportation project selection decision making process (<http://www.ncdot.gov/download/performance/OutreachSummary.pdf>). The TREDIS model was used for assessing economic impacts. The final rankings were posted on NCDOT's website and presented to local stakeholders.

The most interesting aspect about this initiative is that it was in response to the public's interest in having the entire process be transparent. Information publicly available enabled a comparison of the benefits of each project under consideration. NCDOT also worked in close collaboration with local stakeholders, including 17 MPOs and 30 RPOs, which resulted in better decision making.

Although the program is still in the implementation stages, NCDOT plans to increase economic productivity in the state and improve beneficial economic impacts through its selection of transportation projects. They have focused on long-term impacts and will seek to ensure that job retention is a priority, along with decreased transportation costs and improved mobility and access. (Ellis et al. 2012, Eno 2012)

5.2.5 Oregon

The Oregon Department of Transportation (ODOT) is developing a Least Cost Planning (LCP) methodology to evaluate the performance of proposed transportation solutions. LCP methodology incorporates a number of performance measures, including accessibility, equity, land use, environment, safety, security, quality of life, livability, mobility, economic vitality, funding, and finance.

The economic vitality performance measure category includes several economic impact considerations. The department's Economic Vitality Indicator Development Team (IDT) is currently working on formulating the performance measures in this category and exploring methods to quantify the measures. The two most important indicators being considered are related to jobs, including the number of jobs created by transportation projects and changes in state/regional employment that result from improved transportation services. However, IDT recognizes that other measures provided by economic models are important outputs that also need to be considered. These measures include output, GRP, labor income, and local tax revenue. (ODOT 2013)

5.2.6 Texas

Texas Department of Transportation (TxDOT) recently concluded a project, "Economic Considerations in Transportation System Development and Operations." The main goal of this project was to produce a reference handbook for explaining in great detail the various terms, methods, approaches, and analysis techniques in the context of economic implications of transportation investments. TxDOT's development of this reference handbook was an effort to educate and familiarize the department's personnel responsible for transportation investment decisions to consider economic analysis in addition to traditional engineering analysis in project selection decision making. (Kockelman et al. 2013)

Unlike ODOT, where efforts are underway to revamp their transportation planning process by incorporating economic considerations, TxDOT has not yet embarked on institutionalizing economic analysis in its transportation planning mechanism. However, this project and its products provide a foundation for considering economic considerations in the state's transportation planning process (Ellis et al. 2012, Kockelman et al. 2013).

5.3 STATE OF PRACTICE IN STATES WITHOUT ESTABLISHED ECONOMIC IMPACT ANALYSIS PROCEDURES

States without established economic impact analysis considerations in their transportation planning process still use economic analysis in support of major transportation investment decisions. Additionally, an economic analysis is often conducted to serve a variety of other objectives, including public and stakeholder outreach, and regulatory requirements, among others. However, as with any analysis, without established procedures and guidance to adhere to, the economic analyses are based on different types of analytic procedures using a range of tools with varying levels of methodological and theoretical rigor.

A case study approach was used to review the state of practice for analyzing the economic impacts of individual transportation projects. The projects were shortlisted with a goal of informing economic impact analysis for use in Connecticut. Initially, the location of candidate projects was limited to the Northeast Region, but the number of candidate projects using this criterion was limited. Therefore the location criterion for project selection was expanded to include the continental United States and Ontario, Canada, to provide a sufficient number of projects for review. The types of transportation projects reviewed were mostly limited to the types of projects ConnDOT generally undertakes, including highway (including capacity expansion, reconstruction, maintenance and rehabilitation), new transit alternatives, and multimodal investments. After a review of projects where an economic impact analysis was conducted for justifying project investment, a total of 41 projects were selected for review based on availability of information regarding the project and the analysis conducted (See Appendix F).

The projects reviewed were primarily proposed to address an existing transportation challenge or a future travel need of a region, such as to reduce congestion, alleviate truck traffic, divert through traffic, or provide access. None of the projects proposed just promoted economic development. Instead, economic impact potential from investing in the transportation project was used along with other types of justification including travel improvement, congestion alleviation, environmental impact, and safety improvements, to support the transportation project.

The project review showed that economic impact analysis plays a key role in justifying a transportation project when the investment is large. For the projects reviewed, the investments varied from \$1.68 million for one of the alternatives of the Chicago RTA- Public Transit project (Appendix F: Project 20), to \$83.57 billion for the Midwest High Speed Rail project (Appendix F: Project 16). The projects also varied in their scope from local, to regional to national scales. For example, the Sonora Bypass project (Appendix F; Project 4) is a 2.2 mile section of roadway in California (T-PICS 2013m). The Lindberg Station project of the Metropolitan Atlanta Rapid Transit Authority (MARTA) system (Appendix F: Project 11) is also local with regional implications (T-PICS 2013k). The Midwest High Speed Rail project (Appendix F: Project 16) evaluation study covers most states in the Midwest through connections between Chicago,

Minneapolis/St. Paul, Cincinnati, Detroit, and Cleveland, among other major cities (EDRG and AECOM 2011).

The economic measures commonly used across projects include jobs created, income, and measures of value added, such as output and GRP. Each individual analysis further included other economic impact considerations, such as tax revenues, rents and land values (land use changes), among others based on the specific objectives of the project and stakeholder considerations. For example, the I-394 in Minnesota (cosigned with US Highway 12) project (Appendix F; Project 1) noted potential changes in land use patterns in areas afforded higher accessibility due to the project (T-PICS 2013a). The Infrastructure Investment in South Georgia project (Appendix F: 30) study in Georgia that evaluated the economic impact of investments in highway widening and rail infrastructure estimated potential local government tax increases of approximately \$4 million and other government revenue increases of \$17.6 million (Campbell, et al. 2000). These measures are consistent with those reported in a survey conducted in 2000 (Weisbrod 2000) by different transportation agencies in the United States and elsewhere for analyzing the economic potential of transportation projects.

The economic impact analysis analytical tool used by each project is noted in Appendix F wherever the information was readily available. In most studies, a regional economic model was used, such as TREDIS, REMI TranSight, HERS-ST, HEAT, RIMS II, and IMPLAN. Depending on the implementation of the analytical tool, the methodology employed varied from an input-output (IO) model, to a computable general equilibrium framework (and the partial equilibrium variant), to a structural econometric model.

A brief description of these and other software tools is presented in Appendix A as part of the review of candidate software conducted in Chapter 4. An outline of the methodologies employed in the software tools was presented in Chapter 3. In addition to providing an economic impact analysis of a specific transportation investment, some of these studies reviewed and used alternate software tools for the purpose of comparison (Lynch 2000, Weisbrod and Arlee 2009). These comparative studies provide interesting insights into the assumptions utilized and the methodologies implemented in the model systems.

In the “Analyzing Economic Impacts with Different Tools” study, a bus fleet analysis (Appendix F: Project 26) that used three different regional economic models (RIMS II, IMPLAN, and REMI TranSight), significant variation in the economic impact measures were identified (Lynch 2000).

- The impact on jobs varied between 187, 318, and 239, respectively.
- The impact on output/GRP was estimated to be \$10.2 million, \$16 million, and \$21.4 million, respectively.

As noted, the economic impacts resulting from the implementation of different models vary considerably as a result of model formulation assumptions, the range of economic processes implemented, and other factors. While there was a wide deviation across measures in the use of different models, it is interesting to note that there is a general consistency in the estimated values across measures. For example, the estimates of impact on jobs, income, and output/GRP are the least from RIMS II followed by REMI TranSight with the greatest level of impacts reported by IMPLAN. This observation is not intended to be a comment on the validity or

applicability of a particular modeling system or a comparison of the systems. Instead it shows that there is wide variability and each is correct in its own right; an analyst needs to have a thorough understanding of the underlying mechanics of the model used so that the models can be accurately applied and the results presented with confidence with the appropriate caveats about model formulation, model assumptions, and the economic processes modeled.

As noted in Chapter 3, transportation investments affect economic activity through changes to mobility, accessibility, connectivity and reliability. It is through these changes that location choices, travel behavior and subsequently economic activity are affected. Therefore, in addition to using an analytical tool for economic impact analysis, tools for measuring the impacts of transportation investments on land use decisions and travel choices can be applied to comprehensively model the full range of impacts due to a transportation investment including economic, land use and transportation impacts. For example, the Appalachian Development Highways project (Appendix F: Project 24) study combines a transportation model, implemented in TransCAD, with the TREDIS economic impact analysis tool to present the economic impacts of the proposed project (CS 2008).

Several of the transportation projects reviewed have been constructed, others are under construction, and some are still being considered or are in the planning/ design process. Additionally, some of the projects were terminated, such as the Trans-Hudson Express Tunnel project (Appendix F: Project 35) connecting the New York City metropolitan area with New Jersey (ERA 2004). For projects that were built where economic impact analysis was used to justify the investment, very few if any studies have evaluated projects after construction to compare the economic outcomes as a result of the project with those predicted from the economic analysis that was used to justify the project. In addition to characterizing the validity of the predictions, an evaluation can also be useful for reviewing economic analysis methodologies and revising their role in the decision-making process.

The T-PICS website, limited to highway projects, was used to identify candidate projects for the case study. T-PICS was developed as a result of a Transportation Research Board, Strategic Highway Research Program (SHRP2) project, "Impact of Transportation Capacity on Economic Development and Land Use." The goal of this project was to provide an understanding of the economic development and land use implications of highway investments. The T-PICS website is a repository of highway projects that can be utilized by practitioners in the strategy development and sketch planning stages of the transportation planning process. Further, the tool helps practitioners identify relevant projects that they can utilize to develop an analysis framework for evaluating specific transportation investments. The website also includes a meta-analysis tool for analyzing the economic impacts from a project similar to a specific project under consideration. (T-PICS 2013)

5.4 STATE OF PRACTICE IN CONNECTICUT

One of the objectives of this study was to review the state of practice of economic impact analysis of transportation projects in Connecticut. In this regard, focus group sessions were conducted with stakeholders who have an interest in the state's transportation investments.

5.4.1 Focus Group Sessions

Three focus group sessions were held to supplement the national literature scan and economic model comparison with opinions and information specific to stakeholders in Connecticut. Each focus group session used the same basic discussion guide (see Appendix C, Appendix D, Appendix E and Appendix G for more information). The discussion guide served as an outline for a guided discussion with subject matter experts that enabled exploration of new topics and ideas that were raised during the sessions. The overarching discussion themes were as follows:

- Understanding the motivation for transportation investments
- Demonstrating the value of transportation investments
- Reviewing metrics and measures that convey the value of transportation investments

Session participants consisted of representatives from several stakeholder groups.

- Regional Planning Organizations (RPOs) in Connecticut. RPO is a generic term for planning agencies in Connecticut, including Metropolitan Planning Organizations (MPOs), Regional Planning Agencies (RPAs), Councils of Government (COGs) and Councils of Elected Officials (COEs). A pre-focus group survey was administered to the RPO participants, 10 of whom responded.
- ConnDOT staff from the bureaus of engineering and construction, policy and planning, and public transportation provided input from the department's perspective.
- Members of the Transportation Committee of the Connecticut General Assembly.

5.4.2 Observations

Most of the focus group participants were unfamiliar with the specifics regarding economic impact analysis tools and methodologies. As a result, the focus of discussion by session participants was less on the technical aspects of modeling the economic impacts of transportation investments and more on the context within which economic impact analysis tools are deployed and utilized for decision making. Importantly, the focus group sessions provided input from the stakeholders who would be responsible for conducting economic analyses and implementing transportation investment decisions based on the results of the quantitative analyses of proposed projects.

Four key topics from the research team's focus group session observations include

- transparency;
- communication;
- performance measurement; and
- considerations for conducting economic impact analysis for transportation projects.

The four topics are interrelated, but each highlights important aspects of economic impact analysis that must be considered when selecting economic analysis tools for use in project selection decision making. The following is a summary of the focus group session findings.

5.4.2.1 TRANSPARENCY

Economic analysis modeling tools have been used to estimate measures of economic activity and enhance the information available to policy makers and planners for use in making transportation investment decisions. However, the adoption, application and utilization of economic impact analysis and the results of such analyses to inform investment decisions has been inconsistent. As with most challenging decisions, the greatest stress comes not from a challenge in terms of the magnitude of the decision (though it is certainly influential), but from the uncertainty associated with that decision.

Uncertainty involving the use of economic analysis to inform transportation investment decisions has been identified as an issue to be considered. One aspect of uncertainty is associated with the assumptions and inputs that are used by the economic analysis models and methodologies. This is a fundamental concern for the use of any of the modeling tools selected and applied in Connecticut for transportation project selection. Factors of concern include:

- Quality of the data used as inputs into the model. This is an especially acute concern with large, regional modeling tools that rely on disparate data coming from several different geographic locations and state departments.
- Assumptions that are made within the model. It is important that those that apply and use the economic analysis models as decision-support tools be knowledgeable about their capabilities, functionality, and limitations. Familiarity with and a clear understanding of the assumptions that go into specifying and running the economic analysis models should provide for an accurate application of the model systems. Subsequently, the decision makers will develop confidence in the results from the economic analyses for use in supporting transportation investment decisions.

Local and regional planning organizations indicated a lack of confidence in the state's commitment that the results of any economic analysis would outweigh political considerations for final decision making on transportation investment. This concern could be addressed by clearly identifying how the results would be used in the decision making process and then demonstrating commitment to apply the results of the economic analyses fairly and consistently regardless of whether the results are positive or negative. Focus group participants indicated a belief that only results showing positive economic impact would be made publicly available, whereas negative results would not be considered in project selection decisions.

Additionally, concern was expressed regarding the uncertainty associated with the state's long-term commitment to utilizing economic analysis in the project selection decision making process. This concern is based on the potential for shifts in analysis methodologies for project prioritization that periodically can be associated with a change in state administrations, and further, that those that adopted economic analysis as a core concept for the review of projects would be disadvantaged in some manner. States such as Vermont have been able to address this long-term consistency issue by institutionalizing the use of decision-support systems such as asset management in legislation. This level of statewide commitment has shown to be the most effective means of alleviating concerns of consistency across administrations (CS 2002). The value of money concept is another systematic approach to decision making that is heavily utilized in the United Kingdom for evaluating investment in public programs (Jackson 2012).

Key Takeaways

In general, uncertainty associated with the introduction and adoption of economic analysis tools could be reduced through institutionalizing economic analysis as part of the transportation planning process. Uncertainty associated with the application of economic analysis in the project selection decision making process can be mitigated by a commitment to educate stakeholders on the value and purpose of the economic impact analysis. Further ensuring transparency and consistency in their application across the state will build confidence in the results of economic analyses. There was a suggestion that external evaluation is often very helpful in bringing objectivity into the decision making process and avoiding subjective influences in assessing options for transportation investment. The more transparent the process, assumptions, data, and results, the more transportation investment decisions will be data driven, and perceived as data driven, as opposed to being perceived as politically motivated.

5.4.2.2 COMMUNICATION

Respondents stated that a competitive relationship exists between towns and regions that are supported by state and federal funding for transportation projects. There was also general acknowledgement of the need for cooperative relationships to pursue projects. While tension due to competing interests should be expected to play a role in decisions, it was also generally agreed that the state, regions and towns should do a much better job at communicating with each other, and also within their own jurisdictions.

The results of several questions from the RPO pre-focus group session survey are shown in Table 5.1. Respondents were asked to indicate their agreement with each statement on a scale of 1 to 7, with 1 being “strong disagreement” and 7 being “strong agreement.” Ten of the 14 RPOs that participated in the focus group session responded to the survey.

One set of interesting results involves the series of questions regarding communicating to different audiences. According to these results, RPOs are more confident in their ability to communicate to policymakers than to businesses and the general public in their region. In particular, the RPOs indicated that a concerted effort needed to be made to include major business and industry partners, and interest groups in the planning process, especially regarding the economic impacts of transportation projects.

The increased confidence in communicating with policymakers is partly due to RPOs having a history of working with them and an understanding of their priorities. In general, with the traveling public, or end user, RPOs have less of an understanding of what resonates with them, especially in matters comparing transportation and economic considerations. This involves the use of metrics and performance measurement to provide the public with meaningful information that they can relate to in terms of the value of transportation projects. Communication with the public may also be a function of constrained resources, as transportation planners are struggling to meet core responsibilities, let alone conduct an effective public communications program.

Transportation agencies are also learning to communicate with the public using social media and other electronic formats. One aspect that has certainly had an impact on the communication of the effects on the public from proposed transportation projects has been an improved public outreach process. Creative web-based presentations are used to inform the public on complex

concepts regarding key transportation initiatives (NHHS 2013). However, transportation departments and RPOs are faced with constrained budgets and limited resources to continue public outreach innovation activities and sustain public education efforts.

TABLE 5.1: RPO PRE-FOCUS GROUP SESSION SURVEY RESULTS

Question	Average	Standard Deviation
My organization has well-defined economic assessment metrics.	3.1	1.8
Assessment of economic impacts of transportation investments at the local level is important.	5.9	1.0
Assessment of economic impacts of transportation investments at the regional level is important.	5.9	1.0
Assessment of economic impacts of transportation investments at the state level is important.	5.9	1.0
My organization does a good job of communicating the value of transportation investments to:		
End users (traveling public)	3.7	1.6
Private industry	3.8	1.6
Policymakers	4.9	1.8
Uncertainty in funding has a big impact on transportation investment decisions	6.1	1.3
The amount of justification for transportation investment decisions needed is significantly greater than a decade ago.	5.8	1.2
We currently have resources available to do economic assessments in-house.	2.4	1.4
It is a difficult challenge communicating local benefits of investments designed to spur regional economic activity.	4.6	1.7

Key Takeaways

Following are key takeaways related to communication:

- Planners and economic development commissions should strive to work more closely together.
- Performance measures should be established in a collaborative process, required in decision making and communicated regularly to the public.
- Effort should be made to improve the involvement of business and industry in the transportation planning process.

5.4.2.3 PERFORMANCE MEASUREMENT

“What is measured gets managed” is a mantra of many management experts and is applicable for considering the economic impact analysis of transportation investments. If economic analysis tools are to be used in the transportation investment decision making process, it is important to establish the key metrics that describe the results of the analysis that will be used in making investment decisions and that will be communicated to the public. A clear set of metrics can help align goals with project selection and will further enable decision makers to convey the value of the decisions to various stakeholders effectively.

As shown in Figure 5.1, traditional transportation metrics tend to drive the investment decisions of RPOs. This is natural for two reasons: transportation is the core responsibility of the RPOs, and transportation performance measures have been established and understood for some time. In fact, focus group participants suggested that in the past they have been criticized for overstepping their area of responsibility if efforts were made to include economic development in their decision making process. The survey results indicate that encouraging regional economic activity is not ranked as highly as more traditional factors, such as safety and maintaining a state of good repair and/or operations, as an influence in transportation investment decision making.

In my organization, transportation investment decisions are influenced strongly by:



(n=10, with 1 = Strongly Disagree and 7 = Strongly Agree)

FIGURE 5.1: RESULTS FROM RPO PRE-FOCUS GROUP SESSION SURVEY REGARDING TRANSPORTATION INVESTMENT INFLUENCES

Across the three focus group sessions the following metrics surfaced as the most salient and effective ways to communicate with the various stakeholders and their audiences. It was highlighted that transportation metrics should continue to play a major role in the transportation

investment decision making process and should be complemented by the consideration of economic impacts. ConnDOT's current performance measures can serve as a starting point for many of the transportation metrics. In particular, the following should be used to evaluate projects and for communicating with stakeholders:

Transportation metrics

- safety
- state of good repair
- congestion/operations
- emissions/environmental

Economic metrics

- grand list growth
- job growth (permanent)
- property values
- resident turnover

Key Takeaways

Predicting transportation investment impacts requires the application and maintenance of a variety of analytical tools. The sophistication, fidelity, and robustness of these analytical tools will further be determined by the types of questions asked (e.g., longer-term induced impacts will require a modeling tool that can capture the process) and measures used (e.g., agglomeration effects due to the induced impacts of transportation investments will require an economic model to capture the economic activity and a land use model to disaggregate the locational changes). It is vital that resources be committed not only to data collection and quality control for predictive model application, but to model validation and verification using the selected performance metrics.

5.4.2.4 CONSIDERATIONS FOR CONDUCTING ECONOMIC IMPACT ANALYSIS OF TRANSPORTATION PROJECTS

The selection of an economic analysis tool and the types of projects appropriate for its use was an issue that was discussed throughout the focus group sessions. A full regional economic impact analysis modeling tool is most appropriate for larger-scale projects where predicting longer-term economic activity outcomes can be useful in the justification and selection of projects. In these cases, understanding the potential economic activity outcomes of a project can help decision makers justify the need for project investment. For example, the New Haven-Hartford-Springfield commuter rail line was identified as the type of project that would benefit from having longer-term economic impacts identified during the planning phase of the project. Connecticut currently has multiple large-scale transportation infrastructure needs that are competing for limited funding. The use of comprehensive economic impact analysis would be helpful to decision makers to allow them to factor the value of a project's economic potential into the project selection decision making process.

Focus groups session participants suggested that the analytical modeling tools utilized should have the functionality for multi-modal analysis, as most major transportation investment decisions likely involve a comparison of investments across multiple modes.

Additionally, for smaller projects, an objective analysis of benefits and costs over the life-cycle of a project (e.g., BCA) would be useful for considering project alternatives in both the planning and engineering phases of project development.

Key Takeaways

The need for conducting an economic analysis of a transportation project and the methodology for conducting such analyses should be based on the type of project proposed. As a guide, criteria should be developed for determining the type of analysis to conduct, either a full regional economic impact analysis or a BCA based upon the type of project being considered.

Additionally, it is noted that project selection should be based on priorities established for the state's strategic long-range transportation plan such as preservation, safety, efficiency and capacity, as well as quality of life that includes economic and environmental impacts. Not all transportation projects are designed to spur regional economic activity. Therefore, projects need to be considered on the basis of the criteria most appropriate to the project and on state goals, and the use of such measures in determining investment priorities should be consistent.

5.5 SUMMARY

The national scan of the state of the practice and input from focus group sessions provided guidance for the selection, adoption and implementation of economic analysis models for determining the value of transportation investments in Connecticut. Efforts in states with an established economic impact analysis process as part of their transportation planning process, and the success of these programs in achieving larger transportation and non-transportation related strategic goals, is encouraging.

Four lessons learned include the following:

- Transparency in conducting and applying the results of economic analysis for project selection decision making is necessary.
- Communication is needed throughout the economic analysis process between department of transportation staff and analysts, as well as with stakeholders and policymakers at all levels, as appropriate, and the general public. This involves providing information on assumptions used for economic analyses, as well as reporting on the results of such analyses so as to build confidence in the results and use for transportation investment decision making.
- Performance measures should be identified for use in project selection and communicated with department of transportation staff, stakeholders, policy makers and the general public. The metrics need to be customized for various types of groups so as to be meaningful for understanding the value of a project. Consistency throughout the project analysis and decision making process is critical for successful implementation.
- The economic analysis models and methodologies used should be appropriate for the type and size of project(s) being considered. Projects and alternatives should be evaluated on the basis of the issues they are intended to solve.

REFERENCES

- Burke, D., Luskin, D., Rosa, D., and Collier, T. (2005) Transportation and Texas Economy: Some Interim Results. Performed in Cooperation with the Texas Department of Transportation and the Federal Highway Administration. (Website: <http://d2dtl5nnpfr0r.cloudfront.net/tti.tamu.edu/documents/0-4871-1.pdf>, Accessed: April 8, 2013)
- Campell, R.W., Doyle, J.G., Hawkins, R., and Pavlak, T.J. (2000) Infrastructure Investment Would Benefit South Georgia. Public Policy Research Series, Carl Vinson Institute of Government, The University of Georgia, 1(7). (Website: http://www.remi.com/download/publications/transportation/article_329.pdf, Accessed: April 8, 2013)
- CEA (Chumra Economics and Analytics) (2011) Economic Impact of the US Route 460 Corridor Improvement Project. Prepared for David Tyeryar, Deputy Secretary of Transportation.
- Clarke, W., Kane, S., and Shepherd, T. (2012) The Economic Impact of the Metropolitan Atlanta Rapid Transit Authority on the Economy and Labor Mobility of the Region. Carl Vinson Institute of Government, The University of Georgia. (Website: http://www.itsmarta.com/uploadedFiles/About_MARTA/Reports/UGA-Report-on-MARTA-Financial-Impact-2012.pdf, Accessed: April 8, 2013)
- CRC (Columbia River Crossing Project Team) (2009) CRC Economic Benefit Analysis: Final Report TREDIS (Website: http://www.columbiarivercrossing.org/FileLibrary/CRC%20economic%20benefit%20analysis_2012-10-31.pdf, Accessed: April 8, 2013)
- CS (Cambridge Systematics, Inc.) (2002) VTrans Asset Management Vision and Work Plan: Final Report. Prepared for the Vermont Agency of Transportation. (Website: http://vtransplanning.vermont.gov/sites/aot_policy/files/documents/planning/VTrans_Asset_Mgmt_VW.pdf, Accessed: May 18, 2013)
- CS (Cambridge Systematics, Inc.) (2003) Transportation Improvements Grow Wisconsin's Economy: The Economic Benefits of Transportation Investments. Prepared for Transportation Development of Wisconsin. (Website: http://www.remi.com/download/publications/transportation/article_340.pdf, Accessed: April 8, 2013)
- CS (Cambridge Systematics, Inc.) (2008) Economic Impact Study of Completing the Appalachian Development Highway System. Prepared for the Appalachian Regional Commission. (Website: http://www.arc.gov/assets/research_reports/EconomicImpactStudyofCompletingADHS.pdf, Accessed: April 8, 2013)
- CS (Cambridge Systematics, Inc.) (2009) Mid-Atlantic Rail Operations: Phase II Study Final Report. Prepared for I-95 Corridor Coalition. (Website: http://www.i95coalition.org/i95/Portals/0/Public_Files/pm/reports/MAROps%20Phase%20II%20Final%20Report.pdf, Accessed: April 8, 2013)

- CS (Cambridge Systematics, Inc.), EDRG (Economic Development Research Group, ICFC (ICF Consulting) and SEH (Short Elliott Hendrickson, Inc.) (2005) Final Report: Montana Highway Reconfiguration Study. Prepared for Montana Department of Transportation. (Website: <http://archive.org/stream/4F9EA43E-D42D-4916-9A31-7B193140996D#page/n1/mode/2up>. Accessed: April 8, 2013)
- Delcan Arup JV (2010) GO Transit Rail Electrification Study: Appendix 8H - Economic Impacts. TREDIS (Website: <http://www.gotransit.com/electrification/en/default.aspx>, Accessed: April 8, 2013)
- EDRG (Economic Development Research Group) and AECOM (2011) The Economic Impacts of High Speed Rail: Transforming the Midwest. Prepared for the Midwest High Speed Rail Association. (Website: http://www.midwesthsr.org/sites/default/files/pdf/MHSRA_2011_Economic_Study_Technical_Report.pdf, Accessed: April 8, 2013)
- Ellis, D., Glover, B., and Norboge, N. (2012) Refining a Methodology for Determining the Economic Impacts of Transportation Improvements. University Transportation Center for Mobility, Texas Transportation Institute, The Texas A&M University. (Website: http://utcm.tamu.edu/publications/final_reports/Ellis_11-00-68.pdf, Accessed April 14, 2013).
- Eno (2012) Better Use of Public Dollars: Economic Impact Analysis in Transportation Decision Making. A report produced by the Eno Center for Transportation. (Website: <http://www.enotrans.org/wp-content/uploads/wpsc/downloadables/Public-Dollars.pdf>, Accessed: May 18, 2013)
- EOT (Massachusetts Executive Office of Transportation, SCR (South Coast Rail), and EOHED (Massachusetts Executive Office of Housing and Economic Development) (2009) South Coast Commuter Rail Economic Development and Land Use Corridor Plan. (Website: <http://www.southcoastrail.com/downloads/3%20-%20South%20Coast%20Rail%20Corridor%20Plan%20-%20Low%20Resolution.pdf>, Accessed: April 8, 2013)
- ERA (Economics Research Associate) (2004) Economic Fiscal Impacts of the ARC Project. Final Report submitted to New Jersey Transit by Economics Research Associate.
- GAO (2010a) Statewide Transportation Planning: Opportunities Exist to Transition to Performance-Based Planning and Federal Oversight. United States Government Accountability Office, Report to Chairman, Committee on Transportation and Infrastructure, House of Representatives. (Website: <http://www.gao.gov/assets/320/314004.pdf>, Accessed: May 18, 2013)
- GAO (2010b) Statewide Transportation Planning: Surveys of State Departments of Transportation and Regional Planning Organizations. United States Government Accountability Office. (Website: <http://www.gao.gov/special.pubs/gao-11-78sp/index.htm>, Accessed: May 18, 2013)
- HDR and iTRANS (2010) Durham Regional Transit: Long Term Transit Strategy Final Report. TREDIS (Website: http://www.durham.ca/pdf/transit/DRTLTTTS/LTTS_MASTER_March_2010.pdf, Accessed: April 8, 2013)

- INDOT (2013) Economic Impacts of Indian's Statewide Long Range Transportation Plan. (Website: <http://www.in.gov/indot/files/Elreport.pdf>, Accessed: May 18, 2013)
- Jackson, P. (2012) Value for Money and International Development: Deconstructing Myths to Promote a More Constructive Discussion. Development Assistance Committee, The Organization for Economic Co-operation and Development (OECD). (Website: <http://www.oecd.org/dac/effectiveness/49652541.pdf>, Accessed: May 5, 2013)
- Kaliski, J.G., Smith, S.C., and Weisbrod, G.E. (1999) Major Corridor Investment-Benefit Analysis System. Prepared for the Seventh TRB Conference on the Application of Transportation Planning Methods. (Website: http://www.remi.com/download/publications/transportation/article_335.pdf, Accessed: April 8, 2013)
- Kockelman, K., Chen, D., and Nichols, B. (2013) The Economics of Transportation Systems: A Reference for Practitioners. TxDOT Project 0-6628: Economic Consideration in Transportation System Development and Operations.
- Lubin, D. G., Ranney, G.A., and Beal, F.H. (2007) Time is Money: The Economic Benefits of Transit Investment. Chicago Metropolis 2020: One Region – One Future. (Website: <http://www.metropolisstrategies.org/documents/TimeisMoney.pdf>, Accessed: April 8, 2013)
- Lynch, T. (2000) Analyzing the Economic Impact of Transportation Projects Using RIMS II, IMPLAN, and REMI. Prepared for the Office of Research and Special Programs, U.S. Department of Transportation, Washington, D.C. (Website: http://www.remi.com/uploads/File/Articles/article_339.pdf, Accessed: April 8, 2013)
- McMillen, S., Prakash, N., Prisløe, M., and Kalinowski, J. (2009) The Economic and Fiscal Impacts of Alternative Buildouts Associated with The Interchange 84/Route 8 Interchange Reconfiguration. Prepared by the Department of Economic and Community Development for the Connecticut Department of Transportation.
- MDT (2009) US 2 Brockton E. Roosevelt County, MT: Transportation Investment Generating Economic Recovery (TIGER) Discretionary Grant. Submitted by the Montana Department of Transportation (Website: http://www.mdt.mt.gov/recovery/docs/grants/tiger_brockton_app.pdf, Accessed: April 8, 2013)
- MTO (Ministry of Transportation, Ontario) (2011) Niagara to GTA Corridor: Planning and Environmental Assessment Study. (Website: http://www.niagara-gta.com/pdf/3-7-11/Draft%20TDS_Mar%203%202011_Chp%204.pdf, Accessed: April 8, 2013)
- NHHS (2013) New Haven – Hartford – Springfield Rail Program. (Website: <http://www.nhhsrail.com/>, Accessed: May 18, 2013)
- ODOT (2013) Least Cost Planning (LCP). (Website: <http://www.oregon.gov/ODOT/TD/TP/Pages/LCP.aspx>, Accessed: May 18, 2013)

- Perlich, P.S. (2004) Economic and Demographic Impacts of Federally Financed Transportation Infrastructure on the Wasatch Front. Utah Economic and Business Review, Bureau of Economic and Business Research, 64(9-10). (Website: http://www.remi.com/download/publications/transportation/article_346.pdf, Accessed: April 8, 2013)
- REMI (Regional Economic Models, Inc.) (2004) Expanding US Highway 54 in New Mexico: Assessing the Economic Effects. Prepared for Souder, Miller, and Associated. (Website: http://www.remi.com/download/publications/transportation/article_345.pdf, Accessed: April 8, 2013)
- TEMS (Transportation Economics & Management Systems, Inc.) (2006) Midwest Regional Rail Initiative: Benefit Cost & Economic Analysis. Prepared for Illinois Department of Transportation, Indiana Department of Transportation, Iowa Department of Transportation, Michigan Department of Transportation, Minnesota Department of Transportation, Missouri Department of Transportation, Nebraska Department of Transportation, Ohio Department of Transportation, Wisconsin Department of Transportation, and Amtrak. (Website: <http://www.dot.wisconsin.gov/projects/state/docs/mwrri-economic.pdf>, Accessed: April 8, 2013)
- Tolliver, D. and Dybing, A. (2007) Impacts of Transportation Infrastructure on the Economy of North Dakota. A Report to the North Dakota Legislative Council by the Upper Great Plains Transportation Institute. (Website: http://www.remi.com/download/publications/transportation/article_353.pdf, Accessed: April 8, 2013)
- T-PICS (2013) Transportation Project Impact Case Studies. The following references can be accessed on the T-PICS website: <http://transportationforcommunities.com/t-pics/>
- T-PICS (2013) Transportation Project Impact Case Studies. (Accessed February 15, 2013)
- T-PICS (2013a) Transportation Project Impact Case Studies: I-394 Minnesota. (Accessed February 15, 2013)
- T-PICS (2013b) Transportation Project Impact Studies: Anderson Regional Transportation Center, Woburn, MA. (Accessed: April 8, 2013)
- T-PICS (2013c) Transportation Project Impact Studies: Arlington Heights METRA. (Accessed: April 8, 2013)
- T-PICS (2013d) Transportation Project Impact Studies: Bellevue Transit Center, Bellevue, WA. (Accessed: April 8, 2013)
- T-PICS (2013e) Transportation Project Impact Studies: Beltway 8 Houston Segments. (Accessed: April 8, 2013)
- T-PICS (2013f) Transportation Project Impact Studies: Bennington Bypass, VT 279. (Accessed: April 8, 2013)
- T-PICS (2013g) Transportation Project Impact Studies: DART. (Accessed: April 8, 2013)
- T-PICS (2013h) Transportation Project Impact Studies: Emerson Park MetroLink. (Accessed: April 8, 2013)

- T-PICS (2013i) Transportation Project Impact Studies: Hollister SR 156. (Accessed: April 8, 2013)
- T-PICS (2013j) Transportation Project Impact Studies: I-15 Reconstruction – Salt Lake City. (Accessed: April 8, 2013)
- T-PICS (2013k) Transportation Project Impact Studies: Lindberg Station, MARTA (Atlanta). (Accessed: April 8, 2013)
- T-PICS (2013l) Transportation Project Impact Studies: Mercer Co. KY, US-127 Bypass. (Accessed: April 8, 2013)
- T-PICS (2013m) Transportation Project Impact Studies: Sonora & East Sonora SR 49 and SR 108. (Accessed: April 8, 2013)
- T-PICS (2013n) Transportation Project Impact Studies: Sunset Transit Center, Portland, OR. ()
- Vozzolo, D. (2012) Interim Guidance on MAP-21 Fixed Guideway Capital Investment Program. White Paper, HDR Inc. (Website: http://www.hdrinc.com/sites/all/files/content/white-papers/white-paper-images/5088-interim-guidance-on-map-21-fixed-guideway-capital-investment-program_0.pdf, Accessed April 16, 2013).
- Weisbrod, G. (2000) Procedures for Assessing Economic Development Impacts from Transportation Investments. National Cooperative Highway Research Program, Synthesis of Highway Practice. (Website: <http://www.edrgroup.com/pdf/synth290.pdf> , Accessed: May 5, 2013)
- Weisbrod, G. and Arlee, R. (2009) Economic Impact of Public Transportation Investment. Prepared for the American Public Transportation Association. (Website: http://www.apta.com/resources/reportsandpublications/Documents/economic_impact_of_public_transportation_investment.pdf, Accessed: April 8, 2013)
- Wilbur Smith Associates (2011) I-70 Dedicated Truck Lanes Feasibility Study. Presented at the 2011 Mid America Association of State Transportation Officials Conference, Cincinnati, OH. (Website: <http://www.maasto.net/2011presentations/024.I70MAASTO.pdf>, Accessed: April 8, 2013)

6. SUMMARY OF FINDINGS AND RECOMMENDATIONS

6.1 NEED FOR ANALYZING ECONOMIC IMPACTS DUE TO TRANSPORTATION INVESTMENTS

Transportation investments are traditionally motivated by the need to improve safety, alleviate congestion, enhance mobility and accessibility, and increase reliability of transportation networks. In addition to transportation-related considerations, transportation investments are also aimed at promoting economic activity and bringing about economic development in a region. The interactions between transportation investments and economic activity have long been recognized. However, estimating and evaluating the economic impacts of such investments for project selection, programming and prioritization has received increased interest by transportation agencies in recent years, for the following reasons, among others:

- A decline in the availability of funding for transportation projects has led to increased competition for limited federal and state resources.
- A paradigm shift in implementing transportation projects from seeking funding to obtaining financing, resulting in an increased need for transportation agencies to justify the economic value of transportation projects in comparison with other priorities for competing bonding or other financing.
- A growing call at the federal and state levels for funding/financing projects based on performance-based criteria, such as the potential for investment in a program or project to result in economic development.
- Investing in transportation to promote economic development of a region.

RECOMMENDATIONS

- It is suggested that ConnDOT institutionalize procedures for economic impact analysis for future transportation projects and programs so that the analyses conducted are objective, independent, unbiased, and consistent. Further, ConnDOT should clearly define the role and contribution of economic analysis for use in ConnDOT's strategic transportation planning process for the purpose of selecting, programming and prioritizing transportation investments.

6.2 CHARACTERIZING ECONOMIC IMPACTS OF TRANSPORTATION INVESTMENTS

6.2.1 *Transportation Investments as a Facilitator of Economic Development*

Transportation investments cause economic activity in two significant ways.

- Creation of economic activity from the spending of money in the construction of transportation projects. This type of economic activity is short lived and temporary. Economic activity related to project construction needs to be put in the perspective of the state's annual total transportation investment program.
- Economic growth that is the result of the influence of the improvements caused on the transportation system's performance and end user's choices. Transportation improvements impact connectivity, mobility, accessibility, and reliability of the transportation system. Each of these transportation investment impacts interact in complex ways to result in economic activities.

As noted, all transportation investments bring about economic activity, but not all transportation investments result in economic development of a region.

Economic development is a broader and longer-term concept that generally results in the growth of jobs, wealth, tax base, and well-being of a neighborhood, city, region or state. Generally, a program results in economic development when the following conditions are realized:

- Increase in employment and wages that will result in the economic well-being of individuals and households in the region.
- Additional employment choices and opportunities for upward mobility so that individuals are satisfied and others may migrate into the region.
- Improved quality of life and well-being of individuals and households by offering them opportunities to engage in activities.
- Sustaining the above conditions over the long term.

A transportation system facilitates the economic development activity in a region by influencing the movement of people, activities, goods, and services. However, it is not the only factor that can bring about economic development in a region. There needs to be a confluence of other favorable conditions including politics, policy, legal structures such as property rights, labor, education, taxation, quality of life factors and other non-transportation related infrastructure for the economic development impacts to be realized from a transportation investment. The need for other favorable conditions becomes more important as the transportation infrastructure matures, and further transportation investments only bring about marginal improvements to the accessibility, mobility, and connectivity of the transportation system.

Another important consideration is to ensure that proposed transportation projects and alternatives adapt to changing times and needs. Transportation choices and travel behavior of the future may be different than they are today. Therefore, policies and programs should recognize future changes in transportation choices and travel behaviors in response to advances in transportation technologies, transport modes, and fuel options. For example, while futuristic, autonomous vehicles enabled by advances in sensor and computational technologies are seen as a potential for surface transportation in the future. This technology was seen as extremely futuristic at the time it was proposed, but the recent demonstration of this technology (Google driverless car) confirmed the technical feasibility of this development. There is a widespread interest in adopting this technology that may have important implications for future travel behavior and transportation safety, as well as for transportation system investments.

RECOMMENDATIONS

It is recommended that analysts who are well versed in economic theory conduct the economic impact analyses of transportation projects. Further, such analysts need to

- be knowledgeable about the linkages between transportation and the economy;
- have a clear understanding of the different dimensions of economic development and acknowledge the role of transportation as a facilitator of economic development and not as its only cause;
- understand the role of and identify other favorable conditions so that appropriate non-transportation related policy decisions can be made to realize potential economic impacts from transportation investments; and
- understand the local economic and social context and considerations so that appropriate assumptions are made in applying models and interpreting the results.

6.2.2 Processes Characterizing Economic Impacts

Transportation investments bring about economic activity primarily by improving mobility, increasing accessibility, alleviating costs, and increasing reliability. Each of these direct transportation investments impacts interact in complex ways to result in economic activities by reducing costs, improving quality and quantity of labor pools, increasing size of consumer markets, raising efficiency, improving productivity, increasing competitiveness, enabling growth, and altering location patterns among others.

Economic impacts can be classified into direct, indirect and induced impacts. Direct impacts refer to the economic activity that results from improving the economic efficiency of end users caused by the transportation investment. Indirect impacts result from economic activity that is needed to support the direct economic impacts. Induced impacts involve economic activity that results from additional income afforded to employees, and wealth accumulated by businesses. They also include other tertiary and perpetuity economic activity resulting from market access changes, increased competitiveness and attractiveness of the region and due to changes in economic structure.

RECOMMENDATIONS

- Analysts need to have a clear understanding of the processes underlying the influence of transportation investments on the economic activity so that the model can be specified and applied to comprehensively capture the full range of impacts.

6.2.3 Measuring Economic Impacts

In analyzing the economic impacts due to transportation investments, a number of economic indicators and non-economic indicators are used. However, there are some common measurement issues that need to be considered. Economic development is achieved only by generative economic activity. Distributive and transfer activities do not contribute to economic development. Depending on the scale of the analysis and extent of the area of interest, an economic activity may or may not contribute to the economic development of a region.

A number of the indicators used to estimate economic impacts are different manifestations or measurements of the same activity, and, therefore, cannot always be added together to provide an overall estimate of the potential economic activity from the transportation investment. Some indicators are well matched to be used together to provide an estimate of potential economic activity, such as components of GRP or GDP, as appropriate, that estimate the flow of wealth into a region from a specified activity.

All transportation investments lead to economic activity. However, not all economic activity can be qualified as a benefit and will not always contribute positively to economic development. Each of the impacts must be compared against a true baseline in assessing the potential contribution of the economic impact to the economic development.

RECOMMENDATIONS

- Clearly define the analysis area and region of interest. This has important implications for defining the economic development potential of transportation investments.
- Ensure that the analysts that conduct the analyses are aware of and understand how the measures of different economic activity are derived and the types of processes that are captured in the measures. This will enable the analysts to identify and/or avoid common measurement issues.

6.3 ANALYZING ECONOMIC IMPACTS

Two types of interrelated analyses are often conducted to analyze economic impacts from transportation investments. These consist of those for estimating economic impacts, and those for evaluating economic impacts:

- Estimating economic impacts of transportation investments: Analyses aimed at estimating economic impacts attempt to answer the question: What is the overall impact on the regional economy from the proposed transportation project? This type of analysis employs methods and approaches that estimate changes in economic indicators of interest (e.g., wages, jobs, outputs, GDP, and GRP) by modeling the economy with and without a transportation investment.
- Evaluating economic impacts of transportation investments: Analyses aimed at evaluating economic impacts attempt to answer the question: What are the overall costs compared with the benefits over the life cycle of a transportation project? This type of analysis uses techniques to evaluate the net value/outcome/return of the different economic activities by considering the benefits and costs of a project.

RECOMMENDATIONS

Analysts need to

- have a thorough understanding of the mechanisms and processes that drive economic activity resulting from transportation investments so that an appropriate analysis technique can be applied for estimating the changes in economic activity, and for evaluating the net value of the economic impacts;

- be aware of the questions that need to be addressed in the analysis; and
- be able to customize reporting for a range of sophistication of audiences that the analysis is intended for, and their level of involvement in the project.

6.3.1 Methodologies for Estimating Economic Impacts

Several analytical techniques and modeling approaches are available depending on the purpose, scale, and scope of the analysis for transportation projects. These techniques vary in complexity, sophistication, and economic rigor from simple sketch planning tools, to sophisticated regional economic models (REMs) founded on economic theory.

REMs are the most comprehensive and most commonly used for analysis of large-scale transportation investments. Three methodologies are at the core of most REM implementations:

- Input-output models
- Computable general equilibrium models (CGE)
- Econometric models

Each methodology has advantages and limitations for specifying and modeling economic impacts of transportation investments. The CGE approach and its variants (e.g., partial general equilibrium model) are more comprehensive in the treatment of various players in the economy (businesses, households, and governments) and their economic activity. The approach can incorporate a wider range of economic impacts, including induced impacts—one of the focuses of this study. Also, some implementations of CGE incorporate econometric approaches to model dimensions and processes underlying the economy. Based on their ability to capture the temporal dimension of economic activity, CGE models can be further classified into static and dynamic equilibrium models.

RECOMMENDATIONS

- It is suggested that REMs be used to model the economy by accurately capturing the flow of goods and services across different industries and sectors. A model based on general equilibrium principles, the CGE approach and its variant, the partial general equilibrium model, are recommended because of their ability to capture induced impacts. The specific choice will depend on the application context, namely, the level of industry detail by which economic impact results are desired and the desired sophistication of the model (which also influences the effort involved in conducting the analysis; the amount of effort involved is a direct function of the model sophistication).
- The general equilibrium model implementations incorporate only a limited set of induced impacts. The model therefore may need to be supplanted with additional model components for capturing the full range of induced impacts.
- The analysts must be well versed with the implementation of the REM and understand the range of processes that are captured and ignored in the economic model so that the results can be appropriately interpreted.

6.3.2 Methodologies for Evaluating Economic Impacts

The various methods for evaluating the net value of transportation investments are as follows:

- Benefit-cost analysis (BCA)
- Cost-effectiveness analysis
- Cost-utility analysis
- Life-cycle cost analysis.

BCA is widely used because it captures the costs and most direct benefits in evaluating the value of a transportation investment to the society at large. This methodology can also be used to compare alternative transportation investments and objectively select a transportation investment that offers the highest economic value (i.e., benefits outweigh the cost), and compare alternative staging and implementations schedules.

Typically, only direct economic impacts of transportation investments are included in the calculation of benefits of a BCA. The indirect economic impacts are often ignored as manifestations of the direct economic impacts, and induced impacts are not considered due to the difficulty associated with measuring them and uncertainty associated with realizing the impacts.

However, recent literature on the topic emphasizes the need for including broader and longer-term economic benefits (induced impacts) in BCA to provide a more comprehensive evaluation of the economic impact of transportation investments.

RECOMMENDATIONS

- BCA is an appropriate methodology for evaluating the net value, or net return, of a transportation investment.
- Analysts need to consider the full range of benefits and costs to the society at large in applying BCA. Analysts must also be aware of the measurement issues when estimating the economic benefits.
- In addition to the direct impacts, a comprehensive BCA must also incorporate the wider economic benefits, such as agglomeration, competitiveness, and improved labor supply. These wider economic benefits are generally produced as estimates from REMs. This also points to the need for including both REMs and BCA in the modeling toolbox that is used by the analysts, so that the potential economic development due to a transportation investment can be accurately analyzed.

6.3.3 Other Considerations for Analyzing Economic Impacts

Through direct changes to the transportation infrastructure and its performance, transportation investments indirectly impact the economy by affecting location choices, travel behaviors, and economic transactions of households and businesses. Each of these changes interacts in complex ways, and there is a need to accurately model the changes using appropriate analytical tools including a land use model, a transportation model, and an economic model, while also recognizing the linkages under a unifying framework. This will ensure that the impacts associated with transportation investments can be accurately modeled and analyzed.

RECOMMENDATIONS

- The impact of the transportation investment choices and other related considerations should be modeled using appropriate analytical tools. The fidelity and richness of the analytical tools will depend on the types of projects being analyzed.

6.3.4 Candidate Tools

A number of models for analyzing economic impacts of transportation investments were reviewed. This review included models that estimate economic impacts (REMs) and those that are used to evaluate the economic impacts (BCA). A number of factors were used to select the models for which a detailed review was conducted. These factors included the capability to provide the following:

- Model the economic activity in a region.
- Specify the model region for application in Connecticut.
- Recognize the unique industry and household profiles in the region.
- Incorporate outputs from transportation models directly and accommodate multiple modes.
- Be able to model the longer-term induced impacts including agglomeration, competitiveness, and improved labor supply.
- Capture temporal dynamics of economic activity and simulate the annual economic activity due to the transportation investment.
- Have software support and continued development.
- Peer reviewed both in the academic and professional sectors.
- Use in the public sector for analyzing the economic impacts of transportation investments.

Based on these criteria, REMI TranSight and TREDIS were selected for a detailed review. Several features of these models make TranSight and TREDIS useful for analyzing the economic impacts of transportation investments. Both models

- incorporate information related to the structure of the regional economy, and can easily accommodate outputs from a transportation model (e.g., impact of the transport investment on the movement of goods, services, and people into, out of and within the region across modes);
- employ a well developed, methodologically consistent, and potentially transparent approach;
- are sophisticated in their formulation and employ principles from economic theory including input-output, general equilibrium, econometric and economic geography. A full computable general equilibrium model is at the core of TranSight and a partial general equilibrium model forms the basis for modeling the economy in TREDIS;

- provide estimates for a range of economic impacts including direct, indirect, and induced impacts that are likely to occur as changes in the transportation infrastructure occur across a region's economy; and
- can be used to conduct a traditional BCA that only includes benefits from direct impacts. While the model systems are able to estimate the induced impacts (tertiary and perpetuity economic impacts) they are not used in the BCA implemented within the software.

Additionally, both models have several desirable features for conducting economic impact analysis of transportation investments. Both models incorporate implementation of a REM and can be utilized to conduct BCA. Key factors to consider for the selection of a model for use by ConnDOT include that each model

- has unique features that would best serve a specific type of analysis; and
- requires a different set of skills, backgrounds, and professional training, therefore, the analysts need to have expertise in using the selected model and type of analysis being conducted.

RECOMMENDATIONS

Methodology

- A REM model that incorporates a CGE or a variant (e.g., partial general equilibrium) must be selected for its strong theoretical underpinnings and economic rigor. The model should also incorporate temporal dynamics of economic activity and support higher spatial resolution so that economic impacts can be studied in both space and time at a finer scale.
- The selected model system must be transportation aware and able to accommodate transportation model outputs, and convert them into valid inputs for use in an economic model. The model system should also be able to accommodate land use changes (e.g., market accessibility changes) in modeling economic impacts.
- In converting transportation and land use changes, parameters applied should be based on acceptable and publicly available data.

Software

- The economic model embedded in the analytical tool should be peer reviewed in academic and professional arenas.
- The model system should be supported by an organization with a legacy and a vision for continued model development and refinement.
- The software should have a graphic user interface for specifying inputs. The user interface should be intuitive, provide guidance for specifying the inputs, and should help the analyst in navigating the different screens.
- The software should feature user interfaces for visualizing results and for reporting outputs to standard formats (e.g., spreadsheets, flat-file formats).

Data

- The analytical tool should be able to accommodate the state of Connecticut and include surrounding regions, as appropriate. Additionally, the model should include data that is suitable for a local analysis.
- The model should have the flexibility to specify custom parameters.

Out of all the models considered in this study, currently REMI TranSight and TREDIS modeling tools are recommended for ConnDOT's consideration because both are fully developed and are capable of comprehensively analyzing the economic impacts of transportation investments. Model selection criteria and general requirements that were used for this study's detailed review of candidate models will be useful for ConnDOT's consideration of these models and newer models that may become available in the future to evaluate for its use.

6.4 IMPLEMENTATION STRATEGY

The use of economic impact analysis as a tool in transportation investment decision making should be considered in the overall context of strategic planning, long-range capital investment program planning, and asset management. Transportation-related measures provide the foundation for project selection, prioritization and programming. Economic analysis that identifies the economic development potential of a project or projects, as well as the selection of an alternative for a project, can be useful in determining the overall value of a project for the state.

Economic impact analyses that are conducted to support transportation investment decision making should be objective, independent, unbiased, transparent, and consistent. Additionally, the results of economic impact analyses that are used for this purpose need to be customized for presentation to the various stakeholders, including policy makers and the general public.

6.4.1 Role of Analyzing Economic Impacts in the Transportation Investment Decision Making Process

A US Government Accountability Office survey found that the potential economic impact resulting from transportation projects is only one of many factors that are considered for the selection, prioritization, and programming of transportation projects. Other considerations include financial, political, environmental, social, and welfare impacts of transportation investments. These factors are also referenced in the New Start Program under the federal MAP-21 legislation that calls for performance-based evaluation wherein a number of factors including mobility improvements, land use implications, environmental benefits, economic development, congestion relief, and cost effectiveness, among others, will shape the final decision for funding a project. Therefore, a multi-criterion evaluation mechanism should be incorporated in an overall project selection decision making framework.

RECOMMENDATIONS

- A systematic practice should be established that ensures that economic analyses that are conducted for transportation projects are objective, independent, and consistent.
- The transportation investment decision making process should incorporate a multi-criteria evaluation process that takes into consideration various transportation-related

criteria, as well as economic impacts when applicable. This process should also take into consideration input from stakeholders.

6.4.2 Considerations for ConnDOT's Use of Economic Impact Analysis

The use of comprehensive economic impact analysis would be helpful to decision makers so they could factor the value of a project's economic potential into the project selection decision making process.

6.4.2.1 MODEL SELECTION AND RESOURCES

The national scan of the state of the practice and input from focus group sessions provided guidance for the selection, adoption and implementation of economic analysis models for determining the value of transportation investments in Connecticut.

RECOMMENDATIONS

To ensure that economic impact analyses that are conducted are objective, independent, unbiased, transparent, and consistent, the following recommendations should be considered:

- ConnDOT should select a statewide economic model that integrates with existing modeling platforms and analytical tools that are used for making transportation system investment decisions and evaluating land use impacts. Selection and use of a statewide economic model will ensure consistency and continuity in the application of the model for analyzing economic impacts of transportation projects and/or alternatives. A statewide model can be applied for the purposes of long-range transportation planning and capital project programming.
- The expertise necessary to conduct economic impact analyses requires a working knowledge of economic analysis and modeling. Familiarity with Connecticut's economy and the region would provide a valuable foundation for analyzing the economic development potential of Connecticut's transportation investments.
- The economic analyses for ConnDOT's use in transportation investment decision making can be conducted either internally or on a contract basis. Additionally, ConnDOT staff also need to have familiarity with the economic analysis methodology for the purposes of overseeing the work of others and for applying the results of the economic analyses to the overall transportation investment decision making process.
- Considerations for achieving consistency in economic analyses include the use of a selected model for all analyses that are conducted. Additionally, it would be useful to consider using the same analysts to conduct the analyses, to the extent possible. There are several Connecticut economic centers of excellence that could provide this service to ConnDOT if the decision is made not to conduct the economic analyses internally.
- Additionally, it is suggested that ConnDOT staff be trained regarding economic analysis methodology and the use of the results of economic analyses for communicating with stakeholders, policy makers, and the general public.

6.4.2.2 IMPLEMENTATION

A review of the state of the practice in the United States and of inputs provided by this study's focus groups helped identify key considerations for the selection, adoption, and implementation of economic analysis models and for determining the value of transportation investments in Connecticut. The research indicated that economic impact analysis is increasingly incorporated as part of transportation planning efforts in some states. It was also observed that transportation planning efforts have been successful in achieving both transportation and non-transportation objectives, including economic development strategic goals.

RECOMMENDATIONS

Based on the review of state of the practice and the study's focus group sessions, the following recommendations are suggested for conducting and reporting on the results of economic impact analyses for Connecticut's transportation investments:

- Transparency in conducting and applying the results of economic analysis for project selection decision making is necessary.
- Consistency throughout the project analysis and project selection process is critical for successful implementation.
- Communication is needed throughout the economic analysis process between ConnDOT staff and economic analysis analysts, as well as with stakeholders and policymakers at all levels, as appropriate, and the general public.
- Performance measures need to be identified for use in project selection. The metrics need to be customized for various types of groups, including ConnDOT staff, stakeholders, policy makers and the general public. This will help ensure the results of analyses are effectively conveyed in terms that are meaningful for each audience's use in understanding the value of transportation investments for their purposes.
- The economic analysis models and methodologies used must be appropriate for the type and size of project or projects being considered. Projects and alternatives should be evaluated on the basis of the issues they are intended to solve and projected performance metrics as provided in the analyses.

APPENDIX A

MODEL OVERVIEWS

1. REGIONAL ECONOMIC MODELS (REM)

1.1. IMPLAN

Impact analysis for PLANning (IMPLAN) was created by MIG Inc. IMPLAN is a REM system, which can be utilized to study the economic impacts of policies and programs within states, counties, and communities. To estimate the impacts, IMPLAN uses multipliers capturing direct, indirect, and induced effects of the policy or program under consideration. The IMPLAN system comprises three components, each addressing an important aspect of conducting an economic impact analysis. The IMPLAN Data module holds the information that can be utilized to specify the structure of an economy in a region. The IMPLAN Software contains the modeling routines for estimating the impacts and generating the reports. The IMPLAN Appliance is the last module in the software and it stores all the data, models and software setup (MIG 2013).

Website: http://implan.com/v4/index.php?option=com_content&view=frontpage&Itemid=70

1.2. LEAP

The Local Economic Assessment Package (LEAP) is a REM system developed by Economic Development Research Group, with support from the Appalachian Regional Commission. LEAP can be applied to analyze the state of an economy, to diagnose factors for economic development, and to identify strategies for promoting economic development in a region (EDRG 2013).

Website: <http://leapmodel.com>

1.3. REIMHS

The Regional Economic Impact Model for Highway Systems (REIMHS) was developed in 1984. REIMHS is a REM system and can be used to study the economic impacts of highways. It was originally applied to estimate the economic impacts of highways in North Central Texas, but was later used in Arkansas, Louisiana, New Mexico, and Oklahoma. REIMHS uses input-output tables for long-term forecast of economic development impacts (Weisbrod 2000).

Website: None Available

1.4. PRISM

The Parsons Brinckerhoff Regional Infrastructure Scenario Model (PRISM) was developed by Parsons Brinckerhoff. PRISM is a transportation-aware model system that can be utilized to analyze the economic, environmental, and social impacts of transportation investments. The model system features four modules. First, the investment impacts module utilizes data from IMPLAN to model the economic impacts due to changes in the demand for outputs by sectors. Second, the accessibility impacts module estimates the economic impacts of accessibility

improvements resulting from the transportation investment. Third, the benefit-cost tool can be utilized to evaluate the transportation investment by considering the transportation, environmental, safety, and quality of life related costs and benefits. Last, the sustainability tool allows comparing social, economic, and environmental impacts by monetizing them using econometrics. The sustainability tool can be utilized for multi-criterion decision making in the transportation planning process.

Website: <http://prism.pbworld.net/pbcms/web/prism>

1.5. REMI TRANSIGHT

TranSight was developed by Regional Economic Models, Inc. (REMI). It is a “transportation-aware” REM system that can be used to model the economic impacts of transportation investments, including new and expanded highway corridors, toll roads, airports, seaports, rail, freight, and multi-modal developments. The economic formulation in TranSight combines four modeling approaches, Input-Output, General Equilibrium, Econometric, and Economic Geography (REMI 2013).

Website: <http://www.remi.com/transight/>

1.6. RIMS II

The Regional Input-Output Modeling System (RIMS II) is a REM system. It uses input-output multipliers to show how local demand shocks affect total gross output, value added, earnings, and employment. To do this analysis, RIMS II uses separate multipliers for regions that consist of one or more contiguous counties. Six types of multipliers are used: final-demand multipliers for output, earnings, employment, value added, direct-effect multipliers for earnings, and direct-effect multipliers for employment. Within these, there are Type I multipliers that include direct and indirect impacts and Type II multipliers that also consider induced impacts. RIMS II has been used to analyze the local economic impact of federal actions such as military base closings. It has estimated regional economic impacts of government policies, projects, and events (BEA 2013).

Website: <https://www.bea.gov/regional/rims/rimsii/>

1.7. RUBMRIO

The Random-Utility-Based Multiregional Input-Output Model (RUBMRIO) was developed by researchers at the University of Texas at Austin. The software is available for download under open-source licensing agreements. The model simulates the flow of goods, labor, and vehicles across a multi-regional area based on spatial input-output principles. It also simulates trade across regions/zones to mimic foreign and domestic export/import demands (RUBMRIO 2013, Du and Kockelman 2012).

Website: http://www.cae.utexas.edu/prof/kockelman/RUBMRIO_Website/homepage.htm

1.8. TELUS

The Transportation, Economic, and Land-Use System (TELUS) was developed by the Federal Highway Administration (FHWA). TELUS is a comprehensive information-management and decision-support system for transportation planning that can be utilized by transportation

agencies to meet the requirements of the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU). TELUS incorporates four modules for decision support, namely project scoring, project interrelationships, planning analysis and economic (input-output). The economic module employs an input-output modeling framework and can be applied to quantify the economic impacts of a said transportation investment on the local and state economy. The software platform also includes a number of management features that can be utilized to manage transportation projects from the planning through construction stages (TELUS).

Website: <http://www.telus-national.org/>

1.9. TREDIS®

The Transportation Economic Development Impact System (TREDIS) is a “transportation-aware” REM system that can be used to analyze economic impacts, benefits, and costs of transportation policies, plans, and projects. It is commonly used by transportation agency managers and planners, transportation consultants, and public policy analysts and decision makers. TREDIS also can be applied to estimate economic impact of a variety of transportation policies, plans, and projects, including constructing and operating transportation facilities and services, examining alternative strategies in transportation corridors, performing multi-modal freight system evaluations, weighing benefits and costs of alternative public transportation investment strategies or policies, and calculating impacts of congestion on households and industries. TREDIS employs a partial general equilibrium framework to model the economy and estimate the impacts of transportation investments. In addition to the partial equilibrium, the TREDIS model also features economic geography, input-output analysis, and econometric methodologies for modeling various aspects of economic impacts (TREDIS 2013).

Website: <http://tredis.com/>

1.10. TRENDS

Transportation Revenue Estimator and Needs Determination System (TRENDS) was developed in response to requests from the Texas Department of Transportation (TxDOT) and regional Metropolitan Planning Organizations (MPOs) for a tool to support the decision making during the transportation planning process. TRENDS was developed by the Texas Transportation Institute and is a user-friendly, web-based tool that can be utilized to forecast transportation revenues and expenses due to changes in over 70 different types of inputs. The inputs cover transportation, socio-economic factors and demographics that characterize the region and its transportation infrastructure, including population growth rates, fuel efficiency, federal reimbursement rates, inflation rates, taxes, fees, and more. The TRENDS web interface incorporates the TREDIS REM implementation in the backend for estimating the economic impacts due to the changes in the inputs (Ellis et al. 2012).

Website: <http://trends-tti.tamu.edu/>

2. INTEGRATED REGIONAL ECONOMIC AND LAND USE MODELS

2.1. PECAS

Production, Exchange, and Consumption Allocation System (PECAS) is a spatial economic modeling tool to support regional planning. The PECAS model systems comprise two princi-

pal components: Activity Allocation (AA) and Spatial Development (SD). The AA component utilizes spatial input-output modeling principles to model the flow of goods, services, labor and space across sectors between various zones. The AA component models the location of activities (goods, services, jobs and labor) and the interactions across activities. The SD component is aimed at modeling the development and re-development decisions of land in a region by the developers. The primary purpose of PECAS is to model the location choices at a finer spatial scale. The model is not a REM and cannot be utilized to understand the impacts of investments on the regional economy. However, it requires inputs from a REM in simulating the spatial choices and location decisions (Hunt and Abraham 2009).

Website: <http://www.hbaspecto.com/pecas/>

2.2. TELUM

Transportation, Economic, and Land-Use Model (TELUM) was produced within the same larger initiative as the TELUS tool to develop analytical tools to assist transportation agencies in meeting the requirements of the SAFETEA-LU transportation act. TELUM is used to model the land use impacts of transportation investments. The model system forecasts the longer-term population, employment and the related need for land and space, including new housing and jobs, and relocation of businesses due to the new transportation projects and/or improvements (TELUS 2013).

Website: <http://www.telus-national.org/>

3. BENEFIT-COST ANALYSIS MODELS (BCA)

3.1. AASHTO RED BOOK

The AASHTO Red Book is a manual that provides guidance for performing user benefit analysis of highway improvements. The manual includes guidance for performing a BCA and provides information on the various aspects of BCA. In enumerating the benefits and costs, several factors are considered, including vehicle operation factors, road variables, vehicle operating costs, value of time, value of productivity, and accident costs. The original manual was published in 1977 and a major update was published in 2003, with updates to the theory, methodologies, procedures and practices for assessing the user benefits associated with highway improvements. The project that led to the recent update also resulted in software for conducting user benefit analysis in accordance with the guidance provided in the manual. More recently, in 2007, a supplement to the manual titled “Non-User Benefit Analysis for Highways: A Supplement to AASHTO’s User Benefit Analysis for Highways” was published that provides guidance on estimating non-user benefits. The update was in response to calls for comprehensively assessing the impacts of highway improvements by also considering non-user benefits (AASHTO 2010).

Website: https://bookstore.transportation.org/collection_detail.aspx?ID=65

3.2. HEAT

The Highway Economic Analysis Tool (HEAT) is a BCA tool that was developed by Cambridge Systematics as part of a project for the Montana Department of Transportation. Its purpose was to examine the economic impacts of reconfiguring two-lane highways in the state of Montana. The benefit categories included in HEAT result from travel performance impacts, commodity flow changes, and accessibility improvements. The modeling tool also incorporates longer-term wider economic benefits (first, due to profitability and income enhancement of existing busi-

nesses and second, due to increased attractiveness of the region) in estimating the net benefits of transportation investments. HEAT applies the REM developed by REMI for estimating the wider economic benefits (CS 2011, CS et al. 2005).

Website: <http://www.camsys.com/HEAT.htm>

3.3. HEEM-III

The Highway Economic Evaluation Model (HEEM-III), 3rd version of this analytical tool, is a BCA software used by the TxDOT for evaluating highway improvement projects during the transportation planning process. The first version was released in 1976 and was developed by McKinsey and Company, Inc. The second version was developed by Texas Transportation Institute (TTI) and released in 1983. This version updated the program and accommodated a larger number of highway project types. The latest version (version III) was released in 1990 and was also developed by TTI. This version updates the procedures and practices for calculating benefits and costs. The HEEM tool can be utilized to analyze a variety of proposed highway improvements, including adding capacity, bypass (new location), HOV lanes, interchange, and railroad grade separation projects (Memmott 1990, TTI 1993).

Website: <http://d2dtl5nnlpfr0r.cloudfront.net/tti.tamu.edu/documents/1128-1F.pdf>

3.4. HERS-ST

The Highway Economic Requirements System – State Version (HERS-ST) is a BCA tool that was developed by the FHWA to assist federal and state authorities in making decisions about highway investments. The software considers up to six different highway improvement alternatives by combining highway development options such as improvements to pavements, increasing width, and changing alignment. The tool utilizes an optimization routine to select the most effective mix of improvements. It considers various benefit categories, including user travel times, vehicle operation factors, accidents, emissions, agency costs for highway maintenance and operations, residual values. The cost categories include costs for right-of-way acquisition and construction. (FHWA 2013b).

Website: <http://www.fhwa.dot.gov/infrastructure/asstmgmt/hersindex.cfm>

3.5. MICROBENCOST

MicroBENCOST is a BCA software that was developed by TTI in 1993. The tool can be used to analyze a range of software improvements, including added capacity projects, new location or bypass projects, pavement rehabilitation projects, intersections/interchanges, bridge rehabilitation/replacement, railroad crossing improvements, safety projects, and HOV lane projects. The benefit categories considered in the software include user travel times, vehicle operating costs, and accidents. For cost categories, the software considers total initial cost, salvage value, rehabilitation and maintenance costs (TTI 1993).

Website: <http://d2dtl5nnlpfr0r.cloudfront.net/tti.tamu.edu/documents/TTI-1993-ID18389.pdf>

3.6. STEAM

The Surface Transportation Efficiency Analysis Model (STEAM) is a BCA tool that was developed by FHWA in the 1990s. STEAM is a decision making tool used to compare the benefits

and costs of different multi-modal projects and alternatives. It uses information produced from a travel demand model to compute the net value of mobility and safety benefits attributable to transportation projects. STEAM comprises four modules:

1. User Interface: used for specifying inputs and reading the outputs produced at the end of the analysis
2. Network Analysis: reads highway traffic volumes, segment lengths, capacities, and other link data to produce travel times and travel distances based on minimum time assignment
3. Trip Table Analysis: estimates the user benefits based on a comparison of the base scenario (no changes) against the improvement scenario with the multi-modal investment based on comparison of travel times for each trip and out-of-pocket costs;
4. Evaluation Summary: calculates the net present worth and a benefit-cost ratio for the multi-modal investment under consideration (FHWA 2013a)

Website: <http://www.fhwa.dot.gov/steam/>

REFERENCES

- AASHTO (American Association of State Highway and Transportation Officials) (2010) User and Non-User Benefit Analysis for Highways. (Website: <https://bookstore.transportation.org/imageview.aspx?id=884&DB=3>, Accessed: February 15, 2013)
- BEA (Bureau of Economic Analysis) (2013) "RIMS II Online Order and Delivery System" US Department of Commerce (Website: <https://www.bea.gov/regional/rims/rimsii/>, Accessed February 15, 2013)
- CS (Cambridge Systematics) (2011) Highway Economic Analysis Tool (HEAT) (Website: <http://www.camsys.com/HEAT.htm>, Accessed: February 15, 2013)
- CS (Cambridge Systematics), EDRG (Economic Development Research Group), ICF Consulting (ICFC) and Short Elliott Hendrickson, Inc. (ELHI) (2005) Montana Highway Reconfiguration Study: Final Report. Prepared for the Montana Department of Transportation. (Website: http://www.mdt.mt.gov/other/research/external/docs/reconfig/final_report.pdf, Accessed: February 15, 2013)
- Du, X., and Kockelman, K.M. (2012) Tracking Transportation and Industrial Production Across a Nation: Application of the RUBMRIO Model for US Trade Patterns. Presented at the 91st Annual Meeting of the Transportation Research Board, Washington, D.C., January 22-26, 2012.
- EDRG (Economic Development Resource Group, Inc.) (2013) "LEAP: Local Economic Assessment Package [Brochure]" (Website: <http://www.edrgroup.com/pdf/leap%20one-pager%202008.pdf>, Accessed February 15, 2013)

- Ellis, D., Glover, B., and Norboge, N. (2012) Refining a Methodology for Determining the Economic Impacts of Transportation Improvements. University Transportation Center for Mobility, Texas Transportation Institute, The Texas A&M University. (Website: http://utcm.tamu.edu/publications/final_reports/Ellis_11-00-68.pdf, Accessed April 14, 2013).
- FHWA (Federal Highway Administration) (2013a) Surface Transportation Efficiency Analysis Model (STEAM). Federal Highway Administration, US Department of Transportation. (Website: <http://www.fhwa.dot.gov/steam/>, Accessed: February 15, 2013)
- FHWA (Federal Highway Administration) (2013b) Highway Economic Requirements System – State Version (HERS-ST). Transportation Performance Management, Federal Highway Administration, US Department of Transportation. (Website: <http://www.fhwa.dot.gov/infrastructure/asstmgmt/hersindex.cfm>, Accessed: February 15, 2013)
- Hunt, J.D., and Abraham, J.E. (2009) PECAS-for Spatial Economic Modelling: Theoretical Formulation. System Documentation Technical Memorandum 1, Working Draft. (Website: <http://www.hbaspecto.com/pecas/downloads/files/PECASTheoreticalFormulation.pdf>, Accessed: February 15, 2013)
- Memmott, J.L. (1990) The HEEM-III Benefit-Cost Computer Program. (Website: <http://d2dtl5nmlpfr0r.cloudfront.net/tti.tamu.edu/documents/1128-1F.pdf>, Accessed: February 15, 2013)
- MIG (2013) “Economic Impact Analysis, IMPLAN” (Website: http://implan.com/v4/index.php?option=com_content&view=frontpage&Itemid=70, Accessed February 15, 2013)
- REMI (Regional Economic Model Inc.) (2013) (Website: <http://www.remi.com/>, Accessed: May 27, 2013)
- RUBMRIO (2013) “RUBMRIO: Anticipating Trade, Production, and Travel” University of Texas (Website: http://www.ce.utexas.edu/prof/kockelman/RUBMRIO_Website/homepage.htm, Accessed February 15, 2013)
- TELUS (Transportation Economic Land Use System) (2013) (Website: <http://www.telus-national.org/index.htm>, Accessed: February 15, 2013)
- TREDIS (Transportation Economic Development Impact System) (2013) (Website: <http://tredis.com/>, Accessed: May 27, 2013)
- TTI (Texas Transportation Institute) (1993) Economic Development Impacts of Expenditures For State Highway Improvements in Texas: Research Report Summary. Texas Department of Transportation in Cooperation with Federal Highway Administration. (Website: <http://d2dtl5nmlpfr0r.cloudfront.net/tti.tamu.edu/documents/1228-2S.pdf>, Accessed: February 15, 2013)

- TTI (Texas Transportation Institute) (1993) MicroBENCOST: User's Manual. Prepared for National Cooperative Highway Research Program, Project 7-12. (Website: <http://d2dtl5nnlpfr0r.cloudfront.net/tti.tamu.edu/documents/TTI-1993-ID18389.pdf>, Accessed: February 15, 2013)
- Weisbrod, G. (2000) Procedures for Assessing Economic Development Impacts from Transportation Investments. National Cooperative Highway Research Program, Synthesis of Highway Practice. (Website: <http://www.edrgroup.com/pdf/synth290.pdf>, Accessed: May 5, 2013)

APPENDIX B

**COMPARISON BETWEEN THE PARAMETERS IN
REMI TRANSIGHT AND TREDIS MODELS**

Summary Parameters	TranSight	TREDIS
Time Span	2010 to 2060	2010 to 2042
Vehicle Speed Matrix	0 to 80	Fixed in model
Web-based	No	Yes
Response Speed	Fast	Slower Web dependent
Input Metrics (non-transportation)	185	7 (not including industry dimension)
Cost	\$43,000 to \$88,000	\$19,000
Basic Methodology		
Input / Output	Yes (70 Industries)	Yes (440 industries)
New Economic Geography	Yes (Regions interact within model)	Yes (Econometrics)
Econometrics	Yes	Yes
General Equilibrium	Yes	No
Partial Equilibrium	No	Yes
Impacts (Direct Indirect Induced)	Yes	Yes
Additional Modeling Notes		
General Equilibrium Solution	Yes	No
Step-wise Econometric	No	Yes
Demographics (Migration to jobs and wages)	Yes	No
Land, Housing and other capital investment values	Yes	No
User Background		
Economics	Yes (Masters+)	Familiar
Transportation	Familiar	Yes
Model Graphical User Interface		
Template Steps (User friendly)	No	Yes
General Objects	Yes	Optional
Geography		
State	Yes	Yes
County	Yes	Yes
Sub-county	Yes (on request +\$)	Yes (on request +\$)
Visual maps	Yes	No

Demographics	TranSight	TREDIS
Age	Yes (Detailed groups)	General summary
Race / Ethnicity	Yes	No
Gender	Yes	No
Labor Force Participation	Yes	No
Specification of inputs		
Import From Spreadsheets	Yes	Yes
Calculate or Fill Sequentially	Yes	Yes
Additional Analysis		
Benefit Costs Analysis	Yes	Yes
Financial Analysis	Yes	Yes
Reports		
Transportation Oriented	Yes	Yes
General Structure	Trends - Line Graphs (Visual)	Comparative - output oriented
Exportable Spreadsheet Structures	Yes	Yes
Graphics	Trends and pie charts	Trends and pie charts
Available metrics		
Occupations	Yes (94)	No
Consumer consumption	Yes (75)	No
Industries	70 + Aggregates	86 reported (440 run model)
Other metrics (non-transportation)	185	about 10 (all major ones)
Models of Transportation		
Bike	No (could build)	Yes
Pedestrian	No (could build)	Yes
Truck	Yes	Yes
Bus	Yes	Yes
Car	Yes	Yes
Light Rail	Yes	No (could build)
Rail	No (could build)	Yes
Freight Rail	No (could build)	Yes
Air	Yes	Yes
Water/Ship	No (could build)	Yes
Commutation	Yes	Yes

Transportation Demand	TranSight	TREDIS
Accidents	Yes	Yes (by type of vehicle)
Time Costs	Yes	Yes (by type of vehicle)
Pollution	Yes	Yes (by type of vehicle)
Fuel Costs	Yes	Yes (by type of vehicle)
Vehicle Occupancy	Yes	Yes (by type of vehicle)
Trips	Yes	Yes (by type of vehicle)
Congestion	Yes	Yes (by type of vehicle)
Trip Directions	Yes	Yes (by type of vehicle)
Vehicle Storage	Not explicit	Yes (by type of vehicle)
State Registration Costs	Not explicit	Yes (by type of vehicle)
Terminal (fuel sales)	Not explicit	Yes (by type of vehicle)
Toll Charges	Not explicit	Yes (by type of vehicle)

APPENDIX C

**REGIONAL PLANNING AGENCIES
FOCUS GROUP SESSION PRE-SURVEY**

CT Academy - Economic Analysis Study

Focus Group Pre-Survey

In preparation for the CT Academy - Economic Analysis Regional Planning Agency Focus Session on the economic assessment of transportation investments, please help us by completing this brief survey, which should require approximately 5 minutes to complete.

As a reminder, the focus session is scheduled from 1:00 pm to 2:00 pm at ConnDOT (Room G328) on Tuesday, March 12, 2013.

If you have questions or received this in error, contact Terri Clark, Associate Director, CASE at 860-571-7143 or by email at tclark@ctcase.org.

Thank you for your time.

1. Indicate your level of agreement with each of the following statements, with 1 Strongly Disagree and 7 Strongly Agree.

	1 - Strongly Disagree	2	3	4 - Neutral	5	6	7 - Strongly Agree
My organization has well-defined economic assessment metrics.	<input type="radio"/>						
Assessment of economic Impacts of transportation Investments at the local level is important.	<input type="radio"/>						
Assessment of economic Impacts of transportation Investments at the regional level is important.	<input type="radio"/>						
Assessment of economic Impacts of transportation Investments at the state level and is important.	<input type="radio"/>						

2. My organization does a good job of communicating the value of transportation investments to:

	1 - Strongly Disagree	2	3	4 - Neutral	5	6	7 - Strongly Agree
End users (traveling public)	<input type="radio"/>						
Private Industry	<input type="radio"/>						
Policymakers	<input type="radio"/>						

CT Academy - Economic Analysis Study
							
3. In my organization, transportation investment decisions are influenced strongly by:							
	1 - Strongly Disagree	2	3	4 - Neutral	5	6	7 - Strongly Agree
Maintaining a state of good repair and/or operations	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Spurring regional economic activity	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Sustainability	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Equity	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Quality of Life	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Safety	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Environment	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Energy	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
4. Indicate your level of agreement with each of the following statements.							
	1 - Strongly Disagree	2	3	4 - Neutral	5	6	7 - Strongly Agree
Uncertainty in funding has a big impact on transportation investment decisions.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The amount of justification for transportation investment decisions needed is significantly greater than a decade ago.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
We currently have resources available to do economic assessments in-house	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
It is a difficult challenge communicating local benefits of investments designed to spur regional economic activity.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

APPENDIX D

CONNECTICUT GENERAL ASSEMBLY TRANSPORTATION COMMITTEE FOCUS GROUP SESSION QUESTIONS

Question 1

How useful is it for the general assembly to have information about the economic value of a transportation project?

Question 2

What value metrics/ measures are important when considering/ discussing with constituents transportation projects?

APPENDIX E

REGIONAL PLANNING AGENCIES AND KEY CONNDOT STAFF FOCUS GROUP SESSION GUIDE

TOPIC 1

These questions are aimed at understanding motivations for promoting transportation investment initiatives at the Connecticut General Assembly. Further, what is the rationale behind investing in a transportation initiative?

Question 1

What types of factors drive decisions to invest in transportation in the state? What type of justification needs to be provided about transportation investment initiatives?

- Maintaining state of good repair and/or operations
- Spurring regional economic activity
- Sustainability
- Equity
- Quality of life
- Safety
- Energy and Environment

Question 2

In the context of transportation investment initiatives aimed at spurring economic activity in the state, what are other competing projects and/or initiatives? For example, do transportation investment initiatives compete against social welfare, workforce improvement, and poverty type initiatives which are also aimed at improving economic activity?

TOPIC 2

These questions are aimed at identifying the stakeholders and understanding the types of analysis and metrics which are most relevant for communicating the value of transportation investment initiatives.

Question 1

What are the different stakeholder groups (e.g., traveling public, policymakers, funding agencies, private industry partners) that you communicate with for promoting and garnering support for transportation investment initiatives?

Question 2

What metrics and measures appeal most when communicating the value of transportation investments?

- Transportation benefits to traveling public
 - Changes in Vehicle Miles of Travel (VMT), Vehicle Hours of Travel (VHT), Congestion Delay
 - Monetized variants of the above direct transportation benefits
- Changes in economic activity
 - Changes in GDP, GRP, Regional Output, Wages, Income, Employment, Productivity, Capital Investments
 - Personalized variants of the same (e.g., GDP per capita)
- Impact on the environment
 - Changes in greenhouse gas emissions and energy consumption
- Changes in land use
 - Transit oriented development, Location and relocation decisions of individuals and businesses, Increase in property values
- Impacts on different socio-economic and demographic populations
 - Impact on minority population and low-income groups

APPENDIX F

SUMMARY OF SELECTED PROJECTS REVIEWED *(NOTE: AN ECONOMIC IMPACT ANALYSIS WAS CONDUCTED FOR EACH PROJECT REVIEWED)*

ANALYZING THE ECONOMIC IMPACTS OF TRANSPORTATION PROJECTS
APPENDICES

Project Number	Project	Location/ Analysis Area	Type of Transportation Investment		Tool/ Methodology for Assessing Economic Impacts	Scale / Region	Cost	Impacts				Reference
			Project Type	Project Specifics				Jobs Created	Income	Output / GRP	Other	
1	I-394 Minnesota	Minnesota	Highway	Highway Upgrade		8-mile segment	\$300 million	9,400	\$169 million	\$ 457 million	Land-Use changes into commercial use at locations of high accessibility	T-PICS 2013a
2	Bennington Bypass, VT 279	Vermont	Highway	Bypass Construction		4.2-mile bypass	\$26 million	32 direct, 22 indirect	\$2 million	\$ 5 million	Improved traffic	T-PICS 2013f
3	Mercer Co. KY, US-427 Bypass	Kentucky	Highway	Bypass Construction		4.9 mile bypass	\$18.7 million	N/A	N/A	N/A	Diverted trucks from city center	T-PICS 2013l
4	Sonora Bypass	California	Highway	Bypasses Construction		Two 2.2 mile bypasses	\$88.59 million	N/A	N/A	N/A	Helped tourism in downtown area, but lost businesses due to diverted traffic	T-PICS 2013m
5	Hollister Bypass SR-156	California	Highway	Bypass Construction		5.5 mile bypass	\$23.7 million	N/A	N/A	N/A	Diverted truck traffic, businesses lost sales at first but recovered	T-PICS 2013i
6	I-15 Rebuilding/Widening	Utah	Highway	Reconstruction / Widening		17 mile highway	\$1.52 billion	7,500 direct, 5,250 indirect	\$607 million	\$1.84 billion	The acceleration of the build process by 3.5 years saved millions of dollars	T-PICS 2013j
7	Beltway 8	Texas	Highway	Tolled Beltway		2.68 mile segment of 60 mile beltway	\$77.6 million	24,000 direct, 9,840 indirect	\$2.33 billion	\$8.83 billion	High increase in population and employment rates	T-PICS 2013e
8	Bellevue Transit Center/I-405 Improvements	Washington	Multimodal	Passenger Multimodal		Downtown Area	\$176.1 million	6,000 direct, 4,035 indirect	\$577 million	\$1.97 billion	Improved capacity of station, HOV lanes, buses, etc.	T-PICS 2013d
9	Anderson Regional Transportation Center	Massachusetts	Multimodal	Passenger Multimodal		Boston	\$57 million	3,750 direct, 2,170 indirect	\$213 million	\$691 million	Land-Use changes into offices, hotel, and retail space	T-PICS 2013b

ANALYZING THE ECONOMIC IMPACTS OF TRANSPORTATION PROJECTS
APPENDICES

10	Sunset Transit Center	Oregon	Multimodal	Passenger Multimodal	Commuters to Portland	\$147.8 million	400 direct 249 indirect	\$37 million	\$105 million	Office spaces, retail centers, and large residential developments were built	T-PICS 2013n
11	Lindberg Station - MARTA	Georgia	Multimodal	Passenger Multimodal	Atlanta Region	\$26 million	373 direct 208 indirect	\$37 million	\$111 million	Caused a decrease in employment in other areas	T-PICS 2013k
12	LBJ-Skillman DART Station	Texas	Multimodal	Passenger Multimodal	Dallas Region	\$85.4 million	N/A	N/A	N/A	Areas have not yet developed due to lack of access	T-PICS 2013g
13	Arlington Heights Metra Station	Illinois	Multimodal	Station Relocation	Downtown Area	\$4.4 million	349 direct 251 indirect	\$37 million	\$99 million	Businesses moved from the old station to the new station	T-PICS 2013c
14	Emerson Park Development Corporation	Illinois	Multimodal	Passenger Multimodal	Rehabilitated Area	\$3 million	8 direct, 7 indirect	< \$1 million	\$1 million	New single-family developments were built around the area	T-PICS 2013h
15	Metropolitan Atlanta Rapid Transit Authority (MARTA)	Georgia	Economic Impact Assessment	IMPLAN, TREDIS	Operating Budget	\$432 million	4,500 direct 3,300 indirect	\$700 million	N/A	Fastest growing industry sectors are among workers that rely heavily on MARTA for their commute	Clarke et al 2012
					Capital Budget	\$185 million	7,000 in service region; 4,000 elsewhere	\$0.5 - 1.1 billion	N/A		
16	Midwest High Speed Rail (HSR)	Midwest	Transit	150 mph High Speed Rail System 220 mph High Speed Rail System	Regional, Several States; 1,457 miles	\$83.57 billion	58,050	\$2.99 billion	\$7.59 billion	Will greatly improve market access	EDRG and AECOM 2011
					TREDIS	N/A	103,610	\$5.48 billion	\$13.77 billion		
17	Metrolinx	Ontario	Transit	Electrifying Inter-Regional Rail Lines in 2021	Option 1	Cost Factors were included but the total cost of the project was not	130	\$10.53 million	\$12.13 million	Land-use changes in suburban areas will be changed, more jobs created during construction	Delean Anup JV 2010
					Option 2		400	\$34.40 million	\$39.69 million		
					Option 3		530	\$44.68 million	\$51.52 million		
					Option 11		620	\$52.21 million	\$60.18 million		
					Option 15		710	\$60.82 million	\$70.18 million		
Option 18		800	\$67.95 million	\$78.40 million							
18	Public Transit Alternatives in Durham	Ontario	Transit	Long Term Transit Strategy for 2031	Alternative C	\$2.22 billion	300	\$11 million	\$46.7 million	More jobs and other impacts during construction	HDR and iTRANS 2010
					Alternative D	\$3.16 billion	579	\$21.2 million	\$90.2 million		
					Alternative E	\$4.17 billion	594	\$21.7 million	\$92.5 million		

ANALYZING THE ECONOMIC IMPACTS OF TRANSPORTATION PROJECTS
APPENDICES

19	South Coast Commuter Rail	Massachusetts	Transit	Commuter Rail	TREDIS	Commuting Region	3500 - 3,800	\$146 - 160 million	\$448 - 487 million	Growth of real estate values and property taxes were also analyzed	ECT et al. 2009				
20	Chicago RTA - Public Transit	Illinois	Transit	Future Growth Study Based on Different Level of Investment	TREDIS	Maintain Existing	11,395	\$521 million	\$1.42 billion	All impacts are relative to letting the system deteriorate	Lutbin et al. 2007				
						Enhance & Expand	16,855	\$774 million	\$2.11 billion						
21	Toronto-West and Niagara-West Multimodal Corridor Studies	Ontario	Multimodal	Corridor Analysis	TREDIS	Enhance, Expand & Land Use	22,307	\$1.03 billion	\$2.80 billion	Direct transportation benefits were analyzed	MTO 2011				
						Alternative 3-1	12,100	N/A	\$1.03 billion						
						Alternative 4-2	10,500	N/A	\$890 million						
						Alternative 4-3	10,900	N/A	\$930 million						
22	I-95 Corridor: Mid-Atlantic Rail Operations	Mid-Atlantic	Transit	Rail Corridor	TREDIS	5-State Mid-Atlantic Region in 2035	9,873	\$495 million	\$1.27 billion	Traveler benefits were calculated	CS 2009				
23	I-5 Columbia River Crossing	West Coast	Highway	Locally Preferred Alternative in 2030 vs. No Build Study	TREDIS	Large Region: Washington, Oregon, California	4,280	\$231 million	\$614 million	Will greatly increase monkey access	CRC 2009				
												Highway System			
24	Appalachian Development Highways	Appalachian Region	Highway	Highway System	TREDIS, TransCAD	3,000 Mile, 13-State Region	Medium Growth Scenario: 80,491	\$3.20 billion	\$10.10 billion	Industry value and household savings were compared against the rest of the nation	CS 2008				
							High Growth Scenario: 91,670	\$3.64 billion	\$11.53 billion						
25	I-70 Dedicated Truck Lanes	Indiana, Illinois, Missouri, and Ohio	Highway	Highway Truck Lanes	TREDIS	Highway Corridor	258,000	N/A	\$32.3 billion	Reduced congestion and increased safety	Wilbur Smith Associates (2011)				
												Bus Fleet Analysis			
26	Analyzing Economic Impacts with Different Tools		Transit	Bus Fleet Analysis	RIMS II, IMPLAN, and REMI Transight	RIMS II	187	\$3.8 million	\$10.2 million	Using different software it is easy to compare them and see changes by modifying variables	Lynch 2000				
												IMPLAN	318	\$7.7 million	\$16 million
												REMI	239	\$11.8 million	\$21.4 million

27	Impacts of Transportation Infrastructure	North Dakota	Highway and Transit	Mostly Highway, Some Rail	HERS-ST, REMI TransSight, and Cube	State Level	If current highway conditions are maintained	Over 36,000 by 2024	N/A	\$8.13 billion	Airport Impacts were also analyzed	Tolliver and Dybing 2007
28	US Highway 54 Upgrade	New Mexico	Highway	Highway Upgrade	REMI TransSight	Portions of highway	\$511.2 million	1,400	N/A	\$340 million	Reduced Productivity Costs	REMI 2004
29	Federally Financed Infrastructure on the Wasatch Front	Utah	Highway and Transit	Both Highway and Transit	REMI TransSight	Different scales, numbers given are averages per year	Varies	2,829	\$196.9 million	\$211.7 million	Population increase is noted	Perlich 2004
30	Infrastructure Investment in South Georgia	South Georgia	Highway and Transit	Highway Widening and Rail Quality Upgrade	REMI TransSight	Corridor	\$466 million	4,804	\$68 per capita	\$327.6 million	\$4 million annual increase in government taxes and \$17.6 in other government revenue	Campbell et al. 2000
31	Major Corridor Investment-Benefit Analysis	Indiana	Highway	Highway Corridor	REMI TransSight	State Level	\$894 million	1,350	\$80 million	\$100 million	Population increase was also projected	Kaliski et al. 1999
32	Economic Benefits of Transportation Projects in Wisconsin	Wisconsin	Highway	Highway Construction	REMI TransSight	State Level	\$276 million	4,300	\$156 million	N/A	It is noted that other projects may impact the state the same way regardless of their benefit to the transportation	CS 2003
33	Midwest Regional Rail	Midwest	Transit	Regional Rail	RIMS II Model	Large - Midwest Area	\$7.7 billion	57,450	\$1.10 billion	N/A	Provides access to 80% of region, \$4.9 billion in property values	TEMS 2006
34	ARC Major Investment Study	New York/New Jersey	Transit	Commuter Rail	REMI TransSight	New York Metropolitan Region	Average Yearly Impacts during Construction	3,919	\$313 million	\$525 million	2008 - 2017 Impacts	ERA 2004
							Ongoing Impacts for 2020	20,050	\$2.1 billion	\$5.34 million	Office Employment: 7,200	

ANALYZING THE ECONOMIC IMPACTS OF TRANSPORTATION PROJECTS
APPENDICES

35	Trans-Hudson Express Tunnel	New York/New Jersey	Transit	Commuter Rail	New York Metropolitan Region	\$6 billion	28,000 (NY) 16,000 (NJ)	\$2.1 billion (NY) \$2.0 billion (NJ)	\$5.9 billion (NY) \$4.5 billion (NJ)	Taxes generated were calculated	ERA 2004
36	Economic Impact of Public Transportation Investment	United States	Transit	Public Transportation Investment	National Level	\$1 billion of spending on capital	24,000	\$1.1 billion	\$3 billion	Tax Revenue: \$350 million	Weisbrod and Arlee 2009
						\$1 billion of spending on operations	41,000	\$1.8 billion	\$3.8 billion	Tax Revenue: \$530 million	
37	US-2 Bronkton East	Montana	Highway	Highway Reconstruction	13.5-mile segment	Average spending (71% capital, 29% operations)	36,000	\$1.6 billion	\$3.6 billion	Tax Revenue: \$490 million	MDT 2009
						\$21.4 million	315	N/A	N/A	Increased livability, sustainability, safety, and economic competitiveness	
38	Interstate 84/Route 8 Interchange Reconfiguration	Connecticut	Highway	Interchange Reconfiguration	Mostly Local	Alternative 6-7 Scenario 1 - No Buildout	1,589	\$106.2 million	\$212.7 million	More alternatives were analyzed, only one is shown here	McMillen et al. 2009
						Alternative 6-7 Scenario 2 - Mixed Use & W/D	7,382	\$467.1 million	\$891.8 million		
39	Montana Highway Reconfiguration Study	Montana	Highway	Highway Reconfiguration	State Level	Improved Scenario: \$125 million	120	\$6 million	\$9 million	User travel benefits were calculated as well	CS 2005
						Super 2 Scenario: \$510 million	140	\$6 million	\$10 million		
40	US Route 460 Corridor	Hampton Roads	Highway	Highway Upgrade	Regional	Four-Lane Scenario: \$1.3 billion	290	\$12 million	\$23 million	CEA 2011	
						Per \$1 billion of investment	14,120	\$7.3 billion	\$5.6 billion		
41	APTA: Economic Impact of Public Transportation Investment	United States	Transit	Public Transportation Impact Study	National Level	Per \$1 billion of investment	36.1	\$1.6 billion	\$3.6 billion	Tax Revenue: \$490 million	Weisbrod and Arlee 2009

APPENDIX G

STUDY COMMITTEE MEETINGS AND GUEST SPEAKERS

The following is a list of study committee meetings, including presentations given to the CASE study committee by guest speakers and the CASE Research Team. Hyperlinks to recordings of these presentations and meeting proceedings are included below.

OCTOBER 11, 2012 - MEETING 1

- [Introductory Remarks](#)
Richard H. Strauss, Executive Director, CASE
- [Overview of ConnDOT Research Request to CASE Study Committee](#)
Thomas Maziarz, Bureau Chief, Policy and Planning
- [Estimating Economic Impacts of Transportation Improvements](#)
David R. Ellis, PhD, Research Scientist, Texas A&M Transportation Institute
- [Estimating the Economic Benefits of Infrastructure](#)
Jose A. Gomez-Ibanez, PhD, Derek C. Bok Prof. of Urban Planning and Public Policy,
Kennedy School of Government, Harvard University
 - o [Discussion - Gomez-Ibanez Presentation](#)
- [CASE Research Team-Overview of Study Process](#)
Karthik Konduri, CASE Study Manager and Assistant Professor, Department of Civil &
Environmental Engineering, University of Connecticut
- [Committee Discussion](#)
- [Closing Remarks](#)

NOVEMBER 9, 2012 - MEETING 2

- [Introductory Remarks](#)
Richard H. Strauss, Executive Director, CASE
- [Connecting Transportation and Economic Growth in Metropolitan Washington](#)
John McClain, Senior Policy Fellow and Deputy Directory, Center for Regional
Analysis, George Mason University
 - o [Discussion - McClain Presentation](#)

- [Economic Value of Transportation Projects](#)
Jack Wells, Chief Economist, U.S. Department of Transportation
 - [Discussion – Wells Presentation](#)
- [Study Research Update](#)
Karthik Konduri, *Study Manager*, Assistant Professor, Civil & Environmental Engineering, University of Connecticut
- [Closing Remarks](#)

DECEMBER 7, 2012 - MEETING 3

- [Introductory Remarks](#)
Richard H. Strauss, Executive Director, CASE
- [Transportation Investment and Economic Development: Theory, Estimation and Results, and Policy Implications](#)
Joseph (Yossi) Berechman, Chairman, Department of Economics, The City College, The City University of New York
 - [Discussion – Berechman Presentation](#)
- [PECAS Inputs to Cost Benefit Analysis and Equity Analysis](#)
Douglas Hunt, PhD, PEng Principal, HBASpecto, Inc.; Professor of Transportation Engineering, University of Calgary
- [Study Research Update](#)
Karthik Konduri, Study Manager, Assistant Professor, Civil & Environmental Engineering, University of Connecticut
- [Closing Remarks](#)

JANUARY 24, 2013 - MEETING 4

- [Introductory Remarks](#)
Richard H. Strauss, Executive Director, CASE
- [Methods for Assessing the Economic Value of Transportation Projects & Systems](#)
Glen E. Weisbrod, President, Transportation, Energy & Economic Development
Stephen Fitzroy, Senior Vice President, Economic Development Research Group
 - [Discussion – Weisbrod/Fitzroy Presentation](#)
- [Critical Analysis of Conventional Transport Economic Evaluation](#)
Todd Litman, Founder/Executive Director - Victoria Transport Policy Institute
 - [Discussion – Litman Presentation](#)
- [Closing Remarks](#)

APRIL 18, 2013 - MEETING 5 (*meeting was not recorded*)

- Introductory Remarks
Richard H. Strauss, Executive Director, CASE
- Research Update and Discussion, Draft Findings and Recommendations
Karthik Konduri, CASE Study Manager and Assistant Professor, Department of Civil & Environmental Engineering, University of Connecticut

Dale Shannon, Economic Analyst and Consultant, Connecticut Economic Resource Center

MAY 13, 2013 - MEETING 6 (*meeting was not recorded*)

- Introductory Remarks
Richard H. Strauss, Executive Director, CASE
- Discussion, Draft Findings and Recommendations
Karthik Konduri, CASE Study Manager and Assistant Professor, Department of Civil & Environmental Engineering, University of Connecticut

MAJOR STUDIES OF THE ACADEMY

2013

- Health Impact Assessments Study
- Connecticut Disparity Study: Phase 1
- Connecticut Stem Cell Research Program Accomplishments

2012

- Strategies for Evaluating the Effectiveness of Programs and Resources for Assuring Connecticut's Skilled Workforce Meets the Needs of Business and Industry Today and in the Future
- Benchmarking Connecticut's Transportation Infrastructure Capital Program with Other States
- Alternative Methods for Safety Analysis and Intervention for Contracting Commercial Vehicles and Drivers in Connecticut

2011

- Advances in Nuclear Power Technology
- Guidelines for the Development of a Strategic Plan for Accessibility to and Adoption of Broadband Services in Connecticut

2010

- Environmental Mitigation Alternatives for Transportation Projects in Connecticut
- The Design-Build Contracting Methodology for Transportation Projects: A Review of Practice and Evaluation for Connecticut Applications
- Peer Review of an Evaluation of the Health and Environmental Impacts Associated with Synthetic Turf Playing Fields

2009

- A Study of the Feasibility of Utilizing Waste Heat from Central Electric Power Generating Stations and Potential Applications

- Independent Monitor Report: Implementation of the UCHC Study Recommendations

2008

- Preparing for Connecticut's Energy Future
- Applying Transportation Asset Management in Connecticut
- A Study of Weigh and Inspection Station Technologies
- A Needs-Based Analysis of the University of Connecticut Health Center Facilities Plan

2007

- A Study of the Feasibility of Utilizing Fuel Cells to Generate Power for the New Haven Rail Line
- Guidelines for Developing a Strategic Plan for Connecticut's Stem Cell Research Program

2006

- Energy Alternatives and Conservation
- Evaluating the Impact of Supplementary Science, Technology, Engineering and Mathematics Educational Programs
- Advanced Communications Technologies
- Preparing for the Hydrogen Economy: Transportation
- Improving Winter Highway Maintenance: Case Studies for Connecticut's Consideration
- Information Technology Systems for Use in Incident Management and Work Zones
- An Evaluation of the Geotechnical Engineering and Limited Environmental Assessment of the Beverly Hills Development, New Haven, Connecticut

2005

- Assessment of a Connecticut Technology Seed Capital Fund/Program
- Demonstration and Evaluation of Hybrid Diesel-Electric Transit Buses

CONNECTICUT ACADEMY OF SCIENCE AND ENGINEERING
805 Brook Street, Building 4-CERC, Rocky Hill, CT 06067-3405
Phone: 860-571-7143 • e-mail: acad@ctcase.org
web: www.ctcase.org

CONNECTICUT ACADEMY OF SCIENCE AND ENGINEERING

The Connecticut Academy is a non-profit institution patterned after the National Academy of Sciences to identify and study issues and technological advancements that are or should be of concern to the state of Connecticut. It was founded in 1976 by Special Act of the Connecticut General Assembly.

VISION

The Connecticut Academy will foster an environment in Connecticut where scientific and technological creativity can thrive and contribute to Connecticut becoming a leading place in the country to live, work and produce for all its citizens, who will continue to enjoy economic well-being and a high quality of life.

MISSION STATEMENT

The Connecticut Academy will provide expert guidance on science and technology to the people and to the State of Connecticut, and promote its application to human welfare and economic well-being.

GOALS

- Provide information and advice on science and technology to the government, industry and people of Connecticut.
- Initiate activities that foster science and engineering education of the highest quality, and promote interest in science and engineering on the part of the public, especially young people.
- Provide opportunities for both specialized and interdisciplinary discourse among its own members, members of the broader technical community, and the community at large.

CONNECTICUT ACADEMY OF SCIENCE AND ENGINEERING
805 Brook Street, Building 4-CERC, Rocky Hill, CT 06067-3405
Phone: 860-571-7143 • e-mail: acad@ctcase.org
web: www.ctcase.org