ASSESSING THE ECONOMIC BENEFIT OF TRANSPORTATION INFRASTRUCTURE INVESTMENT IN A MATURE SURFACE TRANSPORTATION SYSTEM

FINAL REPORT

Prepared for:

The National Cooperative Highway Research Program

Prepared by:

Cambridge Systematics
4800 Hampden Lane, Suite 800
Bethesda, MD 20814

(December, 2012)

The information contained in this report was prepared as part of NCHRP Project 20-24, Task 80, National Cooperative Highway Research Program.

Acknowledgements

This study was conducted for the NCHRP 20-24 Task 80 Panel, with funding provided through the National Cooperative Highway Research Program (NCHRP) Project 20-24, *Assessing the Economic Benefit of Transportation Infrastructure Investment in a Mature Surface Transportation System*. The NCHRP is supported by annual voluntary contributions from the state Departments of Transportation. Project 20-24 is intended to fund quick response studies on behalf of NCHRP 20-24 Task 80 Panel. The report was prepared by Cambridge Systematics, Inc.. The work was guided by a technical working group. The project was managed by Andrew Lemer, NCHRP Senior Program Officer.

Table of Contents

THIS PAGE INTENTIONALLY LEFT BLANK

ASSESSING THE ECONOMIC BENEFIT OF TRANSPORTATION INFRASTRUCTURE INVESTMENT IN A MATURE SURFACE TRANSPORTATION SYSTEM

FINAL REPORT SECTION 1 –
PROJECT SUMMARY AND OVERVIEW

Prepared for:

NCHRP 20-24 Task 80 Panel

Prepared by:

Cambridge Systematics, Inc.
4800 Hampden Lane, Suite 800
Bethesda, MD 20814

With:

James March

December 2012

The information contained in this report was prepared as part of NCHRP Project 20-24, Task 80, National Cooperative Highway Research Program.

Acknowledgments

This study was conducted for The National Cooperative Highway Research Program, with funding provided through the National Cooperative Highway Research Program (NCHRP) Project 20-24 (80), *Assessing the Economic Benefit of Transportation Infrastructure Investment in a Mature Surface Transportation System*. The NCHRP is supported by annual voluntary contributions from the state Departments of Transportation. Project 20-24 is intended to fund quick response studies to address specific needs of chief executive officers (CEOs) and other top managers of DOTs. The report was prepared by *Cambridge Systematics, Inc*. The work was guided by a technical working group. The project was managed by Andrew Lemer, NCHRP Senior Program Officer.

The research team consisted of Susan Binder, Stacy Cook, Nathan Hutson, Branner Stewart, Wendy Tao and Nicole Waldheim of Cambridge Systematics, with Jim March. The research team would like to thank all NCHRP 20-24 (80) workshop participants for sharing their experience, insights, and time.

Section 1 - Table of Contents

Section 1 - List of Tables

1.0 Introduction

1.1 BACKGROUND

It has become a truism that our nation is at a crossroads in its surface transportation systems and policies. The debate on future investment would benefit from a modern, up-to-date understanding of the implications of a well-performing surface transportation system, or the failure to make a commitment to this national asset. Looking back, there is a strong consensus that the Dwight D. Eisenhower National Interstate System of Defense Highways had an enormous impact on the national economy, in large part by bringing relatively low-cost access to materials, labor, and markets. Although the potential impacts on freight distribution systems and personal mobility were not completely understood when the commitments to execute the Interstate concept began, it was not long before the benefits of this system as the backbone of transportation and commerce were obvious both nationally and locally.

Ironically, the understandings of these benefits were so intuitive that rigorous economic examination of the relationship between surface transportation system performance and economic vitality were not undertaken for decades. Building on the consensus of the importance of the Federal-aid systems; for example, the next generation National Highway System was enacted based in large part on its potential to adjust the Interstate System to accommodate changes in economic geography.

In the post-Interstate era, our nation struggles with the scale and timing of continuing investments needed to operate and preserve our current national assets while dealing with the backlogs due to past underinvestment. Simultaneously, we must make cost-effective improvements and system additions to optimize and improve performance in anticipation and response to market and societal change. A clearer understanding of the dynamic relationships between transport and the economy would contribute to a stronger basis for decisions as we look ahead in a global economy with international markets and competitors.

1.2 PROBLEM UNDERSTANDING

Pursuit of research to address the above questions has been difficult for a number of technical and structural reasons. For example, the scale of such systems – both in terms of the timeframes that their impacts have played out across the country and its industries and in the reach of their impacts from continental trunk highways to local circulation – greatly complicates both the research and interpretation of individual findings. Furthermore, the manner in which

transportation services are woven into the economic fabric of the nation makes them difficult to study and even harder to isolate from other forces that they enable. Another conceptual issue is that the limitations on available data makes it much harder to analyze causes and effects for actions that optimize existing service than focus on completely new facilities.

Even so, this research effort is a critical next step in improving our understanding, steps include: documenting what we know; identifying what new information is needed to fill the information gaps to better inform public debate; developing the means to gather that information; and communicating the updated insights on the economy to a variety of relevant audiences.

The approach used for this project was based in prepared collaboration. It provided updated information to technical experts, researchers, and industry opinion leaders, bringing together a unique gathering of individuals who understand the state of debate on the issues relating to the linkage between the existing surface transportation system and the U.S. economy and the implications of these linkages considering future system performance. This was not exclusively an academic exercise. It required rigorous analytical skills to interpret the academic contributions and their application in the real world, and was managed by those with experience to bring together several key groups, including:

- Those who are on the front lines in delivering transportation and making difficult tradeoffs among classes of investment and operations and can bring those perspectives;
- Those who have worked at the national level and are familiar with the "top-down" macroeconomic and political debates from that vantage point; and
- Those who have the true "user perspective" and know first-hand how businesses are impacted and find opportunities based on the quality of services provided by the surface transportation system.

1.3 OBJECTIVES

This project embraced a pragmatic approach to accomplish the following objectives:

- Examination of academic and professional literature to critically assess what we know as an industry as to the linkages between surface transportation and economic growth and vitality, with consideration of:
  - National level, network analyses, and other comprehensive analyses, including productivity-oriented analyses;
  - State, regional, metropolitan, and local-level analysis (e.g., planning studies); and
  - Industry, sector-level, and microeconomic analyses (e.g., business planning studies) from both the user and beneficiary perspectives.

- Examination of information from nontraditional sources that contain relevant economic information (e.g., anecdotal and case studies). The CS team sought out existing economic research from other fields (where available) to find relevant analyses that bear on the research questions and documented the paucity of information and research gaps.
- Identification of research gaps with recommendations for further research pursuits that would help national, state, regional, metropolitan, and local entities incorporate understandings of the economic linkages with transportation systems into their continuing operations and investment decisions, in the form of a multiphase, priority research program to address the knowledge and practice gaps.
- Collaboration to amplify the reach of the CS team. In concert with the National Cooperative Highway Research Program (NCHRP) Panel, CS conducted and documented a major national workshop of industry leaders in order to amplify the reach of the CS team to accomplish the above objectives.

To clarify, the purpose of NCHRP 20-24 (80) was not to undertake new economic research but to provide direction for those next steps to be taken. In recognition of the variety of target audiences, documentation of the above in this comprehensive volume includes:

- A white paper for the workshop, (found as an appendix to the comprehensive report), summarizing the work and findings to date in a user-friendly format;
- A report presenting the workshop and the information relevant to consideration of research needs (incorporated in Section 2 of the comprehensive report); and"
- A research agenda narrative containing the rationale and descriptions for future potential efforts (incorporated in Section 3 of the comprehensive report); and
- This final comprehensive report that for convenience compiles the information from this project into a single volume and contains material to inform future decisions on new research on the economic benefits of surface transportation infrastructure investment.

A summary of these documents is provided in this Overview Section 1..

2.0 White Paper Synopsis

The white paper, which can be found in full in the Appendix, examines the economic benefits of transportation improvements and methods used to estimate benefits of transportation investment. The objective of the paper is to identify gaps in our knowledge of the economic benefits of transportation investment on individuals, businesses, and national, regional, and local economies. These knowledge gaps informed the development of the research agenda to improve our understanding of the economic benefits of transportation improvements and to enhance analytical tools for estimating benefits of transportation investment in different types of areas. This will support improved transportation decision-making and a greater awareness of the economic benefits of transportation investment.

Below is a brief review of the issues raised in the white paper. Economic analyses of transportation investments, and the literature that has been developed as a result, generally fall into four broad categories:

1. Project-level benefit/cost analysis of user benefits;
2. Estimates of employment supported by transportation investment based on a mix of project studies and input/output analyses and used at various scales;
3. Macroeconomic studies of long-term relationships between transportation investment and various measures of economic activity; and
4. Broad-base studies that attempt to capture local and regional economic benefits that are not reflected in benefit/cost analyses, concentrating on the mechanisms through which transportation improvements enhance local and regional economies.

Each of these various types of analysis reflects the purpose of the sponsor of the literature and can be observed that each attempts to capture different aspects of the economic benefits of transportation investment.

2.1 BENEFIT/COST ANALYSIS OF USER BENEFITS

In general, benefits attributed to users relate to direct benefits and defined as the quality of access and mobility and reflected in travel time savings, improved travel time reliability, vehicle operating cost savings, and reduced crash costs. Although this applies to all transport modes, analyses of benefits undertaken with public transit and passenger rail in mind have expanded to include benefits of improved mobility and the availability of transportation options, especially for users who cannot drive. Considerable research has been conducted to improve estimates of the value users place on time savings, but less research has been conducted on the economic value of other user benefits. User benefits generally

are well understood, notwithstanding complexities in the valuation of some benefits.

There are various classes of transportation system users that may be more or less important based on the context and orientation of the analysis. When the intent is to assess comprehensively, these individual classes of users are often not differentiated or their perspective incorporated. However, these different benefits and to whom they accrue can have important implications. For example, users may include an individual driver/passenger who travels in an automobile for personal or business reasons, a passenger in a multi-passenger vehicle such as bus traveling for personal or business reasons, or a driver/operator who operates a commercial vehicle professionally for the direct benefit of a commercial enterprise and indirectly for its customers. For freight transportation, shippers and receivers of goods also may be considered users of freight transportation. Even though the commercial enterprise does not directly operate vehicles on the system, they are the ones who ultimately make the decisions regarding mode and service choices, pay for the benefit received, and are often most affected by transportation improvements.

Benefit/cost analyses focus on benefits directly realized by users of transportation improvements:

- Travel time savings;
- Improved transportation system reliability;
- Vehicle operating cost savings;
- Reductions in crash-related costs;
- Improved mobility; and
- Availability of travel options.

Considerable research has been done on many of these impacts. Knowledge gaps identified in this study relate primarily to the difficultly of placing a monetary value on some of these user impacts. This is particularly true for the impacts of travel time savings, improved reliability, reduced fatal and injury crashes, improved mobility, and the availability of travel options. Of these, the area receiving the most attention in recent years has been the value to users of improved travel time reliability. While not solely a product of increasing congestion, travel time reliability is strongly affected by congestion. Research has shown that many users value improved travel time reliability more than they do simple travel time savings, especially for trips requiring arrival at a specific time. Reliability is a focus area under the Strategic Highway Research Program (SHRP) and considerable research currently is underway through that program, but the need for further research beyond the SHRP 2 program can be anticipated.

Modal Perspective – Transit

There is a relatively small but growing body of research that focuses specifically on the economic benefits of investment in transit. Since 1995, transit passenger trips have grown at a faster rate than either highway vehicle miles of travel or overall population.[1] In a 2009 study for APTA,[2] Weisbrod and Reno identified a wide range of long-term economic benefits of public transportation investment that cover all four elements of the typology described above, including:

- Travel and vehicle ownership cost savings for public transportation passengers and those switching from automobiles, leading to shifts in consumer spending.
- Reduced traffic congestion for those traveling by automobile and truck, leading to further direct travel cost savings for businesses and households.
- Business operating cost savings associated with worker wage and reliability effects of reduced congestion.
- Business productivity gained from access to broader labor markets with more diverse skills, enabled by reduced traffic congestion and expanded transit service areas.
- Additional regional business growth enabled by indirect impacts of business growth on supplies and induced impacts on spending of worker wages. At a national level, cost savings and other productivity impacts can affect competitiveness in international markets.

Similarly, Litman[3] identifies five categories of transit benefits: mobility benefits; efficiency benefits; travel time impacts; land use impacts; and economic development impacts. He says that mobility benefits result from additional personal travel that would not otherwise occur particularly for the transportation disadvantaged who cannot drive personal vehicles for whatever reason.

ECONorthwest and Parsons Brinckerhoff Quade & Douglas (PBQD) developed a guidebook, *Estimating the Benefits and Costs of Public Transit Projects* under the

---

[1] American Public Transportation Association, "The Case for Business Investment in Public Transportation," Washington, D.C., 2009, http://www.apta.com/resources/reportsandpublications/Documents/case_business_investment_pt.pdf.

[2] Weisbrod, Glen and Arlee Reno, "Economic Impact of Public Transportation Investment," Prepared for: American Public Transportation Association, October 2009, http://www.apta.com/resources/reportsandpublications/Documents/economic_impact_of_public_transportation_investment.pdf.

[3] Litman, Todd, *Evaluating Public Transit Benefits and Costs, Best Practices Guide,* Victoria Transport Policy Institute, 2011.

Transit Cooperative Research Program.[4] The guide discusses in detail various issues related to benefit/cost analyses for public transportation projects. Since many benefits of transit improvements are associated with impacts of those improvements on highway users, they point out how important good multi-modal travel demand models are for estimating impacts of public transportation improvements. The report concludes that benefit/cost analysis has limitations for the assessment of transit projects. Many of transit's impacts are difficult to measure let alone quantify in monetary terms. Furthermore, the distribution of those impacts across different population groups may be more important than the absolute value of the impacts.

Modal Perspective- Railroad

The major freight railroads are privately held companies that own their own right-of-way and equipment and are responsible for all operations and maintenance activities. They are responsible for maximizing shareholder value and will invest only when that investment will be profitable. Nevertheless they interact with other elements of the national transportation system and in some cases have granted permission for their right-of-way to be used for intercity passenger service. Increasingly, the benefits of public investment in the private railroad system are being recognized.

A 2005 study conducted under the National Cooperative Highway Research Program[5] analyzed methods for estimating public benefits of investment in freight rail projects. The study combined a series of case studies with an assessment of methods and models that have been developed to assess benefits of investment in freight projects to develop a framework for establishing the public benefits of investment in freight rail capacity. The 11 cases studied found a wide-ranging variety of public benefits from investment in rail facilities, including economic, safety and security, and transportation benefits. In the case studies, the most frequent benefits cited were removing heavy trucks from highways and the related benefits of reducing accidents, reducing highway delays, improving air quality, and reducing highway maintenance costs.

Modal Perspective – Highways

Numerous reports have been written concerning the benefits of the Interstate Highway System. A detailed analysis of those studies is beyond the scope of this work, but the types of benefits analyzed in those reports are summarized in the

---

[4] ECONorthwest and Parsons Brinckerhoff Quade & Douglas, *Estimating the Benefits and Costs of Public Transit Projects: A Guidebook for Practitioners,* TCRP Report 78, Washington, D.C., 2008.

[5] Cambridge Systematics, Inc., *Return on Investment on Freight Rail Capacity Improvement,* NCHRP 8-36, Task 43, 2005, http://rail.transportation.org/Documents/task43.pdf.

full version of the white paper in the Appendix. Some of these impacts are unique to the development of a major new transportation system that provided quantum improvements in service for passenger and freight transportation performance. Other impacts are relevant to future research on the benefits of transportation investment in a mature transportation system where incremental improvements will be made that nonetheless may affect broader parts of the network.

A report issued on the 40th anniversary of the Interstate system summarizes impacts of the Interstate Highway System on the economy, safety, quality of life, and national defense.[6] The report notes that the Interstate Highway System contributed to economic efficiency and productivity in the following ways:

- By increasing speed and expanding access, freight costs have been reduced substantially. Tractor-trailer operating costs have been estimated at 17 percent lower on interstate highways than other highways.
- The Interstate Highway System made less expensive land more accessible to the nation's transportation system and encouraged development.
- The travel time reliability of shipment by Interstate Highway has made "just-in-time" delivery more feasible, reducing warehousing costs and adding to manufacturing efficiency.
- By broadening the geographical range and options of shoppers, the Interstate Highway System has increased retail competition, resulting in larger selections and lower consumer prices.
- By improving interregional access, the Interstate Highway System has helped to create a genuinely national domestic market with companies able to supply their products to much larger geographical areas, and less expensively.

The economic value of these various benefits is not quantified and many might be realized from other types of transportation improvements as well, but the breadth of the benefits cited is an indication of just how central transportation is to many of our day-to-day activities.

Modal Perspective – Water

The U.S. Marine Transportation System (MTS) consists of waterways, ports and their intermodal connections, vessels, vehicles, and system users. State, local, and private companies all own parts of the system. National, state, and local governments participate in managing, financing, and operating the MTS, but

[6] Cox, Wendell and Jean Love, *The Best Investment a Nation Ever Made, A Tribute to the Dwight D. Eisenhower System of Interstate and Defense Highways,* American Highway Users Alliance, 1996, http://www.publicpurpose.com/freewaypdf.pdf.

most decisions are driven by the marketplace.[7] More than 1,000 harbor channels and 25,000 miles of inland, intracoastal, and coastal waterways in the United States serve over 300 ports, with more than 3,700 terminals that handle passenger and cargo movements. Waterways and ports link to railroad, pipeline, and highway systems that are essential to getting goods to intermediate and final destinations.

The U.S. Department of Transportation's 1999 report to Congress, *Assessment of the U.S. Marine Transportation System,* notes that the MTS provides several types of values to the United States, including:

- **Economic Value –** Derived from features that provide efficient, effective, and dependable all-weather transportation for the movement of people and goods;
- **National Security Value –** Associated with having a swift mobilization to sustain America's military;
- **Environmental Value –** As relates to a safe and environmentally responsible form of transportation; and
- **Recreational Value –** For example, recreational boating and fishing, or sightseeing, excursion, dining, gaming, windjamming, whale watching, or nature cruises.

That report raises a number of issues confronting those who own, operate, and use the MTS. First is how to meet growing levels of demand associated with international commerce, commercial fishing, recreational users, passenger ferry services, and military requirements. Each of these disparate uses is projected to increase substantially over the next 20 years. Second is how to improve the efficiency of commercial operations to meet the needs of an increasingly competitive marketplace. New equipment, increased capacity, and more efficient operations will be required on many parts of the MTS. A third challenge will be how to handle increased marine traffic while sustaining the environment. The MTS encompasses fragile habitats, including coastal and estuarine waters, inland rivers, and wetlands that must be protected. Air pollution around ports and terminals is a growing concern as is vessel discharge, dredging, and the introduction of nonindigenous species.

Employment supported by transportation investment often is of considerable interest, especially during times of high unemployment throughout the economy. Much of the discussion of employment associated with transportation investment relates to the short-run impacts of construction spending itself – the jobs directly supported by construction, the jobs in industries supplying the construction industry, and jobs supported by spending by workers in the

[7] U.S. Department of Transportation, *An Assessment of the U.S. Marine Transportation System,* Report to Congress, 1999, http://ntl.bts.gov/DOCS/report/mtsfinal.pdf.

construction and supporting industries. Such short-term job generation by itself, however, is not a sufficient reason to invest in transportation if other benefits do not outweigh the cost of the transportation investment. In the long term, transportation investment that promotes increased economic activity also will support increased employment.

Macroeconomic analyses to assess the contribution of overall transportation investment to national or regional economic activity have focused on highway investment. Studies have been conducted at the state, regional, and national level. These studies typically use sophisticated economic analysis techniques and rely on statistical relationships between levels of transportation investment and measures of economic activity, but often do not demonstrate causality or the mechanisms through which transportation investment affects measures of economic performance. Moreover, results of these studies can be influenced by the underlying economic analysis methods used in those studies. Several early studies found very large economic benefits from transportation investment, but those studies later were criticized based on the economic methods used. Other issues that can affect the results of such macroeconomic studies are the level of geography being analyzed, the time period involved, and the types of improvements being funded from transportation investments.

Macroeconomic analyses can provide estimates of economy-wide benefits of a transportation investment program that cannot be estimated using other methods.

Despite these issues, macroeconomic analyses can provide estimates of economy-wide benefits of a transportation investment program that cannot be estimated using other methods. One of the most widely cited macroeconomic analyses of the effect of highway investment on economic productivity was conducted for the Federal Highway Administration by Nadiri and Mamuneas. They found that highway investment accounted for about 25 percent of all productivity growth in the U.S. economy during the period 1950 to 1989. From 1952 until 1963, the contribution to overall productivity was 32 percent, but that rate declined during subsequent years until, for the period 1980 to 1989, the contribution to productivity growth was down to seven percent. Thus, as the Interstate system neared completion, the economic impact of additional investment declined. Nadiri and Mamuneas also assessed the relative impact of investment in different types of highways. As would be expected, they found that overall rates of return on investment on higher-order highway systems were substantially greater than rates of return on local road and street investment. They did not examine the composition of highway expenditures by purpose, but if they had, they would have found the share of all expenditures going to actual construction falling over time. This could be another factor leading to the declining rates of return on highway investment since nonconstruction expenditures would not be expected to have as significant an effect on productivity or levels of economic activity.

A recent RAND report summarized findings of studies that examined relationships between highway investment and measures of economic performance. They found a consensus that:

- Construction of the Interstate system had large positive effects on U.S. productivity, but those effects have diminished since construction of the system was completed;
- The Interstate system heavily influenced land use development patterns and the suburbanization of the population; and
- Highway infrastructure has caused positive economic outcomes for industries that use it most intensively.

RAND also notes that past studies have come to different conclusions on several issues, especially whether current highway investment still has large economic effects now that the backbone of the highway network is largely complete or whether it simply causes a relocation of economic activity without significant net growth.

The quality of roads and railroad infrastructure in the U.S. both ranked 20th out of 142 countries, port infrastructure was 23rd and air transport infrastructure was 31st.

Recent studies indicate that the international competitiveness of the United States is slipping relative to other countries. Many factors contribute to the nation's weakening competitiveness, but transportation has been identified as one important area. A recent study by the Economic Development Research Group concludes that without adequate surface transportation investment, future U.S. exports will fall substantially. In the World Economic Forum's latest Global Competitiveness Report, the United States ranked fifth in overall competitiveness, but the relative quality of transportation infrastructure was considerably lower. The quality of roads and railroad infrastructure in the United States both ranked 20th out of 142 countries, port infrastructure was 23rd and air transport infrastructure was 31st. The U.S. ranking for the quality of roads, railroads, and port infrastructure was down from the previous year. Thus, while the United States ranked relatively high in overall competitiveness, the quality of its infrastructure was not on a par with other elements of competitiveness.

Estimating Broader Economic Benefits of Transportation Investment will require improved methods to estimate the full economic impacts of transportation improvements. Traditional user benefit assessments in most benefit/cost analyses do not capture the dynamic developmental impacts of major transportation projects and programs of projects. These impacts may include changes in residential and business location; changes in spatial patterns of production; development of new manufacturing and distribution processes; and the development of new institutions and markets. Macroeconomic models likewise have

weaknesses, primarily because they do not reflect the mechanisms through which transportation investment leads to improved economic outcomes. Without understanding how transportation affects various measures of economic performance, it is very difficult to estimate potential impacts of discrete projects or programs of projects in particular locations.

To overcome this weakness of benefit/cost analyses, authors Sue Wing, Anderson, and Lakshmanan[8] specify a computable general equilibrium (CGE) model that is specifically designed to assess the broader economic impacts of transportation infrastructure investments. They indicate that models of this type should be based on three requisites:

1. Unlike macroscale analyses, they should incorporate information about specific additions or improvements to transportation infrastructure networks (although not necessarily at the level of detail found in microscale analyses).
2. They should trace the economic processes that are triggered by infrastructure improvements (that) may take the form of static general equilibrium effects or dynamic developmental effects.
3. Finally, in order to assess the relative magnitude of different economic mechanisms and to inform policy, they should be amenable to empirical implementation using data that are either available or obtainable at reasonable cost.

The CGE model generates a range of information that cannot be obtained from existing models such as whether the benefits of a capacity expansion accrue mostly to firms or households, whether household benefits are mostly in consumption activities or commuting and whether some industries benefit more than others. Such information may be useful in assessing whether specific objectives that policy-makers attach to a project are likely to be met. Also, the CGE specification is especially well-suited to assessing the impact of infrastructure programs because the implementation of two or more capacity expansions can be modeled simultaneously. This will be useful in identifying complementarities among projects by seeing, for example, whether the benefits of projects A and B implemented simultaneously exceed the sum of the benefits of A and B implemented independently.

Several years ago, the United Kingdom commissioned a study by Sir Rod Eddington to examine long-term links between transport and the U.K.'s economic productivity, growth, and stability. This seminal study found many important links between transportation and economic performance. It concluded

---

[8] Sue Wing, Ian, William P. Anderson, T.R. Lakshmanan, *The Broader Benefits of Transportation Infrastructure,* Boston University Center for Transportation Studies, 2007, http://people.bu.edu/isw/papers/The%20Broader%20Benefits%20of%20Transportation%20Infrastructure.pdf.

that long-term transportation investment should focus on growing and congested urban areas, key interurban corridors, and important international gateways.

The United Kingdom has one of the most rigorous policies with respect to project-level economic appraisal. A significant element of the Eddington study was to review economic analysis methods and identify areas where additional research was required. Among those research priorities were:

- The valuation of time savings and improved travel time reliability;
- The economic benefits of improved freight transportation;
- Mechanisms through which agglomeration economies are realized and methods for estimating the benefits of increased agglomeration;
- Contributions of transport policy and investment in supporting trade; and
- Contributions of transportation attracting foreign investment and globally mobile economic activity.

Agglomeration effects have long been recognized as a result of transportation improvements, and the effects can be significant, but they rarely are included in studies assessing potential benefits of transportation investment. A study commissioned to support the Eddington Transport Study focused exclusively on the relationship between agglomeration and productivity.[9] Agglomeration is not exclusively about higher density and physical proximity between economic entities, however. To the extent that transportation improvements reduce travel times and travel costs, they may still produce agglomeration effects even if businesses and labor do not move closer to one another.[10]

Despite the large body of prior research, much is not well understood about the economic benefits of transportation investment, especially investments made within the context of a mature transportation system. Communication of what the research does have to offer decision-makers is a particularly important element of that research. Numerous areas of future research are identified in the body of the paper that could yield improved information on the benefits of and need for future transportation improvements to serve the needs of the nation's growing population and to keep the United States competitive with other countries that are investing heavily in their transportation infrastructure.

---

[9] Graham, Daniel J., "Investigating the Link between Productivity and Agglomeration for U.K. Industries," Appendix to Eddington Transport Study, 2005.

[10] MVA, op. cit.

3.0 Workshop Summary

The "Transportation and the Economy" workshop brought together critical thinkers to help guide future research on the linkage between transportation infrastructure investment and the economy. This event provided a unique opportunity to solicit contributions on the subject that researchers from Cambridge Systematics, Inc. (CS) will use in subsequent tasks of the National Cooperative Highway Research Program (NCHRP) 20-24(80) project "Assessing the Economic Benefit of Transportation Infrastructure Investment in a Mature Surface Transportation System."

The purpose of the workshop was to collect ideas as to high potential research rather than to find a consensus among the participants on research priorities. It is noteworthy, however, that even with the great diversity of perspectives, there were many common themes. Most prominent was an almost universal agreement that those investing in surface transportation infrastructure need a better understanding of the economic implications of the options they consider in the course of investment and operational decisions. Many expressed the belief that serious information gaps exist that, if filled, would increase their confidence in choosing among options. There was a general recognition that untangling the influence and interaction between transportation and economic vitality, spatial organization, land use, and other goals is a challenge for which macroeconomic analysis alone may be ill-suited. Similarly, some expressed the belief that traditional cost benefit analyses at the project level alone may not be sufficiently informative for decisions with system level impacts and may actually be counterproductive to achieving regional economic development objectives. These issues highlight the complexity and thus the difficulties of communicating options and implications.

The full workshop report, which can be found in Section 2 of the comprehensive report, synthesizes the fast-paced and interactive discussion that took place on April 19, 2012 at the Bolger Center in Potomac, Maryland. It presents one step in the process of identifying the components of a future research agenda. As a digest of that dialogue, it characterizes the themes and insights contributed in the course of voluntary participation by nearly 60 colleagues at the invitation of the organizers on behalf of the National Cooperative Highway Research Program sponsors. The authors of this report thank them for their time and their willingness to collaborate in this endeavor.

In designing the workshop, the intent was to bring together a variety of perspectives based on the wide array of surface transportation services provided across this nation and the diversity of its users (e.g., shippers, carriers, commuters, service providers, tourists). Furthermore, this variety is multiplied by the numerous levels of private sector and governmental agents involved with the ownership and operation of the multimodal U.S. surface transportation system.

The workshop participants dedicated the full day to discussing issues, and identifying gaps in the knowledge base, as well as completely new research directions. They built on a collective understanding of past research, made available prior to the workshop in the white paper prepared for the NCHRP 20-24(80) project.

Academic and technical researchers among the participants confirmed that the rigorous economic literature as a whole on this subject has not been refreshed in quite some time, and could benefit from some new thinking and refinement. It was widely recognized that the transportation system and its infrastructure must be dynamic to serve the rapidly changing needs of transportation users (the "customers"). Since a critical factor driving change is the broader economy, the sense among many participants was that prior retrospective economic research at various scales and over various time periods likely does not adequately reflect current and future relationships between transportation investment and economic growth in an increasingly global economy. Although informative to some degree, the available findings are insufficient to guide today's decisions intended to serve current and future economic goals.

Several themes emerged throughout the workshop discussion, raising issues around which further research needs could be identified:

- A framework for transportation investment, rooted in achieving economic goals at the national level, could be developed for the United States. Similar to the Eddington Transport Study conducted for the United Kingdom, such a framework would provide an analytical focus and help to achieve a consensus for action based on economic goals and principles.[11]
- Targeted refinements to long-standing lines of transportation research would be beneficial to update the relevance to current and future economic environments, including emerging industries. For example, the recognition that reliability and predictability are important transportation attributes was discussed; the importance of these factors for the economic performance of both individual firms and broader regional economies could be studied so that micro and macro economic implications can be quantified and understood.
- Broad economic benefits of transportation system improvements such as economies of agglomeration need better treatment. Further analysis of such broader benefits is important so that they can be reliably included in overall economic benefits assessments.

[11] The Eddington Transport Study – The case for action: Sir Rod Eddington's advice to Government, December 2006.

- Identification and refinement of metrics of economic performance that correlate with investment and other transportation decisions will be important in an era of accountability with a focus on overall system performance.
- Assessment of externalities, both positive and negative, needs consistent treatment from an economic point of view.
- Expanded approaches to considering economic linkages are needed, particularly in the allocation of scarce transportation resources.
- The relationship between transportation and economic competitiveness is not well understood. An improved understanding of those transportation attributes that contribute most to international competitiveness for various industries would help to inform transportation investment decisions.
- Specific research is needed on how to improve communication of the importance of transportation to the economy with the general public and specialized audiences. There was widespread recognition that communication of this linkage is inadequate.

The energy represented in the workshop made it clear that there is great interest in addressing the economic rationale for transportation in order to better incorporate those aspects into decision-making and to better communicate the implications to the critical audiences making public policy.

4.0 Research Agenda

4.1 RESEARCH AGENDA OVERVIEW

The United States continues to deal with tough decisions within a very difficult economic climate. Nowhere is this clearer than in considering future options for the many aspects of our national infrastructure that are delivered at the Federal, state, and local level. Personal access and mobility can easily be taken for granted. However, those responsible for the availability of quality highway and transit services in the future certainly know that even relatively mature facilities and systems require continuous attention to be effective, and the intensity of their use requires a significant dedication of resources. They were originally built on an understanding and consensus as to the importance of well-performing systems to a healthy economy. This is as true today as it was then; maybe more so with the acknowledgment of the pressure of international competition, the scale of deferred investments, and the underinvestment faced by other types of infrastructure as well.

As the economy evolves to reflect changing technologies, consumer preferences, and trends in energy and materials, so too must the transport system adapt to serve new challenges and realities. This argues for renewing the understanding of the linkages between transportation services and economy to gain up-to-date insights on how investments in the system and its efficient operation can best serve those economic goals. Embarking on a sequence of systematic next steps can improve our critical understandings, this includes: documenting what we know; identifying what new information is needed to fill the information gaps to better inform public debate; developing the means to gather that information and doing so; and communicating the updated insights on the economy to a variety of relevant audiences.

Under the National Cooperative Highway Research Program (NCHRP) 20-24(80) project "Assessing the Economic Benefit of Transportation Infrastructure Investment in a Mature Surface Transportation System," the research team undertook a series of activities to help inform action on these issues. As described above in the statement of overall objectives, the logic that has flowed through this project began with a documentation and evaluation of what we know collectively about the linkage between transportation investment and the economy. This collective knowledge was applied through the development of a research agenda. This meant identifying gaps and applying judgment based on an understanding of the motivations of the project sponsors, which was to focus selectively on a limited body of subsequent work that would address the most critical of these gaps. The assessment was not conducted on a theoretical basis or in isolation. It reflects the charge to the research team to consider how to effec-

tively capture the economic benefits of transportation investment, beyond the provision of the transportation services themselves. An understanding of these broader benefits could then be expected to provide further insights into such benefits to both officials and the public.

Ultimately, the goal is to conduct research that will bring an up to date understanding of markets that transportation serves and the economic context within which the transportation function operates to those who make decisions concerning the management and operation of transportation infrastructure. The immediate goal of the research agenda is to fill information voids based on: 1) the white paper[12] that summarized and synthesized the existing literature on transportation and the economy; 2) the multiday workshop[13] to identify the information gaps that could be barriers to understanding how transportation supports economic growth and productivity; and 3) consideration of the challenges set before the research team by the project sponsors.

The "Transportation and the Economy" workshop brought together critical thinkers to help guide future research on the linkage between transportation infrastructure investment and the economy. This event provided a unique opportunity to solicit contributions on the subject to inform the research agenda. In critiquing the available literature and industry knowledge, both academic and technical researchers among the participants confirmed that a combination of approaches that would draw upon relatively historic economic perspectives as well as case studies that explore current and expected trends would be advantageous.

The research team took into consideration both the more traditional academic literature and the applications driven analytical efforts where the methodologies were presented. In the manner of such lines of public policy inquiry, debate has been extensive over time as to the relevance and validity of these analyses. The contexts of these debates has strongly influenced the acceptance of the findings in various forums. It must be recognized that there are many different ways to define the issues and questions; as many different audiences for the insights that this literature can reveal. Furthermore, the great variation in both audiences and analytical approaches continues to mean that no single consensus has developed on the overall research question as to how transportation investment and the economy are related. For example, some audiences have been defined by their desire to use specific findings to guide future actions at different scales; to meet those different needs, studies have defined their research questions at very different scales such as at the national, state, regional, or project level.

---

[12] NCHRP 20-24(80) *White Paper: Transportation and the Economy*, March 2012, Cambridge Systematics, Inc. and Jim March.

[13] Report on the 20-24(80) Workshop, *Transportation and the Economy,* April 19, 2012, Cambridge Systematics, Inc.

In our effort to address an expansive genre, the research team took advantage of the diversity of the research as documented in the White Paper found in the Appendix and the diversity of experience in the field to organize and convene the workshop described above. In contemplation of preparing the research agenda, we solicited input at the workshop from the participants as to their information needs relating to the economic benefits of transportation.

Based on the team's understanding of gaps in the technical literature, some of the issues that arose and were pursued in the workshop setting included:

- **Decision Support –** Information that is critical to incorporate economic benefit information;
- **Multimodal Analyses –** Analyses that went beyond the provision of transportation services through a single modality;
- **Interdisciplinary Perspectives –** Using eclectic investigative approaches such as logistics-based interviews, time series and causation, tradeoff and scenario analyses, case and before/after analyses;
- **Forecasting of Market Change –** Analyses that explore the implications of future industry dynamics rather than "proving" relationships rooted in historic relationships; and
- **Modal Coverage –** Priorities for analyses beyond highways (where the literature is the richest) as well as private sector decisions.

The research team considered the discussions during the workshop and distilled potential research. Defining potential research projects were guided in part by the following:

- Is the issue or gap in fact "researchable"? Is there a discrete research question that can be studied?
- How broad is the question that is being raised? Is this an increment of work that can build on past work? What are the relative rewards of that increment to addressing decision gaps?
- How important have decision-makers seen this area for practical use?
- Is this line of research already robust with existing support?
- Is the dominant perspective and skill set based in economics? Or, is it only tangentially economics (as opposed, for example, to engineering or traffic analysis, or political science)?
- Would a new focus stimulate a line of research that otherwise would not be addressed?

The full research agenda can be found in Section 3 of the comprehensive report, below.

4.2 RESEARCH THEMES

Several thematic areas emerged during the workshop discussions around which the research team has structured its findings.

Theme 1 – Goal-Driven Framework. The development of a transportation investment framework, rooted in achieving economic and performance goals at the national level, could be tailored for the United States. Similar to the U.K. Ministry's Eddington Transport Study, such a framework helps evaluate priority transportation investments based on rigorous evaluation of their contribution to overarching policy goals.

Theme 2 – Macroeconomic Studies. Refinement and incremental improvements to the available macroeconomic models could be beneficial to decision-makers. Specific studies would capture current and anticipated trends and focus specifically on changing and emerging industries.

Theme 3 – Benefits Beyond Benefit/Cost. Analyses that go beyond the straightforward benefit/cost framework and direct user benefits to capture broader benefits and help interpret phenomena such as agglomeration.

Theme 4 – Metrics. Research to explore and develop metrics that could can help communicate the variety of relationships between business operations, economic vitality, and transportation at various levels could help improve the understandings and be incorporated into analytical and decision tools.

Theme 5 – Assessment of Externalities. Research aimed at evaluating in a consistent manner the best practices related to estimates of the economic costs and benefits associated with various types of externalities would result in better informed decisions on investments.

Theme 6 – Resource Allocation Tools. Enhance the capability of decision-makers to quantitatively assess tradeoffs in transportation system management and particularly multimodal investment decisions with better and up-to-date tools and methodologies.

Theme 7 – Competitiveness. Although improved economic competitiveness is generally accepted as a motivation for improving transportation services and reducing the costs associated with transportation use, the dynamics across industries or regions are not clear. An emphasis on understanding how firms/ industries/sectors attempt to deal with transportation barriers and/or potential for trade and export growth as well as changing technology and other trends would be a valuable contribution.

Theme 8 – Communications. Economic insights are not readily understood by public decision-makers or the general public. Challenges to good communication have been attributed to many elements such as technical jargon and the differing perspectives of the many users of transportation. Communication strategies would benefit from better understandings of both the audiences and how transportation services make a difference.

An initial sketch plan or project statement was developed for a total of 15 research projects, arranged by theme. Some projects are more developed than others based on the specific purpose to be achieved and the degree to which either the literature or policy debate exists to define the means to study the issue. The technical approach and estimates of costs and timeline are a combination of the input received at the workshop and assessment of similar activities that have been undertaken.

The research team assigned relative levels of expected impact within each of the thematic areas based on a set of criteria that reflect the importance and extent of influence that the research results would potentially exert. In addition, an overall ranking was assigned that is merely illustrative (i.e., specific order is not as important as whether the projects were assigned nearer to the top or the bottom) and meant to highlight the uniqueness of the research aspect and its potential to address the research goals. Not only are the highest ranked projects of high priority but, absent the policy concerns represented in this research agenda, such projects would be less likely to appear in traditional research plans. Such assessments are informed by the nature of ongoing research in progress and in the pipeline.

For each of the project statements, information is provided that addresses some of the issues associated with executing the research such as sponsorship interest, skill sets, and coordination that arose in the course of the research. An overarching set of observations as to the potential for collaboration and coordination are made to draw attention to the various institutions that may be drawn upon in implementing the agenda as a whole.

4.3 POTENTIAL RESEARCH PROJECTS

A summary of the research agenda is shown below in Table 4.1

Table 4.1 Potential Research Projects Identified under 20-24(80)

Overall Priority	No.	(Abbreviated) Project Name	Scale of Impact	Estimated Cost	Period	Type of Work
Theme 1 – Goal-Driven Framework						
2	1	Goal-driven framework tailored to U.S. economic growth and transportation needs.	1	$800,000 to $1 million	18 months	Policy analysis and outreach
Theme 2 – Macroeconomic Studies						
10	2	Economic development implications of transportation disinvestment.	2	$500,000	18 months	Policy analysis
11	3	Capital stock data reflecting service characteristics.	3	$500,000 to $1 million	2 years	Macro-econometric
Theme 3 – Benefits Beyond Benefit/Cost						
3	4	Identify and quantify agglomeration economies.	1	$500,000 to $750,000	2 years	Multidisciplinary policy and economic analysis
6	5	Comprehensive reviews of past transportation infrastructure projects.	2	$300,000	1 year	Scanning and review
12	6	Short-term stimulative impact of transportation investment.	2	$300,000	1 year	Labor econometrics, policy-related synthesis
Theme 4 – Metrics						
4	7	Develop a set of metrics that can be applied to transportation projects to quantify economic costs and benefits.	1	$200,000	1 year	Scoping and framing
Theme 5 – Assessment of Externalities						
13	8	Develop a comprehensive methodology for evaluating project externalities and develop standards for valuing all externalities.	3	$200,000 to $500,000	2 years	Synthesizing and framing
Theme 6 – Resource Allocation Tools						
7	9	Refining economic analysis tools to meet new MAP-21 freight requirements.	1	Phase I – $250,000; Phase II – $600,000	2 years	Methodology refinement
14	10	Identify transportation projects that contribute most to the economy.	2	$200,000	1 year	Literature and project file review, case studies
9	11	Explore economic basis for a resource allocation tradeoff model.	1	$100,000	6 months	Exploratory precursor to methodology development
8	12	Develop an approach to measure the economic impacts of reliability.	1	$500,000	2 years	Methodology development

Overall Priority	No.	(Abbreviated) Project Name	Scale of Impact	Estimated Cost	Period	Type of Work
Theme 7 – Competitiveness						
4	13	How does transportation fit into the competitiveness calculation?	1	$250,000	1 year	Critical policy analysis and scoping
1	14	Comprehensive and systematic treatment of transportation's role across various industries and economic sectors.	1	$1 million	6 months to 2 years	Policy analysis (with heavy interview and field work)
Theme 8 – Communication						
5	15	Market analysis and application.	2	$1 million	2 years	Marketing, survey and synthesis

THIS PAGE INTENTIONALLY LEFT BLANK

ASSESSING THE ECONOMIC BENEFIT OF TRANSPORTATION INFRASTRUCTURE INVESTMENT IN A MATURE SURFACE TRANSPORTATION SYSTEM

FINAL REPORT SECTION 2 -WORKSHOP REPORT

Prepared for:

The National Cooperative Highway Research Program

Prepared by:

Cambridge Systematics
4800 Hampden Lane, Suite 800
Bethesda, MD 20814

(September, 2012)

The information contained in this report was prepared as part of NCHRP Project 20-24, Task 80, National Cooperative Highway Research Program.

Acknowledgments

This study was conducted for The National Cooperative Highway Research Program, with funding provided through the National Cooperative Highway Research Program (NCHRP) Project 20-24 (80), *Assessing the Economic Benefit of Transportation Infrastructure Investment in a Mature Surface Transportation System*. The NCHRP is supported by annual voluntary contributions from the state Departments of Transportation. Project 20-24 is intended to fund quick response studies to address specific needs of chief executive officers (CEOs) and other top managers of DOTs. The report was prepared by *Cambridge Systematics, Inc*. The work was guided by a technical working group. The project was managed by Andrew Lemer, NCHRP Senior Program Officer.

The research team consisted of Susan Binder, Stacy Cook, Nathan Hutson, Branner Stewart, Wendy Tao and Nicole Waldheim of Cambridge Systematics, with Jim March. The research team would like to thank all NCHRP 20-24 (80) workshop participants for sharing their experience, insights, and time.

Section 2 - Table of Contents

Section 2 - List of Tables

Section 2 - List of Figures

Executive Summary

The "Transportation and the Economy" workshop brought together critical thinkers to help guide future research on the linkage between transportation infrastructure investment and the economy. This event provided a unique opportunity to solicit contributions on the subject that researchers from Cambridge Systematics, Inc. (CS) will use in subsequent tasks of the National Cooperative Highway Research Program (NCHRP) 20-24(80) project "Assessing the Economic Benefit of Transportation Infrastructure Investment in a Mature Surface Transportation System."

This document synthesizes the fast-paced and interactive discussion that took place on April 19, 2012 at the Bolger Center in Potomac, Maryland. It presents one step in the process of identifying the components of a future research agenda. As a digest of that dialogue, it characterizes the themes and insights contributed in the course of voluntary participation by nearly 60 colleagues at the invitation of the organizers on behalf of the National Cooperative Highway Research Program sponsors. The authors of this paper thank them for their time and their willingness to collaborate in this endeavor.

In designing the workshop, the intent was to bring together a variety of perspectives based on the wide array of surface transportation services provided across this nation and the diversity of its users (e.g., shippers, carriers, commuters, service providers, tourists). Furthermore, this variety is multiplied by the numerous levels of private sector and governmental agents involved with the ownership

The purpose of the workshop was to collect ideas as to high potential research rather than to find a consensus among the participants on research priorities. It is noteworthy, however, that even with the great diversity of perspectives, there were many common themes. Most prominent was an almost universal agreement that those investing in surface transportation infrastructure need a better understanding of the economic implications of the options they consider in the course of investment and operational decisions. Many expressed the belief that serious information gaps exist that, if filled, would increase their confidence in choosing among options. There was a general recognition that untangling the influence and interaction between transportation and economic vitality, spatial organization, land use, and other goals is a challenge for which macroeconomic analysis alone may be ill-suited. Similarly, some expressed the belief that traditional cost benefit analyses at the project level alone may not be sufficiently informative for decisions with system level impacts and may actually be counterproductive to achieving regional economic development objectives. These issues highlight the complexity and thus the difficulties of communicating options and implications.

and operation of the multimodal U.S. surface transportation system. The workshop participants dedicated the full day to discussing issues, and identifying gaps in the knowledge base, as well as completely new research directions. They built on a collective understanding of past research, made available prior to the workshop in the white paper prepared for the NCHRP 20-24(80) project.

Academic and technical researchers among the participants confirmed that the rigorous economic literature as a whole on this subject has not been refreshed in quite some time, and could benefit from some new thinking and refinement. It was widely recognized that the transportation system and its infrastructure must be dynamic to serve the rapidly changing needs of transportation users (the "customers"). Since a critical factor driving change is the broader economy, the sense among many participants was that prior retrospective economic research at various scales and over various time periods likely does not adequately reflect current and future relationships between transportation investment and economic growth in an increasingly global economy. Although informative to some degree, the available findings are insufficient to guide today's decisions intended to serve current and future economic goals.

Several themes emerged throughout the workshop discussion, raising issues around which further research needs could be identified:

- A framework for transportation investment, rooted in achieving economic goals at the national level, could be developed for the U.S. Similar to the Eddington Transport Study conducted for the United Kingdom, such a framework would provide an analytical focus and help to achieve a consensus for action based on economic goals and principles.[14]
- Targeted refinements to longstanding lines of transportation research would be beneficial to update the relevance to current and future economic environments, including emerging industries. For example, the recognition that reliability and predictability are important transportation attributes was discussed; the importance of these factors for the economic performance of both individual firms and broader regional economies could be studied so that micro and macro economic implications can be quantified and understood.
- Broad economic benefits of transportation system improvements such as economies of agglomeration need better treatment. Further analysis of such broader benefits is important so that they can be reliably included in overall economic benefits assessments.
- Identification and refinement of metrics of economic performance that correlate with investment and other transportation decisions will be important in an era of accountability with a focus on overall system performance.

[14]The Eddington Transport Study – The case for action: Sir Rod Eddington's advice to Government, December 2006.

- Assessment of externalities, both positive and negative, needs consistent treatment from an economic point of view.
- Expanded approaches to considering economic linkages are needed, particularly in the allocation of scarce transportation resources.
- The relationship between transportation and economic competitiveness is not well understood. An improved understanding of those transportation attributes that contribute most to international competitiveness for various industries would help to inform transportation investment decisions.
- Specific research is needed on how to improve communication of the importance of transportation to the economy with the general public and specialized audiences. There was widespread recognition that communication of this linkage is inadequate.

The energy represented in the workshop made it clear that there is great interest in addressing the economic rationale for transportation in order to better incorporate those aspects into decision-making and to better communicate the implications to the critical audiences making public policy.

1.0 Workshop Overview

1.1 INTRODUCTION

The National Cooperative Highway Research Program (NCHRP) Project 20-24 (80) charged the Cambridge Systematics, Inc. (CS) research team to: 1) explore the basis upon by which the economic benefits of transportation infrastructure investment in a mature surface transportation system have been documented in the literature and by practitioners to date; and 2) prepare a research agenda with the potential to fill information gaps. Two key elements of the approach were taken to accomplish these goals: 1) preparation of a white paper to document the existing literature on the subject and begin identifying gaps in the literature; and 2) convening, in a workshop setting, technical experts, transportation decision-makers, and industry opinion leaders to: a) consider how economic assessment currently is being used; b) identify research that could enhance understanding of how transportation improvements support economic growth and development; and c) identify the most critical research needs.

This report summarizes discussions and presentations at the workshop conducted on April 19, 2012 at the Bolger Center in Potomac, Maryland. It focuses on key issues and points made during the discussion, but does not attempt to include every comment made throughout the day. It contains factual coverage of the opinions of the participants (although not necessarily the opinions of all participants, the research team, or TRB). The overriding purpose in preparing this document is to highlight those insights gleaned from the workshop that will inform the research agenda and thus contribute to the overall project goals.

1.2 WORKSHOP PURPOSE AND APPROACH

The workshop was designed to stimulate creative thinking and serious discussion of the role that the surface transport sector, and particularly infrastructure investment, plays in economic vitality. The agenda structure served to maximize discussion and input from a variety of transportation industry leaders and prominent researchers in the field of economics. This was achieved through minimizing plenary time and presentations, maximizing breakout sessions, and concentrating the energy in a one-day format. Plenary speakers were used to quickly bring the participants to a common platform of economic understanding based on the advance white paper and economic literature as well as to bring to the group a variety of decision-maker perspectives to stimulate discussion during the breakouts.

Workshop participants were chosen because of their abilities to contribute to the dialogue as a result of their current or past roles as: 1) decision-makers and

managers in transportation agencies; 2) researchers in related economics and transportation fields; or 3) planning practitioners. To keep the size of the workshop to a size that promoted dialogue and participation, the CS Team and project sponsors chose to concentrate invitations to those who fit more than one of those roles where possible – but even more importantly, those with interdisciplinary backgrounds who could foster communication across the prime disciplines involved. Participants were selected to provide expertise and perspectives across all surface transportation modes, all levels of government, and various segments of the transportation industry. Participants were encouraged to provide their own views rather than to represent views of particular transportation organizations. Appendix C contains names and affiliations of workshop participants. Table 1.1 contains the summary agenda (See Appendix A for the full agenda).

Table 1.1 April 19, 2012 NCHRP 20-24(80) Workshop Agenda

April 19, 2012		
8:00 a.m.	Kickoff Plenary	Susan Binder, Moderator (CS)
	Welcome	John Horsley (AASHTO)
	White Paper Presentation	Jim March, Presenter
	Discussants	Discussants Panel: Jack Wells (U.S. DOT), Randall Eberts (Upjohn Institute), and Brian Taylor (UCLA)
10:00 a.m.	Practitioners' Perspectives	Planning: Glen Weisbrod (EDRG)
		State DOT: Gene Conti (NCDOT)
		Transit/Urban: Therese McMillan (FTA)
		Shipper: Bruce Carlton (NITLeague)
		Construction: Alison Black (ARTBA)
11:00 a.m.	Breakout #1	Assess the findings
12:00 Noon	Lunch	
1:00 p.m.	Breakout #2	Identify and prioritize the research gaps
2:30 p.m.	Plenary	Report Out's and Reconciliation
3:30 p.m.	Next Steps	Alan Pisarski and Julie Lorenz (Burns & McConnell): Implications for Research – Communications, Messaging, Tools
4:30 p.m.	Reprise and Closing	Rapporteur: Alan Pisarski

Prior to the workshop, a number of resource materials were made available to the participants, most notably the Draft White Paper referred to above, as well as other key background documents (see Appendix B for the complete list) to provide context and serve as a resource for discussions at the workshop. With the major purpose of the study being to consider future research that might help decision-makers incorporate economic considerations into transportation management, the examination of the literature captured in the white paper produced for this study

was shared with all of the participants as an initial means to help them reflect on the existing research and have the benefit of a common base of literature.

2.0 Plenary Presentations

Several plenary presentations were made by transportation and economics professionals to provide a foundation for subsequent discussions of future research requirements and to provide input to inform a research agenda that could ultimately yield timely results for decision-makers concerned with linkages between surface transportation and economic growth and development.

The overview was provided to help substantiate why practitioners and researchers believe they know what they know, with the understanding that knowledge, or filling knowledge gaps, would influence decisions. The combination of pre-workshop resource materials and on-site presentations set the stage for participants to have a meaningful discussion on the dynamic relationship between transport and the economy.

Susan Binder, the CS Project Manager for the NCHRP project, served as moderator and facilitator for the day's workshop. She introduced the agenda for the day and explained the expectations over the course of the effort.

As the key sponsor for the effort, John Horsley, Executive Director of the American Association of State Highway and Transportation Officials (AASHTO), welcomed participants to the workshop. He discussed the importance of using this workshop to lay the groundwork for a research agenda that would shape the future of transportation investments. Although research has been undertaken in the past on this topic, it is dated and has not been updated to reflect national policy, the current and future economy, or the advancement of tools and data. Three ideas he asked participants to keep in mind during the day included:

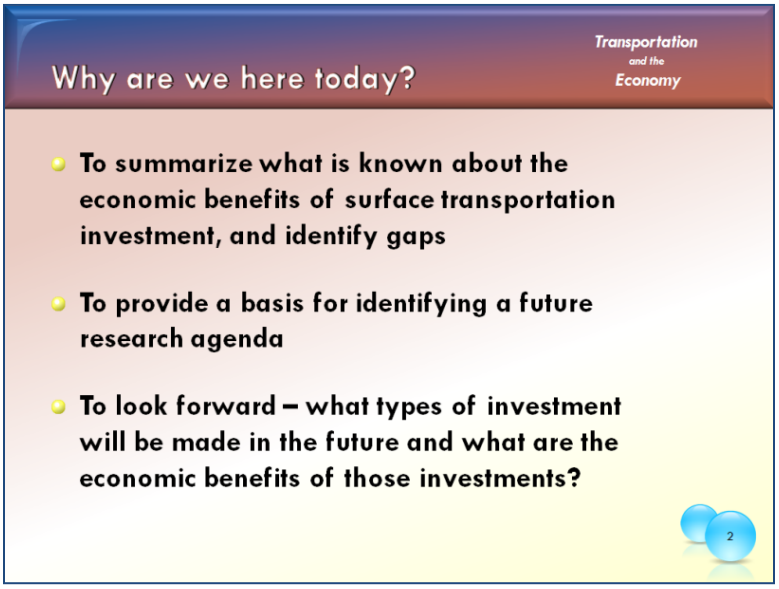
- As described in the white paper, the Eddington Report explores transportation's role in productivity and competitiveness in the U.K. Think about the possibilities for a similar study for the United States.
- There has been a lot in investment in freight, but lately there has been significant job growth in the U.S. in the service sector jobs. In a service/information age economy, think about how transportation can enhance productivity and efficiency.
- Consider "game changers" or "disruptive technologies" by thinking about transportation history. There are events that can change what is produced and how it is moved (e.g., the opening of the Ohio River in the early 1800s forced farmers to identify new ways to package and ship items). It is

important to anticipate these events where possible and to learn and apply lessons learned.

2.1 PLENARY PANEL 1

The first plenary panel addressed the economic literature, based on the advance white paper and the economics perspectives of the panelists. Jim March, prime author of the white paper *Assessing the Economic Benefit of Transportation Infrastructure Investment in a Mature Surface Transportation System,* presented an overview of past research, examining not only these economic benefits, but also the methods used to estimate them and the gaps in the knowledge base. A panel of three discussants followed, tasked with providing reactions to the literature review to stimulate the audience.

Figure 2.1 Why Are We Here Today?
Jim March Presentation Slide

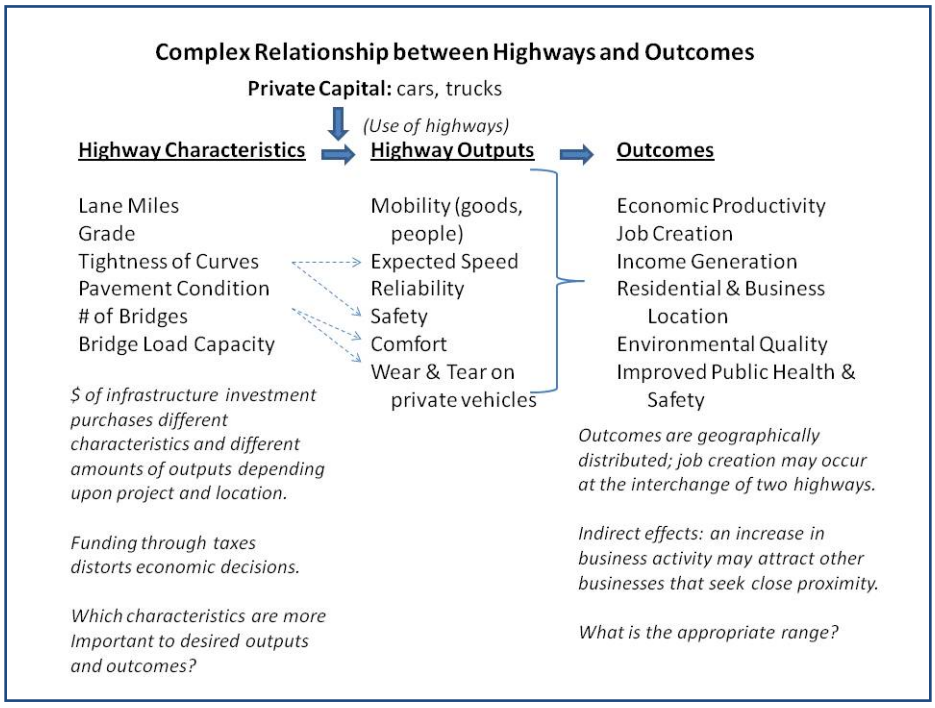


Jack Wells, Chief Economist for the U.S. Department of Transportation, spoke on the different types of economic analyses, including benefit/cost analysis, measurement of employment effects, macroeconomic analyses of factors contributing to economic growth, and economic impact studies. He mentioned the particular limitations for each analysis type, but noted the general effectiveness of benefit/cost analysis. In particular, he described how the application and

practice of benefit/cost analysis tools has been greatly improved with the requirements of the U.S. Department of Transportation's Transportation Investment Generating Economic Recovery (TIGER) program and by recommendations from TIGER grantees. He argued that such structured analyses, as opposed to impact analyses, can truly help to distinguish between good and bad investments, as well as being highly useful for policy analysis.

Randall Eberts, from the Upjohn Institute for Employment Research, first raised the question, "What is the net rate of return of transportation investment?" His presentation addressed whether or not this question needs to be answered at all given that the question is ultimately about the allocation of resources, not necessarily whether transportation infrastructure is valuable or beneficial. Mr. Eberts directed the focus of his presentation on highways, and presented ideas about the complex relationship between highways and outcomes of highway infrastructure. He described a way of breaking down the relationship into highway characteristics, highway outputs, and outcomes, as shown in one of his presentation slides below, Figure 2.2.

Figure 2.2 Complex Relationship between Highways and Outcomes
Randall Eberts Presentation Slide



Mr. Eberts discussed the need to develop a better structure for economic analysis. He asserted that "we cannot adequately measure the service flow of highway capital stock without taking into account characteristics of the system and outputs." He claimed that "ignoring these effects leads to biased estimates of the effect of highway capital stock on economic outcomes…and also leads to

different estimates for different time periods and different locations." He suggested that most studies do not take these factors into consideration.

Eberts' presentation suggested that as characteristics change; outputs and outcomes change. The industry needs to look at all of these to develop a better structure for analysis. It would be useful for practitioners to have a more standard model; from that basis practitioners could use a consistent framework for making decisions.

Brian Taylor, from the University of California, Los Angeles (UCLA), discussed the nexus between politics, planning, and policy. Mr. Taylor called out the "Elephant in the room," asking "Why economic analyses play such a small role in decision-making?" He suggested the industry needs to recognize the logic of political decision-making and think creatively about how to incorporate economic analysis into this logic in order to get more high-performance projects built. Taylor suggested that the geographic equity of outlays is more important politically than economic benefits. He noted that the disconnect needs to be understood by analysts; for example, it is not possible to put 40 percent of transit improvements into New York City despite the fact that it is the most efficient – economic efficiency cannot work against geo-political logic.

Mr. Taylor also addressed the politics of transportation expenditures, noting the immediate effects of direct spending on infrastructure are transfers – which interest elected officials far more than economists. Economists tell us that the need is to focus on the transportation effects – consumption, productivity, competitiveness – and to do this we need to communicate these expenditure effects in a clear, easy to understand manner to elected officials and the motoring public.

An audience member raised the question of "How can the equity and distributional fairness argument be credibly treated." Taylor responded that the expectation of geo-political equity and distributional fairness in the design of programs is so strong in most cases that there is little reason to expect that projects can ever be selected solely on the basis of highest return.

2.2 PLENARY PANEL 2

The next panel was constructed to include users of the information that comes from the economic research. Panel members included state and Federal officials (with experience at the Federal, state, and local levels), a planning practitioner who has supported decision-makers across that landscape, and associations who use these kinds of analyses to inform their membership. The practitioners were asked what economic information they need to analyze in their particular environments.

Glen Weisbrod, from the Economic Development Research Group (EDRG), explained that EDRG works with transportation agencies and economic development organizations. The information and economic analysis they provide

plays a role, Weisbrod says, along every step of the way. It is used in developing long-range visions, possible modal and multimodal transportation solutions, project selection, and alternatives analysis (to determine an efficient configuration of transportation modes and land use).

Weisbrod suggested that rather than calling the transportation system "mature" it should be considered as "evolving." He noted that issues such as the quality of life, competitiveness of business, and jobs are the concerns of planners and decision-makers and resonate with the public.

The transportation industry (public and private) needs to maintain the functionality of the transportation system where it is needed, Weisbrod said. It is implicit that transportation's goal is to adequately serve the needs of the populace and the economy. However, he suggests today we have the wrong mix of facilities in the wrong places, hurting our competitiveness and limiting our potential. The transportation industry needs to be able to understand the marginal economic impact of doing a project or not doing a project, and to be able to graph this on a more macro level.

What is needed now, Weisbrod urged, is research methods to relate to national policies so we can build the right facilities in the right places, make informed decisions as whether to build new facilities or maintain existing facilities, and make other important transportation infrastructure decisions.

Gene Conti, Transportation Secretary for the North Carolina Department of Transportation (NCDOT), spoke on the project prioritization process put in place in North Carolina to help depoliticize the selection of transportation projects and assist in choosing projects that address state goals. The prioritization looks at investing in projects that improve safety, infrastructure health, and mobility, but the process does fall somewhat short in measuring the economic benefits of these projects. NCDOT is actively working on better ways to analyze these projects for their economic impacts as well as translate that information to the public.

Therese McMillan, Deputy Administrator for the Federal Transit Administration (FTA), spoke about the need to consider all modes in the discussion and to view users through the lens of all parts of society. She encouraged participants to think at a systems level about economic benefits and not in the singular context of one mode or another. In looking at all users, she suggested that we think about the value we place on the economically disadvantaged in framing the questions and defining the economy and who it serves. Lastly, Deputy Administrator McMillan suggested that history has told us that things change drastically, but our forecasts do not pick up on these shifts. As a result, investments are based on the past. Tools are needed to help us anticipate future scenarios, so investments can be made that reflect the dynamics of uncertainty.

Bruce Carlton, President and CEO of The National Industrial Transportation (NIT) League, explained that companies view transportation as a cost center for their business. The attempt to keep total logistics costs as low as they possibly can. The logistics industry takes a very granular look at system reliability and all aspects that slow-down or stop freight. Carlton noted that travel time and travel system reliability are the main focus, and that, through this lens, the outstanding need is for more work on the interface between land use/spatial planning and economic analysis. Carlton also presented the idea that there is a need to look at regulations being imposed at the state and local level to be sure that economic development incentives are not working against the smooth function of the transportation system. Certain economic development incentives could, for example, inadvertently push truck traffic into commuting lanes during rush hour. This could be an area for research. Researchers also may want to consider the requirements of an U.S. economy that is again changing to a more dynamic and diverse model of sourcing. The research should analyze how the U.S. adjusts, and should adjust, to dynamic sourcing.

Alison Black, Vice President of Policy and Chief Economist at The American Road and Transportation Builders Association (ARTBA), spoke on the need to develop basic metrics to estimate the before and after effects of transportation investments. Case by case benefits are needed to demonstrate accountability to taxpayers and return on investment. Although literature discusses the importance of before and after studies, the reality is they do not happen enough.

3.0 Breakout Groups

Following the morning plenary session participants broke into three groups to provide more opportunity for discussion and help address questions that would inform the research agenda effort.

3.1 BREAKOUT SESSION PART 1

Part 1 of the breakout session provided an opportunity for the participants to respond to the plenary presentations. Participants were encouraged to assess the findings suggested by each speaker, and to provide perspectives based on their own professional experience and knowledge. During the breakout groups, the transportation and economics professionals were encouraged to identify gaps and key information needs related to economic benefits that would be useful to policy-making, such as defining and prioritizing programs and projects.

3.2 BREAKOUT SESSION PART 2

The same members continued in Part 2 of the breakout session to build off the assessments they shared. In this period, they were asked to suggest the most relevant gaps based on their experience in the industry, and to identify specific approaches and data resources that might be useful to addressing the priority gaps. They were encouraged to think about what has been or could be learned from other sectors beyond transportation, and situations that represent the state of the art. Following this discussion, each breakout group selected a "reporter" to inform the plenary on the outcomes of the morning and afternoon breakout sessions. These were presented in afternoon plenary when the groups reconvened.

4.0 Summary of Discussion

The reports from the breakout sessions to the plenary group revealed common themes that had arisen and been identified as priorities by each of the breakout groups. During the last plenary session, Susan Binder facilitated a discussion of the breakout group "report-outs" as well as a discussion of the issue of communication.

An overview of key themes and perspectives on research gaps and possible research topics follows.

- **Goal-driven framework.** The development of framework transportation investment strategy, rooted in achieving economic goals at the national level, could be tailored for the U.S., similar to the Eddington Transport Study conducted for the U.K. Such a framework would provide an analytical focus and help to achieve a consensus for action based on economic goals and principles.[15]
- **At the margin**. Targeted refinements to longstanding lines of transportation research that update their relevance to current and future trends, including emerging industries, would be beneficial. For example, the recognition that reliability and predictability are important transportation attributes could be studied so that the implications for various industries can be quantified and understood.

[15]The Eddington Transport Study – The case for action: Sir Rod Eddington's advice to Government, December 2006.

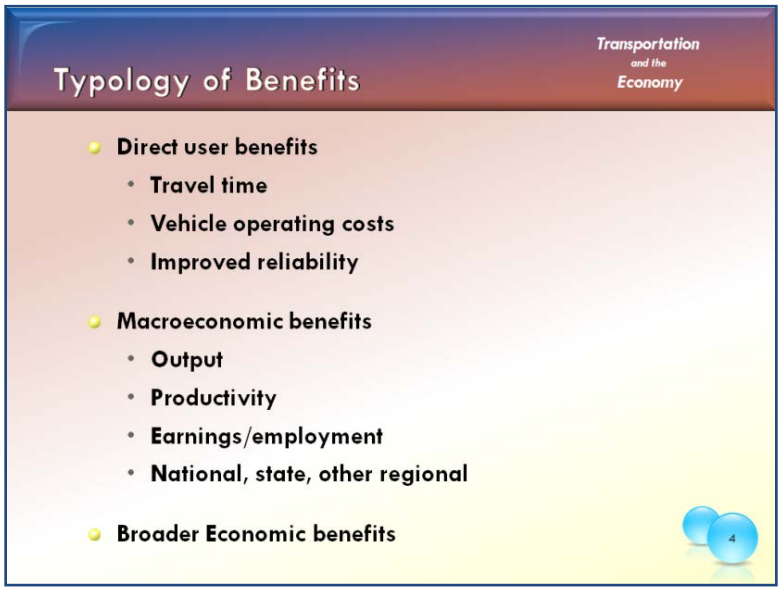
- **Broader benefits.** Broader benefits beyond direct user benefits, such as agglomeration, need better treatment. Further analysis of such broader benefits is important so that they can be legitimately represented in the benefit framework.
- **Metrics.** Identification and refinement of metrics of economic performance that correlate with investment and other transportation decisions will be important in an era of accountability with a focus on overall system performance.
- **Assessment of externalities,** both positive and negative, needs consistent treatment from an economic point of view.
- **Allocation of resources.** Expanded approaches to considering economic linkages are needed, particularly in the allocation of scarce and suboptimal transportation resources.
- **Competitiveness.** An improved understanding of the relationship between transportation and economic competitiveness would help to inform change and investment in this sector. Although it is generally accepted as a driver for improving transportation services and reducing the costs associated with transportation use, there also was a general acknowledgment that the relationship between transportation and competitiveness is not well understood.
- **Communications.** Specific research is needed as to how to improve communication of the implications of transportation to the economy to the general public and specialized audiences. There was widespread recognition that communication of this linkage inadequate.

4.1 THEMES

Goal Driven Framework

Some workshop participants were previously familiar with the United Kingdom's Eddington Report that presents "a wide range of evidence, information, and recommendations on transport's long-term impact on the U.K.'s economic growth, productivity, and stability within a sustainable development context." Several participants suggested that adapting the report's concept to suit conditions in the United States would improve current U.S. practices (utilizing, for example, macroeconomic and regional models) and support more comprehensive multimodal analysis.

Figure 4.1 Typology of Benefits for Consideration in a Framework
Jim March Presentation Slide

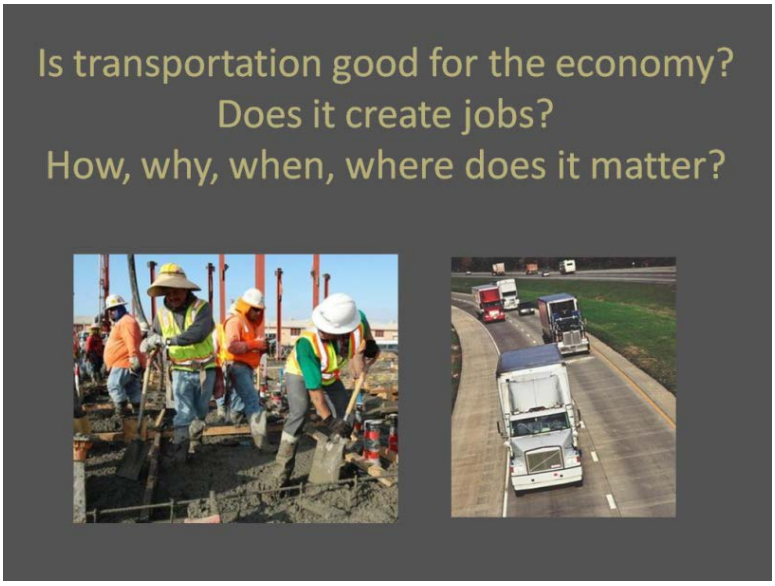


Participants of the workshop discussed the value of developing such a framework for the United States; many individuals saw it as an important next step to expanding the understanding of transportation's impact upon the U.S. economy. Bob Skinner, Executive Director of the Transportation Research Board (TRB), stated that a prerequisite for a research agenda is a technically sound framework. Others were supportive of a U.S. Eddington-style study because it would communicate a consensus as to the economic underpinnings and provide for a consistent set of policy criteria for investment.

One breakout group discussed what the purpose of a framework should be for both evaluation and decision-making. It was suggested that the purpose of the framework would be to serve as:

- A multimodal benefit-cost framework to cover systems, programming, projects, and before and after studies; and
- A standard for assessing actions that offer the greatest return from a national perspective.

Figure 4.2 Is Transportation Good for the Economy?
Julie Lorenz Presentation Slide



Broader Benefits

Both workshop presenters and participants recognized the need for a clearer understanding of the economic impacts of agglomeration, specifically on the quantitative relationship between higher employment density and the mechanisms leading to an increase in productivity. Although in both literature and practice, agglomeration effects have been recognized as a result of transportation *improvements*, they are rarely included in studies assessing potential benefits of transportation *investment*. Of particular concern is our ability to quantify benefits without double-counting those benefits that simply reflect travel time savings or other user benefits already included in benefit-cost analyses. Brian Taylor of UCLA noted that although there are fundamental research questions we need to address about agglomeration economies in transportation, there also is a need to better operationalize what we already know for practitioners.

In contrast, although there was strong support for using benefit-cost and other analytical techniques that provide a rigorous treatment (including requiring "after" studies to assess what actually took place once the effects of the improvement were able to be studied), there was skepticism as to over reliance on those structures. The tendency to avoid "double-counting," and thus reliance, on transportation measures such as time savings may have actually been detrimental as they have masked the mechanisms and impacts for users and nonusers alike and ignored the very localized tangible benefits that enable larger scale benefits.

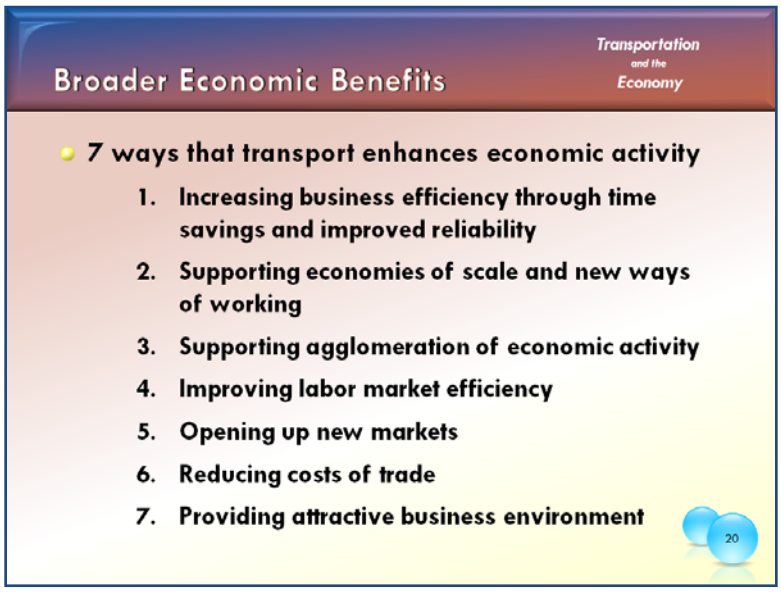
Although there are studies that have looked at completed projects using statistical and economic analysis techniques, further research is needed to credibly predict the broader benefits of new investments.

Workshop participants brainstormed several major research areas that warrant further examination:

- The mechanisms through which agglomeration economies are realized;
- The methods for estimating the benefits of increased agglomeration, including forecasting agglomeration impacts;
- Moving beyond site-specific impacts, for instance at a transit-oriented development (TOD) to a cluster of TODs and effects systemwide;
- Measuring the different scales of agglomeration at national, regional, and local levels;
- Measuring how global variables affect ranges of benefits; and
- The effects of agglomeration on equity.

Discussion of this last element recognized that depending on the scope of measurement, there will likely be winners and losers from agglomeration. This is because investing in the promotion of agglomeration gives a competitive advantage to one area at the expense of other areas. An example was given regarding the consolidation of shippers on the west coast. Although some private sector firms would benefit from consolidation (i.e., economies of scale at a limited number of nodes), public and planning practices may dictate against agglomeration to spread limited resources out more equitably.

Figure 4.3 Seven Ways that Transport Enhances Economic Activity
Jim March Presentation Slide



Metrics

The issue of better measuring the economic impacts of transportation investments was brought up by several speakers in the course of the plenary session. The question was discussed most comprehensively by Randall Eberts of the Upjohn Institute, who emphasized that for three decades researchers have been asking the question, "What is the net rate of return of transportation investments?" and thus far have not come to a conclusive answer. At the beginning of the workshop, Jack Wells of the U.S. DOT noted that the passage of the Recovery Act had created a lot of interest in measuring the number of jobs created by infrastructure investment projects, and discussed the controversy that arose at the time within the Federal government over which methodology to use in measuring these effects, either prospectively or retrospectively. These discussions led to a decision by the White House not to use traditional input/output approaches in quantifying the immediate employment impacts of transportation investment.

Mr. Eberts noted that the vast majority of transportation investment reflects diverted resources from the private sector. Thus, the question regarding net return must include not only whether returns are positive or negative in absolute terms, but whether they compare favorably with returns from private sector economic activity.

On the other hand, if the public sector is held to an excessively high bar to prove that its activities are economically justified prior to project implementation, this could have a chilling effect on investing in needed priorities. The answer regarding net rate of return is complex and relies on aggregations of different scenarios and timeframes for investment. For this reason, statistics such as the average number of jobs created by a certain amount of Federal investment, for example, are not as useful as they may appear on the surface.

Workshop participants discussed several major research gaps, including the following:

- A major deficit in the record of transportation projects is that there is far more debate on the merits prior to the ribbon cutting than after. When projects do miss the mark, the "after analysis" is oftentimes highly politically charged, undercutting its research value. Estimates of both short-term and longer-term impacts of a variety of different types of projects in different locations are needed to provide a basis for estimating impacts of proposed transportation system improvements. What is needed is an understanding of how projects that have been fully completed are contribution to the economic success of its locale.
- The value to users of reducing or preventing delay has been quantified, but little data is available on the economic benefits of improved reliability for different types of personal and commercial movements.

- Correlating the experience of utility networks (e.g., electric generation, water treatment, communications) with transportation networks could inform policy and develop new approaches to consider economic benefits.

Figure 4.4 Direct User Benefits – What We Know
Jim March Presentation Slide

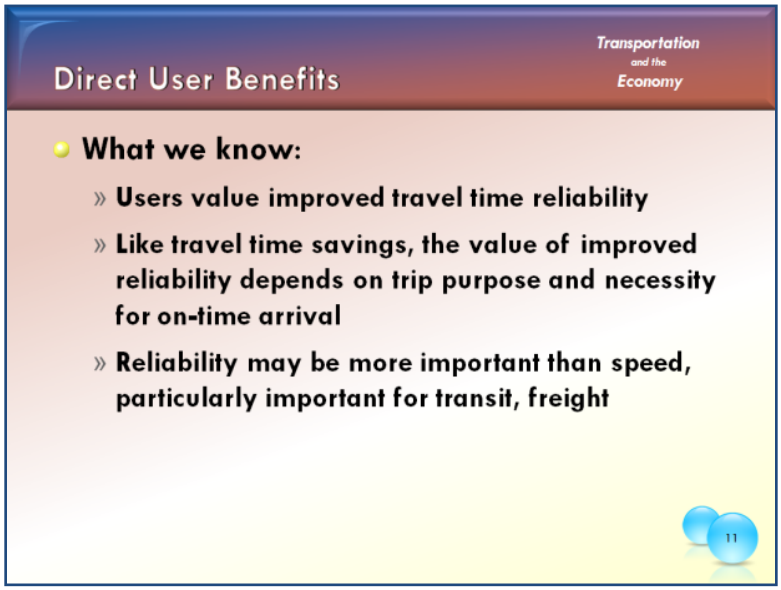
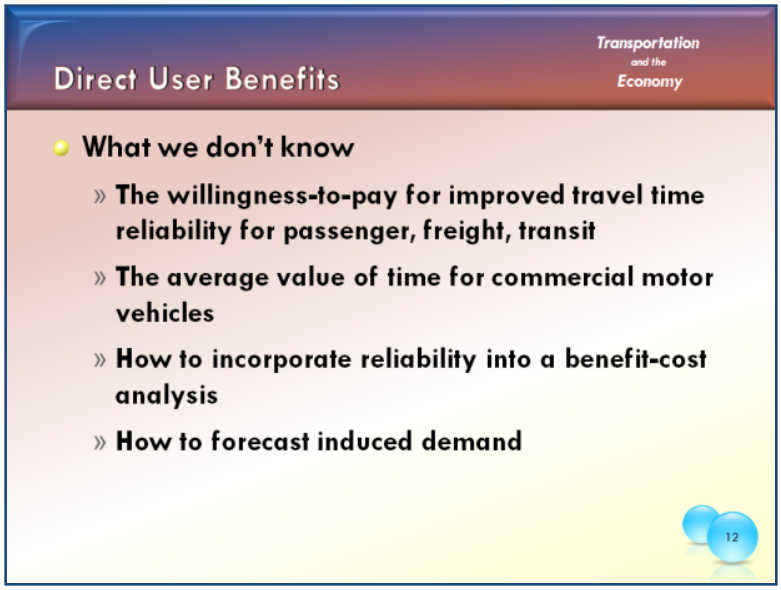


Figure 4.5 Direct User Benefits – What We Don't Know
Jim March Presentation Slide



Externalities

External costs associated with transportation projects may include:

- Air/noise/water pollution;
- Economic costs associated with crashes that are not covered by insurance; and
- Congestion costs.

Externalities are included in some benefit-cost analyses at the project level, but some participants questioned the accuracy of the various values placed upon these externalities. Presently there is no consistent mechanism of measurement for many of these factors. This can result in arbitrariness to the data that reduces the credibility of the economic analyses or can even prevent the incorporation of externalities into economic analyses altogether. Aspects of a potential research problem statement related to this topic include:

- We need to apply more consistent and reliable information in the evaluation of negative externalities. Recommended values for these costs mostly come from advocacy groups and should be critically reviewed. Furthermore academic research on external costs of transportation improvements shows a wide range of estimates depending on assumptions made in the studies. Credibility and objectivity are needed, and until future research produces more consistent estimates of external costs, economic analyses may have to use ranges of values for the various external costs.

Externalities of Transportation Spending may include:

- ***Environmental effects such as air or water pollution.***
- ***Safety impacts, including injuries and fatalities.***
- ***Property damage.***
- ***Land use impacts.***
- ***Impacts on time due to congestion and efficiency of operations.***

- Standards are needed to make measurement of external costs more rigorous. This would include basic research into externalities, resulting in quantifiable factors, metrics, and values.

Allocation of Resources

Workshop participants identified the need to understand the economic tradeoffs in the allocation of resources, such as the economic benefits of investing more heavily in one mode than another, or investing in maintaining and operating existing facilities rather than constructing new capacity. Tools exist to make these tradeoffs, but they have limitations. A particular difficulty is the fact that the types of benefits from alternative investments may be quite different, making it more difficult to evaluate and compare the overall benefits of those investment alternatives. Another factor is that there may be system effects of certain investments that are difficult to quantify. These system effects may be within a

single mode or may cross modes. Further research is needed to improve our ability to compare investment options across modes and to identify synergies between investment in one mode and the performance of other modes.

The U.K. and other European countries have adopted a "Value for Money" framework to enable them to evaluate the full range of benefits and costs associated with alternative transportation investments. The Value for Money framework has evolved as the broadest formulation of how alternative investments should be evaluated in a mature transportation system. While the level of analysis clearly must be consistent with the scope of the investment decisions, workshop participants agreed that future research focused on how to move towards a Value for Money framework in the U.S. is needed.

In addition, workshop participants brainstormed a wide range of knowledge gaps that have implications for investment choices. One element that resonated through a variety of research questions relating to the apparent advantages of capital projects over others. From a life-cycle cost perspective, deterioration in the service and condition of transportation systems is often not incorporated into program-level benefit-cost analyses. Furthermore, communicating the benefits of maintenance and operational improvements to the public is difficult, leading to the so-called "ribbon cutting" problem – elected officials generally see greater political value in constructing new capacity than in maintaining existing facilities.

Competitiveness

The theme of "competitiveness" and its role in transportation investment decisions was discussed at length in both plenary and breakout sessions. A participant noted that Europe and China are investing more in infrastructure than the United States. This led to the question: what does it mean to be internationally competitive? It was suggested by some that the U.S. may need an international comparison to evaluate trends in its competitiveness, particularly with respect to transportation. Others commented that competitiveness also is relevant at local and regional levels, not just internationally. For example, metro areas in the U.S. compete for commercial investments with transportation infrastructure and reliability being factors that affect commercial location decisions. Workshop discussions made it clear that the term "competitiveness" is broadly used, and not well defined.

The term competitiveness has been used with increasing frequency in recent years in the context of international trade and other areas of the economy. However, while its use in this context is not new, there was concern amongst workshop participants that the ubiquitous use of the phrase in recent years is undermining its value as a research term. Tracing the historical usage of this term, the founding of the "Council on Competitiveness" in 1986 helped to inject the term into common parlance within Federal circles. For many years, the term was tied principally to manufacturing and aimed at addressing the concerns of industries that felt they could no longer "compete" with foreign imports. The

role of transportation and supply chain considerations in this conversation only emerged later. The logistics revolution in the 1990s introduced the concept that supply chains, and not only countries, compete against each other. As the line between manufacturing and logistics began to break down, planners and politicians began to take heed of the fact that all contributing factors to the shelf price of products, including transportation costs, should be considered when choosing between different forms of industrial policy.

Some participants with disciplinary connections to the field of economics commented that competitiveness, particularly as it is invoked in political discourse, may be inappropriately applied and misleading. The term is sometimes used, for example, in place of comparative advantage, a different concept with very specific meaning in the Ricardian model of trade and spatial development. These participants cautioned that any research on "competitiveness" should be designed with clear delineation of what the term means.

The concept of competitiveness has taken on particular urgency following the sharp rise in unemployment in 2009 and the need to identify any further factors that would place the U.S. workforce at a disadvantage. While transportation costs are not usually a "make or break" factor as to whether a U.S. product is made domestically or overseas, there are instances where transportation costs are a principal factor. Research is needed to identify those industries which are particularly dependent on transportation to remain internationally competitive and specific elements of the transportation system that are key to those industries. Research also is needed to identify those transportation facilities that are critical to the efficient movement of exports and imports and to assess their vulnerabilities to service disruptions.

Communications

Some workshop participants asserted that – even if there is acceptance and strong support that research can produce useful information for decision-makers – communications, messaging, and "credible advocacy" are important activities needed to support execution of the research agenda and application of its results. The participants pointed out that during the era of the Interstate System design and construction, the positive link between transportation and the health of the economy virtually "sold itself." In the post-Interstate era, however, much of the conversation has shifted to operating, preserving, and optimizing our transportation system and the connection between transportation, economy, and jobs has not been successfully translated to decision-makers nor the public. Julie Lorenz framed this issue assertively in her plenary presentation which presented the question, "Would Roger Ebert give our story two thumbs up?" Ms. Lorenz articulated the problems and challenges of communicating the messages about transportation needs in the U.S. She explained that the message is not clear as to what actions are needed by whom, and the information that is communicated is not competitive with the 5,000 or more messages U.S. citizens are bombarded with daily.

In summary, the workshop discussion presented many reasons to conduct economic analysis of transportation projects and many different audiences for the results of such analysis. Evidence of the linkage between an efficient transportation system and enhanced economic growth and productivity can inform policy-making at the Federal level, strategies for enhancing mega-regional economies, and state and local transportation planning and programming to make the most efficient use of scares transportation resources to achieve economic development, employment, and other goals. As stated by Alan Pisarski during his presentation, issues such as cost, reliability, convenience, safety, and security are all things the transportation industry "measures badly…and describes badly." Pisarski argued that clarifying data issues and the visualization of benefits of transportation investment are key to making the case for transportation investment across the nation.

Results of transportation studies must be communicated in a manner so that complex transportation and economic information is accessible to a range of audiences. Even "decorative economics," the phrase coined by Jack Wells, has its purpose and its place and if done well, can communicate effectively the role of transportation in the economy.

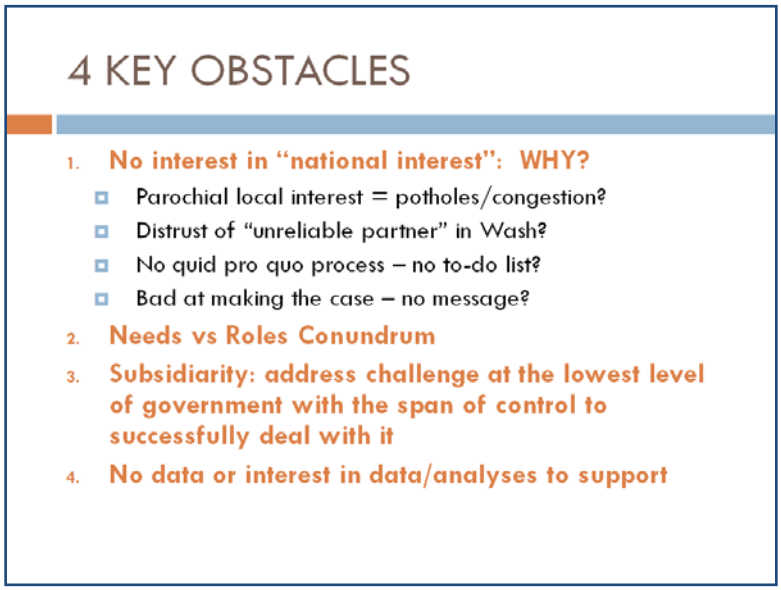
Workshop participants identified numerous gaps in our knowledge of how to communicate the economic benefits of transportation that would be useful to address:

- Communication tools about transportation quality, lifespan, costs, and funding need to be improved, and messaging should be more consistent within the transportation industry itself;
- The industry needs to comprehend how this topic resonates with the public, and to which audience;
- The transportation industry may benefit from an improved understanding and use of social media as a tool to establish credibility and to garner public support and understanding;
- Currently, the relative benefits and rates of return from transportation investment compared to other public investment is not well understood;
- Proposals to improve transportation systems through increased investment funded by fuel tax increases often have not been presented in ways that users recognize that benefits will outweigh the small increment in travel. Participants voiced that currently it seems that the general public views transportation as a cost rather than as an investment; and
- Participants suggested that there is a high demand for economic analyses that are both understandable to the public and show the linkages from projects to the outcomes.

5.0 Closing Statement

In closing the workshop, Alan Pisarski acted as rapporteur and presented an on-the-spot summary of the day's discussions. He and Susan Binder concentrated their wrap-up on next steps which include consideration of the input received during the workshop into the development of a research agenda. The research problem statements identified throughout the day will be taken into consideration in the development of a research agenda that will be provided to the NCHRP Panel.

Figure 5.1 Four Key Obstacles (for Transportation)
Alan Pisarski Presentation Slide



A. Agenda

Transportation and the Economy
NCHRP 20-24(80) Workshop Agenda

April 18-19, 2012
The Bolger Center
Potomac, Maryland

April 18th		
6:30 p.m.	Dinner	
	Welcome	Jack Basso, AASHTO
	Charge to the Group	Speaker: Robert D. Atkinson, Information Technology and Innovation Foundation
April 19th		
8:00 a.m.	Kickoff Plenary	Susan Binder, Moderator (CS)
	Welcome	John Horsley (AASHTO)
	White Paper Presentation	Jim March, Presenter
	Discussants	Discussants Panel: Jack Wells (U.S. DOT), Randall Eberts (Upjohn Institute), and Brian Taylor (UCLA)
10:00 a.m.	Practitioners' Perspectives	Planning: Glen Weisbrod (EDRG) State DOT: Gene Conti (NCDOT) Transit/Urban: Therese McMillan (FTA) Shipper: Bruce Carlton (NITLeague) Construction: Alison Black (ARTBA)
11:00 a.m.	Breakout #1	Assess the findings: • What's missing? • What are the key information needs related to economic benefits?
12:00 Noon	Lunch	
1:00 p.m.	Breakout #2	Identify and prioritize the research gaps: • Identify resources, approaches? • What can be learned from other sectors and application of the state of the art? • Where is the highest probability of success?
2:30 p.m.	Plenary	Report Out's and Reconciliation
3:30 p.m.	Next Steps	Alan Pisarski and Julie Lorenz: (Burns & McConnell): Implications for Research – Communications, Messaging, Tools
4:30 p.m.	Reprise and Closing	Rapporteur: Alan Pisarski

B. Reports Provided to the Workshop Participants

NCHRP 2-24(80) Handouts

4. 22nd Annual State of Logistics Report®, *Navigating Through the Recovery,* Council of Supply Chain Management Professional (CSCMP), National Press Club, Washington, D.C., June 15, 2011.
5. *Using Economic Impact Analysis To Develop Supportable Transportation Decisions – Across All Planning Stages,* Glen Weisbrod (TREDIS Software Group), Julie Lorenz (Burns & McDonnell).
6. *U.S. Transportation Construction Market Facts and Figures,* The American Road and Transportation Builders Association (ARTBA), April 6, 2012.
7. *A New Economic Analysis of the Infrastructure Investment,* Department of the Treasure, with the Council of Economic Advisers, March 23, 2012.
8. NCHRP 20-24-(80) White Paper: Transportation and the Economy, March 2012, Cambridge Systematics and Jim March.

C. NCHRP 20-24(80) Workshop Attendees

Name	Agency
Adrian Moore	Reason Foundation
Alan Pisarski	Consultant
Alison Conway	City College of New York
Alison Black	American Road and Transportation Builders Association
Andy Lemer	Transportation Research Board
Arlee Reno	Cambridge Systematics, Inc.
Art Guzzetti	American Public Transportation Association
Beverley Swaim-Staley	Maryland Department of Transportation
Billy Leung	Regional Economic Models, Inc.
Bob Skinner	Transportation Research Board
Branner Stewart	Cambridge Systematics, Inc.
Brian Taylor	UCLA
Bruce Carlton	The National Industrial Transportation League
David Winstead	Ballard Spahr LLP
Dean Wise	BNSF Railway Company
Richard (Dick) Mudge	Delcan Corporation
Don Halligan	Maryland Department of Transportation
Doug Frechtling	George Washington University
Emil Frankel	Bipartisan Policy Center
Gene Conti	North Carolina Department of Transportation
Glen Weisbrod	Economic Development Research Group
Greg Cohen	Highway Users Alliance
Jack Basso	AASHTO
Jack Wells	U.S. Department of Transportation
James Ritzman	Pennsylvania Department of Transportation
Janet Oakley	AASHTO
Jason Craig	CH Robinson
Jim March	Consultant
John Gray	Association of American Railroads
John Horsley	AASHTO
John Vickerman	Vickerman & Associates, LLC

Name	Agency
John Wong	University of North Texas
Joung Lee	AASHTO
Julie Lorenz	Burns & McDonnell
Kam Movassaghi	Fenstermaker
Ken Simonson	Associated General Contractors of America
Leo Penne	AASHTO
Mark Burris	Texas A & M
Mary Lynn Tischer	Federal Highway Administration
Matt Chase	National Association of Development Organizations
Morteza Farajian	Virginia Department of Transportation
Nathan Hutson	Cambridge Systematics, Inc.
Nicole Waldheim	Cambridge Systematics, Inc.
Randall Eberts	W.E. Upjohn Institute for Employment Research
Richard Woo	Maryland State Highway Administration
Robert Atkinson	Information Technology and Innovation Foundation
Rolf Schmitt	Federal Highway Administration
Ron Mitchum	Berkeley-Charleston-Dorchester Council of Governments (SC)
Rose Dolphin	Cambridge Systematics, Inc.
Scott Nystrom	Regional Economic Models, Inc.
Stacy Cook	Cambridge Systematics, Inc.
Stephen Lockwood	Parsons Brinckerhoff
Susan Binder	Cambridge Systematics, Inc.
Susan Gorski	Michigan Department of Transportation
Therese McMillan	Federal Transit Administration
Wendy Tao	Cambridge Systematics, Inc.
Zhenhua Chen	George Mason University

ASSESSING THE ECONOMIC BENEFIT OF TRANSPORTATION INFRASTRUCTURE INVESTMENT IN A MATURE SURFACE TRANSPORTATION SYSTEM

FINAL REPORT SECTION 3 - RESEARCH AGENDA

Prepared for:

NCHRP 20-24 Task 80 Panel

Prepared by:

Cambridge Systematics, Inc.

4800 Hampden Lane, Suite 800
Bethesda, MD 20814

With:

James March

October 2012

The information contained in this report was prepared as part of NCHRP Project 20-24, Task 80, National Cooperative Highway Research Program.

Acknowledgments

This study was conducted for the NCHRP 20-24 Task 80 Panel, with funding provided through the National Cooperative Highway Research Program (NCHRP) Project 20-24, *Assessing the Economic Benefit of Transportation Infrastructure Investment in a Mature Surface Transportation System*. The NCHRP is supported by annual voluntary contributions from the state departments of transportation. Project 20-24 is intended to fund quick response studies on behalf of NCHRP 20-24 Task 80 Panel. The report was prepared by Cambridge Systematics, Inc. The work was guided by a technical working group. The project was managed by Andrew Lemer, NCHRP Senior Program Officer.

Disclaimer

Instructions to Workshop Participants

This project is being conducted for the NCHRP 20-24 Task 80 Panel as part of NCHRP Project 20-24, Assessing the Economic Benefit of Transportation Infrastructure Investment in a Mature Surface Transportation System. The report has not gone through the usual rigorous review process established and monitored by the Transportation Research Board Executive Committee or the Governing Board of the National Research Council, and is being provided to participants of the project workshop only and should not be described as a "TRB Report." It should be described as a contractor's report conducted for the NCHRP 20-24 Task 80 Panel with funding provided through National Cooperative Highway Research Program Project 20-24.

Section 3 - Table of Contents

Section 3 - List of Tables

Executive Summary

The United States continues to deal with tough decisions within a very difficult economic climate. Nowhere is this clearer than in considering future options for the many aspects of our national infrastructure that are delivered at the Federal, state, and local level. Personal access and mobility can easily be taken for granted. However, those responsible for the availability of quality highway and transit services in the future certainly know that even relatively mature facilities and systems require continuous attention to be effective, and the intensity of their use requires a significant dedication of resources. They were originally built on an understanding and consensus as to the importance of well-performing systems to a healthy economy. This is as true today as it was then; maybe more so with the acknowledgment of the pressure of international competition, the scale of deferred investments, and the underinvestment faced by other types of infrastructure as well.

As the economy evolves to reflect changing technologies, consumer preferences, and trends in energy and materials, so too must the transport system adapt to serve new challenges and realities. This argues for renewing the understanding of the linkages between transportation services and economy to gain up-to-date insights on how investments in the system and its efficient operation can best serve those economic goals. Embarking on a sequence of systematic next steps can improve our critical understandings, this includes: documenting what we know; identifying what new information is needed to fill the information gaps to better inform public debate; developing the means to gather that information and doing so; and communicating the updated insights on the economy to a variety of relevant audiences.

Under the National Cooperative Highway Research Program (NCHRP) 20-24(80) project "Assessing the Economic Benefit of Transportation Infrastructure Investment in a Mature Surface Transportation System," the research team undertook a series of activities to help inform action on these issues. Ultimately, the goal is to conduct research that will bring an up-to-date understanding of markets that transportation serves and the economic context within which the transportation function operates to those who make decisions concerning the management and operation of transportation infrastructure. The immediate goal is to identify a research agenda to fill information voids based on: 1) a white paper[16] that summarized and synthesized the existing literature on

[16] NCHRP 20-24(80) *White Paper: Transportation and the Economy*, March 2012, Cambridge Systematics and Jim March.

transportation and the economy; 2) a multiday workshop[17] to identify the information gaps that could be barriers to understanding how transportation supports economic growth and productivity; and 3) consideration of the challenges set before the research team by the project sponsors.

The "Transportation and the Economy" workshop, described in more detail in a separate report, brought together critical thinkers to help guide future research on the linkage between transportation infrastructure investment and the economy. This event provided a unique opportunity to solicit contributions on the subject to inform the research agenda. In critiquing the available literature and industry knowledge, both academic and technical researchers among the participants confirmed that a combination of approaches that would draw upon relatively historic economic perspectives as well as case studies that explore current and expected trends would be advantageous. Several thematic areas emerged during the workshop discussions around which the research team has structured its findings:

Theme 1 – Goal-Driven Framework. The development of a transportation investment framework, rooted in achieving economic and performance goals at the national level, could be tailored for the United States. Similar to the U.K. Ministry's Eddington Transport Study, such a framework helps evaluate priority transportation investments based on rigorous evaluation of their contribution to overarching policy goals.

Theme 2 – Macroeconomic Studies. Refinement and incremental improvements to the available macroeconomic models could be beneficial to decision-makers. Specific studies would capture current and anticipated trends and focus specifically on changing and emerging industries.

Theme 3 – Benefits Beyond Benefit/Cost. Analyses that go beyond the straightforward benefit/cost framework and direct user benefits to capture broader benefits and help interpret phenomena such as agglomeration.

Theme 4 – Metrics. Research to explore and develop metrics that could can help communicate the variety of relationships between business operations, economic vitality, and transportation at various levels could help improve the understandings and be incorporated into analytical and decision tools.

Theme 5 – Assessment of Externalities. Research aimed at evaluating in a consistent manner the best practices related to estimates of the economic costs and benefits associated with various types of externalities would result in better informed decisions on investments.

Theme 6 – Resource Allocation Tools. Enhance the capability of decision-makers to quantitatively assess tradeoffs in transportation system

[17] Report on the 20-24(80) Workshop, *Transportation and the Economy,* April 19, 2012, Cambridge Systematics.

management and particularly multimodal investment decisions with better and up-to-date tools and methodologies.

Theme 7 – Competitiveness. Although improved economic competitiveness is generally accepted as a motivation for improving transportation services and reducing the costs associated with transportation use, the dynamics across industries or regions are not clear. An emphasis on understanding how firms/industries/sectors attempt to deal with transportation barriers and/or potential for trade and export growth as well as changing technology and other trends would be a valuable contribution.

Theme 8 – Communications. Economic insights are not readily understood by public decision-makers or the general public. Challenges to good communication have been attributed to many elements such as technical jargon and the differing perspectives of the many users of transportation. Communication strategies would benefit from better understandings of both the audiences and how transportation services make a difference.

An initial sketch plan or project statement was developed for a total of 15 research projects, arranged by theme. Some projects are more developed than others based on the specific purpose to be achieved and the degree to which either the literature or policy debate exists to define the means to study the issue. The technical approach and estimates of costs and timeline are a combination of the input received at the workshop and assessment of similar activities that have been undertaken.

The research team assigned relative levels of expected impact within each of the thematic areas based on a set of criteria that reflect the importance and extent of influence that the research results would potentially exert. In addition, an overall ranking was assigned that is merely illustrative (i.e., specific order is not as important as whether the projects were assigned nearer to the top or the bottom) and meant to highlight the uniqueness of the research aspect and its potential to address the research goals. Not only are the highest ranked projects of high priority but, absent the policy concerns represented in this research agenda, such projects would be less likely to appear in traditional research plans. Such assessments are informed by the nature of ongoing research in progress and in the pipeline.

For each of the project statements, information is provided that addresses some of the issues associated with executing the research such as sponsorship interest, skill sets, and coordination that arose in the course of the research. An overarching set of observations as to the potential for collaboration and coordination are made to draw attention to the various institutions that may be drawn upon in implementing the agenda as a whole.

A summary of the research agenda is shown below in Table ES.1

Table ES.1 Potential Research Projects Identified under 20-24(80)

Overall Priority	No.	(Abbreviated) Project Name	Scale of Impact	Estimated Cost	Period	Type of Work
Theme 1 – Goal-Driven Framework						
2	1	Goal-driven framework tailored to U.S. economic growth and transportation needs.	1	$800,000 to $1 million	18 months	Policy analysis and outreach
Theme 2 – Macroeconomic Studies						
10	2	Economic development implications of transportation disinvestment.	2	$500,000	18 months	Policy analysis
11	3	Capital stock data reflecting service characteristics.	3	$500,000 to $1 million	2 years	Macro-econometric
Theme 3 – Benefits Beyond Benefit/Cost						
3	4	Identify and quantify agglomeration economies.	1	$500,000 to $750,000	2 years	Multidisciplinary policy and economic analysis
6	5	Comprehensive reviews of past transportation infrastructure projects.	2	$300,000	1 year	Scanning and review
12	6	Short-term stimulative impact of transportation investment.	2	$300,000	1 year	Labor econometrics, policy-related synthesis
Theme 4 – Metrics						
4	7	Develop a set of metrics that can be applied to transportation projects to quantify economic costs and benefits.	1	$200,000	1 year	Scoping and framing
Theme 5 – Assessment of Externalities						
13	8	Develop a comprehensive methodology for evaluating project externalities and develop standards for valuing all externalities.	3	$200,000 to $500,000	2 years	Synthesizing and framing
Theme 6 – Resource Allocation Tools						
7	9	Refining economic analysis tools to meet new MAP-21 freight requirements.	1	Phase I – $250,000; Phase II – $600,000	2 years	Methodology refinement
14	10	Identify transportation projects that contribute most to the economy.	2	$200,000	1 year	Literature and project file review, case studies
9	11	Explore economic basis for a resource allocation tradeoff model.	1	$100,000	6 months	Exploratory precursor to methodology development
8	12	Develop an approach to measure the economic impacts of reliability.	1	$500,000	2 years	Methodology development

Overall Priority	No.	(Abbreviated) Project Name	Scale of Impact	Estimated Cost	Period	Type of Work
Theme 7 – Competitiveness						
4	13	How does transportation fit into the competitiveness calculation?	1	$250,000	1 year	Critical policy analysis and scoping
1	14	Comprehensive and systematic treatment of transportation's role across various industries and economic sectors.	1	$1 million	6 months to 2 years	Policy analysis (with heavy interview and field work)
Theme 8 – Communication						
5	15	Market analysis and application.	2	$1 million	2 years	Marketing, survey and synthesis

1.0 Overview

The Cambridge Systematics, Inc (CS) research team has developed this draft research agenda based on all of the work under Task 20-24(80), including: 1) the development of a white paper[18] that summarized and synthesized the existing literature on transportation and the economy; 2) a multiday workshop[19] attended by transportation leaders, economists, and logistics industry professionals who identified the information gaps and possible research needs that would lead to a better understanding of the ways a mature transportation supports economic growth and productivity; and 3) consideration of the challenges set before the research team by the project sponsors.

It is widely recognized that the transportation system and its infrastructure must be flexible to meet the dynamic and changing needs of transportation users (the "customers"). Changing economic conditions will influence transportation requirements, and conversely, well-targeted investments in transportation can impact positively on economic growth. Likewise, failure to provide the transportation infrastructure and services required to meet a growing and evolving economy can adversely affect economic performance and quality of life. With the increased emphasis on performance in Moving Ahead for Progress in the 21st Century Act, MAP-21, (P.L. 112-141), new and updated tools will be needed. An understanding of the significance of goods movement is reflected in MAP-21 provisions that, for the first time, require U.S. Department of Transportation (DOT), in cooperation with states, to identify a critical national freight system that can focus investment to benefit U.S. economic growth and competitiveness in the global economy and to report biennially on the condition and performance of that system. Thus, research that will help decision-makers to focus on economically driven goals, and prioritize investment and operations to optimize our transportation networks for such users is key. Research priorities will specifically involve developing and refining the tools necessary to identify and then prioritize the most effective investments. Based on MAP-21, the results of investments to what will constitute a freight network (which will receive higher Federal share) will then be reflected regularly in the report to Congress on its condition and performance.

Most research examining relationships between transportation and economic performance has been retrospective in nature, looking at how past infrastructure

---

[18] NCHRP 20-24(80) *White Paper: Transportation and the Economy*, March 2012, Cambridge Systematics, Inc. and Jim March.

[19] Report on the 20-24(80) Workshop, *Transportation and the Economy,* April 19, 2012, Cambridge Systematics, Inc.

investment affected past economic growth and productivity. Although informative to some degree, the available findings are insufficient to guide today's decisions on how to invest in a mature transportation system to serve current and future economic goals.

The research agenda presented in this report is designed not only to fill in the gaps in the knowledge we have today, but is also intended to set the stage for a forward looking approach to assist future decision-making about transportation investment. This research agenda also includes projects that focus on how to improve the communications about transportation's potential and actual impacts on the economy to both public officials and to the public.

2.0 Research Agenda

2.1 RESEARCH FOCUS AREAS

Based on the gaps discussed in the NCHRP 20-24(80) White Paper and the NCHRP 20-24(80) Workshop Report, the following research agenda was developed to improve the industry's understanding of the role of transportation in the economy. The identified research projects are arranged under eight themes:

Theme 1 – Goal-Driven Framework. The development of a transportation investment framework, rooted in achieving economic and performance goals at the national level, could be tailored for the United States. It would be similar to the U.K. Ministry's Transport Analysis Guidance (TAG) efforts that responded to the recommendations of the Eddington Transport Study.[20] Such a framework would help to support transportation planning and capital programming, establishing an economic basis for the various types of transportation investments that would be most effective in meeting national economic goals and objectives.

Theme 2 – Macroeconomic Studies. Some selective research initiatives, targeted to refine and incrementally improve the available macroeconomic models, can be beneficial to decision-makers. In choosing to undertake specific studies, there would be an expectation that their relevance and ability to answer real world questions would improve based on updates to capture current and future trends, and to focus specifically on changing and emerging industries.

Theme 3 – Benefits Beyond Benefit/Cost. The rigorous application of a benefit/cost framework can contribute discipline and transparency to economic treatment of transportation issues. However, it tends to miss the broader benefits that go beyond direct user benefits, such as agglomeration. Further analyses of such broader benefits are important so that they can legitimately and reliably be represented in the benefit/cost framework. New MAP-21 requirements, such as those for freight that will require both U.S. DOT and the states to adapt tools to identify and prioritize projects on the 30,000-mile national freight network, make this broader perspective all the more critical.

Theme 4 – Metrics. There is an appetite among decision-makers, planners, and stakeholders for metrics that capture the relationships between

[20] The Eddington Transport Study – The case for action: Sir Rod Eddington's advice to Government, December 2006.

transportation and economic performance. Identification and refinement of such metrics are particularly important in an era of accountability to help focus on overall system performance. Research to explore and develop metrics that can help communicate the variety of relationships between business operations, economic vitality, and transportation at various levels could help improve the understandings and be incorporated into analytical and decision tools.

Theme 5 – Assessment of Externalities. The treatment of externalities (e.g., air and water pollution, safety, and congestion) in project and program assessments is very uneven, in large part because there is no consensus on the appropriate values to use for externalities in economic analyses. Research aimed at developing unbiased and robust estimates of the economic costs of various types of externalities and the best practice for how to consider them in benefit/cost frameworks and in other economic analyses is needed to allow a consistent treatment from an economic point of view. Realistic consideration of externalities will result in better informed decisions on investments.

Theme 6 – Resource Allocation Tools. Few tools and techniques are available that provide decision-makers the ability to quantitatively assess tradeoffs in transportation system performance and resulting economic performance when they make multimodal investment decisions. It is not expected that decisions will be made exclusively on the basis of these quantitative benefit assessments, but decision-makers will have a better basis for weighing quantitative estimates of benefits with other factors that enter into final investment decisions.

Theme 7 – Competitiveness. An improved understanding of the relationship between transportation and global economic competitiveness would help to inform investment within the transportation sector. Although improved economic competitiveness is generally accepted as a motivation for improving transportation services and reducing the costs associated with transportation use, this has not been explored further or applied in a manner that would quantify the relationships between transportation system improvements and the competitiveness of different industries or different regions of the country. Under this theme, a systematic research initiative would undertake a series of case studies at the individual business/firm level, scaled up to industries and economic sectors, in a manner that can better relate transportation to profit and productivity. These might consider location decisions, the mix of labor and other inputs, sales and distribution strategies; for example, as means to advance an understanding of the specific dynamics and contributions of the transportation service. It would be appropriate to prioritize studies of those firms/industries/sectors dealing with transportation barriers and/or potential for trade and export growth as well as changing technology and other trends.

Theme 8 – Communications. Specific research is needed on how to improve communication with both the general public and with specialized audiences unfamiliar with transportation or economic jargon as to the benefits of transportation investment to national and regional economic performance. These are worthy initiatives of a "stand-alone" nature that would apply marketing skills to the challenge of making a complex and abstract subject relevant to the layman and public debate. Simultaneously, developers of the various research products under the above themes should recognize that their findings should be prepared to be understood by both technical and nontechnical audiences. Authors should be encouraged to use "plain speech" to better explain to the general public the implications and findings of their research.

2.2 RESEARCH PRIORITY CRITERIA

For each project statement, an initial "sketch plan" was developed, describing a potential technical approach for the research project, including estimates of costs and times for execution. Building on the policy priorities indentified in the workshop that were determined to be the most useful to decision-making at various levels, the research team has assigned two sets of rankings to reflect the relative reach or impact of such work as well as an overall priority. The rationale for the scale of impact is as follows.

Highest Impact (1) – An area of research of great importance to a large majority of the transportation industry. The results of this research product would be a potential "game changer," would likely have high potential of providing a new way of thinking about transportation and the economy, and will be influential beyond the results of most research findings. The research would be expected to have a strong positive impact upon the transportation industry and has high feasibility and high likelihood of success. Within this category, high priority should be given to research that would not be so likely to receive funding from traditional institutional research sponsors. Priority also should consider, whether the research needs to be initiated quickly due to possible lengthy research prior to a useful results.

Intermediate Impact (2) – An area of research of great importance to one or more sectors in the industry, or of moderate importance to a large majority of the transportation industry, that is responsive to policy directives.

Lower Impact (3) – An area of research that has potential to be useful to some sectors of the industry, but is not far reaching. This category of projects is lower risk, and is more likely to be taken on by universities and similar research institutions.

In addition, an overall ranking was assigned that is merely illustrative (i.e., specific order is not as important as whether the projects were assigned nearer to the top or the bottom) and meant to highlight the uniqueness of the research

aspect and its potential to address the research goals. Not only are the highest ranked projects of high priority but, absent the policy concerns represented in this research agenda, such projects would be less likely to appear in traditional research plans. Such assessments are informed by the nature of ongoing research in progress and in the pipeline.

2.3 RESEARCH STATEMENTS

Theme 1 – Goal-Driven Framework

Project 1 – Commission a new goal-driven, national framework tailored to U.S. economic growth and transportation needs

Estimated Cost: $800,000-$1 million (startup; with later phases to be considered)
Overall Rank: 2 (Scale of Impact: 1)
Anticipated Time for Execution: 18 months
Type of Work: Policy Analysis with Outreach

Considerations in Accomplishing this Work: The perspective envisioned in such an effort would require collaboration beyond the transportation research community alone to capture the synergies between transportation and economic policy, with sensitivity to the potential intergovernmental implications of such a policy framework. A sponsoring team that included governors, mayors, legislators, academics, business leaders (transportation providers and users), and transportation officials would be ideal. The interdisciplinary analyses and strategies development would draw heavily on policy analysis skills such as those used by Transportation Research Board policy studies, independently authorized commissions, and various "think tanks."

Synopsis

Identify how the United States can establish a comprehensive framework for economic analysis of transportation investments (e.g., similar to the Eddington study) and then determine how to implement analysis procedures to carry out the recommended economic analysis (e.g., the U.K. Ministry of Transport's "Transport Analysis Guidance"). The Eddington study for the United Kingdom used information on the relationships between transportation improvements and economic performance to develop and justify a comprehensive national transportation investment strategy. A study of similar scale and focus could be undertaken for the United States to design a national performance goal-driven framework that explicitly incorporates a strategic economic rationale.

The national economic framework should be compatible with and integrated with emerging performance management framework concepts by the Federal Highway Administration (FHWA) and the American Association of Highway and Transportation Officials (AASHTO) that have begun to incorporate economic analysis concepts. This effort should include identifying significant mechanisms at the transportation project and system levels that impact on economic performance. Relevant past work on which the framework also should rely include the results of various Strategic Highway Research Program (SHRP) projects such as SHRP 2 C11 and SHRP 2 C03 and the experience of the U.S. Department of Transportation (U.S. DOT) with Transportation Investment Generating Economic Recovery (TIGER) discretionary grant and Transportation Infrastructure Finance and Innovation Act (TIFIA) evaluations.

One would expect that the institutional mechanisms in the United States for either the overall "Eddington-type" framework study or the subsequent assembly and development of implementing guidance would differ from that in the United Kingdom in large part because the two countries have different intergovernmental relationships and means to shared responsibilities. For transportation investments in the United States, the Federal government has historically been averse to prescribing methodologies for analysis. FHWA, for example, could have but did not prescribe planning and analysis methods for traffic forecasting or for other technical planning steps. Rather, they encouraged the development of methods by agencies and the private sector. Thus, while the U.K. Ministry is the locus of the "Transport Analysis Guidance" efforts, in the United States it may be appropriate to consider other arrangements, or shared responsibilities for guidance development among the U.S. DOT, interests such as AASHTO and the American Public Transportation Association (APTA), industry resources such as the Transportation Research Board (TRB) and university transportation programs, etc. This effort should not only explore the various policies to establish and achieve national economic goals through various investment strategies but the options to implement them and their governance implications.

In a second phase of research, subsequent to the goal and investment strategy component, the project could go on to define and outline how to develop the potential components of a framework, including tools, metrics, data, reporting, and updating would support the agreed upon priorities. The U.K. Ministry's TAG provides methodological guidance for agencies to undertake analysis of transportation investments. In addition to an overall framework, the TAG includes modular guidance about how to address specific aspects of transportation investment analysis for all modes and for all scales of projects. The SHRP 2 C03 and SHRP 2 C11 results provide the initial building blocks for the likely guidance materials that will be identified or developed.

A goal-driven framework for the United States tailored to the institutional environment for transportation investment in the United States would address all modes and all types and levels of investments as to how they would interface with other levels and scopes of analysis and remain compatible within the national goal-driven framework. Federalism and partnership has been a key element to date of the U.S. model. Therefore, given the diversity of investment roles and responsibilities in the United States, a third phase might address how the framework would apply to levels of transportation investment analysis beyond the national, to include regional, state, metropolitan, and/or local.

Theme 2 – Macroeconomic Studies

Project 2 – Economic Development Implications of Transportation Disinvestment

Estimated Cost: $500,000
Overall Rank: 10 (Scale of Impact: 2)
Anticipated Time for Execution: 18 months
Type of Work: Policy Analysis

Considerations in Accomplishing this Work: A variety of entities are available that can provide a blend of applied practice and academic research, sponsored under the applied research programs by transportation officials such as AASHTO and APTA. Reaching out to the economic development community could bring a beneficial perspective.

Synopsis

Many decision-makers within Federal, state, and local governments are confronting the reality of determining which elements of the nation's transportation infrastructure network they can afford with current resources and which would require supplementing with additional resources on a daily basis. It would be more comfortable to discuss the implications for economic development from the "up-side" with the assessment of demonstrating the value for the dollars that are spent and the critical contribution of transportation investment and management to those goals. However, strictly as a research construct, conducting a study from the analytical point of view of the "down-side" (answering the question: what would happen if facilities were eliminated or operations reduced?) may offer the ability to capture and quantify their value. Adverse economic consequences, for example, will likely result from a transportation system that is not maintained to optimize its service and asset value but allowed to deteriorate. In particular, the implications for delay and future retrofit costs might be more quantifiable from this vantage. Translating such change in travel costs and impacts on markets could help to "tell the story" of the implications of impacts on the system to the costs of sustaining economic growth through job access, transport costs to firms, and environmental consequences.

Cities and metropolitan areas are major economic generators of wealth and innovations. Extensive research has shown that the economic health of our urbanized areas is heavily reliant on comprehensive, well-maintained, and efficiently operated roadway and transit systems, ports, and airports. Yet nonmetropolitan areas of the nation provide food, fiber, energy, recreation, and the natural resources necessary for the nation's growth and nonmetropolitan areas contain the clear majority of the nation's transportation networks, including inland waterways, railroads, and Interstates. Indeed, given the complex interplay of metropolitan and nonmetropolitan economies, it is difficult to determine how changes in key nodal points and capacities of different facets of the transport system would affect national and regional growth and the

distribution of income. Moreover, it is also clear that transportation planning techniques cannot be simply run in reverse to ascertain the effects of proposed changes because new data and techniques are required. In an era of constrained resources, it is clear that decision-makers need new analytical tools to assess the impact of changes in the transport network on growth, business formation, and job creation.

Evidence of a vicious cycle could be documented. Disinvestment in roadways while demand remains steady would result in increased congestion, poorer surface conditions, and severely compromised safety. This, in turn, could reduce demand since costs are higher or by shifting it elsewhere. This has been evident historically during some periods in transit systems with poorer on-time performance or reduced hours of operation with poorly maintained rolling stock leading to increased fares and further reduction in demand and service. All of this effectively reduces access in terms of time or in terms of traveling to a destination. For businesses, it could reduce access to a wider array of skilled labor and to intermediate goods. Movement of freight would likely be impacted. For users in general, it will result in increased costs to travel.

Some questions that should be considered include the following:

What are the probable economic impacts, both short- and long-term, on growth outcomes and distribution of proposed budget reduction scenarios currently being debated?

What modeling methods are available to estimate disinvestment effects on transport system integrity in urban areas, regionally, and in nonmetro areas? Will there be distributional asymmetries of disinvestment economic development?

What are the transportation network effects and path dependencies of different disinvestment scenarios by mode and what are the intermodal effects and repercussions? How will disinvestment in one mode affect intermodal tradeoffs or how will disinvestment in one network, such as a freeway system, affect those primary arterial roads that connect to them?

The project also would specifically address the timeline for making multimodal investment decisions and the distribution of the different types of benefits over different timeframes. This would integrate with the "framework" included in the description of Project 1.

Project 3 – Update macroeconomic work with an improved capital stock data set that reflects service characteristics as much as facility cost/ physical value

Estimated Cost: $500,000 to $1 million
Overall Rank: 11 (Scale of Impact: 3) Anticipated Time for Execution: 2 years
Type of Work: Macro econometric

Considerations in Accomplishing this Work: Such an effort could be tackled by researchers with the capacity to manipulate and integrate large data sets. Data collection will be a significant challenge. Sponsorship by governmental agencies who not only have the ability to serve as a repository for these materials but also could assure that they would continue to be accessible to practitioners and future researchers would be beneficial.

Synopsis

Past econometric efforts may have suffered from looking almost exclusively at expenditures over a period and correlating them with national or regional economic statistics such as GDP. These analyses tended to oversimplify and mask the variation across the transportation system – particularly since investments at a large scale are "lumpy" and represent forecasted ultimate need. In concert with performance management, these capital stock analyses could be revamped to include more of the underlying elements and relationships and the mobility and access goals that are being served. It is recognized that a comprehensive update of capital stock data would likely be an ambitious undertaking.

Therefore, this project has two interrelated components: 1) improve the dataset to consider more than the cumulative capital contribution; and 2) use it to conduct analyses better related to the transportation services (condition and quality as a result of initial capital and preservation expenditures). The concept is to study the connection at the heart of the linkage with the economy, reflecting that the expenditure-based analyses that have been undertaken in the past only represent part of the picture. For example, subsequent research approaches, which could be scoped out as part of this study to test the application of the data set, could replicate prior studies but look at changes in the asset value over time due to use and deterioration, or segregating the cost of mitigation actions that do not directly relate to transportation services. The items chosen also should focus on the use of the system as a measure of its correlation (e.g., tonnage moved, employment centers connected). Barriers to goods movement and employment access could be reviewed and incorporated as service characteristics to investigate these relationships rather than strictly expenditures.

Theme 3 – Benefits Beyond Benefit/Cost

Project 4 – Identify and quantify agglomeration economies and other nondirect impacts that result from transportation capital investments and operational expenditures

Estimated Cost: $500,000-$750,000
Overall Rank: 3 (Scale of Impact: 1) Anticipated Time for Execution: 2 years
Type of Work: Multidisciplinary Policy and Economic Analysis

Considerations in Accomplishing this Work: Interest in this kind of research is high and timely among scholars of urban issues however the transportation components are rarely emphasized. Teaming of the transportation with other interests could be leveraged under various programs such as cooperative research programs sponsored by AASHTO, APTA, as well as with University Transportation Centers.

Synopsis

This research project will seek to provide an updated understanding of the role of agglomeration or other nondirect impacts in the economy that are enhanced by transportation investments. Work on industrial clusters in creating competitive advantage of firms and regions, has identified geography or space as a critical factor in determining economic development and performance. While transport infrastructure provides the necessary connections to such agglomerations the construction of a project will not by itself ensure that desired outcomes will necessarily follow. Nonetheless, it is still recognized and accepted that infrastructure policy can play an important role in impacting local and regional economic conditions. Transport policy and planning would be well-served with guidance on the specific mechanisms through which agglomerations (clusters) can be served by transport projects or policies. The key issue is to determine the mechanisms through which the larger economy is impacted and the evidence to support or disprove the larger impact.

This project will include: 1) a review of the existing international and U.S. literature about agglomeration and other indirect impacts, including economic geography; findings should be considered for applicability to the United States; 2) review of existing U.S. approaches such as TREDIS and REMI to evaluating the impacts of transportation investment on agglomeration benefits; and 3) development of metrics that can be used to quantify the economic impacts of agglomeration and other nondirect impacts of transportation investments. Research should use the data to develop metrics/characteristics that can best measure the transportation effects of agglomeration and other nondirect impacts, and apply it to varying size and density communities and their business composition.

The research should document prior case studies and perhaps also include a new series of case studies that focus on identifying principal barriers to achieving or maximizing economic benefits from agglomeration and other nondirect impacts. For instance, NCHRP 20-24(80) Workshop participants noted that even with

notable successes in transit-oriented development, there are still many barriers to taking full advantage of investments. Known clusters in the United States (e.g., technology cluster in Silicon Valley, Biomedical cluster in Pittsburgh, creative cluster in Southern California, etc.) and their concentrations could be documented, including discussing the historical roles transportation has played in the preservation and or enhancement of these clusters. The project should utilize other examples of existing industry clusters in North America to the maximum extent possible to highlight the analytic and data issues in relating industry cluster growth and development to transportation factors.

This research should list the major barriers to maximizing the impact from transportation investments, and identify possible treatments to address such barriers. Issues that should be considered in this research include:

Review the implications of telecommuting and relocation of firms;

Identify synergies such as production processes and just-in-time manufacturing beyond user benefits;

Examine metropolitan areas as well as interregional travel to consider labor market efficiency, opening up new markets, reducing costs of trade, providing attractive business environment, and knowledge spillovers;

Examine issues of how true agglomeration economies can be distinguished from simple responses to travel time savings, reliability, and other user benefits already included in benefit/cost analyses; and

Discuss the mechanisms, processes and channels, and data through which transport's influence on clusters may be measured and documented.

Project 5 – Comprehensive reviews of past transportation infrastructure projects

Estimated Cost: $300,000
Overall Rank: 6 (Scale of Impact: 2) Anticipated Time for Execution: 1 year
Type of Work: Scanning and review

Considerations in Accomplishing this Work: Rarely are funds dedicated to analysis of transportation projects that are conducted simultaneously with their development and execution since that would add to the cost of the project. "Before and after" projects could be extremely advantageous to the transportation community at large in order to document lessons learned and guide future decision-making. Governmental sponsorship, particularly by entities with discretionary grant decision-making, would be logical choice, drawing upon researchers from consultancy and academia while providing access to project sponsors and their records. Success will depend upon the ability to retrospectively find sources, which will be challenging.

Synopsis

While projecting impacts of future investments is potentially useful, a slightly less ambitious yet sorely needed activity is a comprehensive and rigorous review

of past transportation infrastructure projects to see the extent to which their originally advertised impacts matched what was actually achieved. A major deficit in the record of transportation projects is that there is far more debate on the merits prior to the ribbon cutting than after. When projects do miss the mark, the after analysis is oftentimes highly politically charged, undercutting its research value. The research effort should include an after-action review of projects that have been fully completed and for which the political considerations have somewhat subsided. Compiling these case studies would provide a useful resource. Particularly insightful cases could suggest expanded follow-on analyses.

Project 6 – Examining the Short-Term Stimulative Impact of Transportation Investment

Estimated Cost: $300,000
Overall Rank: 12 (Scale of Impact: 2) Anticipated Time for Execution: 1 year
Type of Work: Labor econometrics, Policy-related synthesis

Considerations in Accomplishing this Work: This aspect of economic impact has frequently been caught up in the credibility gap of political rhetoric. In order to lay the groundwork for a serious treatment of the issues, it would be important to pair credible (apolitical) researchers from beyond the transportation community with those who understand the context and the dynamics of the recent use of such funds.

Synopsis

As far back as the era when Keynesian "pump priming" policies were generally accepted techniques of fiscal policy, using public works as a stimulus tool were controversial. The dual benefits of short-term job creation and long-term economic potential were behind many of the choices made for grants under TIGER and other American Reinvestment and Recovery Act (ARRA) discretionary grant programs. ARRA/TIGER reporting criteria have mandated recipient states and metropolitan planning organizations (MPO), transit agencies, and others that receive Recovery Act funds to submit quarterly reports on the number of jobs created or retained, among other data. These job calculations were to be based on the total hours worked divided by the number of hours in a full-time schedule, expressed in full-time equivalents. Section 1201 of ARRA directs DOT to estimate the direct, indirect, and total jobs created by the projects funded under the Department's allocation.

A recently completed NCHRP 8-36 Task 103 Report (Mining Recovery Act Data for Opportunities to Improve the State of Practice for Overall Economic Analysis of Transportation Investments) conducted a detailed investigation of the short-term job impacts from jobs data provided at the national level and for four states that shared data. That report notes a national average of 10.55 jobs per millions of dollars and wide variation by project type. For the four states that reported, data quality was noted to be of a higher quality relative to that obtainable from public domain sources reflected in the national average. The average in these

four states ranged from 9.0 to 16.8. In addition, the report points to several reporting issues and inconsistencies. Another key finding in this report relates to states that have in-house mechanisms for deriving indirect and induced gains attributable directly to ARRA expenditures that could be contrasted with macroeconomic methods of obtaining the same as conducted by the Council of Economic Advisors (CEA). That report highlighted four issues that merit further research and investigation by way of better analyzing the data reported by agencies with a goal of providing better estimates short-term job effects and inference to a potential larger or a wider job impact:

Explore the potential for a richer state-level analysis with data on payroll and hours to ensure robustness of estimates and to address variability in short-term impacts;

Address the impact of labor market frictions on wage rates and short-term jobs effects;

Estimate or identify indirect and induced from short-term job numbers that could be contrasted to those established at the macroeconomic level and finally; and

Address lag effects of Federal Database expenditure and payroll and hours data at the state level.

Subsequently, additional work in this area has been commissioned to explore ARRA and is being conducted by Transportation Research Board that will explore the effectiveness of infrastructure spending as stimulus and use the experiences to suggest effective features for any future transportation stimulus programs. That report also could likely have additional research issues that will target ARRA data.

These studies indicate that much is yet to be improved in terms of processing short-term jobs data so as to provide more credible information of actual ARRA expenditures as well as meeting Section 1201 requirements of wider job impacts (indirect and induced). However, it might be neither practical nor feasible for all states to share data and there might be some similarities across states in terms of effects. At the same time, the focus on short-term jobs also is questioned across many circles and that this has the potential to detract from longer-term perspectives and views.

Proposed research questions include:

Effective sampling methods to explore state-level jobs data in greater depth. State-level segmentations may be considered that would add value. Alternative useful and innovative classifications for drawing state samples would be of value and could be investigated as part of this research. Examples could include candidate states in Bureau of Economic Analysis-Defined Regions or distributions implicit in the Recovery Act Database (RADS) System by project type, state sampling based on reporting quality to

address selection issues, and states with higher proportion of economically distressed regions, and employment slackness conditions in states.

Explore means to address lag effects in short-term job estimates, possibly for representative states.

Devise methods to project or determine wider job effects from short-term job effects. Much of this is typically conducted using input-output methods. Can case examples of candidate ARRA project showcase alternative ways of addressing this issue and if so, could those be translated into potential implications for monitoring and/or evaluation?

Is the focus on short-term jobs warranted? What do some of these projects have by way of documented larger economic gains in these states, locations? Can new methods being developed be used to address the longer-term implications of these funded projects that could be contrasted with prior results and short-term jobs?

Theme 4 – Metrics

Project 7 – Develop a set of metrics that can be applied to transportation projects to quantify the economic costs and benefits of investment

Estimated Cost: $200,000
Overall Rank: 4 (Scale of Impact: 1) Anticipated Time for Execution: 1 year
Type of Work: Scoping and framing

Considerations in Accomplishing this Work: A specialized focus on economic indicators could draw upon the business community (in the form of chambers or business schools), paired with transportation professionals. Relatively large investments of human resources at DOTs are being made either directly by staff or with the help of consultants and could be leveraged to include this perspective as well.

Synopsis:

The goal of this project would be to identify and evaluate means to succinctly capture the components of the relationship between transportation and economic performance and its net effect, including an explanation about how such a metric could/should be used and how misinterpretation should be avoided. This would entail exploring the options available in the short- and longer-term based on currently available data and future data that would be needed to satisfy the need. For example, a "return on investment" (ROI) characterization has been referred to by decision-makers as an advantageous attribute for projects that they would use to evaluate "go/no-go" or choose among them. However, there is skepticism that such a calculation could be devised that truly represents the ROI commonly used in the private sector due to a variety of factors such as the different goals of the public beyond "profit" that are being addressed. A single metric is unlikely to apply in a public sector context but a series or cluster of metrics might fill the information gap. Among the concepts that should be explored for usefulness and feasibility in addition to measures of return on investment include indicators of impacts on labor access, indicators of market range, and the level/cost of buffer times.

The ultimate metrics would be very useful as a component of the communication tools discussed under Theme 8 and also could relate closely to the goals identified in Project 1. Key to success for this project would be to focus on the transportation services and outcomes, including the variety of relationships between business operations, economic vitality, and transportation at various levels, rather than the transportation facilities themselves. Thus, a multimodal "door-to-door" perspective is warranted.

Theme 5 – Assessment of Externalities

Project 8 – Develop a comprehensive methodology for evaluating project externalities and develop standards for valuing all externalities

Estimated Cost: $200,000-$500,000
Overall Rank: 13 (Scale of Impact: 3) (this work is the primary focus of other research efforts)
Anticipated Time for Execution: 2 years
Type of Work: Scoping and framing

Considerations in Accomplishing this Work: Transportation externalities have been routinely highlighted by advocates both "for and against" transportation investments and decisions. Drawing from those findings in a comprehensive manner to build an objective bank of knowledge about assigning a cost to these impacts would require a balanced sponsorship and teaming arrangement that would benefit from the bringing together a wide range of interests.

Synopsis

Transportation agencies routinely evaluate claims and values presented for externalities based on third-party tools and estimates of both the impacts and the costs. A consistent and comprehensive methodology, including measurement standards, would improve the abilities and credibility of sponsoring agencies. The expanding scale of what is considered an externality has been a challenge which should be addressed. The ability to use accepted estimates would help to price transportation investments and to identify the true costs of transportation infrastructure and transportation use. Key categories of measured externalities may include environmental (air/water pollution/health impacts/greenhouse gas emissions), safety, wear and tear, delay, and perhaps measures of energy use (e.g., national security effects of greater/less petroleum use). Beginning with a comprehensive review of the work to date with an emphasis on the basis for prior assessments, this research project should include the development of acceptable methodologies to measure and evaluate transportation project externalities, including the cost of the "base case" (the "no build," status quo).

Theme 6 – Resource Allocation Tools

Project 9 – Refining economic analysis tools to meet new MAP-21 freight requirements

Estimated Cost: Phase I, $250,000, Phase II $600,000
Overall Rank: 7 (Scale of Impact: 1) Anticipated Time for Execution: Phase I, 1 year; Phase II 2 years (concurrent)
Type of Work: Methodology refinement

Considerations in Accomplishing this Work: Close coordination with U.S. DOT/FHWA should be an element of this work in order to build upon previously developed methodologies and to expand existing tools to bring economic insights related to freight into national- and state-level analyses in a timely manner.

Synopsis

With the increased emphasis on freight in MAP-21, new and updated tools will be needed. The law requires U.S. DOT in cooperation with the states to designate a national freight network of up to 30,000 miles that are most critical to the movement of the nation's freight. U.S. DOT also is required under MAP-21 to biennially produce a report on the conditions and performance of the freight network and begin development of new or improved performance assessment tools to evaluate freight-related projects and impacts. The Act increases the Federal share for freight mobility projects identified in state plans from 80 percent to 90 percent for non-Interstate projects and from 90 percent to 95 percent for projects on the Interstate system. These provisions for the first time will identify a critical national freight system that can focus investment to benefit U.S. economic growth and competitiveness in the global economy. Thus, it should be a priority to develop and refine the tools necessary to identify and prioritize the most effective investments on this freight network.

Fortunately, FHWA in its previous Freight Benefit/Cost research (http://www.ops.fhwa.dot.gov/freight/freight_analysis/bca_study_phase2/index.htm#3), assessed ways of improving the conventional benefit/cost analysis framework to address freight projects. The methodology sought to quantify the effects of transportation system improvements in relation to: 1) immediate cost reduction to carriers and shippers; 2) the impact of improved logistics while keeping output fixed; and 3) additional gains from reorganization such as increased demand, new or improved products. The overall result as described in the Phase II report (FHWA Freight BCA Study: Summary of Phase II Results) concluded that "the impact of highway-performance improvement on shippers, is real and is measurable. Moreover, the results were sufficient to permit a preliminary estimate of a markup factor; an approximation of the percentage by which benefits found in available benefit/cost models should be increased to reflect freight benefits. These preliminary estimates were in the range of 14.7 to 15.9 percent."

The FHWA report went on to identify two immediate applications of the findings reported. One pertains to FHWA's Condition and Performance analysis process. The second pertains to freight planning at the state and local level.

9. The first recommendation pertains to the Highway Economic Requirements System (HERS) model process, and related analysis tools and activities conducted on behalf of the biennial Conditions and Performance Report to Congress. These should be modified to recognize the productivity benefits of highway investment that stem from attendant investments by private firms in advanced logistics. Such modifications should be both qualitative and quantitative. At the qualitative level, the Conditions and Performance Report should acknowledge and explain the import and quantitative materiality of highway investment for productivity growth. At the quantitative level, HERS-based estimates of benefits in relation to highway spending alternatives should be "marked up" appropriately given the results of this study and of possible later phases that will be designed to further strengthen this empirical work.

The FHWA Phase II Report, concluded that "although the initial analysis results were national in scope, they can be reproduced at the project level using the computer model and processes developed under the study. In principle, the model could be equipped with a user-friendly interface and made widely available." The report recommended, however, that, prior to rolling out the model for widespread use, FHWA conduct an acceptance-testing process in two corridors. The rollout process would thus proceed in five steps, as follows:

Development of acceptance testing criteria;

Execution of the model in two corridors;

Evaluation against the acceptance testing criteria;

Refinement of the model; and

Rollout.

Specific and measurable acceptance testing criteria would relate to the functionality and efficiency of the model in the field, its relevance to all pertinent issues and, to the extent possible by way of ex-post-evaluation, its accuracy. With the new MAP-21 requirement for identifying a national freight network and reporting to Congress biennially on national freight system condition and performance this recommendation becomes particularly relevant for immediate attention. Both the national HERS analysis tool for condition and performance and state and local analysis tools need to be modified to better recognize and incorporate freight system and project economic benefits. In identifying those critical freight projects on the nationally freight system that should justify higher Federal match, these tools would be critical. The research could be conducted in two concurrent phases: Phase I would be focused on refining national tools to incorporate freight into the biennial conditions and performance process.

Phase II would focus on refining benefit/cost tools to incorporate freight for state and metropolitan planning.

Project 10 – Identify transportation projects that contribute most to the economy

Estimated Cost: $200,000 *(Phase 1; potential subsequent phase additional $200,000)*
Overall Rank: 14 (Scale of Impact: 2) Anticipated Time for Execution: 1 year
Type of Work: Literature and project file review, case studies

Considerations in Accomplishing this Work: A Federal regulatory process was put into place based on statutory criteria for selecting projects of national and regional significance under the previous authorizing legislation. An independent third-party effort would be useful to consider how economic perspectives, treating explicitly economic outcomes at the national level in a rigorous manner, could be introduced.

Synopsis

Conduct research that identifies the types of transportation projects that contribute most to the performance of the national economy. This would involve assembling information on the estimated impacts from previous studies and from project reports, also relying heavily on SHRP 2 CO3 and on the U.S. DOT's TIGER and TIFIA experience. In a second phase, case studies could be developed for a set of projects selected as demonstrating the greatest potential and relatively accessible data.

Project 11 – Explore economic basis for a resource allocation tradeoff model

Estimated Cost: $100,000
Overall Rank: 9 (Scale of Impact: 1)
Anticipated Time for Execution: 6 months
Type of Work: Exploratory precursor to methodology development

Considerations in Accomplishing this Work: Researchers would need to focus on the mechanisms within current models in accomplishing this effort. In documenting those mechanisms, they would blend elements of an assessment of current practice with consideration of alternatives which would better address incorporating economics-driven goals. This could argue for a peer-to-peer style effort among researchers and clients.

Synopsis

Various models and other tools exist which help to "grade" or "rank" individual infrastructure investments. Since benefits can be viewed as the result of the combination of investments at the system level and the resulting transportation performance attributes, a research project would be beneficial if it could contribute to better understanding of the cumulative impacts on economic performance at a regional or state level. A part of the challenge is the "silo" orientation of many existing tools: evaluation of projects remains within individual modes and do not consider the interactions or tradeoffs between them.

This project would be of an exploratory nature, reviewing current economic analysis tools used in the United States and in other countries in these regard and identifying possible approaches as to how those tools could be improved or customized to effectively assess tradeoffs among transportation investment alternatives. This assessment also would address the degree of confidence that can be placed, with current tools, in the economic implications of tradeoff choices. As part of this review, an immediate by-product could be of assistance to decision-makers who expressed the need for guidance in interpreting benefit/cost and other analyses at the system or individual project level.[21]

Project 12 – Develop an approach to measure the economic impacts of reliability

Estimated Cost: $500,000
Overall Rank: 8 (Scale of Impact: 1)
Anticipated Time for Execution: 2 years
Type of Work: Methodology development

Considerations in Accomplishing this Work: Reliability has been studied from an engineering perspective, facing challenges in measuring its multiple forms. Building on those understandings but going beyond the traffic to capture the economic implications will require an interdisciplinary research approach.

Synopsis

Research suggests that travel time reliability benefits are large, particularly in congested areas. Research indicates that trip time predictability is of greater importance than reliability per se. The measure of reliability used in benefit/cost analysis should not only consider trip time variance but also the extent to which prior information can help mitigate the effects of longer than usual trips. Inadequately measuring these benefits could cause a bias in project and policy analysis. A practical method is needed for explicitly incorporating travel time reliability (as a separate category from travel time) into benefit/cost analysis. The need to better understand the economic implications relating to reliability is a key area for research, building upon the research programmed for SHRP 2. The value of preventing system delay, in absolute terms, has been quantified; however, the measurement of reliability within the transportation system and the different types of impacts that reliability has for passengers and different types of freight has not been assessed.

This research project should identify and test possible metrics for calculating reliability under different contexts for various modes and industries; the research should be outcome-oriented, and should not simply focus on system outputs. A methodology to correlate changes in transportation system reliability to the

[21] NCHRP 02-19(2) *Guidance on Using Existing Analytic Tools for Evaluating Transportation Investments*, 1998.

economic performance of different industry sectors would be advantageous. This may be different for different modes.

Focus areas for this research project should include:

Stratify the value of time (rather than just an average) for different industries and firms with different cost structures. Consider the various perspectives considering that the value of time to the driver/passenger is different than value to the enterprise/employer.

Since travel time reliability is increasingly recognized as an important user benefit, quantifying the buffer time and seeing how standard deviation around the travel time can be incorporated into the appraisal of alternative investments and/or operations would be valuable. Depending upon the individual industry, the role of reliability may be very important and so we may be underestimating it. Therefore, the value of such appraisals would be increased if stratified or illustrated by trip type, by market.

Consider using the willingness-to-pay principles as a means to value user benefits. Segregate passenger and freight markets.

Investigate the concept of "induced demand" through the user perspective rather than the transportation provider perspective. It may reflect user responses to reduced transportation costs and a reflection of "pent up" demand. Framing induced demand in an even fashion as both environmental cost and economic benefit is important.

Note: SHRP 2 has just released a related RFP but it does not highlight business usage. L35: Local Methods for Modeling, Economic Evaluation, Justification, and Use of the Value of Travel Time Reliability in Transportation Decision-Making. The purpose of this project is to introduce the economic value of travel time reliability into practice, test it, and provide public agencies with examples of step-by-step procedures on how to incorporate and justify the value of travel time reliability into decision-making.

Theme 7 – Competitiveness

Project 13 – How does transportation fit into the competitiveness calculation?

Estimated Cost: $250,000
Overall Rank: 4 (Scale of Impact: 1)
Anticipated Time for Execution: 1 year
Type of Work: Critical policy analysis and scoping

Considerations in Accomplishing this Work: A deliberate exploration of the economic rationale behind competitive advantage and trade policy would be necessary to help articulate the issues and their relationship to transportation. Research skills would include those from political economy as well as market knowledge.

Synopsis

Improving the economic posture of our nation on a global scale, and the ability to successfully compete with other jurisdictions (on a smaller scale) are commonly accepted goals even in the most contentious of public debates. Overcoming distance as efficiently and effectively and reliably as possible, moving inputs (both people and things) as well as finished products is a critical function of transportation. How can this be translated in a credible fashion into regional and national economic policy? Research should be conducted that considers how various transportation options and investments affect industries – how it helps some and hinders others. Transportation's role in defining a dynamic marketplace and recognizing how transportation contributes to competitive responses is rarely focused on and yet there are numerous examples in economic history.

An improved understanding of the relationship between transportation and international economic competitiveness in a modern marketplace would help to inform change and investment within the transport sector as a contribution to the larger economy. The purpose of this research would be to get beyond the rhetoric and bring the economic thinking to the transportation debate.

This project should reach out to firms within specific industries identified for inclusion in the study to capture the cost structure of companies and determine how transportation fits into that structure. Although not all firms would be willing to share this information, enough may be willing to do so to develop an understanding of this question.

Project 14 – Develop a comprehensive and systematic treatment of transportation's role across various industries and economic sectors

Estimated Cost: $1 million (scalable at $100,000 per in-depth industry case plus funding for integrated overview product)
Overall Rank: 1 (Scale of Impact: 1)
Anticipated Time for Execution: 6 months per industry
Type of Work: Policy Analysis with heavy interview and field work

Considerations in Accomplishing this Work: The development, collection, and presentation of a series of industry studies will be an excellent resource. One challenge for carrying out the work will be to coordinate the activities that are likely to require different approaches and skills: identifying the industries for focus on within the budget, find cooperative entities from which to solicit information and insights with proprietary sensitivities, using data collection mechanisms that will be well-received by each industry, and present the findings relevant to a variety of purposes. These will require strong interdisciplinary and communication skills and may draw upon different sets of individuals for different industries.

Synopsis

A sectoral approach to current and future transportation requirements will help identify transportation investments that can make industries more efficient and thus improve productivity to the benefit of all, not just to the benefit of one region over another. The objective of these studies would be to describe the supply chains of industries, "telling the story" at the firm level and then tracing out an understanding of how changes in the performance of the transportation system affect supply chains and how these changes make industries more or less competitive (and, therefore, more or less able to contribute to economic growth). The sectors chosen for the initial work should take into consideration technological change and policy goals such as increasing U.S. exports.

The investigations of supply chains would focus at first on the firm level with subsequent scaling up the results to industry and sectoral levels. This information could be considered proprietary by firms and, thus, there would be better access to the information if the overall project was paired with local Chambers of Commerce or received similar endorsements. Anecdotal and case study approaches are often regarded as less rigorous than other research approaches. However, firm- and sector-level studies can be very successful in building an understanding of the mechanisms that are involved in economic behavior. They can serve as "explanatory snapshots" and be very useful in identifying and explaining the trends and relationships that might be buried in analysis conducted at a higher scale. Recognizing some overlap and cross-cutting information with Project 15, the analyses should take into consideration the movement of people (for employment/commuting as well as discretionary travel and consumption) and goods (including inputs and finished products).

Knowledge of supply chains is the missing link between the direct economic effects of transportation investments (e.g., reduced delay and driver labor costs,

reduced fuel costs, improved reliability of delivery times, etc.) and the economic value of these changes to the economy. Filling that gap can put us in a position to better understand how the travel time and other changes impact the productivity, market/labor access, and competitiveness of specific industries, especially where we have complex supply chains operating over densely developed transportation networks that are subject to emerging trends and new technologies.

The recent TRB Special Report 304, How We Travel: A Sustainable National Program for Travel Data, and 'TRB summer 2012 conference on "Measuring the Transportation System from a Supply Chain Perspective" both recommended a greater focus on logistics and supply chains. This also would contribute to thinking about the mandated National Freight Strategic Plan and the state freight plans encouraged by MAP-21.

An increased focus on logistics is important because supply chain, sourcing, and distribution strategies have been changing significantly over the past several years. Shippers have sought to diversify ports of entry to hedge against labor disruptions and capacity shortages, located distribution centers closer to customers, and investigated in-sourcing and near-sourcing strategies to counter wage, quality, and time-to-market concerns about Asian-based suppliers. These and other logistics trends have changed how freight moves and will have far-reaching implications for the agencies and entities that operate, maintain, and invest in the freight transportation system.

The project would make use of text, case studies, and illustrations to explain how shippers, carriers, and receivers make decisions about where to buy, make, warehouse, and sell raw materials, parts, and finished products, which we see as supply chains moving goods over the transportation network. An initial step for this project would be to select a representative sample of industry/commodity supply chains that are important because of their impact on the national economy, freight transportation systems, and communities. Candidates might include retail merchandise supply chains, agricultural supply chains, and energy resource supply chains, focusing on both import- and export-related issues. The cases would highlight the substantially different logistics strategies adopted by those industries and their often radically different freight transportation needs. The case studies also would help decision-makers better understand how factors such as commodity type and weight, travel time and reliability, cost, and regulation shape freight flows and modal choices; where transportation investment is needed; and when public policy and investment can (and cannot) influence freight movements.

Theme 8 – Communication

Project 15 – Market Analysis and Application

Estimated Cost: $1 million
Overall Rank: 5 (Scale of Impact: 2)
Anticipated Time for Execution: Phased over 2 years
Type of Work: Marketing, survey, and synthesis

Considerations in Accomplishing this Work: This project combines a number of the elements raised under the communication theme because they could benefit from a common and broad knowledge base. The challenges of communicating with the public about transportation generally and transportation economics specifically argue for sequencing the research findings in order to provide usable components as quickly as possible. This might conflict with a more logical approach from a research point of view which would begin with the more expansive analyses and proceed with applications. Balancing delivery and timing concerns would argue for direction from project sponsors and conducting the research on parallel tracks with a high degree of coordination. Funding would be scalable, based on the number of markets studied; this level of effort was selected to provide some minimum level of coverage across the economy.

Synopsis

Transportation professionals are unsophisticated in use of the tools developed to communicate our issues. We are comfortable presenting the features of facilities and how to construct them; for example, or how they operate from a technical point of view. There is less experience with successful ways to communicate with the public as to what the actions to put new infrastructure into place, maintain it, and operate it, mean to its users and beneficiaries.

As groundwork for this line of research, market analyses should be conducted. This is new work as the subject is rarely treated in such a manner; i.e., investigating what the consumer wants or thinks they want in "purchasing" transportation as a commodity that will help advance their economic standing. This is further complicated by the fact that in doing so, the "market" must be stratified among many classes or users and each key consumer group tested individually. The analyses should take into consideration the movement of people (for employment/commuting as well as discretionary travel and consumption) and goods (including inputs and finished products).

Several approaches could be adopted as part of studying these market segments and documenting the range of perceptions:

Conduct a set of surveys or focus groups to determine what the market segment members really know about transportation and its relationship to economic health. Such interaction could be studied to determine the level of interest and knowledge and what language they relate to. Included in these interactions would be testing the value that these segments place in transportation and their "willingness to pay" for various levels of transportation performance.

Test various social networking techniques to determine whether, with greater exposure to the issues and consequences, an appreciation can be developed which could improve attention and interest in local, regional, state, or national transportation decisions.

Determine the most successful features in "telling the story" about transportation's economic role in terms of major sectors (e.g., manufacturing, services, tourism, finance/insurance/realty) and universally.

Create and test a series of illustrative messages as to the importance of the topic relative to other public policy and resource allocation questions to determine whether transportation choices can overcome the "trust" issues associated with government. Among the elements to be tested, for example, could be language that differentiates:

- Between public and private transportation expenditures (how private expenditures are passed along to ultimate consumers);
- Productivity improvements that enable growth and efficiency over the long term from expenditures that protect current assets and retain the productivity currently enjoyed; and
- Between public transportation expenditures as investment rather than a cost.

In addition to documenting the market segments as a lens through which transportation is perceived, this research effort should provide guidance as to the best approaches to explain the relationships reflected in the economic literature to practitioners, official, and the general public.

3.0 Institutional Considerations

Collaboration and coordination will be two important elements in the execution of an effective program of research relating to the economic benefits of transportation infrastructure investment. First, collaboration with the various entities that within and outside the transportation industry can help to leverage the considerable knowledge and capabilities as well as the resources available to conduct the research. The opportunity for collaboration is great for this interdisciplinary venture. The quality and usefulness of the research would likely be improved if it were conducted not in a vacuum but instead included from the start with the very users and customers it seeks to better understand and communicate with. With advance planning, it is realistic to bring together the interests, perspectives, and skill sets in the traditional transportation arena with the complimentary interests, perspectives, skill sets in the business community, and the economics profession.

Examples of the way that such teaming could be encouraged include teaming with:

Organizations that represent individual industries that are transportation system users and logistics service providers – not only would this facilitate access to industry expertise but also could provide an opportunity to convene forums for input into and peer review of research findings plus opportunities for joint sponsorship;

Federal agencies such as U.S. DOT, U.S. Department of Commerce (Economic Development Administration), and the Federal Reserve Bank (Division of Research and Statistics);

State agencies through AASHTO (and the coordinated research programs of TRB), the National Governors' Association;

Transit agencies through APTA (and the Nationally Coordinated Transit Research Program); and

Academic resources who have demonstrated an interest or focus in transportation and applied economics.

Second, continuing coordination across the individual aspects of this research would be beneficial to foster integration of the findings on a timely basis. It is expected that the subjects that are covered across this wide-ranging agenda have the potential for important synergies and there will be opportunities in various research activities for the data collection and interpretation efforts to converge and be mutually supportive. Frequently, research is sponsored and conducted

on an individual project basis, thus the problem statements above. However, it would be beneficial to establish a governing or oversight approach that took advantage of a coordinating panel or other mechanism to assure that there was coordination where appropriate across the entire initiative.

4.0 Concluding Observations

Looking forward, this research agenda is but an outline – a starting point for a roadmap to refreshing out collective understanding of the relationship between transportation investments, and today's (and tomorrow's) economy. In conducting this research, one can observe that the transportation profession has often confined itself to working within its technical and engineering comfort zone. Even though it was recognized by most that transportation is the servant to other purposes, a means to a greater end rather than the end in itself, those ends were rarely questioned. In an era where basic access and mobility were lacking, the transportation solutions (in terms of physical infrastructure) appeared so obvious and the consensus so strong that the profession wasted no time in second guessing their worth and the public agreed.

In a post-Interstate era, some could argue that the transportation system has matured and, with the majority of the basic linkages across the country in place, the greatest economic benefits are associated with preservation alone. Without adopting a user perspective, it might be easy to fall into that trap. Instead and with great significance, this economy is dynamic and ever-changing – if it were stagnant, it would make transportation forecasting easier in the short run but certainly would be an indicator of rough times ahead. As a people, we have ever higher expectations for access and mobility, even as demographics change, population growth continues, new technologies have significant impacts on how we live and move, sensitivities grow in terms of the impacts of such expectations, and economic trends change the landscape worldwide. It is more than a defensive stance to explicitly consider the issues surrounding the value of the transportation system and how best to optimize not only the legacy system but also additional capabilities that it can bring as it evolves.

One can argue that this preservation and optimization cycle is much harder than the initial construction stage and requires a degree of sophistication that is not easily deployed. A firm understanding of the role of transport, how it interacts with economic activity to bring benefits, and how it contributes to achieving our economic goals takes continuous up date – something that has not been done in a comprehensive way.

This compilation of research activity and the rationale behind it is an effort to fill such a need as we move ahead with investment decisions for the near and short terms.

APPENDIX

ASSESSING THE ECONOMIC BENEFIT OF TRANSPORTATION INFRASTRUCTURE INVESTMENT IN A MATURE SURFACE TRANSPORTATION SYSTEM

A WHITE PAPER

Prepared for:

NCHRP 20-24 Task 80 Panel

Prepared by:

Cambridge Systematics, Inc.
1. 4800 Hampden Lane, Suite 800
Bethesda, MD 20814

With:

James March

March 2012

The information contained in this report was prepared as part of NCHRP Project 20-24, Task 80, National Cooperative Highway Research Program.

Acknowledgements

This study was conducted for the NCHRP 20-24 Task 80 Panel, with funding provided through the National Cooperative Highway Research Program (NCHRP) Project 20-24, *Assessing the Economic Benefit of Transportation Infrastructure Investment in a Mature Surface Transportation System*. The NCHRP is supported by annual voluntary contributions from the state Departments of Transportation. Project 20-24 is intended to fund quick response studies on behalf of NCHRP 20-24 Task 80 Panel. The report was prepared by Cambridge Systematics, Inc.. The work was guided by a technical working group. The project was managed by Andrew Lemer, NCHRP Senior Program Officer.

Disclaimer

The opinions and conclusions expressed or implied are those of the research agency that performed the research and are not necessarily those of the Transportation Research Board or its sponsoring agencies. This report has not been reviewed or accepted by the Transportation Research Board Executive Committee or the Governing Board of the National Research Council.

Instructions to Workshop Participants

This project is being conducted for the NCHRP 20-24 Task 80 Panel as part of NCHRP Project 20-24, Assessing the Economic Benefit of Transportation Infrastructure Investment in a Mature Surface Transportation System. The report has not gone through the usual rigorous review process established and monitored by the Transportation Research Board Executive Committee or the Governing Board of the National Research Council, and is being provided to participants of the project workshop only and should not be described as a "TRB Report". It should be described as a contractor's report conducted for the NCHRP 20-24 Task 80 Panel with funding provided through National Cooperative Highway Research Program Project 20-24.

Table of Contents

List of Tables

List of Figures

Executive Summary

This white paper examines the economic benefits of transportation improvements and methods used to estimate benefits of transportation investment. The objective of the paper is to identify gaps in our knowledge of the economic benefits of transportation investment on individuals, businesses, and national, regional, and local economies. These knowledge gaps will inform the development of a future research agenda to improve our understanding of the economic benefits of transportation improvements and to enhance analytical tools for estimating benefits of transportation investment in different types of areas. This will support improved transportation decision-making and a greater awareness of the economic benefits of transportation investment.

Economic analyses of transportation investments generally fall into four broad categories:

Project-level benefit-cost analysis of user benefits;

Estimates of employment supported by transportation investment based on a mix of project studies and input/output analyses and used at various scales;

Macroeconomic studies of long-term relationships between transportation investment and various measures of economic activity; and

Broad-base studies that attempt to capture local and regional economic benefits that are not reflected in benefit-cost analyses, concentrating on the mechanisms through which transportation improvements enhance local and regional economies.

Each of these various types of analysis attempts to capture different aspects of the economic benefits of transportation investment.

Benefit-cost analyses focus on benefits directly realized by users of transportation improvements:

- Travel time savings;
- Improved transportation system reliability;
- Vehicle operating cost savings;
- Reductions in crash-related costs;
- Improved mobility; and
- Availability of travel options.

Considerable research has been done on many of these impacts. Knowledge gaps identified in this study relate primarily to the difficultly of placing a monetary value on some of these user impacts. This is particularly true for the impacts of travel time savings, improved reliability, reduced fatal and injury crashes,

improved mobility, and the availability of travel options. Of these, the area receiving the most attention in recent years has been the value to users of improved travel time reliability. While not solely a product of increasing congestion, travel time reliability is strongly affected by congestion. Research has shown that many users value improved travel time reliability more than they do simple travel time savings, especially for trips requiring arrival at a specific time. Reliability is a focus area under the Strategic Highway Research Program (SHRP) and considerable research currently is underway through that program, but the need for further research beyond the SHRP 2 program can be anticipated.

Employment supported by transportation investment often is of considerable interest, especially during times of high unemployment throughout the economy. Much of the discussion of employment associated with transportation investment relates to the short-run impacts of construction spending itself – the jobs directly supported by construction, the jobs in industries supplying the construction industry, and jobs supported by spending by workers in the construction and supporting industries. Such short-term job generation by itself, however, is not a sufficient reason to invest in transportation if other benefits do not outweigh the cost of the transportation investment. In the long term, transportation investment that promotes increased economic activity also will support increased employment.

Macroeconomic analyses can provide estimates of economy-wide benefits of a transportation investment program that cannot be estimated using other methods.

Macroeconomic analyses to assess the contribution of overall transportation investment to national or regional economic activity have focused on highway investment. Studies have been conducted at the state, regional, and national level. These studies typically use sophisticated economic analysis techniques and rely on statistical relationships between levels of transportation investment and measures of economic activity, but often do not demonstrate causality or the mechanisms through which transportation investment affects measures of economic performance. Moreover, results of these studies can be influenced by the underlying economic analysis methods used in those studies. Several early studies found very large economic benefits from transportation investment, but those studies later were criticized based on the economic methods used. Other issues that can affect the results of such macroeconomic studies are the level of geography being analyzed, the time period involved, and the types of improvements being funded from transportation investments.

Despite these issues, macroeconomic analyses can provide estimates of economy-wide benefits of a transportation investment program that cannot be estimated using other methods. One of the most widely cited macroeconomic analyses of the effect of highway investment on economic productivity was conducted for

the Federal Highway Administration by Nadiri and Mamuneas. They found that highway investment accounted for about 25 percent of all productivity growth in the U.S. economy during the period 1950 to 1989. From 1952 until 1963 the contribution to overall productivity was 32 percent, but that rate declined during subsequent years until, for the period 1980 to 1989, the contribution to productivity growth was down to seven percent. Thus as the Interstate system neared completion, the economic impact of additional investment declined. Nadiri and Mamuneas also assessed the relative impact of investment in different types of highways. As would be expected, they found that overall rates of return on investment on higher-order highway systems were substantially greater than rates of return on local road and street investment. They did not examine the composition of highway expenditures by purpose, but if they had, they would have found the share of all expenditures going to actual construction falling over time. This could be another factor leading to the declining rates of return on highway investment since nonconstruction expenditures would not be expected to have as significant an effect on productivity or levels of economic activity.

A recent RAND report summarized findings of studies that examined relationships between highway investment and measures of economic performance. They found a consensus that:

- Construction of the Interstate system had large positive effects on U.S. productivity, but those effects have diminished since construction of the system was completed;
- The Interstate system heavily influenced land use development patterns and the suburbanization of the population; and
- Highway infrastructure has caused positive economic outcomes for industries that use it most intensively.

The quality of roads and railroad infrastructure in the U.S. both ranked 20th out of 142 countries, port infrastructure was 23rd and air transport infrastructure was 31st.

RAND also notes that past studies have come to different conclusions on several issues, especially whether current highway investment still has large economic effects now that the backbone of the highway network is largely complete or whether it simply causes a relocation of economic activity without significant net growth.

Recent studies indicate that the international competitiveness of the U.S. is slipping relative to other countries. Many factors contribute to the nation's weakening competitiveness, but transportation has been identified as one important area. A recent study by the Economic Development Research Group concludes that without adequate surface transportation investment, future U.S. exports will fall substantially. In the World Economic Forum's latest Global Competitiveness Report, the U.S. ranked fifth in overall competitiveness,

but the relative quality of transportation infrastructure was considerably lower. The quality of roads and railroad infrastructure in the U.S. both ranked 20th out of 142 countries, port infrastructure was 23rd and air transport infrastructure was 31st. The U.S. ranking for the quality of roads, railroads, and port infrastructure was down from the previous year. Thus, while the U.S. ranked relatively high in overall competitiveness, the quality of its infrastructure was not on a par with other elements of competitiveness.

There is an increasing recognition that improved methods are needed to estimate the full economic impacts of transportation improvements. Traditional user benefit assessments in most benefit-cost analyses do not capture the dynamic developmental impacts of major transportation projects and programs of projects. These impacts may include changes in changes in residential and business location; changes in spatial patterns of production; development of new manufacturing and distribution processes; and the development of new institutions and markets. Macroeconomic models likewise have weaknesses, primarily because they do not reflect the mechanisms through which transportation investment leads to improved economic outcomes. Without understanding how transportation affects various measures of economic performance, it is very difficult to estimate potential impacts of discrete projects or programs of projects in particular locations.

Several years ago the United Kingdom commissioned a study by Sir Rod Eddington to examine long-term links between transport and the UK's economic productivity, growth, and stability. This seminal study found many important links between transportation and economic performance. It concluded that long-term transportation investment should focus on growing and congested urban areas, key interurban corridors, and important international gateways.

The United Kingdom has one of the most rigorous policies with respect to project-level economic appraisal. A significant element of the Eddington study was to review economic analysis methods and identify areas where additional research was required. Among those research priorities were:

- The valuation of time savings and improved travel time reliability;
- The economic benefits of improved freight transportation;
- Mechanisms through which agglomeration economies are realized and methods for estimating the benefits of increased agglomeration;
- Contributions of transport policy and investment in supporting trade; and
- Contributions of transportation attracting foreign investment and globally mobile economic activity.

Despite the large body of prior research, much is not well understood about the economic benefits of transportation investment, especially investments made within the context of a mature transportation system. Communication of what the research does have to offer decision-makers is a particularly important ele-

ment of that research. Numerous areas of future research are identified in the body of this paper that could yield improved information on the benefits of and need for future transportation improvements to serve the needs of the Nation's growing population and to keep the U.S. competitive with other countries that are investing heavily in their transportation infrastructure.

1.0 Introduction and Overview

1.1 BACKGROUND

The objective of this white paper is to document the findings of an exploratory review of the current understanding of the links between transportation and the health of the economy, taking into consideration recent international and domestic trends. In turn, this effort will provide a basis for a subsequent assessment of the gaps in current understanding, and the design for a multiphase program of economic research to clarify the importance of continuing transportation system investment in the United States economy. The ultimate goal of the overall effort will be to inform decision-makers at national, regional, state, and metropolitan levels as to the synergies and tradeoffs with regard to economic growth embodied in funding and financing surface transportation systems.

1.2 SCOPE AND METHODOLOGY

The approach to preparing this white paper was to examine the academic and professional literature to critically assess the industry's body of knowledge as to the linkages between surface transportation and economic growth and vitality. This is an extremely wide field of inquiry and therefore every relevant source could not be included. In selecting material to illustrate the level of understanding that is available to decision-makers, the authors considered:

- National level, network analyses, and other comprehensive analyses, including productivity-oriented analyses;
- State, regional, metropolitan, and local-level analysis (e.g., planning studies); and
- Industry, sector-level, and microeconomic analyses (e.g., business planning studies) from both the user and beneficiary perspectives.

We solicited input from a wide variety of sources and sought to develop a resource that can serve as a step toward building a consensus on the meaning of the economic findings and amplify a future research agenda.

1.3 OVERVIEW

The questions ultimately to be addressed by the study of the available literature supplemented by practitioner understandings incorporated in this white paper include:

10. What are the benefits of transportation improvements and how are they changing as our transportation systems evolve;

What does the literature tell us about the benefits from various types of improvements;

What are the mechanisms through which transportation improvements generate economic benefits; and

Most importantly for this paper, what further research is needed to assist policy-makers and the general public alike in understanding the economic benefits of transportation improvements?

These issues will be addressed in this white paper by:

- Identifying an overall framework to potentially completely consider, accurately assess, and present the benefits in the form of a taxonomy or typology;
- Summarizing the state of knowledge about economic benefits by type of benefit; and
- Summarizing the state of knowledge about benefits by mode and investment type.

Throughout the paper, information is frequently characterized by transportation mode. This segregation is not the result of a desire to deemphasize multimodal aspects, but rather because research knowledge has often been generated by individual mode. Under each discussion category, a first approximation of research needs have been highlighted with the expectation that this will be expanded and clarified with subsequent project activities.

Subsequently, the NCHRP 20-24(80) effort can consider the influence of transportation investment and services in the context of a changing environment wherein the demand for transportation and the systems themselves continue to evolve.

2.0 An Overall Framework for Transportation Benefits in a Mature Economy

2.1 THE VALUE FOR MONEY FRAMEWORK

Over the years countless studies have been conducted to assess the economic benefits of transportation infrastructure investments. More recently, attention has been focused on understanding the entire framework of how transportation investments and policies impact the economy in societies with mature transportation systems. Detailed attention has been focused on the development and application of such an overall framework in the United Kingdom, and this topic also is being addressed in the U.S. and in other industrial nations. Currently, the United Kingdom may be furthest along both in formulating an overall framework and filling in the details of procedures and methods to make economic evaluation a driving factor in transportation investment decisions.

The Value for Money framework has evolved as the broadest formulation of how alternative investments should be evaluated in a mature transportation system.

The evolution of an overall framework for transportation benefits in the United Kingdom has now been described using the nomenclature "Value for Money." This term recognizes that a wide variety of economic and other impacts of transportation investment have positive or negative value in relation to the level of monetary investment represented by the action. The Value for Money framework has evolved as the broadest formulation of how alternative investments should be evaluated in a mature transportation system. There is no magic to the particular nomenclature of value for money. Rather, the framework it describes is intended to deal with all economic and other impacts in a careful and coordinated way, without bias or double counting. As formulated in the United Kingdom, a value for money framework adds broader economic benefits to the travel time savings, vehicle operating cost savings, and other user benefits included in traditional benefit-cost analysis; monetizes other benefits to the extent possible; and includes nonquantitative impacts. This was introduced in 2006 as Sir Rod Eddington completed a study for the United Kingdom Departments for Transport and Treasury to examine transport's role in sustaining the United Kingdom's productivity and competitiveness.

A major part of that seminal "Eddington Report" was devoted to examining the wider benefits of transport improvements beyond those captured in traditional benefit-cost studies. The Eddington Study identified seven microeconomic mechanisms through which transport investment enhances economic activity that can be summarized as:

- Increasing business efficiency through time savings and improved reliability for business travelers, freight, and logistic operations;
- Increasing business investment and innovation by supporting economies of scale or new ways of working;
- Supporting clusters and agglomerations of economic activity;
- Improving the efficient functioning of labor markets, increasing labor market flexibility, and the accessibility of jobs;
- Increasing competition by opening up access to new markets;
- Increasing domestic and international trade by reducing the costs of trading; and
- Attracting globally mobile activity (to the UK) by providing an attractive business environment and good quality of life.

The most important response to the Eddington Report's call for more comprehensive and systematic analysis was the United Kingdom Department for Transport's (DfT) efforts to extend their Transport Appraisal Guidance" (TAG) to include quantification of "wider economic benefits' (WEB) into cost-benefit analysis starting in 2009. "TAG Units" provide guidance for addressing all of the objectives of an investment, and are updated as new research becomes available. In developing its guidance, the DfT was very concerned that there be no double counting of user benefits when wider economic benefits are included in the analysis.

The United States Department of Transportation (DOT) has explored the use of value for money in regards to its investment programs. The development of TREDIS by the Economic Development Research Group might be considered one U.S. response to the challenge of implementing integrated methods to incorporate broader economic impacts into economic analysis.

The framework for broad and careful economic analysis can only be successful to the extent that the various economic impacts of transportation investment are well understood and tools are available to estimate those impacts under different circumstances.

2.2 A TAXONOMY OF TRANSPORTATION BENEFITS

A major purpose for studying and assessing the benefits of transportation investments is to support or guide investment decisions. Benefits examined in studies have varied depending primarily on the purpose of the study and the type, location, and scope of transportation investments being assessed. From a blend of academic and applied research studies, one can isolate several types of studies that form a taxonomy that can be useful in considering the breadth of relevant research and identifying notable gaps. We offer the following structure for purposes of discussion, recognizing that these are not definitive but overlapping and that there is a degree of understanding in one or more areas that helps to inform the others:

11. User benefits, particularly at the project level using benefit-cost analyses;

Employment benefits, in either the short- or long-term derived from a mix of project studies and input/output analyses and used at various scales;

Macroeconomic benefits, frequently using an econometric approach and focusing on the longer-term relationships; and

Broad-base studies that attempt to capture a more complete range of benefits than those typically included in benefit-cost analyses, concentrating on the mechanisms through which transportation improvements benefit local and regional economies.

Project-level user benefit-cost analyses typically focus on the direct benefits of projects to individual users and compare those benefits to project costs. Among the direct benefits to transportation users included in benefit-cost analyses are:

- Travel time savings;
- Improved transportation system reliability;
- Vehicle operating cost savings;
- Reductions in crash-related costs;
- Improved mobility; and
- Accessibility and availability of travel options.

There has been increasing recognition that these user benefits included in project-level benefit-cost analyses do not present a complete picture of the benefits of transportation investment, in particular the benefits that lead to increased economic productivity. For example, the increased productivity of firms that have access to wider labor and materials markets go beyond just travel time savings. Likewise, the value of redundancy and the availability of transportation choices inherent in a system or network have value beyond the individual links and

nodes and conventional notions of reliability. Current project-level analyses that focus on direct user benefits do not capture these benefits.

Employment studies of transportation investment typically have focused on three categories of employment associated with construction and operation of transportation facilities:

- Direct employment of those working on the project itself, including various types of construction workers, engineers, and other staff working for companies directly involved in the project;
- Indirect employment of those working in industries supplying the equipment and materials used in constructing the project; and
- Induced employment of workers supported by the expenditure of wages earned by those directly or indirectly employed by the project.

Of course, the money spent on wages, equipment, materials, and other activities that support direct and indirect employment represents project costs in a traditional benefit-cost analysis. Once the project has been completed and the wages associated with project expenditures have all been spent, no further employment is supported by the act of making the initial transportation investment. However, to the extent that the project contributes to increased economic activity, additional long-term employment growth may result. The employment aspects are not the focus of this paper; however, they are raised here to put short-term benefits into context.

Longer-term macroeconomic studies of the benefits of transportation investment also have been explored. Such studies have been done at both the national and regional levels with an emphasis on investments in individual modes of transport by various levels of government. Benefits correlated with investments and examined in these studies include:

- Lower overall logistics costs;
- Increased output;
- Increased economic productivity; and
- Improved international competitiveness.

Most macroeconomic analyses do not explain the mechanisms by which transportation investment increases output and productivity, and thus are of somewhat limited use in assessing the potential benefits of specific new investments. Many also suffer because macroeconomic relationships between transportation investment and economic productivity in the past may not hold for future transportation investments in a different context.

Broader-based approaches attempt to bridge the gaps between the first three types above. The broader economic benefits (introduced above in the context of value for money analyses) studied include:

- Changes in land use and business location to take advantage of improved accessibility;
- Improved access to specialized labor and other factors of production; and
- The agglomeration of economic activity associated with transportation improvements.

Agglomeration is a term denoting the benefits arising from improved linkages between related economic entities that allow those entities to operate more efficiently.

It should be noted that while there is some general agreement that these broader economic benefits of transportation investment should be considered when assessing the full benefits and costs of transportation improvements, there has been concern that our ability to quantify those benefits is limited without double-counting those benefits that simply reflect travel time savings or other user benefits already included in benefit-cost analyses. Studies have examined impacts of completed projects and estimated their broader economic benefits using statistical and economic analysis techniques, but further research is needed to credibly predict the broader benefits of new investments.

One reason that predicting land use and agglomeration effects of transportation improvements is difficult is that other factors may simultaneously influence those changes such as overall market conditions and other public policy incentives intended to promote economic growth and development. That explains why transportation can contribute significantly to economic development in some areas but not in others. Another confounding factor that affects our ability to estimate the economic benefits of transportation is that economic development adjacent to a transportation improvement in one location may simply have stayed in or moved to another location if the transportation improvement had not been made. Estimating how much net new development will be stimulated by a proposed transportation improvement is difficult.

While the focus of this project is on the economic benefits of transportation investment, it is important to recognize that transportation improvements may generate positive or negative environmental impacts and other positive or adverse impacts that also must be evaluated in making investment decisions. Mitigating any negative impacts often adds significant costs to major transportation projects, especially in urban areas.

Some adverse impacts associated with transportation improvements relate to economic benefits discussed above. For instance, impacts on land use and business location decisions, while they may have a net positive impact, may have adverse impacts on areas from which economic activity is attracted. For example, highway improvements in the suburbs often are criticized for drawing economic activity away from the central city and contributing to sprawl.

3.0 Economic Benefits to Users of Transportation Infrastructure

Benefits of transportation investment thus may be viewed from several different perspectives, often depending on the purpose and thus scope of the analysis. The following section of this paper summarizes representative literature where the user benefit has been the focus. Research on the economic benefits of transportation investment that directly accrue to transportation users has been conducted primarily to support improvements in benefit-cost analyses used to support project-level investment decisions. Our goal is to cover the treatment for all surface transportation modes; however, we recognize that the literature is dominated by highway-oriented studies.

Users defined. As a point of clarification, there are various classes of transportation system users that may be more or less important based on the context and orientation of the analysis. Users may include an individual driver/passenger who travels in an automobile for personal reasons, a passenger in a multipassenger vehicle such as bus traveling for personal reasons, or a driver/operator who operates a commercial vehicle professionally for the direct benefit of a commercial enterprise and indirectly for its customers. For freight transportation, shippers and receivers of goods also may be considered users of freight transportation. Even though they do not directly operate vehicles on the system, they are the ones who make many of the decisions regarding mode and service choices and are most affected by transportation improvements.

For all of these users, benefits generally relate to the quality of access and mobility as reflected in travel time savings, improved travel time reliability, vehicle operating cost savings, and reduced crash costs. Transit and passenger rail analyses also may include benefits of improved mobility and the availability of transportation options, especially for users who cannot drive, as benefits of investment in those modes. Considerable research has been conducted to improve estimates of the value users place on time savings, but less research has been conducted on the economic value of other user benefits. User benefits generally are well understood, notwithstanding complexities in the valuation of some benefits.

3.1 TRAVEL TIME SAVINGS

The U.S. DOT recently updated its guidance[22] for the valuation of travel time savings based on a detailed review of the literature. This guidance summarizes findings of travel time studies from around the world and concludes that, while there is a broad consensus on the approach to valuing travel time savings and general agreement on the values to be used, there still is some arbitrariness in the relative value of time savings for different types of trips. The greatest agreement is on the value of time savings for business travel, which generally is valued at the average wage rate. Values of time savings for nonbusiness travel are generally valued at some percentage of the wage rate, and but that percentage is somewhat arbitrary. The U.S. DOT guidance recommends valuing business travel at 100 percent of the median gross wage of travelers in the region for both local and intercity trips. Values for personal travel are lower and vary according to whether the trip is local or long distance. Local travel for nonbusiness purposes is recommended to be valued at 50 percent of the median gross wage, whereas intercity travel for nonbusiness purposes is valued at 70 percent of the gross wage. The report notes that these values are on the high side of values estimated in other studies.

The U.S. DOT guidance on the value of travel time savings points out that individuals' valuation of travel time savings can vary considerably, even when the trip purpose and personal incomes are the same.

The U.S. DOT guidance on the value of travel time savings points out that individuals' valuation of travel time savings can vary considerably, even when the trip purpose and personal incomes are the same. Statistical analysis conducted by Small, Winston, and Yan of revealed-preference and stated-preference data from users of State Route 91, a congestion-priced facility in the Los Angeles region, supports this conclusion.[23] Information on the distribution of the willingness to pay for travel time savings is important for congestion pricing since without differences in the willingness to pay for travel time savings, congestion pricing policies would not work. With high congestion charges, few would choose to use a priced facility. Once tolls were reduced to the point where they were lower than

[22] U.S. Department of Transportation, "The Value of Travel Time Savings: Departmental Guidance for Conducting Economic Evaluations Revision 2," Washington, D.C., 2011, http://ostpxweb.dot.gov/policy/reports/vot_guidance_092811.pdf.

[23] Small, Kenneth, Winston, Clifford, and Yan, Jia, "Uncovering the Distribution of Motorists' Preferences for Travel Time and Reliability," Los Angeles, 2005, http://www.socsci.uci.edu/~ksmall/Value%20of%20time%20note.pdf.

the value of time savings, large numbers of users would divert to the priced lanes, leading to congestion. The willingness to pay for time savings can be expected to vary depending on unique characteristics of the traveler, the trip, and travel choices available. The authors conclude that differences in the value that users place on travel time and reliability allows policy-makers to implement value pricing in new ways that could be more popular with the public as well as more efficient.[24]

The Transportation Research Board's (TRB) Transportation Economics Committee discussed the importance of improved understanding of the distribution of the value of travel time savings (VTTS) for different groups of users in a 2007 Research Needs Statement.[25] The Research Needs Statement notes that the value of time savings can vary for the same individual from one trip to the next depending on trip purpose, the magnitude of time savings, who pays, and other factors. Three specific areas of future research were identified as follows:

- Advancing theory and empirical evidence about the distributions of VTTS for populations and for major subgroups of travelers in different settings, including the distributions of VTTS for different types of commercial travel.
- Advancing theory and empirical evidence concerning variations in VTTS for particular individuals for different trip types and different travel situations. Included among considerations meriting attention is the potential nonlinearity of VTTS with respect to the amount of time saved per trip (e.g., the value of 15 minutes saved is probably not 5 times the value of 3 minutes), and the need to distinguish the benefits of time savings due to operational improvements from the benefits of improved trip time reliability.
- Developing models and valid procedures for aggregating disaggregate information about VTTS distributions in order to provide accurate estimates of how the typical population traveling during a given time period in a given corridor or facility will respond to alternative pricing options, for example, pricing based on time-of-day and vehicle occupancies.

Recent research by Shaw, et al., found that the VTTS for those late for an appointment may be 300 percent higher than for a regular trip.[26] Based on this finding they conclude that the VTTS used in evaluating High Occupancy Toll

---

[24]Small, Kenneth, Winston, Clifford, and Yan, Jia, "Differentiated Road Pricing, Express Lanes, and Carpools: Exploiting Heterogeneous Preferences in Policy Design," 2006 http://www.socsci.uci.edu/~ksmall/Diff_Pricing_Paper.pdf.

[25]Transportation Research Board, "Distribution of the Value of Travel Time Savings," Research Needs Statement, Washington, D.C., 2007, http://rns.trb.org/dproject.asp?n=13545.

[26]Shaw, W. Douglass, Sunil Patil, Mark Burris, and Sisinnio Concas, "Variation in the Value of Travel Time and its Impact on the Benefits of Managed Lanes," *Transportation Planning and Technology,* Vol. 34, pages 547-567, 2011.

Lane projects and other managed lane projects is likely too low if average VTTS estimates are used, because a portion of managed lane users only use the lanes when they have to be on time.

3.2 TRAVEL TIME RELIABILITY

The ability to predict travel time for both passenger and freight transportation has received increased recognition in recent years as an important quality and is now starting to be included in benefit-cost analyses. Reliability is a measure of the dispersion of the travel time distribution for a given transportation facility. Variations in travel time are often the result of one or more sources of nonrecurring delay that cause travel times to vary from average levels when no incidents or other sources of nonrecurring delay are present. Congestion compounds the effects of incidents and makes travel times more difficult to reliably estimate. When travelers cannot reliably predict their travel times, they face risks (and potential costs) of either arriving at their destination later than expected if they do not leave enough time for unexpected delays, or of arriving earlier than expected if nonrecurring delays do not occur on particular trips (and thus absorbing the nonproductive cost of the "buffer time"). The cost of arriving either too late or too early varies among individuals and across trip purposes.

Considerable research has been done on measuring reliability and assessing strategies to improve reliability. A major initiative under the Strategic Highway Research Program 2 (SHRP 2) focuses reliability. Webinars and workshops have been conducted to share research findings and several pilot projects are underway to assess research products. Research also has been conducted specifically to improve estimates of the value of travel time reliability that should be used in benefit-cost analyses. A web site maintained by the Transportation Research Board's Transportation Economics Committee summarizes the use of reliability in benefit-cost analysis in different countries.[27]

Values assigned to travel time reliability vary considerably among countries. In Australia the ratio of the value of travel time reliability to the value of travel time is 1.3 for automobiles, while for transit the value is three times the value of time. In France one researcher estimated the value of travel time reliability at from two to 20 times the value of time for automobile travel. For transit, a value six times the value of time is used in France. Research on the value of travel time reliability is still underway in Japan. Draft guidance in the United Kingdom recommends measuring delay in terms of the standard deviation in travel time and valuing each minute of standard deviation equal to 0.8 times the value of a minute of travel time. For transit the measure of reliability is the average number of minutes a transit vehicle is late. Each minute of lateness is valued at three

[27] http://bca.transportationeconomics.org/benefits/travel-time-reliability/reliabilityandbca.

times the value of a minute of travel time. Because of uncertainties in these values, the UK does not include reliability in the approved Value for Money appraisal process for highway projects. A study of the wider benefits of transportation improvements done in connection with the Eddington Transport Study in the UK concluded that further research was needed to improve the understanding of the implications of enhanced travel time reliability.[28]

Travel time reliability is especially important for freight transportation since carriers often have discrete windows within which they are required to make deliveries. Travel time reliability related to freight transportation is discussed in more detail below.

Travel time reliability is a particularly important issue when examining mature transportation systems in metropolitan areas because there often are limited opportunities for increasing capacity to reduce the severity of delays associated with congestion. Travel time reliability also can be an issue in rural areas, especially around work zones or when severe weather causes delays.

Despite the growing recognition that travel time reliability is major component of user costs, it has not been routinely considered in economic analyses of highway investments. Ignoring reliability in these analyses means that a significant portion of user benefits has not been captured, leading to an under valuation of transportation investments. This is especially true for a mature highway system where demand management and operational strategies are used as congestion treatments, given the economic and environmental constraints of adding physical capacity. Fortunately, research is currently underway in the SHRP 2 program to account for reliability in investment decisions

3.3 OPERATING AND SAFETY COSTS

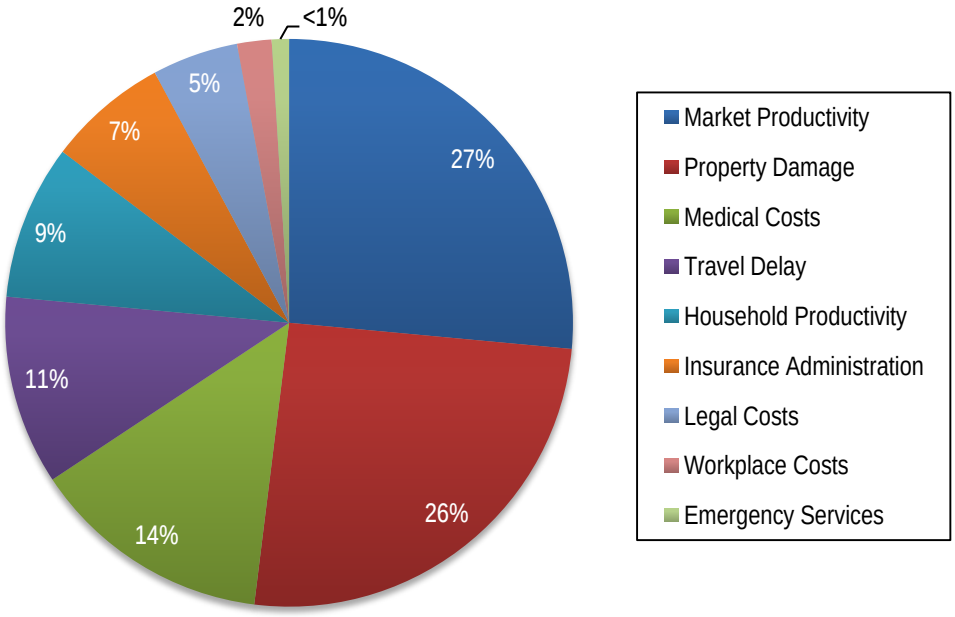
Two major categories of user benefits typically found in benefit-cost analyses are vehicle operating costs and reduced crash-related costs. Investments to improve both the performance and condition of the highway system can reduce highway vehicle – both commercial and passenger vehicles – operating costs. The largest impact of improvements in highway performance is to reduce vehicle fuel consumption by smoothing the flow of traffic. Investments to improve highway condition primarily affect tire wear and vehicle maintenance costs, although vehicle operating costs on badly deteriorated pavements are higher than on smooth surfaces.

Many transportation investments have important safety benefits. Some improvements are made specifically to correct safety deficiencies of the infrastructure, but in other cases improved safety is a subsidiary benefit of

[28] MVA, "Wider Economic Impacts of Transport Interventions," Appendix to Eddington Transport Study, 2006.

investments intended primarily to improve the condition or performance of the transportation system. Considerable research has been done on the economic cost to society of traffic crashes. The most comprehensive analysis is the National Highway Traffic Safety Administration's (NHTSA) study, *The Economic Costs of Motor Vehicle Crashes 2000.* Figure 3.1 illustrates the breakdown of crash costs by category. The largest components of the cost to society are lost market productivity (including lost labor) and property damage. The report estimates only about a quarter of these costs are paid by those involved in the crash; the rest are borne by society through insurance premiums, higher taxes, and other means. These estimates do not include the cost of pain and suffering associated with traffic crashes.

Figure 3.1 Share of Economic Costs by Motor Vehicle Crash Type *2000*



Source: U.S. Department of Transportation, National Highway Traffic Safety Administration, *The Economic Impact of Motor Vehicle Crashes 2000* (Washington, D.C., 2002), available at http://www.nhtsa.dot.gov/people/economic/, as of December 2002.

Many studies have attempted to place a monetary value on individual injuries and fatalities using a variety of techniques, including wage premiums for high-risk occupations and purchases of safety improvement products. The NHTSA report notes, "These willingness-to-pay costs can be an order of magnitude higher than the economic costs of injuries. Currently, most authors seem to agree that the value of fatal risk reduction lies in the range of $2 to $7 million per life saved" in 2000 dollars. The Federal Highway Administration (FHWA) recently updated its official estimate of the value of an avoided fatality to $6 million in 2009 dollars, using a willingness-to-pay approach. This estimate

includes 11 types of costs: property damage, lost earnings, lost household production, medical costs, emergency services, travel delay, vocational rehabilitation, workplace costs, administrative, legal, and pain and lost quality of life.[29] FHWA also places lesser values on avoided injuries.

The economic costs of traffic crashes are well-established. Further research would be beneficial to quantify the crash-reduction benefits of safety improvement strategies, especially for less-studied strategies such as behavioral modification and emergency medical response. NCHRP 622: *Effectiveness of Behavioral Safety Strategies,* defines research needs in this area. In addition, AAA recently prepared an update of the study, *Crashes verses Congestion – What's the Cost to Society?*, which suggests the costs to society of crashes are greater than the cost of congestion. The study also reveals further research is needed to more fully understand the relationship between crashes and congestion and opportunities to make investment decisions explicitly considering both issues.

Most of the work on the economic costs of transportation crashes has been done for highway crashes, but much of the highway work would be transferrable to other modes.

3.4 MODAL PERSPECTIVE: TRANSIT INVESTMENT

APTA indicates that 17 new light rail, heritage light rail, and streetcar systems; 10 new commuter rail lines; one new heavy rail system; and seven new busways have opened since 1995.

While the research summarized above might have been intended to draw conclusions concerning surface transportation infrastructure in general, much of the research has focused on the user benefits of highway investment. There is a growing body of research that examines the economic benefits of investment focusing specifically in transit. Since 1995, transit passenger trips have grown at a faster rate than either highway vehicle miles of travel or overall population.[30] The American Public Transportation Association (APTA) indicates that 17 new light rail, heritage light rail, and streetcar systems; 10 new commuter rail lines; one new heavy rail system; and seven new busways have opened since 1995. During the same period many existing systems have been extended, including 7

[29] FHWA Circular T7570.2, *Motor Vehicle Accident Costs (1994),* and the U.S. DOT Memorandum, *Treatment of the Economic Value of a Statistical Life in Departmental Analysis,* 2009, Annual Revision.

[30] American Public Transportation Association, "The Case for Business Investment in Public Transportation," Washington, D.C., 2009, http://www.apta.com/resources/reportsandpublications/Documents/case_business_investment_pt.pdf.

busways; 9 commuter rail systems; 18 heavy rail systems; and 71 light rail, heritage light rail, and streetcar systems.

In a 2009 study for APTA[31], Weisbrod and Reno identified a wide range of long-term economic benefits of public transportation investment that cover all four elements of the typology described above, including:

- Travel and vehicle ownership cost savings for public transportation passengers and those switching from automobiles, leading to shifts in consumer spending.
- Reduced traffic congestion for those traveling by automobile and truck, leading to further direct travel cost savings for businesses and households.
- Business operating cost savings associated with worker wage and reliability effects of reduced congestion.
- Business productivity gained from access to broader labor markets with more diverse skills, enabled by reduced traffic congestion and expanded transit service areas.
- Additional regional business growth enabled by indirect impacts of business growth on supplies and induced impacts on spending of worker wages. At a national level, cost savings and other productivity impacts can affect competitiveness in international markets.

Similarly, Litman[32] identifies five categories of transit benefits: mobility benefits, efficiency benefits, travel time impacts, land use impacts, and economic development impacts. He says that mobility benefits result from additional personal travel that would not otherwise occur particularly for the transportation disadvantaged who cannot drive personal vehicles for whatever reason.

ECONorthwest and Parsons Brinckerhoff Quade & Douglas (PBQD) developed a guidebook, *Estimating the Benefits and Costs of Public Transit Projects* under the Transit Cooperative Research Program.[33] The guide discusses in detail various issues related to benefit-cost analyses for public transportation projects. Since many benefits of transit improvements are associated with impacts of those improvements on highway users, they point out how important good multi-

---

[31] Weisbrod, Glen and Arlee Reno, "Economic Impact of Public Transportation Investment," Prepared for: American Public Transportation Association, October 2009, http://www.apta.com/resources/reportsandpublications/Documents/economic_impact_of_public_transportation_investment.pdf

[32] Litman, Todd, *Evaluating Public Transit Benefits and Costs, Best Practices Guide,* Victoria Transport Policy Institute, 2011.

[33] ECONorthwest and Parsons Brinckerhoff Quade & Douglas, *Estimating the Benefits and Costs of Public Transit Projects: A Guidebook for Practitioners,* TCRP Report 78, Washington, D.C., 2008.

modal travel demand models are for estimating impacts of public transportation improvements. The report concludes that benefit-cost analysis has limitations for the assessment of transit projects. Many of transit's impacts are difficult to measure let alone quantify in monetary terms. Furthermore, the distribution of those impacts across different population groups may be more important than the absolute value of the impacts.

3.5 MODAL PERSPECTIVE: ECONOMIC BENEFITS OF RAILROAD IMPROVEMENTS

The major freight railroads are privately held companies that own their own right-of-way and equipment and are responsible for all operations and maintenance activities. They are responsible for maximizing shareholder value and will invest only when that investment will be profitable. Nevertheless they interact with other elements of the national transportation system and in some cases have granted permission for their right-of-way to be used for intercity passenger service. Increasingly, the benefits of public investment in the private railroad system are being recognized.

A 2005 study conducted under the National Cooperative Highway Research Program[34] analyzed methods for estimating public benefits of investment in freight rail projects. The study combined a series of case studies with an assessment of methods and models that have been developed to assess benefits of investment in freight projects to develop a framework for establishing the public benefits of investment in freight rail capacity. The 11 cases studied found a wide-ranging variety of public benefits from investment in rail facilities. Those benefits are summarized as follows:

- Economic:

  Attracts New Business;

  Avoids Business Relocation Costs;

  Avoids or Delays New Highway Construction;

  Creates New Jobs – Direct;

  Creates New Jobs – Indirect;

  Keeps or Expands Existing Business;

  Expands Regional/National Economy;

  Increases Revenue (Recurring Stream or Taxes);

[34] Cambridge Systematics, Inc., *Return on Investment on Freight Rail Capacity Improvement,* NCHRP 8-36, Task 43, 2005, http://rail.transportation.org/Documents/task43.pdf.

Reduces Highway Maintenance Costs;

Reduces Shipper Logistics Costs; and

Retains Existing Jobs.

- Environmental:

  Improves Air Quality;

  Lowers Noise Levels; and

  Reduces Fuel Usage.

- Safety/Security:

  Improves HazMat Safety/Security;

  Improves Security;

  Reduces Accidents; and

  Upgrade to Meet Safety/Security Standards.

- Transportation:

  Eliminates Bottleneck;

  Heavy Trucks Removed From Highways;

  Improves Competitiveness;

  Improves Carrier Efficiencies, Reduces Costs;

  Improves Service Reliability;

  Increases Capacity;

  Reduces Highway Delays;

  Reduces Passenger Rail Delays;

  Reduces Freight Rail Delays; and

  Upgrade to Meet Industry Standards.

- Other:

  Has National Significance; and

  Minimizes Community/Construction Impacts.

All of these benefits, of course, are not realized from every public investment in rail. In the case studies the most frequent benefits cited were removing heavy trucks from highways and the related benefits of reducing accidents, reducing highway delays, improving air quality, and reducing highway maintenance costs. In some case studies the benefits were quantified, but in others benefits were only analyzed in qualitative terms. Most benefits listed above were quantified in at least one case study. As noted above, diversion of traffic from highway

to rail is one of the most often cited benefits of public investment in rail. The public benefits of moving freight off the highways and onto rail accrue to:

- Other highway users who experience reduced delay, reduced vehicle operating costs, and reduced crash costs;
- Public agencies that have lower costs to maintain highways in a state of good repair; and
- The general public that is exposed to lower air pollution and noise.

The magnitude of these benefits is directly related to the volume of truck traffic projected to divert to rail. The U.S. Department of Transportation's Comprehensive Truck Size and Weight Study (CTS&WS) discusses factors that affect shipper mode choice. Those factors include:

- **Transit time –** the time required to move a shipment between origin and destination;
- **Service quality –** the reliability of transportation services;
- **Asset productivity –** ensuring that all aspects of transportation operations are operating efficiently;
- **Carrier use –** contractual and other partnership arrangements between shippers an d carriers are becoming more common and more important; and
- **Customer satisfaction –** ensuring that transportation services contribute to overall customer satisfaction between the shippers and customers.

The importance of these factors will vary from commodity to commodity and from market to market, but in the case of rail investment aimed at diverting truck traffic to the railroads, the investment must significantly change one or more of these factors before it could be expected to cause any substantial diversion. Other factors also affect the choice between rail and truck, especially shipment size, shipment distance, commodity value per ton, product density, and lane density (tons shipped in a particular corridor annually). In general, shipments shorter than 400 to 500 miles are dominated by truck and it is difficult for rail to compete at such distances except for low-value, high-density shipments in corridors with high lane densities.[35]

There has not been nearly as much research on modal diversion for freight as there has been for passenger traffic. The U.S. DOT has developed an Intermodal Transportation and Inventory Cost Model to analyze potential mode shifts in freight as the result of a variety of potential policy interventions. This model was used in the Department's CTS&WS noted above and several other recent studies

[35] U.S. Department of Transportation, *Comprehensive Truck Size and Weight Study,* Washington, D.C., 2000, http://www.fhwa.dot.gov/reports/tswstudy/TSWfinal.htm.

to assess potential diversion from truck to rail associated with railroad capacity improvements. The model documentation[36] notes that:

> *"The factors influencing a shipper's choice of mode are complex and highly interdependent….They involve tradeoffs between the cost of transportation and overall transit time and delivery reliability, but there are more subtle underlying factors. Research reveals that the principal decisions in this mode selection process are those that affect the receiver of the goods rather than the shipper….The most important tradeoffs involve the annual use of a product by the receiver. High annual use of a product allows the receiver to order large replacement shipments and to take advantage of the low transport costs afforded by economies of scale in shipping associated with large shipment sizes. High value of the product imposes a penalty to ordering more than can be readily used by tying up capital in inventory. Excess inventory can be avoided by ordering product more frequently in smaller shipment sizes. Small shipment sizes carry their own penalties. Ordering is a costly process. Smaller shipment sizes typically carry high unit cost of transportation, and if the shipment size is smaller than a full vehicle load, the load must be picked up at the origin by the freight carrier and consolidated before shipment, then deconsolidated and delivered at the destination end. Most LTL (less than truckload) trucking, parcel carriers and air-freight systems perform consolidation/deconsolidation of smaller shipments into full vehicle loads. The consolidation and deconsolidation processes also are expensive, sometimes exceeding the cost of line haul transportation."*

The Heartland Corridor is an example of a recent rail improvement project to increase rail capacity, reduce truck traffic and associated energy consumption and environmental emissions, and stimulate economic development in a multi-state corridor. The $321 million project increased clearances in 28 tunnels to allow double-stack trains to operate between the Port of Norfolk and Columbus, Ohio and on to Chicago. Travel time between Norfolk and Chicago has been reduced by one-third from three days to two days.[37] The Heartland Corridor project is a public-private partnership involving the Norfolk Southern railroad, the states of Virginia and Ohio, and the Federal government.

---

[36] U.S. Department of Transportation, *ITIC-IM Version 1.0 Intermodal Transportation and Inventory Cost Model Highway-to-Rail Intermodal User's Manual,* 2005, http://www.fra.dot.gov/downloads/Policy/ITIC-IM%20documentation%20v1_0.pdf.

[37] *The TransportPolitic,* "New Heartland Corridor Increases Freight Capacity between East Coast and Chicago," 2010, http://www.thetransportpolitic.com/2010/09/13/new-heartland-corridor-increases-freight-capacity-between-east-coast-and-chicago/.

Virginia also considered potential railroad improvement options in its study of alternatives for improving the I-81 corridor, a heavily used freight corridor. A rail diversion study conducted by the Virginia Department of Rail and Public Transportation found significant potential to divert truck traffic to rail if rail improvements were made, but rail improvement would be required in other states to achieve maximum diversion.[38] The rail improvement option ultimately was dropped in favor of targeted capacity additions to I-81.

3.6 MODAL PERSPECTIVE: ECONOMIC BENEFITS OF THE INTERSTATE HIGHWAY SYSTEM

Numerous reports have been written concerning the benefits of the Interstate Highway System. A detailed analysis of those studies is beyond the scope of this white paper, but the types of benefits analyzed in those reports are summarized below. Some of these impacts are unique to the development of a major new transportation system that provided quantum improvements in service for passenger and freight transportation performance. Other impacts are relevant to future research on the benefits of transportation investment in a mature transportation system where incremental improvements will be made that nonetheless may affect broader parts of the network.

Cox and Love, in a report issued on the 40th anniversary of the Interstate system summarize impacts of the Interstate Highway System on the economy, safety, quality of life, and national defense.[39] No new empirical research was conducted for this study, but the authors draw upon some of the research cited above. They note that the Interstate Highway System contributed to economic efficiency and productivity in the following ways:

- By increasing speed and expanding access, freight costs have been reduced substantially. Tractor-trailer operating costs have been estimated at 17 percent lower on interstate highways than other highways.
- The Interstate Highway System made less expensive land more accessible to the nation's transportation system and encouraged development.
- The travel time reliability of shipment by Interstate Highway has made "just in time" delivery more feasible, reducing warehousing costs and adding to manufacturing efficiency.

---

[38] Virginia Department of Transportation, *I-81 Corridor Improvement Study, Freight Diversion and Forecast Technical Report,* Richmond, 2007, http://www.virginiadot.org/projects/resources/Freight%20Final.pdf.

[39] Cox, Wendell and Jean Love, *The Best Investment a Nation Ever Made, A Tribute to the Dwight D. Eisenhower System of Interstate and Defense Highways,* American Highway Users Alliance, 1996, http://www.publicpurpose.com/freewaypdf.pdf.

- By broadening the geographical range and options of shoppers, the Interstate Highway System has increased retail competition, resulting in larger selections and lower consumer prices.
- By improving interregional access, the Interstate Highway System has helped to create a genuinely national domestic market with companies able to supply their products to much larger geographical areas, and less expensively.

With respect to safety they estimate that travel on the Interstate system saved 187,000 lives between 1957 and 1996 and avoided costs of $368 billion associated with reduced fatalities and injuries during that time period. Cox and Love say that the Interstate Highway System has improved quality of life in the following ways:

- Reduced travel times;
- Expanded mobility;
- Democratization of mobility;
- Expanded employment freedom;
- Expanded residential freedom;
- Ease of making multipurpose trips;
- Empowerment of the poor;
- Lower retail prices;
- Improved access to health care;
- Improved air quality;
- Improved security; and
- Improved access to leisure activities.

The economic value of these various benefits is not quantified and many might be realized from other types of transportation improvements as well, but the breadth of the benefits cited is an indication of just how central transportation is to many of our day-to-day activities. Impacts of the Interstate Highway System have been examined by many other authors as well.[40,41,42] Impacts have not

---

[40] PB Consult, "Technical Memorandum Task 2: The Economic Impact of the Interstate Highway System," NCHRP Project 20-24 (52) "Future Options for the National System of Interstate and Defense Highways," 2006, http://www.interstate50th.org/docs/techmemo2.pdf.

[41] HISTORYnet.com, "President Dwight Eisenhower and America's Interstate Highway System," 2006, http://www.historynet.com/president-dwight-eisenhower-and-americas-interstate-highway-system.htm.

always been as universally positive as those cited by Cox and Love. For instance Armbruster discusses the role that the Interstate Highway System had on the decline of the central city.[43] He notes:

> *"The IHS has proved both a blessing and, frankly, a disaster to the United States. When managed properly and efficiently a regional metropolitan network built around interstate highways creates a highly mobile economy and provides the freedom and convenience of personal transportation and the capacity necessary for freight transportation. However, it is almost never managed properly and produces such pejorative effects as congestion due to much too many private automobiles operating within a specific 'trip area'; pollution due to the carbon emissions of automobiles, economic losses due to lost economic productivity (a direct product of congestion) and constant upkeep; and a semiurban landscape that emphasizes anonymous architectural design and is at best a poor generator of healthy communities."*

Chandra and Thompson examined the impact of rural Interstate highways on economic activity.[44] Their analysis, using county-level data from the entire continental United States, assessed the impact of major new highways on economic activity in rural counties through which they pass. In analyzing these economic impacts, Chandra and Thompson also examined the extent to which economic growth in counties with the new Interstate highways came at the expense of counties further away. They found that total earnings in rural counties with Interstate highways grew faster than earnings in all other rural counties. However earnings in counties adjacent to Interstate counties fell relative to other rural counties. They conclude that the net effect of a new Interstate on regional growth is essentially zero. Another part of their analysis dealt with the relative impact of new Interstate highways on different industries. Industries that rely on transportation generally were found to benefit from new highway construction, but the impact is more ambiguous for other industries.

---

[42] Deakin, Elizabeth, *The Social Impacts of the Interstate Highway System,* The University of California Transportation Center, 2006, http://www.sortclearinghouse.info/cgi/viewcontent.cgi?article=1302&context=research.

[43] Armbruster, Andrew, "The Interstate Highway System Its Development, and Its Effects on the American Spatial, Economic and Cultural Landscape," 2005, http://www.emich.edu/studentorgs/place/Officers/andrew/Econ%20375%20-%20The%20Construction%20of%20the%20IHS-B.pdf.

[44] Chandra, Amitabh and Eric Thompson, "Does Public Infrastructure Affect Economic Activity? Evidence from the Rural Interstate Highway System," *Regional Science and Urban Economics* Vol 30, pp. 457-490, 2000.

Earnings in manufacturing, retail trade, services, transportation, communications, and public utilities increased in counties through which an Interstate passes. In adjacent counties, manufacturing earnings rose, but retail trade and government earnings fell.

Results of these and other studies highlight the fact that the Interstate Highway System is not in-and-of-itself the progenitor of urban sprawl; but rather urban sprawl was created when we began to exploit the system in order to satisfy mass consumption and various methods of obtaining profit, and because of lax zoning standards and regional control.

Others have discussed the impact of the Interstate Highway System on suburban development patterns and linked its construction to the decline of the central city. Like this paper by Armbruster, most have concluded that construction of the Interstate system was one of several factors contributing to the movement of residential development and jobs to the suburbs.

Finally, research has been done on the maintenance, expansion, and extension of the highway system supporting the Interstate Highway System through connector roads, bypasses, and other investments that would and do keep the Interstate Highway System to some degree relevant to current and future trends. The U.S. SHRP 2 funded 100 pre/post case studies[45] of the economic and land development impacts of highway and highway/intermodal projects to establish standards for a national database of pre/post case studies including requirements for: a) pre/post impact comparison; b) coverage of both local and regional level impacts; c) a wide range of alternative perspectives for viewing and measuring impacts; d) comparison of local changes over time relative to reference sources such as state trends; and e) reliance on both quantitative data and qualitative observations regarding local economic conditions.

The study focused on 10 different forms of highway system expansion, including the development of major highways, beltways, connector routes, bypasses, bridges, interchanges, industrial access roads, highway widening projects, intermodal freight terminals, and intermodal passenger terminals. Overall, project costs ranged from around $2 million for small industrial park access roads to over $5 billion for some major interstate highways (and even higher if megaprojects such as the Oresund Bridge and Boston's Central Artery are included). Projects also varied from one to 244 miles in length. All 100 cases had measures of job impact, with 85 showing evidence of a positive change in jobs for the impact area, while two (both rural bypasses) had a negative change. For all other impact elements, between 36 and 74 percent of the cases had observations

[45] EDR Group. "SHRP 2 Project C03 Interactions between Transportation Capacity, Economic Systems and Land Use: Final Report." Highway Economic Impact Case Study Database and Analysis Findings, October 2011, http://www.edrgroup.com/pdf/SHRPC03FinalReport.pdf.

regarding the direction of impact, and in all of those cases the reported direction of impact was positive.

The common lesson for future project planning from the SHRP study is that contextual factors are key determinants of the timing, nature, and magnitude of economic impacts from transportation projects. Foremost among the contextual factors are elements that are (or can be) within the control of planners and governmental officials. They include an effective planning process that builds on a shared vision for development and an ability to achieve consensus among local agencies and developers regarding economic development goals. This can include actions such as zoning policy, investment in complementary sewer/water infrastructure investments and project planning integrated with broader public investment and private development efforts. The following conclusions were drawn from the case studies:

- **With supporting policies, highways can shape land development in desired ways.** Some types of projects, particularly beltways and bypasses, can have a profound impact on the spatial pattern of regional growth and development. Such projects can influence patterns of real estate demand and prices, affecting quality of life, availability of support services, and a community's tax and employment bases. Land use impacts of major highway infrastructure need to be anticipated and planned for, particularly in growing areas. In the more successful case studies, these impacts have largely been anticipated and planned. In the absence of supporting policies, however, desired economic development is much less certain.

- **Zoning and site preparation can enable or prevent economic development impacts.** If a local area is to achieve maximum economic impacts from a new transportation project, one critical requirement is that the surrounding area must offer a good supply of sites available for development (or redevelopment). Conversely, a community desiring to prevent new development can act to block sites from being available. Either way, the most effective way to control the development outcome is then by: a) enabling zoning to define allowable forms of development; and then b) ensuring that infrastructure availability and site preparation will support the allowable uses. These basic statements apply for all forms of transportation projects, though they are most immediately applicable for projects that open up access to specific land sites. Such projects include town bypasses, access routes to economically depressed urban areas, highway interchanges, and intermodal facilities.

- **Real estate market conditions can accelerate or delay development impacts.** Some factors affecting project impacts are not fully within the control of public officials or private parties. Prominent among these factors is the local real estate market, which can be affected by national and global economic trends, as well as regional growth and competitiveness conditions. As a general rule, transportation access and travel time enhancements help attract large scale commercial and industrial investments (and hence generation of

new jobs) most quickly in areas where there is an trained workforce, available sites for business location, and strong economic conditions that support expansion of demand for business products and services. In areas that are economically depressed or otherwise lacking in some of those factors, the economic impacts of transportation projects may unfold at a slower rate.

- **A shared vision among stakeholders enables development impacts.** Local projects such as passenger intermodal (transit) stations, new urban bridges and urban roadway interchanges can attract business investment to adjacent areas where the access enhancement is most pronounced. However, when that enables significant new building development, then it becomes important to ensure that there is a common vision for the area. Visioning can thus be considered a tool for gaining consensus on the future of an area in which a new transportation project is planned. This exercise allows all interested parties, including local planning authorities, regional and state funding authorities, developers, and other interested agencies, to develop and agree on a clear vision for the future of the site. The case studies provide examples of both success and failure in establishing development visions for the areas of local transportation terminals, and they show that greater development occurs when such a vision is in place.
- **Effective interagency coordination can facilitate development impacts around intermodal facilities.** Intermodal centers have particularly high need for coordination, which must take place at two levels. One level of coordination is among stakeholders in transportation terminal operations and use, including those responsible for roads and parking, as well as the applicable freight rail or rail transit operating organizations. The other level of coordination is among stakeholders in land and building development, including both government agencies and private businesses.
- **Effective integration with larger projects can increase development impacts.** Transportation investments made as part of larger development projects can have more profound economic impacts than those undertaken as solo projects.
- **Projects aimed at supporting target growth industries can be particularly effective.** Some transportation projects are designed to meet the needs of specific industries that already are growing and already proven to be particularly important job generators. Such projects are most often successful because there already are business organizations ready to take advantage of access improvements.

A recent NCHRP project examined the future of the Interstate Highway System and the types of improvements that might be needed to support changing demo-

graphic and economic development patterns.[46] This is one of the few studies that have taken a strategic look at future investment options for what many consider to be a completed Interstate system. This study is not discussed in detail because it does not contain a rigorous analysis of benefits from proposed investments, but the types of improvements and the types of benefits identified in the report are instructive in considering analyses that may be needed in the future to estimate economic benefits from investments to sustain the performance of a key portion of the nation's surface transportation system.

The NCHRP study cites three major challenges over the next 30 to 50 years that were identified in an American Association of State Highway and Transportation Officials (AASHTO)-sponsored "visioning" conference:

- **Global economic integration.** Reliable transportation service is critical in a just-in-time era of higher value commerce and competitive, lean production. Yet both global and domestic supply chains are hampered by key gaps in the highway network and by bottlenecks and low levels of service in key Interstate corridors.
- **Metropolitan congestion.** The expansion of metropolitan areas, with their edge cities and exurban sprawl where much of congestion occurs, poses a complex challenge for urban transportation. Increasingly, intercity movements among "megaregions" also are becoming a problem. In all these settings the community and environmental context will require new mixes of modes and systems management schemes to support the metropolitan economies while still maintaining an attractive quality of life.
- **Postindustrial geography.** Maintaining connectivity is essential not only to serve rural communities, but also to support the shifting agricultural and energy extraction and production needs of a growing population and economy.

The NCHRP report discusses a "new vision" for transportation investment. While new capacity options are at the core of this vision, it is recognized that new capacity must be provided in a way that is consistent with environmental and other local goals and objectives. Among the factors that must be considered are needs to: 1) reduce overall greenhouse gas emissions; 2) increase safety and transportation security; 3) consider the community impacts of new and expanded facilities; 4) apply innovative systems operations and management strategies; and 5) implement a national solution to a national problem.

[46] PB Consult, "Future Options for the National System of Interstate and Defense Highways," Task 10 Final Report, NCHRP Project 20-24 (52), Washington, D.C., 2007, http://onlinepubs.trb.org/onlinepubs/trbnet/acl/NCHRP_20-24_52task10_NCHRPFinal.pdf.

Future investment needs are grouped into three categories: 1) freight logistics network improvements; 2) metropolitan mobility improvements; and 3) new geography connections. Within each of these categories, investment requirements for more specific types of improvements are estimated. Approximately 70 percent of the investment requirements identified in the report are associated with metropolitan mobility improvements, 26 percent with improvements to the freight logistics network, and 4 percent with connections to new population and economic centers that currently are not served by the Interstate system. The analysis assumes much greater investments in transit and operational improvements will be made than currently is the case, but still concludes that significant lane-mile additions will be needed to serve the needs of an expanding population and growing economy. The report cites literature discussed above relating to the benefits of increased investment, but does not attempt to quantify most benefits since that would require a much more detailed analysis than the project allowed.

3.7 FUTURE RESEARCH FROM A USER BENEFITS PERSPECTIVE

User benefits of transportation improvements have been studied extensively because they are the benefits most often included in benefit-cost analysis. The principal issue requiring further research is the valuation of travel time reliability. Past research has shown that users value reliability at least as much as average travel time, but there is not a current consensus on the exact value that users place on reliability. Further, differences exist among different groups of users in the value they place on reliability. Research into the valuation of travel time reliability could be coupled with case studies that demonstrate the benefits of projects that improve travel time reliability. Some of this work is being done under the SHRP 2 program, but because case studies can be among the most compelling evidence of the benefits of transportation investment, additional documentation of benefits of real-world projects should be considered.

Freight transportation clearly is vital to the nation's economy and it affects the performance of the entire transportation system. Much is known about the benefits of freight investment, but more research is needed in some areas to improve our understanding of how different stakeholders value those benefits. One area where more research may be needed is in the value to shippers and carriers of travel time and travel time reliability for different types of commodities. Research to date on the value of truck travel time has come up with widely disparate results, and even less is known about the value of reliability other than the qualitative understanding that travel time and reliability are much more important for some kinds of commodities than others. While a considerable amount of research has been conducted on the value of time for passenger transportation, less has been done related to freight. With a mature highway system the focus of most future improvements will not be on improving highway access

but on reducing congestion and improving the reliability of the transportation system. The need for further research on travel time reliability has been mentioned in other sections of this paper, and there seems to be a consensus that this is an area where additional research would improve decision-making, not just for highway improvements, but for improvements to other modes that either compete with highways or that use highway infrastructure.

4.0 Macroeconomic Benefits of Transportation Investment

Whereas benefit-cost analyses examine the microeconomic effect of investments on users of the transportation system, another line of research has examined the macroeconomic effects of transportation investment programs on broad measures of economic performance such as economic output and productivity. Beginning with the work of David Aschauer in the late 1980s, considerable research has been conducted to estimate the macroeconomic benefits of transportation and other infrastructure investment and to answer the question of whether the nation is investing enough money in infrastructure.

Studies that have examined relationships between transportation investment and economic output also have differed in the level of geography they have examined. Those studies that were subnational in scope all have lower estimates of the impact of transportation investment on output than studies conducted at the national level. Some have argued that the difference can be attributed to spillover effects – investment in one state has benefits that extend beyond the state boundaries.

4.1 SEMINAL MACROECONOMIC RESEARCH

The key studies seeking to establish a systematic link over time between the long-run level of national transportation investment dollars (measured in terms of accrued "capital stock" of highways) and growth of the national economy are summarized below.

Fernald concludes that, "returning road growth to pre-1973 levels would (not) raise productivity growth to pre-1973 levels."

Alicia Munnell explored several relationships between public capital and economic activity at the state level in a 1990 study[47] that built on work by David Aschauer.[48] First she examined the effect of public capital investment on private sector output. Overall, she found

[47] Munnell, Alicia H., "How Does Public Infrastructure Affect Regional Economic Performance," New England Economic Review, September/October 1990, pp. 11-33.

[48] Aschauer, David A., "Is Public Expenditure Productive?", Journal of Monetary Economics, vol. 23, no. 2, pp. 177-200, 1989.

that a 1 percent increase in public capital would raise national output by about 0.15 percent, slightly less than half the level that she and Aschauer had estimated in earlier studies using national level data. The impact of public capital investment was about the same as the impact of private investment. Munnell's second analysis assessed the role of public capital in private sector investment. Findings were mixed – on the one hand public sector investment was found to stimulate private sector productivity which in turn stimulated private investment. On the other hand, public capital was found to be a substitute for private capital – for any given level of output, the greater the public investment, the less private investment was required. Munnell's third analysis examined relationships between public capital and employment growth. Here too, she found a positive relationship between the provision of public capital and gains in private sector employment. While most of her analysis was reported in terms of the impact of total public capital investment, she did examine the separate impacts of highways, water and sewer, and other public capital investment and found a highway investment had a significant effect on private sector output.

John Fernald[49] found that before 1973 highway investment had a significant effect on productivity growth, especially for those industries that are vehicle-intensive. He concludes that "results suggest that the aggregate correlation between productivity and public capital primarily reflects causation from public capital to productivity, and that public investment may account for a substantial share of the slowdown in productivity growth after 1973." After 1973, however, he found that returns on highway investment returned to levels earned by other investments. Fernald concludes that, "returning road growth to pre-1973 levels would (not) raise productivity growth to pre-1973 levels." Coincidentally Fernald found that after 1973, congestion began to erode highways' contribution to productivity just when the contribution of highway investment to productivity growth began declining.

Marlon Boarnet, in a 1997 study of California counties, found that relieving congestion had a positive effect on productivity.[50] Benefits of congestion reduction were greater in those counties with the greatest congestion. Boarnet concluded that future studies of links between public capital and productivity should focus more on the service flows delivered by the infrastructure than simply on the value of the capital stock. To do so requires disaggregate studies,

---

[49] Fernald, John G., "Roads to Prosperity? Assessing the Link between Public Capital and Productivity," *The American Economic Review,* Vol. 89, No. 3, June 1999, pages 619–638, http://www.Federalreserve.gov/pubs/ifdp/1997/592/ifdp592.pdf.

[50] Boarnet, M. G. "Infrastructure Services and the Productivity of Public Capital: The Case of Streets and Highways." National Tax Journal 50(1): 39-57, (1997).

but congestion data often are not available at the national or state level. Furthermore, he concludes that national or state-level analyses may mask important local relationships since benefits of reduced congestion vary according to the local context.

In a 1996 study for the Federal Highway Administration, Nadiri and Mamuneas[51] examined the benefits of highway investment to 35 industries. They found that highway investment accounted for about 25 percent of all productivity growth in the U.S. economy during the period 1950 to 1989. From 1952 until 1963 the contribution to overall productivity was 32 percent, but that rate declined during subsequent years until, for the period 1980 to 1989, the contribution to productivity growth was down to seven percent. During this same period, however, Nadiri and Mamuneas estimated that the net social rate of return on nonlocal highway investment was 16 percent. Over the period 1950 to 1989 they found that U.S. industries realized production cost savings of 18 cents annually for each dollar invested in highways, roads, and streets. When the analysis was limited to investment just on nonlocal highways, the savings were greater – 24 cents annually for each dollar invested.

In a 1998 update to their earlier study, Nadiri and Mamuneas analyzed impacts of highway investment on 35 specific industry groups to reinforce the interpretation of a causal relationship between the infrastructure investment and increases in economic activity.[52] They found that impacts of highway investment varied substantially among different industry groups. Cost savings resulting from highway investment were realized by 32 of the 35 industry groups analyzed by Nadiri. Those cost reductions, in turn, allowed industries to expand output to meet the increased demand resulting from lower prices. Service and transportation industries were the greatest beneficiaries of the increased highway investment, with manufacturing industries also benefiting.

In another update to their earlier work, Nadiri and Mamuneas[53] developed a general equilibrium model to assess benefits of highway investment to both con-

---

[51] Nadiri, M. Ishaq and Theofanis P. Mamuneas, "Contribution of Highway Capital to Industry and National Productivity Growth," Report Prepared for Apogee Research, Inc., for the Federal Highway Administration Office of Policy Development, September 1996.

[52] Nadiri, M. Ishaq and Theofanis P. Mamuneas, "Contribution of Highway Capital to Output and Productivity Growth in the U.S. Economy and Industries," prepared for the Federal Highway Administration, Washington, D.C., 1998, http://www.fhwa.dot.gov/policy/gro98cvr.htm.

[53] Mamuneas, Theofanis P., and M. Ishaq Nadiri, "Production, Consumption and the Rates of Return to Highway Infrastructure Capital," unpublished manuscript, University of Cyprus, and New York University and National Bureau of Economic

Footnote continued

sumers and producers in the economy. Results were generally comparable to the earlier study, but showed higher rates of return, in part because of the inclusion of the consumer sector. Net rates of return to all highway and street investment estimated in this update were 1960 to 1969 – 48.0 percent; 1970 to 1979 – 29.8 percent; 1980 to 1989 – 21.2 percent; and 1990 to 2000 – 11.6 percent. The authors conclude that there is "no serious underinvestment in highway capital." This update did not break out the nonlocal portion of highway investment as their earlier study had done. If investment in nonlocal highways continued to produce substantially higher returns than investment in all highways, returns even during the latest period may have been above private rates of return.

In 1999 the Eno Transportation Foundation convened a forum at which a group of academic, government, and private-sector leaders discussed the importance of transportation investment for the future of the U.S. economy.[54] The forum focused on two issues:

- Improving the tools used in the economic analysis of the relationship between transportation investment and growth; and
- Improving ways to communicate findings to policy-makers and the public.

The forum included a presentation by Ishaq Nadiri of his latest research for FHWA. Forum participants generally agreed that Nadiri's research captured the national effects of building the Interstate Highway System, but believed that more analysis of local effects of such transportation investments is needed. An important area of future research identified by the forum participants was to "incorporate the level of use of transportation infrastructure into studies." They noted that "…increases in traffic congestion are believed to have profound effects on the use and value of roads and highways. But these effects have not been fully measured." Other research needs identified at the forum include:

- Improve the ability to determine whether increases in local economic activity associated with transportation investment represents new activity that would not have occurred in the absence of the transportation investment or are simply relocations of activity from other areas;
- Conduct more case studies of benefits resulting from specific improvements to ease public understanding of how highway investment could benefit them and their region; and

Research, August 2006, http://editorialexpress.com/cgi-bin/conference/download.cgi?db_name=IIPF62&paper_id=11.

[54] Eno Transportation Foundation, *Transportation Investment and New Insights in Economic Analysis,* Washington D.C., 1999, http://www.fhwa.dot.gov/policy/otps/060320e/060320e.pdf.

- Improve the theoretical underpinnings for studying U.S. competitiveness in the world economy and the contribution of transportation investment to international competitiveness.

Studies by Keeler and Ying[55] and Keeler[56] examine the impact of highway investment on costs to Class I trucking firms. They conclude that between 1950 and 1973 expansion of the highway network lowered trucking costs by 19 percent. These savings equaled from 33 to 44 percent of the total capital investment on Federal-aid highways during this period. A related analysis, however, found that highway investment had little or no effect on trucking costs between 1966 and 1983. This may in part reflect the growing congestion on parts of the highway system that Fernald suggested might be dampening the impacts of highway investment during the latter part of this period.

Ward and de Haan note, "Empirical research on the relationship between public capital and growth should provide answers to two important questions. First, does an increase in the public capital stock foster economic growth? Second, the policy relevant question for infrastructure investment is not what is the effect of extra infrastructure, holding everything else constant, but what is the net effect of more infrastructure given that infrastructure construction diverts resources from other sectors. In other words, is the existing stock of capital optimal?"[57] Based on a review of previous studies that conclude that there is a consensus on the first question – an increase in public capital does appear to foster economic growth. Findings on the second question are more ambiguous. The majority of recent studies have shown that returns on infrastructure investment are lower than previous decades when the Interstate network effects were more dramatic but returns are still comparable to the return on private investment. But, as Nadiri and Mamuneas found above, the answer to this question may depend on what data are used and how the analysis is framed. When they looked at the entire highway capital stock they found returns no greater than normal returns, but when they looked at investment in higher-order highways, the returns were indeed greater than returns to private investment.

---

[55] Keeler, Theodore E., and John S. Ying, "Measuring the Benefits of a Large Public Investment," *Journal of Public Economics,* Vol. 36, 1988, pages 69–85.

[56] Keeler, Theodore E, "Public Policy and Productivity in the Trucking Industry: Some Evidence on the Effects of Highway Investments, Deregulation, and the 55 MPH Speed," *American Economic Review,* Vol. 76, No. 2, May 1986, pages 153–158.

[57] Romp, Ward and Jakob de Haan, "Public Capital and Economic Growth: a Critical Survey," EIB Papers, Vol. 10 No. 1, 2005, http://www.eib.org/attachments/efs/eibpapers/eibpapers_2005_v10_n01_en.pdf.

4.2 META ANALYSES

Bhatta and Drennan summarized about 40 studies that examined the impacts of transportation infrastructure investment on various measures of economic development, including output; productivity; production costs; increases in income, property values, employment, and real wages; and the rate of return on transportation investment.[58] Fifteen of the papers the authors summarize use output as a measure of economic benefit. Twelve of those studies found a positive and statistically significant relationship between transportation investment and economic output, while three found no effect. One criticism leveled at studies that assess impacts of transportation investment on output is that it is difficult to determine whether increased output was the result of the transportation investment or whether increased investment was in response to increases in output. To partially overcome this problem, several studies disaggregated output by industry sector. Those studies all found a positive and statistically significant relationship between highway investment (as measured by the highway capital stock) and output. Fernald, in his study cited above, concludes that it is increases in capital investment that lead to productivity increases and not the other way around. This conclusion also is supported by Boarnet.

A recent study by the RAND Corporation explains the relationship between highway investment and economic activity as follows:

> *"Highway infrastructure can affect the economy in a number of ways, nearly all of them related to increasing mobility. It can enable producers to reach markets more cheaply and to increase the size of their market area. It can enable workers to choose among a wider array of employment opportunities and to live farther from their workplaces. It can enable producers to have a broader choice of input suppliers. Related to lowering the costs of reaching markets or inputs, it can increase the speed with which producers can reach markets or inputs, allowing them to hold lower inventories and carry out just-in-time production."*[33]

The RAND study drew several conclusions based on a review of studies that examined relationships between highway investment and measures of economic activity. They found a consensus that:

---

[58] Dev Bhatta, Saurav and Drennan, Matthew, *The Economic Benefits of Public Investment in Transportation: A Review of Recent Literature, Journal of Planning Education and Research 22:288-296,* 2003, http://www.spa.ucla.edu/up/webfiles/DrennanEcon.Ben.Pub.Trans.pdf.

[59] Shatz, Howard J., et.al., *Highway Infrastructure and the Economy: Implications for Federal Policy,* The RAND Corporation, Santa Monica, California, 2011, http://www.rand.org/pubs/monographs/2011/RAND_MG1049.pdf.

- Construction of the Interstate system had large positive effects on U.S. productivity, but those effects have diminished since construction of the system was completed;
- The Interstate system heavily influenced land use development patterns and the suburbanization of the population; and
- Highway infrastructure has caused positive economic outcomes for industries that use it most intensively.

RAND also notes that past studies have come to different conclusions on several issues, especially whether current highway investment still has large economic effects now that the backbone of the highway network is largely complete or whether it simply causes a relocation of economic activity without significant net growth?

RAND notes that "the presence of state-level effects of new infrastructure is the most contested area of the literature, although most analysts find some positive effect of infrastructure on economic activity" at the state level. They note that study findings vary dramatically concerning whether there are positive spillover effects where investment in one state has a positive economic effect on adjacent states or a negative spillover where investment in one state draws economic activity from adjacent states. Macroeconomic analyses done at the state level generally have shown smaller economic effects from transportation investment than analyses done at the national level. RAND summarizes several studies that show positive spillovers where investment in one area causes statistically significant positive economic effects in adjoining areas and several other studies reporting negative spillovers. One study divided highways into five categories and found that only interstate and other major highways have an influence on employment growth.[60] RAND concludes from its literature review that "this evidence is consistent with the idea that *some* highway infrastructure investment can lead to positive productivity or output outcomes. However, there is a strong possibility that such investment will have negative effects on neighboring states." This same conclusion holds for analyses of substate-level impacts. Summarizing their analysis of studies that have examined economic impacts across states, within states, and within metropolitan areas they conclude, "Although there may be gains in the area receiving the infrastructure, there also are likely to be losses in neighboring areas, and sometimes these losses equal or outweigh the gains. In some cases, this leads overall effects on economic outcomes to be on net close to zero." RAND notes that characteristics of the area through which new infrastructure passes have a strong influence on the type and level of economic impacts.

---

[60] Jiwattanakulpaisarn, Piyapong, Robert B. Noland, Daniel J. Graham, and John W. Polak, "Highway Infrastructure and State-Level Employment: A Causal Spatial Analysis," *Papers in Regional Science,* Vol. 88, No. 1, March 2008, pages 133–159.

The RAND study went beyond the traditional qualitative review of the literature on the economic effects of highway infrastructure investment and performed what they labeled a "meta-analysis" to more rigorously analyze the various studies and tried to determine how the study design affected the results of the studies. Among the study design variables they investigated were: 1) level of geography; 2) the time period of the analysis; 3) the type of infrastructure; 4) the economic outcome analyzed; 5) whether alternative outcomes also were analyzed; 6) whether the study investigated the spillover effects to adjacent areas; and 7) whether the effect of highway infrastructure was found to be statistically significant. Linear regression analysis was then used to estimate the influence of these independent variables on the dependent variable – whether the study found that highway infrastructure had a positive and statistically significant effect on the outcome variable. RAND indicated that the most important finding of its metaanalysis was that:

> *"…research that analyzed the relationship between infrastructure and productivity tended to find a positive and significant result. Secondarily, research that analyzed the relationship between infrastructure and output tended also to find a positive and significant result. This means that research that analyzed the relationship between infrastructure and employment was less likely than other papers to find a positive and significant result…. Finally, we also found that papers that analyzed national-level data were more likely to find a positive and significant relationship between infrastructure and economic outcomes. We believe that this reflects the findings of much of the analysis at the state level and below – that highway infrastructure has a tendency to reallocate economic activity and not just to increase it. Furthermore, national-level studies may be more likely to capture geographically distant spillovers that might not be found in a study concentrating on more constrained geographic areas."*

4.3 MODAL PERSPECTIVE: PUBLIC TRANSIT

In Weisbrod's and Reno's 2009 study for APTA described above, $1 billion of public transportation investment was estimated to produce a long-term savings of $1.7 billion in addition to $1.8 billion in short-term GDP growth associated with employment and income generated by the investment. Total benefits of public transportation investment thus were estimated to be $3.5 billion for each $1 billion invested annually. The authors point out that social and environmental benefits of public transportation investment, which are not included in the estimated economic benefits, would push total benefits even higher.

As noted above, most benefit-cost analyses do not examine how transportation investments affect economic growth and productivity, but those benefits are

included in the Weisbrod/Reno methodology. The approach can be used to estimate national economic benefits of public transportation investment and with a few changes also can be used to estimate local and regional economic benefits as well. The authors identify one area where additional research could improve the comparison of investment in alternative modes. They recommend considering all investment and spending on the various modes to improve estimates of the number of jobs supported by spending on each mode. This approach, they say, also would recognize the benefits of highway investment on public transportation services and the potential for investment in public transportation to reduce household expenditures on automobiles and free up money for spending on other goods and services.

4.4 MODAL PERSPECTIVE: FREIGHT TRANSPORTATION INVESTMENT

The movement of freight is central to large portions of the U.S. economy. Shipments of raw materials, intermediate products, and final goods must move efficiently across the country and around the world in today's global economy. As transportation has become more efficient, shippers have adopted new distribution systems and manufacturing, wholesale, and retail industries have adopted new practices to minimize total logistics costs. But today congestion on large parts of the freight distribution system is threatening those new logistics processes.

Data from FHWA[61] in the table below show that in 2009 almost $15 trillion of commodities were moved on the nation's freight transportation system. By 2040 population and economic growth are projected to increase the value of goods hauled to almost $40 trillion. Of that amount one-quarter is projected to be either exports or imports that must pass through international gateways.

Trucks hauled about 65 percent of the value of all goods shipped in the U.S. in 2009, followed by multimodal shipments and mail. The value of shipments by air was only six percent in 2009, but that share is expected to nearly double by 2040. Multimodal shipments, which include imports that arrive by ship, also are expected to account for a significantly larger share of the total in 2040 than they do in 2009. While the value of goods hauled by rail represents only three percent of the total value of goods hauled, rail handles 10 percent of the tonnage and is critical to the movement of coal, metallic ores, chemicals, fertilizers, and other high-density/low-value commodities that typically move long distances from origin to destination.

[61] Federal Highway Administration, *Freight Facts and Figures,* 2010, http://ops.fhwa.dot.gov/freight/freight_analysis/nat_freight_stats/docs/10factsfigures/pdfs/fff2010_highres.pdf.

Table 4.1 Value of Shipments by Transportation Mode
2009 and 2040 (Billions of 2007 Dollars)

	2009		
	Total	Domestic	Exports
Total	14,647	12,078	1,053
Truck	9511	9,087	211
Rail	421	323	46
Water	263	99	14
Air, air and truck	884	147	349
Multiple modes and mail	2,639	1,618	391
Pipeline	595	532	4
Other and unknown	334	273	39

Source: FHWA, Freight Facts and Figures 2010, Table 2-2.

The American Association of State Highway and Transportation Officials' report, *Freight Demand and Logistics, Bottom Line Report,*[62] cites four factors that affect the growth in freight volumes: consumption, production, trade, and supply chain management. A growing population with a growing personal income will consume more goods and services in the future, thereby increasing the amount of freight that must be hauled to satisfy this growing demand. Efficient transportation can bring these personal consumption goods to customers quickly and cheaply; this is particularly important for the growing volume of Internet sales that are delivered directly to the consumer.

Increased production associated with a growing economy is another source of increasing demand for freight transportation. The value of manufactured goods is projected to increase by 5.4 percent a year according to Global Insight, an economic forecasting firm, led by automobiles, high-tech electronics, and other durable goods. This growth, which is faster than growth in the overall economy,[63] will create increasing demand for the transportation of raw materials, intermediate products, parts, supplies, and finished goods.

Global Insight projects that by 2030 the combined value of U.S. exports and imports will be 60 percent of GDP, up significantly from 23 percent in 1997. This growing volume of exports and imports is another source of freight transportation growth that will place additional strain on international gateways, many of which already operate at or near capacity.

The final factor cited in the *Freight Demand and Logistics Bottom Line* report that will affect future freight volumes is supply chain management. Over the past 30 years freight transportation costs have dropped substantially due to deregulation and other factors. This has led many industries to substitute transportation for warehousing and inventories in

[62] American Association of State Highway and Transportation Officials, *Freight Transportation Demand and Logistics Bottom Line Report,* http://downloads.transportation.org/DR_3%20Freight%20Demand_Report-12-07.pdf.

[63] American Association of State Highway and Transportation Officials, op.cit.

their overall logistics system. Businesses using the new supply chain management practices hold little or no inventory; they track customer purchases and replace stock as needed to prevent stock outs. This requires smaller, more frequent deliveries and places a premium on reliability. Other supply chain management changes cited in the Bottom Line report that depend on the availability of reliable transportation include:

- Outsourcing production to Asia and Mexico to reduce the cost of labor and parts;
- Implementing just-in-time logistics practices to reduce the cost of holding inventory; and
- Supporting larger, more cost-effective regional warehouses to reduce distribution costs.

Among the transportation-related changes that have allowed these changes in supply chain management are:

- Economic deregulation and the subsequent restructuring of the freight transportation industry in the 1980s, which triggered strong competition and lower shipping prices;
- Increased public sector investment in the Interstate Highway System through the 1980s and early 1990s, which reduced travel time and improved trip reliability for motor carriers; and
- Adoption of new technologies (e.g., intermodal freight containers, computers and related information technologies, bar coding, radio frequency identification tags, and satellite communications) by shippers and carriers, which significantly improved the productivity and reliability of freight operations.

Benefits of on-demand supply chains include:

- Lower-cost products since manufacturers tie up less working capital in inventory;
- Fewer stock outs, which increases consumer loyalty and satisfaction because store shelves are fully stocked with the right product at the right time;
- More innovative products, as retailers and consumer goods companies work closer together on product design before the product enters the supply chain; and
- Speedier introduction of new and updated products.

Placing a monetary value on the benefits that producers and consumers derive from these new supply chain management practices is difficult, but the pervasiveness of such practices is a strong indication of the benefits. The ability of firms to continue innovative supply chain and business logistics practices will depend in part on the continued high level of service and reliability of the transportation system.

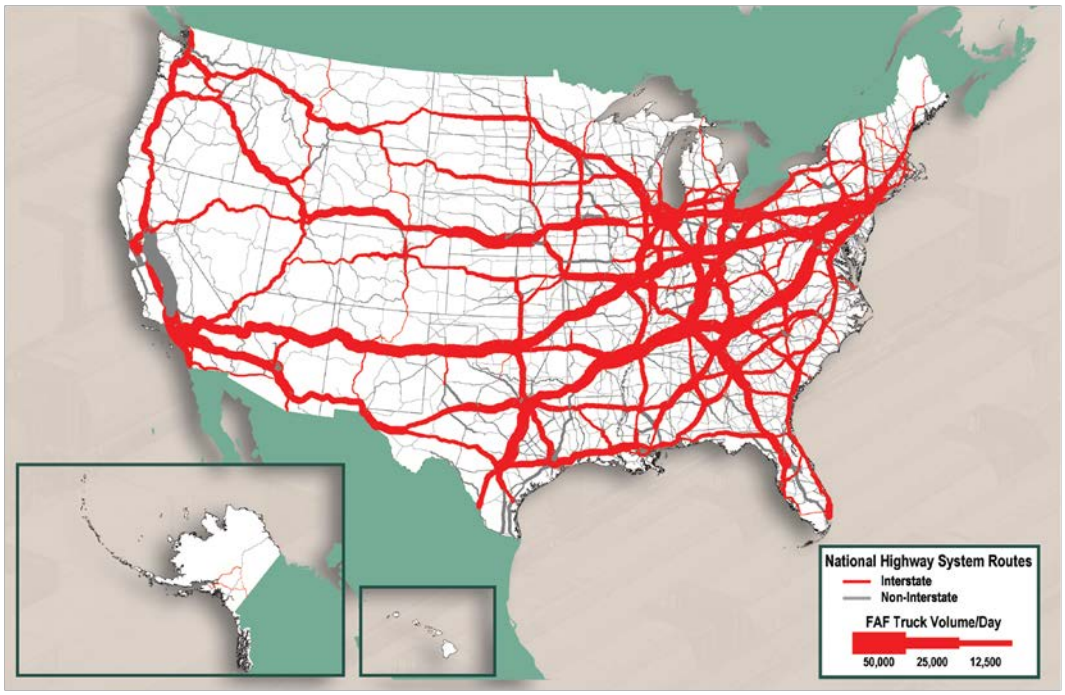
One indicator of the importance of combined effect of reduced transportation costs and innovations in supply chain management practices is the declining share of GDP represented by total logistics costs. Since the deregulation of transportation in 1980, the Council of Supply Chain Management Professionals reports that total logistics costs have declined from about 16 percent of GDP to about one-half that percentage in 2010. Businesses and consumers benefited because lower transportation costs resulted in cheaper goods and wider access to global suppliers and markets.[64] In the past several years there have been some slight increases in logistics costs associated with increased fuel costs and growing congestion. The Boston Logistics Group estimates that declining transportation system reliability was a significant factor in rises in logistics costs between 2005 and 2006.

Capacity already is a problem on many freight corridors and at major international gateways and intermodal terminals. The projected growth in shipments will only add to this congestion. For high-value, perishable, and other time-sensitive shipments, delays create significant costs. The following figure shows that by 2040 a significant number of Interstate and other National Highway System routes are projected to carry very high volumes of long-haul freight traffic in addition to the passenger and local truck traffic using those routes. Many of these routes go through major metropolitan areas where long-distance truck traffic must mingle with local traffic, exacerbating urban congestion problems. Many long-haul truckers try to avoid traveling during peak periods, but as peaks continue to extend to more hours of the day, it is increasingly difficult for truckers in many corridors to avoid them. This is particularly true for truckers who have delivery schedules that cannot be missed without significant penalties. Bottlenecks often occur at junctions of major routes in or around metropolitan areas affecting traffic for miles upstream of the bottleneck. An FHWA report estimated that the top 10 highway bottlenecks in the country cause an average of 1.5 million annual truck hours of delay each.[65]

[64] American Association of State Highway and Transportation Officials, op.cit., page 4-23.

[65] U.S. Department OF Transportation, Federal Highway Administration, *An Initial Assessment of Freight Bottlenecks on Highways.* Washington, D.C., October 2005, www.fhwa.dot.gov/policy/otps/bottlenecks/.

Figure 4.1 Average Daily Long-Haul Freight Traffic on the National Highway System
2040



Source: FHWA, Freight Facts and Figures 2010.

In a 2008 study of freight mobility, the U.S. Government Accountability Office (GAO) found a widening gap between the volume of freight that must be moved and the available transportation system capacity.[66] The resulting congestion imposes costs on consumers, shippers, and carriers as well as urban centers where high freight volumes coupled with high passenger volumes create air pollution, noise, and other environmental effects that impose health costs on society. The GAO noted a number of strategic projects that have been undertaken specifically to improve freight movement, including:

- Alameda Corridor in California where 200 at-grade rail-highway crossings were eliminated by running rail tracks below grade. This resulted in a doubling of train speeds between the Ports of Los Angeles and Long Beach and transcontinental rail yards 20 miles away.

[66] U.S. Government Accountability Office, Freight Transportation, *National Policy and Strategies Can Help Improve Freight Mobility,* Washington, D.C., 2008, http://www.gao.gov/new.items/d08287.pdf.

- Construction of the State Route 47 Expressway in California that bypasses congested local roads and connects the ports of Los Angeles/Long Beach to a nearly intermodal container transfer facility.
- The Chicago Region Environmental and Transportation Efficiency (CREATE) project in Illinois, a public-private partnership to ease freight and passenger congestion through Chicago's rail hub. This project eliminates many rail-highway grade crossings, adds six new rail overpasses to separate passenger and freight tracks, and upgrades tracks, switches, and signal systems.

The issue of the impact of congestion on freight and business activity was addressed in a recent TRB paper by Weisbrod and Fitzroy.[67] They note there is growing evidence that congestion is having adverse effects on regional economies. These effects are not well understood and generally are not taken into account in transportation planning and decision-making. The authors cite an NCHRP study, *Economic Implications of Congestion,*[68] which examined how congestion affects: 1) the availability of skilled labor; 2) the cost of acquiring specialized material inputs; and 3) the size of customer delivery markets. That report also showed that the impacts of congestion vary by industry, depending on requirements for skilled workers and shipping by truck. An FHWA report notes that congestion affects productivity in several ways.[69] Businesses must use more operators and equipment when shipping takes longer, they must hold more inventory when transportation systems are unreliable, and they must use more distribution centers when traffic is slow.

The Economic Development Research Group conducted a study of the cost of congestion in the Portland, Oregon region.[70] Business leaders in the region were asked about specific responses they had made in their business practices because of congestion in the transportation system. Among the responses were:

- Intel has moved their last shipment departure time up two hours for outbound shipments to avoid peak-period congestion. A missed flight affects production across the globe and can result in costly operational changes.

---

[67] Weisbrod, Glen and Stephen Fitzroy, *Defining the Range of Urban Congestion Impacts on Freight and their Consequences for Business Activity,* paper presented at the 2008 TRB annual meeting, 2007, http://www.edrgroup.com/pdf/trb-paper-urban-congestio.pdf.

[68] Weisbrod, Glen, Donald Vary and George Treyz. *Economic Implications of Congestion.* NCHRP Report #463, National Cooperative Highway Research Program, Transportation Research Board, Washington, D.C., 2001.

[69] Federal Highway Administration, *Freight Story 2008,* Washington, D.C., 2008, http://ops.fhwa.dot.gov/freight/publications/fhwaop03004/freight.pdf.

[70] Economic Development Research Group, *The Cost of Congestion to the Economy of the Portland Region,* 2005, http://www.portofportland.com/PDFPOP/Trade_Trans_Studies_CoCReport1128Final.pdf.

- Sysco Foods opened a new regional distribution center in Spokane to better serve their market area, because it was taking too long to serve its market from the Portland area).
- Providence Health Systems reported medical deliveries, which have to be rapid and frequent, were requiring more than four hours in some cases. As a result, Providence is planning a relocation of warehousing and support operations at a considerable cost.
- OrePac has increased inventories by seven to eight percent because of congestion delays, which represents a lost opportunity for other investment.
- PGE estimates that it spends approximately $500,000 a year for additional travel time for maintenance crews.

FHWA's *Freight Story 2008* gives several other examples of the cost of congestion. A study by Isbell found that Nike spends an additional $4 million per week to carry additional inventory to compensate for shipping delays.[71] A study by the Congressional Budget Office found that a week-long disruption of operations at the Ports of Los Angeles and Long Beach could cost the U.S. economy between $65 and $150 million per day.[72]

Weisbrod and Fitzroy identified seven mechanisms through which congestion can affect regional economies:

- Effects on freight and service delivery;
- Effects on business scheduling;
- Effects on business operations;
- Effects on intermodal connections;
- Effects on worker travel;
- Effects on business locations; and
- Effects on other activities (externalities).

Each of these mechanisms adversely affects businesses in multiple ways. The authors draw three major policy implications from this analysis:

- Current impact studies may be underestimating the full costs of congestion and the full benefits of investing to reduce future congestion growth, as they

---

[71] Isbell, John, "Maritime and Infrastructure Impact on Nike's Inbound Delivery Supply Chain," TRB Freight Roundtable, 2006, http://www.trb.org/conferences/FDM/Isbell.pdf.

[72] U.S. Congressional Budget Office, *The Economic Costs of Disruptions in Container Shipments,* Washington, D.C., 2006, http://www.cbo.gov/ftpdocs/71xx/doc7106/03-29-Container_Shipments.pdf.

fail to capture the full range of business and economic implications generated by congestion growth.

- While the implications of congestion growth can be severe, it is most likely impossible to solve those impacts merely by building more roadway capacity. That is because the interactions of traffic congestion, business location decisions and land use patterns lead to complex interactions that make single dimension policies (such as capacity building) self-defeating. Rather, congestion growth and its adverse economic impacts are most likely to be minimized by policies that combine roadway capacity investments with investment in modal alternatives (for both passenger and freight travel) and pricing schemes that can facilitate the movement of high-value and priority freight shipments without undue delay.
- To design and implement such policies, transportation planning and economic impact analysis models must become more sensitive to the different facets of traffic impact and economic consequences.

Weisbrod and Fitzroy conclude that future analyses of the impacts of congestion should specifically examine the effects of reliability, connectivity, market access, and multimodal interactions. More research is needed in each of these areas to assist state and regional officials analyze these impacts.

Winston and Shirley,[73] in a study for FHWA, quantified the impact of congestion on one element of business costs – shippers' inventory costs. They note that most previous research on congestion has focused on motorists and has neglected how firm's costs are increased by delays in shipping their goods. Using three different methods to estimate impacts of congestion, Winston and Shirley conclude that the impact of congestion on shippers' inventory cost is about $7 billion annually. When combined with TTI estimates of congestion cost to motorists, they conclude that costs of congestion to shippers represent about 25 percent of the total cost of congestion. These inventory cost estimates are based on national data; further research would be required to estimate how inventory costs in specific local areas are affected by congestion.

Another indicator of the cost of congestion to commercial motor vehicle operators is the value they place on travel time savings. Estimating the value of travel time savings for commercial motor vehicles is more difficult than for passenger vehicles because revealed-preference studies, which show results of real-world decisions, are difficult to conduct – trucks generally are not allowed on managed lanes where the willingness to pay a congestion toll to save relatively well known amounts of time can be observed. Previous studies have had to rely on stated-preference surveys to analyze tradeoffs between travel time savings and the

[73] Winston, Clifford and Chad Shirley, "The Impact of Congestion on Shippers' Inventory Costs," report to the Federal Highway Administration, 2004, http://www.fhwa.dot.gov/policy/otps/060320d/060320d.pdf.

willingness to pay to achieve those savings. Stated-preference surveys generally are less reliable than revealed-preference studies. Smalkoski and Levinson report on a stated-preference survey of commercial motor vehicle operators they conducted from which they derived a value of time of $49.42 per hour.[74] This value is higher than the average value of time for commercial motor vehicles of $25.55 from other studies they reviewed, but the methodology that Smalkoski and Levinson used was more robust than the other studies. Their value of time for commercial vehicles is more than twice as high as the U.S. DOT's recommended value of time for business travel and almost three times as high as the U.S. DOT's recommended value of time for personal trips of all purposes.[75]

In recent years there has been considerable interest in the issue of separating freight from passenger travel as a potential strategy to both move freight more efficiently and deal with growing congestion. One method for separating truck from passenger traffic would be to construct exclusive truck lanes. Poole and Samuel indicate that exclusive truck lanes would have four principal benefits:

- They would provide the capacity needed to move the growing volumes of projected truck traffic;
- They would allow increased trucking productivity if longer combination vehicles were allowed to use these facilities;
- They would reduce highway crashes involving trucks; and
- They would reduce congestion on many key Interstate Highways.[76]

The issue of allowing longer combination vehicles (long double and triple trailer combination vehicles) to operate on portions of the Interstate system has been advocated by trucking interests for years and has been studied by the Federal Highway Administration, the Transportation Research Board, and others. Currently, those vehicles are allowed in only about 20 states; 13 western states allow LCVs to operate on portions of their state highway systems and other states, including New York, Massachusetts, Florida, Ohio, and Indiana allow LCVs to operate on turnpikes. Previous studies have all estimated large increases in productivity if LCVs were allowed to operate more widely, but offsetting these productivity gains would be added infrastructure wear, potential adverse safety consequences, and potential diversion of rail traffic to highways.

---

[74] Smalkoski, Brian and David Levinson, *Value of Time for Commercial Vehicle Operators,* University of Minnesota, http://nexus.umn.edu/Papers/TruckValueOfTime.pdf.

[75] U.S. Department of Transportation, *The Value of Travel Time Savings: Departmental Guidance for Conducting Economic Evaluations Revision 2,* Washington, D.C., 2011, http://ostpxweb.dot.gov/policy/reports/vot_guidance_092811.pdf.

[76] Poole, Robert W. and Peter Samuel, *Corridors for Toll Truckways: Suggested Locations for Pilot Projects,* Reason Foundation Policy Study 316, 2004, http://reason.org/files/793064eac9c618556e26ea4a24b3acba.pdf.

Perhaps the greatest obstacle to allowing more widespread LCV operations, however, is the adverse public reaction such a policy would provoke.

Poole and Samuel point out that virtually all negative impacts of LCV operations would be eliminated if those vehicles were allowed to operate on a network of exclusive truck lanes. The authors evaluated a number of potential truck corridors in the U.S. to assess both their ability to generate toll revenues and the potential cost of constructing exclusive truck toll lanes. The most promising corridors were on portions of I-80, I-90, I-15, and I-75. One of the corridors identified by Poole and Samuel was I-81 between Tennessee and Pennsylvania. The Virginia Department of Transportation assessed the feasibility of constructing exclusive truck lanes on I-81 and did not find them financially feasible, but they did not include LCV operations on those lanes and they did not consider those exclusive lanes being extended into adjoining states.

A study under the National Cooperative Freight Research Program was recently completed, titled *Framework and Tools for Estimating Benefits of Specific Freight Network Investments.*[77] This project "defines a wide range of public and private benefits and impacts of freight infrastructure investments and identifies the tools and supporting data necessary to evaluate these benefits and impacts. The Framework is capable of handling projects that span all of the different freight modes and is able to assess benefits from a variety of project types and scales. It distinguishes how benefits and impacts are evaluated at the local, regional, state, and national level; and in so doing, it recognizes the role that different public-sector entities play in making funding decisions for freight investments." This study fills a major void to date in analysts' ability to assess multimodal freight transportation improvements.

The study identifies four general types of stakeholders in freight transportation: asset providers, service providers, end users, and other impacted parties. Each of these stakeholder groups has unique interests in freight transportation improvements and it is important to understand those perspectives in evaluating investment options. Four types of improvements are identified that may increase freight system capacity:

- **Physical infrastructure projects.** Enhance the capacity, design speed, or volume of freight infrastructure.
- **Productivity projects**. Increase the allowable size, weight, or volume of freight vehicles.
- **Reliability and density projects**. Affect the utilization or safety of freight vehicles.

[77] National Cooperative Freight Research Program, *Framework and Tools for Estimating Benefits of Specific Freight Network Investments,* NCFRP Report 12, Washington, D.C., 2011, http://onlinepubs.trb.org/onlinepubs/ncfrp/ncfrp_rpt_012.pdf.

- **Integration and consolidation projects**. Allow for more efficient communication or transfer of materials between freight vehicles, infrastructure, and facilities.

The study identifies a number of existing analytical tools that can be used in different phases of the freight analysis to provide information for freight investment decision-making. Tools generally fall into one of the following types:

- **Strategic planning tools** include tools used to assess long-term needs and deficiencies impacting the transportation system and the lifecycle costs of operating and maintaining transportation infrastructure (for asset providers); and longer-term market analyses, production, and site selection alternatives (for service providers and end users).
- **Carrier cost and performance analysis tools** are operational analysis tools that estimate the operational performance and cost of freight carrier operations under alternative scenarios to represent the impact of transportation projects, programs, or policies, and primarily are used by freight infrastructure providers and carriers.
- **Shipper cost and performance models** estimate the cost and time characteristics of alternative freight mode and service options, and are intended to represent the total logistics time, cost, and safety/reliability tradeoffs available for a shipment so that optimal shipping decisions can be made. These tools primarily are used by end users (i.e., the businesses that generate outgoing freight or the consignees who receive the freight and ultimately pay the shipper cost).
- **Transportation system efficiency models,** often defined as benefit/cost analysis systems, are intended to evaluate the benefit and cost streams over a specified period of analysis to determine whether a proposed investment will yield benefits in excess of its cost.
- **Economic development impact models** estimate impacts of transportation projects on income and jobs in the economy, and are primarily used by public-sector (local, regional, or state) transportation agencies to explicitly consider business productivity and economic development impacts that are not represented by transportation system efficiency tools.
- **Financial impact accounting tools,** typically used by those who have a direct stake in the cost of a project, provide estimates on how the proposal will affect outgoing cost streams, incoming revenue streams, cash flow, borrowing or bond requirements, net profit or loss over time, upside/downside risk, and rate of return.
- **Risk assessment tools** assist private-sector asset providers and end users in understanding and quantifying critical areas of uncertainty related to making investment decisions.

One reason the Freight Evaluation Framework is so valuable is that it explicitly provides a multimodal analysis capability.

The report summarizes the individual analytical techniques and models within each of these areas and develops a "Freight Evaluation Framework" to integrate these various tools and provide a mechanism for allocating the costs and benefits of a variety of different types of freight improvements to different stakeholder groups so that all parties understand how projects affect various stakeholders. One reason the Freight Evaluation Framework is so valuable is that it explicitly provides a multimodal analysis capability. This is important because: 1) freight projects often have intermodal dependencies or multiple modes are present in the project; 2) projects often have cross-modal impacts; and 3) supply chains typically are integrated across multiple modes and reliability and inventory-cost impacts must be considered from one end of the supply chain to the other.

The Freight Evaluation Framework was tested by applying it to six different case studies. In addition to the case studies the research team worked with AASHTO, TRB, and the NCFRP-05 project panel to conduct a workshop to evaluate the Freight Evaluation Framework. In general the participants found the framework to be particularly useful in identifying, accounting for, and categorizing costs, benefits, and potential beneficiaries of freight improvements. A concern of the participants, however, is that the framework focuses on benefits of congestion reduction and does not adequately consider economic development and access benefits of freight projects. The report concludes that there are numerous tools available to estimate the benefits of freight investment, but that further guidance is needed to assist analysts use these tools within the context of the multimodal Freight Evaluation Framework.

The Houston-Galveston Area Council's (H-GAC) Regional Goods Movement Study[78] illustrates how an economic framework can be used to recommend solutions to improve the movement of goods in southeastern Texas. The Houston area is one of the fastest growing metropolitan areas in the country and includes several of the nation's busiest ports as well as a concentration of manufacturing industries that depend on freight to compete. Congestion, growth, and industry make freight infrastructure improvements an imperative for the long-term prosperity of the Houston-Galveston area. Economic impacts are a screening criteria used to evaluate project solutions within the Regional Goods Movement Study. The evaluated project/solution packages include improvements to existing

[78] Cambridge Systematics et al., "H-GAC Regional Goods Movement Study", prepared for Houston-Galveston Area Council, December, 2011, http://www.h-gac.com/taq/regional%20goods%20movement/reports/default.aspx.

infrastructure, access to new growth areas, and freight rail and passenger rail improvements.

A key part of the study was to identify existing and near-term needs that have significant impact on freight movements. The results of the study showed that significant benefits will accrue to both trucks and passenger vehicles by improving freight intermodal connectors and freight significant roadways. Total travel in terms of both distance and time are improved and this gives rise to transportation cost savings to the users and to maintenance and operations savings for the public sector. The results also indicate that average system speeds will increase, leading to a reduction in delay. As delay is reduced, so are emissions. The data show that much of the improvement will be on noninterstate routes, indicating that local and neighborhood roads will experience improved conditions as trucks are diverted to roads designed to handle the traffic. The total economic benefit of these improvements, including multiplier effects, amounted to $32 billion over the 2018 to 2035 period.

A separate assessment of transportation projects that would connect growth areas in the Houston-Galveston region, including a north-south port connector project and the completion of the circumferential Grand Parkway, would yield total benefits of $18 billion over the 2018 to 2035 period. The data showed that not only do freeways inside the urban core experience reductions in congestion, but so do many nonfreeway routes outside the urban core, indicating that local and neighborhood roads will experience improved conditions as trucks are diverted to roads designed to handle the traffic and provide faster speeds. The diversion of traffic from local roads reduces the community impacts arising from freight transportation.

Finally, a third solutions package was to pursue multimodal opportunities that balance freight and passenger needs. There is an increased need to pursue rail alternatives for both passenger and freight mobility, which have gained support among the public and private sectors. The potential advantages of commuter rail as a freight mobility solution are: 1) investment in rail infrastructure that benefits both passenger and freight rail; 2) congestion relief on some of the region's most significant truck corridors; and 3) public benefits, including improved economic competitiveness, air quality, and safety. A combination of freight improvements and the implementation of commuter rail amounted to benefits of over $5 billion between 2018 and 2035.

Further emphasizing the broad scale of benefits transportation can bring to a regional economy, many regions have embraced freight transportation as an economic development strategy. These include the following:

- **Columbus, Ohio**. The Mid-Ohio Regional Planning Commission (MORPC) engages leaders in the central Ohio region in a public/private partnership for the mobility of freight and goods and to strengthen the region's economy. This is done in order to advance the region's freight movement in a reliable, multimodal and intermodal, efficient, cost-effective, safe, and environmen-

tally responsible manner, and to maintain central Ohio as an international freight center. Freight initiatives over the past decade have focused on the conversion of the former Rickenbacker Air Force Base into a major logistics hub. This effort has garnered significant support from MORPC as well as ODOT, the private sector, and the Central Ohio economic development community. In 2010, Norfolk Southern's Heartland Corridor was completed, allowing double-stacked freight trains to move uninterrupted from Columbus to the Port of Virginia (Hampton Roads). As a result of numerous freight improvements in addition to the Heartland Corridor, Rickenbacker has attracted significant private investment and is a fast growing national distribution center.

- **Detroit.** The Southeast Michigan Council of Governments (SEMCOG) maintains a partnership with the Detroit Regional Chamber through the Translinked initiative to promote Southeast Michigan as a freight hub. Translinked is the Detroit Regional Chamber's initiative working to create a regional industry cluster of excellence around transportation, distribution, and logistics. Linking the region's assets in business, talent, infrastructure, and location, Translinked seeks to ensure the region's transportation infrastructure continues to meet the anticipated growth in international trade and freight movement. The concentration of manufacturing in the Detroit area and cross-border trade with Canada make the efficient movement of goods crucial to the competitiveness of the Detroit economy and to future opportunity. The Detroit region is now looking into how to further utilize its highway, rail, air, and Great Lakes location to become a stronger inland hub for the movement of freight.
- **St. Louis.** The St. Louis region is actively pursuing strategies to further develop the area as a global multimodal logistics center where all the activities relating to transport, logistics, and goods distribution are carried out by various operators. This includes positioning St. Louis as the primary platform from which China engages the central United States. The efficiencies resulting from consolidating and regionalizing freight flows in the St. Louis region are expected to translate to reduced costs and higher productivity, benefiting many industries in the region, including manufacturing.
- **Kansas City.** Kansas City SmartPort is a nonprofit economic development effort to promote and develop Kansas City as a preeminent inland logistics hub. SmartPort leverages Kansas City's location with its airport, waterway, highway, and rail facilities to encourage the expansion of distribution and supply chain activities in the metropolitan area.
- **Chicago**. The Chicago Region Environmental

CREATE has regional and national significance as Chicago is the country's top-ranking rail hub.

and Transportation Efficiency Program (CREATE) consists of strategic improvements (e.g., overpasses, grade crossings, track upgrades, etc.) to the rail system in the Chicago area, reducing freight bottlenecks, and raising operating speeds. In doing so, it improves the economic competitiveness of the region's manufacturing and transportation industries, critical foundations to the Chicago metropolitan area's economy. Additionally, CREATE will reduce the freight industry's impact on metropolitan communities by reducing grade-crossing delay and by reducing freight engine vehicle emissions. CREATE has regional and national significance as Chicago is the country's top-ranking rail hub. Freight shipment is a backbone to the national economy and CREATE will help to improve interstate commerce and eliminate bottlenecks throughout our region and the country. An estimate of the impact on the region's economy showed that by as early as 2021 the Chicago region would experience a potential loss in excess of $1 billion in production and the equivalent of over 3,000 jobs per year if rail capacity and infrastructure issues are not addressed. By 2040, these values would be close to $7 billion and the equivalent of 12,000 jobs per year.

- **El Paso.** The El Paso/Juárez region's international border crossings (road and rail) are a system of regional, statewide, and national significance. This system provides a critical link between factories, primarily located in Ciudad Juárez (El Paso's sister city on the other side of the Rio Grande), and distribution centers and consumer markets located in metropolitan El Paso, Texas, New Mexico, and beyond. Overall, border-dependent businesses and travelers support nearly 700,000 jobs on both sides of the border. However, this vital system is being stressed by continued growth in traffic, trade, and pedestrian volumes, driven by the growing populations and economies of Texas and the El Paso/Juárez region, in particular. Congestion is worsening, and given forecasts for strong future growth, trip times and costs for travelers will increase, service reliability for freight shippers and carriers will decrease, and the ability of the system to recover from emergencies and service disruptions will become more severely taxed. These issues may erode the efficiency and productivity of the El Paso border crossing system, leading to economic implications that would reverberate locally, regionally, nationally, and internationally. Infrastructure, service, and operational improvements have been proposed within the Texas Department of Transportation's "El Paso Regional Ports of Entry Operations Plan" to alleviate congestion at the border crossings and maintain the flows of commerce that support a dynamic, internationally competitive economy in the El Paso-Ciudad Juarez region.

4.5 MODAL PERSPECTIVE: ECONOMIC BENEFITS OF MARINE TRANSPORTATION INVESTMENT

The U.S. Marine Transportation System (MTS) consists of waterways, ports and their intermodal connections, vessels, vehicles, and system users. State, local, and private companies all own parts of the system. National, state, and local governments participate in managing, financing, and operating the MTS, but most decisions are driven by the marketplace.[79] More than 1,000 harbor channels and 25,000 miles of inland, intracoastal, and coastal waterways in the United States serve over 300 ports, with more than 3,700 terminals that handle passenger and cargo movements. Waterways and ports link to railroad, pipeline, and highway systems that are essential to getting goods to intermediate and final destinations.

The U.S. Department of Transportation's 1999 report to Congress, *Assessment of the U.S. Marine Transportation System,* notes that the MTS provides several types of values to the U.S., including:

- **Economic value –** efficient, effective, and dependable all-weather transportation for the movement of people and goods;
- **National security value –** swift mobilization to sustain America's military;
- **Environmental value –** safe and environmentally responsible form of transportation; and
- **Recreational value –** recreational boating and fishing, or sightseeing, excursion, dining, gaming, windjamming, whale watching, or nature cruises.

That report raises a number of issues confronting those who own, operate, and use the MTS. First is how to meet growing levels of demand associated with international commerce, commercial fishing, recreational users, passenger ferry services, and military requirements. Each of these disparate uses is projected to increase substantially over the next 20 years. Second is how to improve the efficiency of commercial operations to meet the needs of an increasingly competitive marketplace. New equipment, increased capacity, and more efficient operations will be required on many parts of the MTS. A third challenge will be how to handle increased marine traffic while sustaining the environment. The MTS encompasses fragile habitats, including coastal and estuarine waters, inland rivers, and wetlands that must be protected. Air pollution around ports and terminals is a growing concern as is vessel discharge, dredging, and the introduction of nonindigenous species.

[79] U.S. Department of Transportation, *An Assessment of the U.S. Marine Transportation System,* Report to Congress, 1999, http://ntl.bts.gov/DOCS/report/mtsfinal.pdf.

The U.S. Maritime Administration raised additional issues related to ports and intermodal transportation in its 2009 report, *America's Ports and Intermodal Transportation System.*[80] Among the findings from this report are the following:

- America's ports and Marine Transportation System are critical to the national economy. The importance of our port system will only grow as globalization continues and the American economy becomes more integrated into the world economy.
- America's Marine Transportation System faces growing congestion challenges.
- Competing land-use issues adversely impact port expansion efforts.
- Small- and medium-sized ports have an essential role in the development of our marine highway system.
- Inland rail and road bottlenecks impede efficient port-related cargo flows.
- Improved data on port cargo flows are needed to identify bottlenecks and changing trade patterns.
- There is unused capacity on America's waterways that can relieve congested road and rail systems.
- Investment and modernization of the nation's river lock system is needed to support the increased movement of commodities on America's Marine Highways.
- America's ports face competition from an expanding Canadian, Mexican, Central American, and Caribbean port system.

The report recommends a number of actions to address issues identified above. Further research on the benefits of the MTS receives scant direct attention, but there are research implications associated with some recommendations. The first recommendation is to "develop a national freight policy to include a framework for planning, operations, and investment." This is consistent with recommendations from numerous other groups for the development of a comprehensive national freight policy. While a strong base of research is available to support the development of such a national freight policy, additional research would be required before a national freight policy reflecting current issues affecting all freight modes could be developed.

Another recommendation is to "establish criteria that prioritize the selection of projects for Federal funding based on national system needs that support international trade and our global competitiveness." Such criteria would have to

[80] U.S. Maritime Administration, *America's Ports and Intermodal Transportation System*, Washington, D.C., 2009, http://aapa.files.cms-plus.com/PDFs/MarAd%20Ports%20report%20January%202009.pdf.

reflect the benefits of a variety of MTS improvements to the various MTS users. As will be discussed in the next section on international competitiveness, further research is required to identify the types of transportation investments that contribute most directly toward improving the nation's competitiveness.

The Maritime Administration also recommended that "Metropolitan Planning Organizations should incorporate national transportation system strategies and priorities in state, local, and regional transportation planning and investment." The nexus between national, state, and local transportation priorities is an issue for all modes, and in many cases priorities of the different levels of government do not coincide. In some cases, priorities may actually conflict. Further research is needed to identify ways that national infrastructure needs can be met with minimal adverse impacts on local priorities.

The use of Federal incentives to promote desired objectives is included in a number of recommendations. Further research would be required to identify the types of incentives that would most cost-effectively accomplish the desired objectives with a minimal distortion of market mechanisms. Likewise, public-private partnerships are recommended as potential solutions to several different types of problems. Experience with public-private partnerships for transportation projects is limited in the U.S. and further research would be required to identify appropriate roles for the private sector and the various levels of government.

Congress requires that the U.S. Department of Transportation submit a "condition and performance" report biennially to assist in the deliberations on the level and nature of Federal highway and transit programs. The *Transportation Research Board Special Report 279, The Marine Transportation System and the Federal Role: Measuring Performance, Targeting Improvement,*[81] recommended that a conditions and performance reporting process for the MTS be developed along the lines of the report prepared for highways and transit. In 2007 the Maritime Administration commissioned a study to develop a framework for evaluating Marine Transportation System condition and performance.[82] The MTS conditions and performance report provides detailed data on the use of various components of the MTS. Many sources of data related to the MTS were identified, but a number of data gaps and needs also were found, including:

---

[81] Transportation Research Board, *The Marine Transportation System and the Federal Role: Measuring Performance, Targeting Improvement,* TRB Special Report 279, Washington, D.C., 2004, http://onlinepubs.trb.org/onlinepubs/sr/sr279.pdf.

[82] Cambridge Systematics, Inc., *A Framework for Evaluating Marine Transportation System Condition and Performance,* prepared for the U.S. Maritime Administration, Washington, D.C., 2007.

- Relative lack (other than tonnage, value, TEUs, passengers, vessel types, and vessel movements) of data on the performance of MTS facilities and elements;
- Lack of integrated performance data for all system elements across modes;
- Lack of data on linked or chained trips (the ability to follow freight or passengers across different modes, end-to-end, through the intermodal system);
- Lack of "user experience" data on system performance;
- Lack of a consolidated "one-stop" source for detailed data on MTS facilities and infrastructure, ownership, operations, activities, funding, revenues, needs, and planning initiatives;
- Lack of data on the systemwide benefits and return-on-investment value of the MTS; and
- Lack of integrated systems information to facilitate military use of the nation's commercial seaports.

The report recommended developing periodic reports on MTS conditions and performance, modeled generally on the highway and transit reports; developing an MTS data management program to support the conditions and performance report; and developing an investment analysis system that would allow investment/performance relationships to be assessed. It was noted that the U.S. Army Corps of Engineers has a long history of economic analyses of its investment decisions on the inland waterway system, but nothing comparable exists for other elements of the MTS. Developing such a system would take many years, but much would be learned in the process of developing that system.

4.6 INTERNATIONAL COMPETITIVENESS

One of the economic benefits most often mentioned in connection with transportation investment is improved international competitiveness. There is growing recognition that the U.S. is competing in a global economy and that inefficiencies in any part of the production and distribution process can adversely affect the ability of U.S. firms to compete with companies in other countries.

President Obama, in his 2010 State of the Union address, set a goal of doubling U.S. exports in five years. To achieve this goal a National Export Initiative (NEI) was established. In September 2010 a report was released laying out a plan for how the goal of doubling U.S. exports in five years would be achieved.[83] One of

[83] Export Promotion Cabinet, *Report to the President on the National Export Initiative: The Export Promotion Cabinet's Plan for Doubling U.S. Exports in Five Years,* National Export

Footnote continued

the key initiatives to promote growth in exports dealt directly with transportation.

Improvements in the U.S. transportation and supply chain infrastructure are critical to enabling exporters from all 50 states to get their goods to ports quickly and inexpensively. Maintaining a globally competitive, user-focused U.S. supply chain infrastructure is critical to the success of the NEI and to sustained American economic growth. The Departments of Commerce and Transportation have entered into a Memorandum of Understanding to work together and with stakeholders to develop and implement a comprehensive, competitiveness-focused national freight policy. The resulting policy will foster end-to-end U.S. freight infrastructure improvements that facilitate the movement of goods for export and domestic use. The goal is to improve the competitiveness of U.S. supply chains in domestic and international commerce and national economic development, while supporting environmental sustainability and livable communities.

Canada, the European Union, and other competitors already have adopted similar policies that promote their supply chains and national development. Many of the United States' most important exporters are farmers located in rural areas and manufacturers that have built plants in rural areas to keep production costs low. These exporters, like their counterparts in the urban markets, are connected to export ports through a systematic and smoothly functioning network of airports, railroads, roads, and waterways and would benefit from access to containers where and when they need them. Shortages of export containers have hampered the country's ability to meet worldwide demand for agricultural products. The Export Promotion Cabinet will take a fresh look at how empty containers are made available to exporters to help ensure that exporters can get what they need, and will analyze the United States' entire transportation system (including air freight) to ensure that investments are meeting the needs of the nation's exporters.

The Economic Development Research Group (EDRG) conducted a study for the American Society of Civil Engineers in 2011 titled, *Failure to Act: The Economic Impact of Current Investment Trends in Surface Transportation Infrastructure,* in which it sought to provide an objective analysis of the economic implications of the failure to invest adequately in the nation's surface transportation infrastructure.[84] EDRG noted that deteriorating infrastructure puts pressure on the prices of U.S. exports in two ways:

Initiative, Washington, D.C., 2010, http://www.whitehouse.gov/sites/default/files/nei_report_9-16-10_full.pdf.

[84] Economic Development Research Group, *Failure to Act: The Economic Impact of Current Investment Trends in Surface Transportation Infrastructure,* prepared for the American Society of Civil Engineers, Washington, D.C., 2011, http://www.asce.org/uploadedFiles/Infrastructure/report_Card/ASCE-FailureToActFinal.pdf.

- Exporting firms directly experience higher transportation costs with their own truck fleet for shipments to the Mexican and Canadian borders or to an airport or seaport.
- Exporting firms absorb price increases related to transportation costs on some portion of intermediate supplies that arrive by truck and go into a final product. Those intermediate supplies may be domestically produced, or they may be foreign imports that must incur a land bridging cost from an airport or seaport, or from the Canadian or Mexican borders.

EDRG estimates that if surface transportation conditions are not stabilized at current levels, significant losses in exports will occur. By 2020 the value of exports could go down by $28 billion and by 2040 losses could be over $70 billion. Major industries affected include finance and insurance, wholesale trade, aerospace, motor vehicle parts, agriculture, forestry, fisheries, and professional services. EDRG notes that many of these industries are key technology sectors that drive national innovation.

The World Economic Forum (WEF) publishes a Global Competitiveness Report annually in which it ranks countries according to their relative global competitiveness. Competitiveness is measured using 12 "pillars of competitiveness" that are described below.[85]

- **Basic Requirements:**

  First pillar: Institutions. The institutional environment is determined by the legal and administrative framework within which individuals, firms, and governments interact to generate income and wealth in the economy.

  Second pillar: Infrastructure. Extensive and efficient infrastructure is critical for ensuring the effective functioning of the economy, as it is an important factor determining the location of economic activity and the kinds of activities or sectors that can develop in a particular economy. Infrastructure includes all modes of transportation, electric transmission, and telecommunications networks.

  Third pillar: Macroeconomic environment. The stability of the macroeconomic environment is important for business and, therefore, is important for the overall competitiveness of a country.

  Fourth pillar: Health and primary education. A healthy workforce is vital to a country's competitiveness and productivity.

- **Efficiency Enhancers:**

[85] World Economic Forum, *The Global Competitiveness Report 2011-2012,* Geneva, 2011, http://www3.weforum.org/docs/WEF_GCR_Report_2011-12.pdf.

Fifth pillar: Higher education and training. Quality higher education and training is crucial for economies that want to move up the value chain beyond simple production processes and products.

Sixth pillar: Goods market efficiency. Countries with efficient goods markets are well positioned to produce the right mix of products and services given their particular supply-and-demand conditions, as well as to ensure that these goods can be most effectively traded in the economy.

Seventh pillar: Labor market efficiency. The efficiency and flexibility of the labor market are critical for ensuring that workers are allocated to their most efficient use in the economy and provided with incentives to give their best effort in their jobs.

Eighth pillar: Financial market development. The recent financial crisis has highlighted the central role of a sound and well-functioning financial sector for economic activities.

Ninth pillar: Technological readiness. In today's globalized world, technology has increasingly become an important element for firms to compete and prosper. The technological readiness pillar measures the agility with which an economy adopts existing technologies to enhance the productivity of its industries, with specific emphasis on its capacity to fully leverage information and communication technologies (ICT) in daily activities and production processes for increased efficiency and competitiveness.

Tenth pillar: Market size. The size of the market affects productivity since large markets allow firms to exploit economies of scale. Traditionally, the markets available to firms have been constrained by national borders. In the era of globalization, international markets have become a substitute for domestic markets, especially for small countries.

- **Innovation and Sophistication Factors:**

  Eleventh pillar: Business sophistication. Business sophistication is conducive to higher efficiency in the production of goods and services. This leads, in turn, to increased productivity, thus enhancing a nation's competitiveness. Business sophistication concerns the quality of a country's overall business networks as well as the quality of individual firms' operations and strategies.

  Twelfth pillar: Innovation. The final pillar of competitiveness is technological innovation.

Although substantial gains can be obtained by improving institutions, building infrastructure, reducing macroeconomic instability, or improving human capital, all these factors eventually seem to run into diminishing returns. The same is true for the efficiency of the labor, financial, and goods markets. In the long run, standards of living can be enhanced only by technological innovation. Innovation is particularly important for economies as they approach the frontiers

The U.S. ranked 36th for Basic Requirements that include transportation and other essential infrastructure, 3rd for Efficiency Enhancers, and 6th for Innovation and Sophistication Factors.

of knowledge and the possibility of integrating and adapting exogenous technologies tends to disappear.

The WEF bases its rankings on an objective analysis of data related to each of the 12 pillars and an Executive Opinion Survey completed by a cross section of business executives in each country. Over 400 executives from a cross section of firms in the United States responded to the survey.

Overall, the United States ranked 5th in global competitiveness behind Switzerland, Singapore, Sweden, and Finland. Germany, the Netherlands, Denmark, Japan, and the United Kingdom rounded out the top 10 countries. Separate rankings are made for the three categories of factors that contribute to a country's competitiveness. The U.S. ranked 36th for Basic Requirements that include transportation and other essential infrastructure, 3rd for Efficiency Enhancers, and 6th for Innovation and Sophistication Factors. Rankings are further broken down by each of 12 pillars of competitiveness. Within the Basic Requirements category, the United States ranked highest in infrastructure – 16th out of 142 countries. Rankings in the other three pillars under Basic Requirements were significantly worse. In the Executive Opinion Survey only three percent of the respondents listed inadequate infrastructure as among the top five problems in doing business.

The most problematic factors were tax rates, inefficient government bureaucracy, access to financing, tax regulations, and inflation. Within the infrastructure category the quality of infrastructure used by various transportation modes was ranked against other countries. Both the quality of roads and railroad infrastructure in the U.S. ranked 20th out of 142 countries, port infrastructure was 23rd, and air transport infrastructure was 31st. The U.S. ranking for the quality of roads, railroads, and port infrastructure was down from the previous year. Thus while the U.S. ranked relatively high in overall competitiveness, the quality of its infrastructure was not on a par with other elements of competitiveness.

In a 2008 study for FedEx, SRI International developed an Access Index and several Access Opportunity Indices that were used to rank countries across different dimensions of access.[86] The Access Index is similar to the Infrastructure element of the Global Competitiveness Index discussed above in that it includes data on the quality of various transportation modes and telecommunications availability. In addition the Access Index includes information on the openness of a country

[86]SRI International, *The Dynamic Force of Access: An Update of the Access Index*, FedEx, http://about.van.fedex.com/files/exec_full_2008.pdf.

to international trade and the penetration of news and media services. The United States ranks 10 out of 109 countries in the 2008 Access Index. Most of the countries that were in the top 10 in the Global Competitiveness Index also are in the top 10 in the Access Index.

SRI developed three Access Opportunity indices that quantify the benefits of access for key groups of beneficiaries – people, businesses, and nations. The Access Opportunities Index – People is primarily a measurement of citizens' access to education, employment, and telecommunications and the extent to which this access promotes higher economic growth, quality of life, and consumer choice. The U.S. ranks 13th in the Access Opportunities Index – People. Transportation is not among the explicit variables upon which this index is calculated, but to the extent that transportation does provide access to education, health care, and employment, it is an important factor that contributes to preparing citizens to live, work, and prosper in an interconnected global economy.

SRI's Access Opportunities Index – Business is more directly related to the international competitiveness of businesses. The report notes that, "Access continues to transform the ways in which businesses operate, compete, evolve, and create value." One innovation mentioned is "unbundling production from delivery." Amazon.com is given as an example – other smaller retailers use Amazon's logistics and distribution services enabling them to scale up their business without having to invest in the specialized services they purchase from Amazon. Four indicators make up the Access Opportunities Index – Business:

- **Market Reach.** Access helps businesses extend their Market Reach, creating opportunities for specialization, efficiency, investment, and growth.
- **Supply Chain Strength.** Access helps strengthen supply chains by making them more efficient, flexible, and agile, thereby lowering business costs and increasing profitability.
- **Innovation.** Access spurs Innovation by facilitating exchange of ideas and talent within and across national borders, and stimulates demand for innovation by raising consumer expectations.
- **Growth and Competitiveness.** Access has become a key driver of business growth and has transformed the rules of competition for all businesses.

The United States ranks 16th out of the 109 countries in the Access Opportunities Index – Business. Again, this index was not calculated based on explicit transportation variables, but good transportation certainly is important to business, especially with respect to market reach, supply chain strength, and growth and competitiveness.

SRI's Access Opportunities Index – Nations reflects the aggregate opportunities that access provides to nations around the world. The Access Opportunities Index – Nations has four components:

- **Broader Markets.** The ability of a nation's industries to specialize and expand depends on the breadth of the markets from which they obtain inputs and sell outputs. This component explores the benefits of market reach on national economic performance and prospects.
- **Global Connection.** The presence of a seamless network of global "connectivity" for both physical and digital objects promises to usher in fundamental changes in economic and social structures. This component examines opportunities for Global Connection that Access creates.
- **National and International Cohesion.** Access to opportunities to participate, choose, and improve provides a means to strengthen ties and understanding between previously distinct groups. This component examines how Access contributes to National and International Cohesion.
- **Growth and Prosperity.** Nations typically seek to raise their level of output, trade, and investment in order to support higher incomes and better standards of living. Under this component, the SRI team focuses on how global Access generates accelerated Growth and Prosperity.

Overall, the United States ranks 25th in the Access Opportunities Index – Nations. The report finds a strong correlation between a country's score on this index and its GDP per capita. At higher levels of access, GDP per capita increases exponentially as access increases.

Although the Access Index draws heavily from data collected by the WEF in developing its World Competitiveness Index, the role of transportation and the relative ranking of U.S. transportation systems compared to those in other countries are more difficult to discern from the Access Index and the Access Opportunity indices. But one key point that SRI/FedEx makes is that "the lines between physical and information Access are blending and bending as more and more consumers and businesses exchange goods, services, and information over the Internet, unhampered by physical separation." In any case, this report, along with the WEF report, shows that the U.S. is not in the top echelon of countries in many dimensions of international competitiveness, including the quality of its transportation systems.

4.7 ECONOMIC BENEFITS OF MAINTAINING TRANSPORTATION SYSTEMS IN A STATE OF GOOD REPAIR

Some segments of the Interstate Highway System are 50 years old and many National Highway System segments are older than that. A recent AASHTO report notes that only one-half the nation's major roads are in good condition

and in some major metropolitan areas that percentage even smaller.[87] Driving on rough roads accelerates vehicle depreciation, reduces fuel efficiency, and causes wear and tear to tires and vehicle suspension systems. The Road Information Program (TRIP), a cosponsor of the report, estimates that, "For the average driver, rough roads add $335 annually to typical vehicle operating costs. In urban areas with high concentrations of rough roads, extra vehicle operating costs can be as high as $746 annually."

The Interstate system represents only 1 percent of total highway mileage in the country, but carries 24 percent of heavy truck traffic.

Heavy truck traffic is responsible for a large share of roadway deterioration, along with weather, moisture, age, and maintenance practices. The Interstate system represents only 1 percent of total highway mileage in the country, but carries 24 percent of heavy truck traffic. AASHTO estimates that each mile of Interstate Highway currently carries 10,500 vehicles a day, but by 2035 average truck traffic will be 22,700 vehicles per day. This additional truck traffic will cause substantially more wear and tear on pavements and add to pressures to maintain pavements and bridges in a state of good repair.

Failure to maintain roads in good condition can increase long-term lifecycle costs to keep roadways functioning efficiently. If routine preservation is not performed when needed, the costs to reconstruct a roadway after 25 years can be more than three times the costs of performing those preservation treatments and avoiding the need for major reconstruction.

Even the most routine preservation projects can cause major delays on high-volume roads, however. States are adopting a variety of practices to minimize motorist delay during pavement and bridge preservation actions. In metropolitan areas resurfacing is often done at night when traffic volumes are lower. This increases project costs, but reduced traffic disruption more than offsets the added costs. Another strategy that some states have adopted, especially for major improvements, is to actually close facilities while they are being reconstructed. For instance the AASHTO report cites the Indiana DOT's closing of two heavily traveled Interstate Highways so that work could proceed round-the-clock to reconstruct those facilities. Work was completed in 55 days, 30 days ahead of schedule, saving taxpayers an estimated $1 million per day in lost wages and productivity for each day that traditional construction would have added. Other states have successfully used this technique for major reconstruction projects. Considerable research has been conducted to document accelerated construction

[87] American Association of State Highway and Transportation Officials and TRIP, *Rough Roads Ahead, Fix Them Now or Pay for it Later,* Washington, D.C., 2009, http://roughroads.transportation.org/RoughRoads_FullReport.pdf.

techniques that states have used in different situations, but less research was found on either how to quantify the benefits of using various accelerated construction techniques in different situations or on guides for states on the use of various types of accelerated construction techniques in different situations. California has developed a schedule and traffic analysis tool called CA4PRS that allows planners and designers to optimize project scheduling, traffic management, and budget for a variety of pavement rehabilitation and maintenance strategies.[88]

Completing repairs quickly is only one consideration in reducing motorist delays associated with highway preservation activities. Another factor receiving increasing attention is lengthening the time between preservation activities through the use of high-quality materials. Caltrans began implementing a Long-Life Pavement Rehabilitation Strategies program in 1998. The goal of the program is to rebuild approximately 2,800 lane-km of high-volume freeways with pavements that are designed to last more than 30 years with minimal maintenance. This strategy of "Get in, get out, stay out" reduces the need to frequently disrupt traffic in major metropolitan areas for maintenance activities which ultimately reduces overall lifecycle costs as well.

A recent study for the Michigan Department of Transportation compared short-term and long-term economic impacts of different mixes of investment.[89] In general, shifts in the program mix toward greater expenditures on increased capacity and new roads and lower expenditures on preservation-related activities were found to increase economic benefits measured in terms of user travel time savings, short-term construction-related employment, and longer-term impacts on employment, gross state product, personal income, population, and state government tax revenues accruing to the Michigan economy. Beyond a point, however, the benefits from increasing the share of program expenditures for new capacity declined, reflecting the growing adverse effect of deteriorating highway conditions on travel times. The report concludes, however, "As important as economic progress is to a state currently undergoing economic trauma, we should not lose sight of the myriad quality-of-life considerations in assessing our strategies. Benefits related to safety, health, and equitable treatment of the State's citizens are all part of the value of living, working, and playing in Michigan." Future research in Michigan and other states to quantify

---

[88] California Department of Transportation, "CA4PRS Implementation Project for Rapid Rehabilitation," http://www.dot.ca.gov/hq/research/roadway/llprs/index.htm.

[89] University of Michigan Institute of Labor and Industrial Relations and Economic Development Research Group, Inc., *Evaluating the Economic Benefits to Michigan of Alternative Road-Bridge Investment Mixes,* prepared for the Michigan Department of Transportation, Lansing, Michigan, 2008, http://www.michigan.gov/documents/mdot/MDOT_Research_Report_RC1518_250377_7.pdf.

economic and other impacts of alternative mixes of program expenditures would be valuable.

Major transit systems also are aging rapidly. The Federal Transit Administration reports that only 30 percent of assets owned by the nation's largest rail agencies are in good or better condition. Unlike most state highway agencies that already have well developed asset management systems, few transit operators have comparable asset management processes.[90] Little research was found on the costs of deferred equipment or guideway maintenance, although there is a clear recognition that preventive maintenance will extend the useful life of transit vehicles. FTA reports that active preventive maintenance programs improve vehicle reliability and lower future maintenance costs.[91] FTA also reports that despite riders' preference for newer vehicles, there does not appear to be any empirical evidence that vehicle age or condition actually affects ridership.

Studies of particular aging transit systems in Philadelphia, Chicago, New York, and San Francisco have assessed the consequences for the economy of not maintaining transit systems in a state of good repair. A study for the New York MTA, *Lasting Economic Benefits of Public Transportation Investment* (Cambridge Systematics, 1996), found that investments to maintain a state of good repair had somewhat higher economic returns to the regional and state economies than investments in system expansion. However, all categories of investment showed positive returns and the existing conditions of assets and the mix of state of good repair investments versus expansion investments may alter the results.

4.8 MEASURING TRANSPORTATION IN THE ECONOMY

Another line of macroeconomic research related to transportation that has not received as much attention as the research noted above is measuring the importance of transportation within the overall economy. One early measure of the importance of transportation to the economy was the "transportation bill" estimated by the Eno Foundation. The transportation bill included total spending on transportation services, equipment, etc., throughout the economy, but it did not measure the total contribution of the transportation industry to the economy or the overall final demand for transportation throughout the economy.[92] Han and Fang developed several measures of transportation within the

---

[90] Federal Transit Administration, *Transit State of Good Repair: Beginning the Dialogue*, Washington, D.C., 2008, http://www.fta.dot.gov/documents/SGR.pdf.

[91] Federal Transit Administration, *Useful Life of Transit Buses and Vans,* Washington, D.C., 2007, http://www.fta.dot.gov/documents/Useful_Life_of_Buses_Final_Report_4-26-07_rv1.pdf.

[92] Han, Xiaoli and Bingsong Fang, "Measuring Transportation in the U.S. Economy," Journal of Transportation and Statistics, January 1998, http://ntl.bts.gov/lib/9000/9100/9108/han.pdf.

overall economy using the System of National Accounts. These measures reflected transportation's share of GDP and Gross Domestic Demand, but they note that the transportation-related final demand component of GDP is not a complete indicator of the importance of transportation to society because it does not reflect transportation consumed as an intermediate demand and transportation provided by consumers to themselves.

To address this issue the U.S. Department of Transportation's Bureau of Transportation Statistics and the Bureau of Economic Analysis jointly developed "transportation satellite accounts" that capture not only the for-hire transportation industries appearing directly in the U.S. input-output accounts, but also transportation services provided by nontransportation industries for their own use that must be extracted from the input-output data.[93] The significance of the transportation satellite accounts is that they give a more comprehensive picture of the role of transportation in the nation's economy than other available data. Among the economic indicators provided by the transportation satellite accounts are:

- The share of total costs attributable to transportation for various industries;
- The value of for-hire and in-house transportation services used by different industries;
- The value added by for-hire and in-house transportation services by major transportation modes;
- Transportation requirements to meet an added increment of demand for different commodities;
- Economic multipliers for different transportation modes that indicate the total economic impact associated with increased investment in different modes; and
- Changes in these various indicators over time.

The Bureau of Transportation Statistics notes future research that could be done to improve and extend measures in the transportation satellite accounts. This includes:

- Updating data sources used in creating distribution weights;
- Adding other modes of in-house transportation, such as the business use of automobiles, when information becomes available; and

[93] U.S. Department of Transportation, Research and Innovative Technology Administration, Bureau of Transportation Statistics, *Transportation Satellite Accounts: A Look at Transportation's Role in the Economy,* Washington, DC, 2011, http://www.bts.gov/publications/transportation_satellite_accounts/2011/pdf/entire.pdf.

- Treating in-house transportation in the same manner as the I-O accounts treat the use of for-hire transportation, that is, including only transportation expenses associated with moving intermediate inputs to the industry plus the expenses for certain direct transportation services. Doing so would require detailed information on the type of commodities carried by in-house truck and on the origin and destination of the transported commodities.

A variable used in some macroeconomic analyses of the contribution of highway investment to economic growth is a measure of the highway capital stock. The highway capital stock is a measure of the current value of the nation's highways, roads, and bridges. This value is estimated by looking at historical highway investment patterns and depreciating the value of previous year's investments according to the expected productive life of the highway assets purchased with those investments. The most recent research into estimation of the highway capital stock was done by Barbara Fraumeni for the Federal Highway Administration.[94] In this analysis Fraumeni not only depreciates the value of the capital stock to reflect deterioration of pavements and bridges, but she also reflects added travel time and vehicle operating costs associated with operating on deteriorated pavements. No adjustment, however, is made for added travel time and vehicle operating costs associated with increasing congestion on many parts of the highway system. Fraumeni estimates that the value of the highway capital stock in 2007 was about $1.5 trillion in 2000 dollars. The value of the capital stock has been steadily increasing since 1956, but the rate of growth has slowed somewhat in recent years. If adjustments were made to reflect the declining productivity associated with increasing congestion, the slowdown in recent years might be even greater.

4.9 FUTURE RESEARCH FROM A MACROECONOMIC PERSPECTIVE

Several areas of potential future research have been identified in previous research. One is to extend the analysis done by Nadiri and Mamuneas on differences in productivity gains associated with investment in higher order transportation systems compared to gains associated with all transportation investment. Clearly the benefits of different types of improvement on different parts of the transportation system vary and these would be expected to have different effects on national economic productivity.

A second area of potential future research is to improve measures of the capital stock to reflect transportation system characteristics that are important in stimu-

[94] Fraumeni, Barbara M., *Productive Highway Capital Stocks and the Contribution of Highways to Growth in GDP,* prepared for the Federal Highway Administration, Washington, D.C., 2007, http://www.fhwa.dot.gov/policy/otps/phcsmsumm08.pdf.

lating economic development. This could be expected to provide more robust estimates of the impact of transportation investment on economic growth and productivity. Eberts recommends that among the important highway characteristics to include in macroeconomic analyses are congestion levels, pavement condition, travel volumes by vehicle type, and reliability.[95] At the state level Eberts found such system characteristics had a significant effect on production functions.[96] Research has shown that congestion dampens the benefit of highway investment on productivity. That line of research could be extended to improve estimates of how much congestion is adversely affecting overall economic productivity on a macroeconomic scale. This builds on a recommendation by RAND for further research on how transportation system condition and level of service affect economic performance. Related to the issue of congestion eroding the productive value of the highway capital stock is the fact that the composition of the highway program has changed over time. A smaller share of total highway expenditures now goes for actual construction than was the case 20 years ago. Without adjustments for the changing composition of highway program, it is not surprising that economic return from highway investment is lower than in the past.

A third potential area for future research is to explore how the large volumes of future freight traffic could be hauled efficiently without further disruption of passenger traffic. What are the advantages and disadvantages of options such as greater public investment in rail improvements, construction of exclusive truck lanes, etc.? What will be the economic cost of the status quo in terms of international competitiveness, increased transportation and logistics costs, and increased congestion highway congestion? Future research also has been recommended to support multimodal freight analysis tools. The Freight Evaluation Framework developed through a National Cooperative Freight Research Program project is promising, but it has not been extensively tested.

Related to the issue of how to efficiently serve both passenger and freight traffic on highway and railroad networks is the issue of how to efficiently serve local and through traffic in and around major metropolitan areas where conflicts most often occur.

RAND had several other recommendations for future research that are all worthy of consideration, including: 1) comparing macroeconomic benefits of transportation infrastructure against the cost of providing that infrastructure to assess the net benefits; 2) using more recent data to estimate the effects of trans-

---

[95] Eberts, Randall W., *How Levels of Investment in Transportation Affect Economic Health,* paper presented at TRB conference, "Information Requirements for Transportation Economic Analysis," Washington, D.C., 2000.

[96] Eberts, Randall W., *Highway Infrastructure: Policy Issues for Regions,* working paper prepared for "Conference on Assessing the Midwest Economy," sponsored by the Federal Reserve Bank of Chicago, 1997.

portation investment; and 3) assessing the macroeconomic effects of investment in modes other than highways. Despite the significant amount of research that already has been done to quantify relationships between highway investment and measures of economic performance, additional statistical research could be conducted to compare macroeconomic benefits of transportation infrastructure to the cost of providing that infrastructure to provide a measure of the net benefits of highway infrastructure. Statistical research could be broadened to assess how the condition and level of congestion of transportation infrastructure affects economic performance. More research using the most recent data available would confirm whether the relationships from even a decade ago still hold with the rapidly changing patterns of globalization and supply chain management. In addition, macroeconomic impacts of more types of transportation infrastructure should be assessed. Almost all studies RAND found in their literature review dealt with highways and far fewer with public transit or intercity freight railway infrastructure.

Eberts offers several suggestions for future research to improve estimates of the impacts of transportation investment on state and regional economies. One is to conduct a series of historical case studies in particular states to relate changes in economic indicators to specific transportation improvements. With enough observations, analysts could develop more precise estimates of the impacts of future transportation investments. Eberts recognizes, however, that economic conditions in a state or region change and that more recent relationships between transportation and economic development would provide better evidence of potential future impacts than findings from earlier investments. He further suggests that if enough characteristics of both the transportation system and the state economy are included in such analyses, that results might then be applied to other states by comparing characteristics of those states to states for which detailed economic impact analyses have been conducted and making appropriate adjustments to reflect differences between the states. Another potential future research area identified by Eberts is to make greater use of the Census Bureau's Longitudinal Research Datafile (LRD) that contains data on individual manufacturing establishments. This would allow a greater spatial correspondence to be made between changes in transportation and changes in economic activity for different industry groups at the firm level.[97]

As transportation facilities and equipment continue to age and deterioration accelerates under the influence of growing traffic volumes, increasing investment will be required to maintain highway, transit, and other transportation systems in a state of good repair. Prior research has demonstrated the importance of timely maintenance and rehabilitation, but uncertainties remain concerning the continuing performance of preventive maintenance strategies as facilities age. For instance, can even the most effective preventive maintenance strategies

[97] Eberts, 2000, op. cit.

indefinitely postpone the need for major pavement and bridge reconstruction, or at some point will reconstruction still be required?

For transit, further research may be needed to develop the kinds of comprehensive asset management systems that are widely used by highway agencies. Research also might be conducted to further explore the relationship between the age and condition of transit vehicles and ridership for different segments of the population and for different types of trips.

5.0 Broader Economic Benefits of Transportation Investment

Benefit-cost analyses have been criticized by some because they do not include many economic benefits resulting from transportation investment. Sue Wing, Anderson, Lakshmanan[98] note:

> *"…decisions about the levels and allocations of transportation infrastructure investments must currently be made with incomplete information about their economic impacts. Analytical tools are limited to microscale analyses, which may not capture the full range of economic benefits induced by a project or program, and macroscale analyses, which are too broadly defined to provide guidance on the relative benefits of specific projects and programs. The situation calls for analytical tools defined as a "mesolevel" that can provide impacts assessments that are both comprehensive and capable of representing specific expansions of infrastructure capacity."*

To overcome this weakness the authors specify a computable general equilibrium (CGE) model that is specifically designed to assess the broader economic impacts of transportation infrastructure investments. They indicate that models of this type should be based on three requisites:

12. Unlike macroscale analyses, they should incorporate information about specific additions or improvements to transportation infrastructure networks (although not necessarily at the level of detail found in microscale analyses);
13. They should trace the economic processes that are triggered by infrastructure improvements (that) may take the form of static general equilibrium effects or dynamic developmental effects; and
14. Finally, in order to assess the relative magnitude of different economic mechanisms and to inform policy, they should be amenable to empirical implementation using data that are either available or obtainable at reasonable cost.

---

[98] Sue Wing, Ian, William P. Anderson, T.R. Lakshmanan, *The Broader Benefits of Transportation Infrastructure,* Boston University Center for Transportation Studies, 2007, http://people.bu.edu/isw/papers/The%20Broader%20Benefits%20of%20Transportation%20Infrastructure.pdf.

Sue Wing, et al., note that the CGE model generates a range of information that cannot be obtained from existing models such as whether the benefits of a capacity expansion accrue mostly to firms or households, whether household benefits are mostly in consumption activities or commuting and whether some industries benefit more than others. Such information may be useful in assessing whether specific objectives that policy-makers attach to a project are likely to be met. Also, the CGE specification is especially well-suited to assessing the impact of infrastructure programs because the implementation of two or more capacity expansions can be modeled simultaneously. This will be useful in identifying complementarities among projects by seeing, for example, whether the benefits of projects A and B implemented simultaneously exceed the sum of the benefits of A and B implemented independently. Weisbrod notes, however, that while CGE models are appropriate for simulating supply, demand and intensity of use of labor at a regional level, local factors such as highway and intermodal connectivity and access changes are usually not fully covered.[99]

5.1 STATIC AND DYNAMIC EFFECTS

Sue Wing, Anderson, Lakshmanan[100] also distinguish two classes of economic impacts – "static general equilibrium" impacts and "dynamic developmental impacts." Static general equilibrium impacts reflect the many effects associated with time and monetary savings that users realize as a result of the transportation improvement. Dynamic developmental impacts include "transformations in the structure and pattern of the economy, such as changes in the spatial pattern of production, creation of new industries and interindustry linkages, changes in the lifestyles and preferences of households, and the evolution of institutions and markets." While real, these dynamic impacts are very difficult to predict, so the CGE model developed by Sue Wing, Anderson, and Lakshmanan only captures the static general equilibrium impacts which are the direct result of market mechanisms. Despite the inability to reflect the dynamic impacts of transportation improvements, the authors see this type of CGE model as a "useful step toward better understanding the economy-wide consequences of transportation infrastructure in the economy."

---

[99] Weisbrod, Glen, "Models to Predict the Economic Development Impact of Transportation Projects: Historical Experience and New Applications," Annals of Regional Science, January 2008, http://www.edrgroup.com/pdf/models-to-predict-the-eco.pdf.

[100] Sue Wing, Ian, William P. Anderson, T.R. Lakshmanan, *The Broader Benefits of Transportation Infrastructure,* Boston University Center for Transportation Studies, 2007, http://people.bu.edu/isw/papers/The%20Broader%20Benefits%20of%20Transportation%20Infrastructure.pdf.

Iacono and Levinson[101] reviewed the various methods that have been used to estimate the economic impact of transportation improvements, including project-level benefit-cost analysis, estimates of induced demand, and both aggregate and disaggregate economic analysis methods. They conclude that each of these approaches has limitations for estimating the economic impacts of upgraded facilities. Project-level models used to date do not adequately reflect the dynamic effects of transportation improvements and do not account for all project impacts. The authors note with respect to induced demand that neither the short-term behavioral responses to increases in transportation capacity nor the long-term "codevelopment" processes whereby transportation and land use develop jointly over time are understood well enough to develop reliable estimates of induced demand and to understand the underlying economic benefits reflected by induced demand. They recognize that induced demand is a reflection of economic benefits associated with transportation projects, not disbenefits as many maintain.

"A good evaluation approach should both provide consistent estimates of project impacts and provide insight into the process that generated those impacts, so that the results can be applied in a policy-relevant context."

As pointed out by Sue Wing, et al., the econometric modeling approaches that have been used to estimate macroeconomic benefits of transportation investment have limited applicability to individual projects or programs of projects and lack the policy-sensitivity to accurately reflect the economic impacts. The authors recommend combining elements of the various approaches to determine how consistent the results are and where results differ, trying to uncover the reasons why they differ. They conclude, "A good evaluation approach should both provide consistent estimates of project impacts and provide insight into the process that generated those impacts, so that the results can be applied in a policy-relevant context." Little such research has been conducted to compare estimates of economic benefits using different methods of analysis.

Weisbrod and Reno's 2009 APTA study illustrates the dynamic and intermodal interrelationships as they looked at long-term economic benefits of public transportation investment. As stated previously, their work illustrates how, over time, reduction in costs for individual users and businesses can influence modal choice and, in turn, traffic congestion and access to labor. Weisbrod and Reno assert that social and environmental benefits of public transportation investment

---

[101] Iacono, Michael and David Levinson, *Methods of Estimating the Economic Impact of Transportation Improvements,* Minnesota Department of Transportation, TRS 0802, 2008.

which are not included in the estimated economic benefits would push total benefits even higher.

Weisbrod and Reno detail methods for estimating a broad range of potential transit benefits. Methods focus on how to estimate benefits of public transportation investment on the economy of a given area rather than the user benefits included in traditional benefit-cost analysis. As noted above, most benefit-cost analyses do not examine how transportation investments affect economic growth and productivity, but those important benefits are included in the Weisbrod/Reno methodology.

In a study prepared to support the Eddington Transport Study discussed above, the British consulting firm MVA looked explicitly at the wider economic impacts of transportation investment.[102] Guidance from the Department for Transport (DfT) for that study identified four categories of benefits that are not captured in conventional project appraisal:

- **Agglomeration –** the increase in productivity which has been resulting from higher densities of employment;
- **More people working –** the increase in output arising from better transport encouraging more people into work;
- **Move to more productive jobs –** the increase in productivity resulting from relocating jobs into higher productivity areas; and
- **Increased output in imperfectly competitive markets –** the increase in production resulting from transport improvements.

The study used a suite of transportation models, including a detailed transportation-land use model to analyze these potential impacts for a variety of different transport improvements. The study concluded that it was feasible to estimate the wider economic benefits of transportation improvements and that those impacts can be substantial, increasing overall benefits of some transportation improvements by as much as 50 percent. Agglomeration benefits were generally found to be greater than the other economic benefits studied. Further research was recommended to better understand: 1) the mechanisms through which the wider impacts actually come about, especially agglomeration impacts; and 2) possible transport responses that have either been excluded from the present analysis or that cannot currently be modeled, particularly about the implications of travel time reliability. The study noted that the DfT is seeking to commission further research on the spatial scale of agglomeration effects.

---

[102] MVA Consultants, "Wider Economic Impacts of Transport Interventions," Appendix to Eddington Transport Study, 2006.

5.2 AGGLOMERATION EFFECTS

Agglomeration effects have long been recognized as a result of transportation improvements, but they rarely are included in studies assessing potential benefits of transportation investment. As noted in the study by MVA, agglomeration effects can be significant. Another study commissioned to support the Eddington Transport Study focused exclusively on the relationship between agglomeration and productivity.[103] The author of that study report, Daniel Graham, explains agglomeration economies as follows:

> *"Remy Prudomme of France has done a lot of work in terms of the power of increase access to jobs, etc. Wendell has quoted it a lot. Remy is a friend of ours.*
>
> *Agglomeration economies are positive externalities that arise through the spatial concentration of economic activity. According to urban economic theory, firms derive productive advantages from locating in close proximity and the existence of such benefits can explain the formation and growth of cities and dense industrial areas. The main sources of agglomeration externalities are thought to arise from improved opportunities for labour market pooling, knowledge interactions, specialization, the sharing of inputs and outputs, and from the existence of public goods. As the scale and density of urban and industrial agglomerations increase, we expect to find an increase in the external benefits available to firms….The prevalence of transportation costs is crucial in generating tendencies towards spatial concentration, and in fact, the level of urban or industrial density experienced by any firm is partly dependent on the nature of transport provision. This is because transport systems to some extent determine proximity, or the ease of access, to other firms and to labour markets. In effect, transport can change urban or industrial densities by rendering a larger scale of activity more accessible."*

Agglomeration is not exclusively about higher density and physical proximity between economic entities, however. To the extent that transportation improvements reduce travel times and travel costs, they may still produce agglomeration effects even if businesses and labor do not move closer to one another.[104]

In his study, Graham measures agglomeration as the effective density of employment available to firms in each ward in Britain. Firm level data are used to develop a production function with agglomeration entered as a variable

---

[103] Graham, Daniel J., "Investigating the Link between Productivity and Agglomeration for UK Industries," Appendix to Eddington Transport Study, 2005.

[104] MVA, op. cit.

affecting the production function. Data from 1995 to 2002 were used to develop the production functions for firms in 28 industry groups. Elasticities of agglomeration were developed that measured the change in productivity associated with a proportional change in agglomeration. Results showed that for primary industries (mining, agriculture, forestry, etc.) the elasticity of agglomeration is insignificant indicating that agglomeration had no effect on productivity. Industries in the manufacturing sector had mixed results. Some realized a growth in productivity associated with changes in agglomeration while others did not. The weighted average elasticity for manufacturing firms was 0.077, meaning that a 10 percent increase in agglomeration produced a 7.7 percent increase in productivity. Graham notes that this is comparable to results found by others. Elasticities of agglomeration were found to be positive in 11 of 13 service sector industries with a weighted average elasticity of 0.197. A 10 percent increase in agglomeration leads to nearly a 20 percent increase in productivity. Elasticities were even higher when the measure of agglomeration was changed from distance to travel time – for manufacturing firms the average elasticity increased from 0.077 to 0.11 and for service sector firms the elasticity rose from 0.197 to 0.27. Thus when transportation improvements reduce travel times between two points they can have significant effects on productivity. At the same time when congestion causes increases in travel times, productivity declines. Graham concludes, "an increase in effective densities induced through transport investment may have associated productivity benefits via agglomeration. Agglomeration gives rise to efficiency gains, and transport investment can alter the intensity of this relationship by changing the level of agglomeration available to firms."

Studies by Ciccone,[105] Duranton,[106] and others support Graham's findings and point to significant benefits of agglomeration to economic productivity that are not being included in transportation benefit-cost studies conducted at the project level.

The theory that market size contributes to economic growth has been known at least since Adam Smith, but Alfred Marshall first proposed the specific mechanisms by which agglomeration benefits arise in 1920.[107] His pioneering work has evolved into the "New Economic Geography," which is a synthesis best described by Paul Krugman in his 1991 paper *Increasing Returns and Economic*

---

105 Ciccone, Antonio and Robert E. Hall, "Productivity and the Density of Economic Activity," *The American Economic Review,* Vol. 86, No. 1, 1996, http://www.crei.cat/files/filesPublication/87/090505103655_productivity20and20the20density20ciccone%5B1%5D.pdf.

106 Duranton, Gilles and Diego Puga, *Microfoundations of Urban Agglomeration Economies,* June 2003, http://sites-final.uclouvain.be/econ/DW/DOCTORALWS2004/bruno/puga%20handbook.pdf.

107 Marshall, A. *Industry and Trade*, Macmillan & Co, New York, 1919.

Geography, for which he won the Nobel Prize. This theory posits that benefits arise from five separate consequences of higher residential and industrial densities: matching, sharing, knowledge spillovers (or learning), competition, and access to labor. These five consequences may be called collectively agglomeration effects.

These agglomeration effects involve firm interactions that result from higher concentration of employment. These benefits result from an increase in the number and size of firms interacting with a region. Empirical research indicates that employment density increases worker and firm interactions, which results in increased business productivity.[108] In particular, these business-to-business and worker-to-worker agglomeration effects reflect the benefits of proximity between firms.

Altstadt and Weisbrod (2011) develop an econometric model of the relationship between access/connectivity characteristics of local areas and relative levels of business productivity, job concentration, and export base. These relationships are estimated using simultaneous, nonlinear equations that allow access threshold effects to be recognized, and for different relationships to apply among 54 industry sectors. They provide a framework to analyze the broader productivity and agglomeration benefits on a regional and national scale, along with their implications for estimating the wider economic benefits of specific transportation investment.[109]

Remy Prud'homme studied large cities around the world to assess their contribution to economic growth and factors that affect this contribution. He notes that, "The efficiency of the transport system therefore appears as a key, probably the key, variable in determining the productivity of large cities, and beyond, the welfare of their country at large. If the transport system fails to turn a large agglomeration of people and enterprises into an effective labor market, then the potential of megacities will not be realized, and the enemies of large cities will be proven right. If, on the other hand, thanks to sufficient infrastructure and to efficient management, people and goods and ideas flow easily within the large cities of developing countries, then they will become the engines of growth that large cities, and only large cities, can be."[110]

---

[108] Krugman, P. (1991). "Increasing Returns and Economic Geography," *Journal of Political Economy*, 99, pages 483-499.

[109] Alstadt, Brian and Glen Weisbrod, *The Relationship of Transportation Access and Connectivity to Local Economic Outcomes: A Statistical Analysis,* Submitted to the Transportation Research Board 2012 Annual Meeting, August 10, 2011.

[110] Prud'homme, Remy, *Urban Transport and Economic Development,* Keynote speech for the 7th conference on the Development and Planning of Urban Transport in developing Countries (CODATU VII), New Delhi, 1996, http://region-developpement.univ-tln.fr/fr/pdf/R5/R5_Prudhomme.pdf.

5.3 MODAL PERSPECTIVE: TRANSIT INVESTMENT

In a 2009 study for APTA, the study that has been referenced above by Weisbrod and Reno detail methods for estimating a broad range of potential transit benefits. Methods focus on how to estimate benefits of public transportation investment on the economy of a given area rather than the user benefits included in traditional benefit-cost analysis. As noted above, most benefit-cost analyses do not examine how transportation investments affect economic growth and productivity, but those important benefits are included in the Weisbrod/Reno methodology. The approach can be used to estimate national economic benefits of public transportation investment and with a few changes also can be used to estimate local and regional economic benefits as well. The authors identify one area where additional research could improve the comparison of investment in alternative modes. They recommend considering all investment and spending on the various modes to improve estimates of the number of jobs supported by spending on each mode. This approach, they say, also would recognize the benefits of highway investment on public transportation services and the potential for investment in public transportation to reduce household expenditures on automobiles and free up that money for spending on other goods and services.

Public transportation investment has many benefits that do not directly benefit local and regional economies, but nevertheless have economic value. For instance, to the extent that public transportation reduces automobile travel, air pollution, greenhouse gases emissions, and noise will be reduced. A substantial volume of research has been conducted on the cost of these environmental factors, especially the adverse health effects of air pollution, but the range of estimates varies widely.

While a primary objective of streetcars is to provide circulation within urban centers.[111] The American Public Transportation Association lists 29 existing streetcar systems, 4 systems under construction, and approximately 80 systems being planned in U.S. and Canadian cities.[112] Smatlak notes that, "Transportation is the key to creating great public places, and cities across the country are taking a new look at an old idea – the city streetcar….By connecting together key activity centers, parking and other forms of transit with convenient service levels, the streetcar becomes the key to creating a vibrant cityscape that is attractive to all."

ECONorthwest and PBQD cite a unique benefit of public transportation that often is not included in benefit-cost analyses – the "option value" of having the

---

[111] Smatlak, John, *U.S. Streetcar Systems,* http://www.railwaypreservation.com/vintagetrolley/vintagetrolley.htm.

[112] American Public Transportation Association, APTA Streetcar and Heritage Trolley Site, http://www.heritagetrolley.com/PlannedSystems.htm.

service available even if it is used infrequently. They liken this benefit to stock options and say that methods used to evaluate financial options can be used to establish transit's option value. Factors that enter into their calculations of the option value of public transportation are the expected cost of automobile trips, the standard deviation of auto trip costs, the "exercise price" or cost of using public transportation as an alternative to the auto, and the expected frequency with which public transportation might optionally be used instead of the auto. The option value of transit is not a monetary benefit to the local or regional economy, but reflects a willingness of auto users to pay to have public transportation available as an option. The authors provide ranges of potential option values based on differing assumptions about the variables noted above, but do not indicate whether those values have been validated by other means such as willingness-to-pay surveys. Since providing travel choices is one of the main justifications for public transportation investment, further research into the value that users place on having these options may be warranted.

ECONorthwest and PBQD discuss the impact public transportation may have on land values and land use development patterns. They note that changes in property values are a direct reflection of travel benefits and as such should not be included in benefit-cost analyses to avoid double-counting. They point out, however, that public transportation improvements can create agglomeration, just as major highway projects can. When the clustering of business activity creates economies of scale or reductions in infrastructure costs due to more compact development patterns, those benefits reflect more than simply the increased accessibility provided by the improvement and should be considered in transit investment decisions.

The U.S. Government Accountability Office (GAO) concludes that population increases and other demographic factors may increase the future demand for public transportation and hence its benefits.[113] A principal factor leading to increased demand will be the 20 percent increase in overall population projected by the Census Bureau between 2010 and 2030. Some of this increased population will move to central cities and close-in suburbs that in many metropolitan areas are expected to be redeveloped. This will increase density and drive the demand for more public transportation. GAO also expects more emphasis on transit-oriented development around transit stations in both urban and suburban areas to increase demand. A third factor expected to increase public transportation ridership is the growing number of older persons who either cannot drive to prefer to take public transportation for many of their trips. Some transit agency officials interviewed by GAO during the course of their study indicated that their agencies lacked the technical expertise to accurately forecast future ridership. A

---

[113] U.S. Government Accountability Office, Public Transportation: *Transit Agencies' Actions to Address Increased Ridership Demand and Options to Help Meet Future Demand,* Washington, D.C., 2010, http://www.gao.gov/new.items/d1194.pdf.

related difficulty for transportation planning agencies will be forecasting the distribution of population growth, especially within different parts of metropolitan areas. Zoning and other local policy levers can influence development patterns, but if those tools do not recognize the location preferences of both households and businesses, they will not be effective and could lead to investment in the wrong areas.

Another area of particular interest in exploring the benefits to transportation investment in a mature surface transportation system is the opportunity for development in infill areas near transit. In the last few decades, the concept of a transit-oriented development (TOD) has been touted as an opportunity for stronger integration between land use and transportation planning that could lead to positive economic outcomes. The earlier research focused on dense residential neighborhoods and mixed-use development featuring housing built over retail and the use of hedonic price models to measure the land values near TODs.[114,115] More recent studies have focused on the exploration of the relationship between transit and job concentrations at TODs.[116] Based on a summary of the literature, the following factors emerge as critical in creating viable transit service in the era of dispersed employment:

- **Employment Density.** The concentration of workers in a given area (generally measured as employees per acre), with higher densities associated with beneficial impacts for transit ridership.
- **Destination Size.** The total number of jobs at a destination, with larger concentrations likewise having beneficial impacts for transit ridership. Pushkarev and Zupan, working when jobs were much more highly concentrated than they are now, referred to "Downtown size" measured in nonresidential square feet.
- **Origin Proximity.** The closer a dense commuter neighborhood is to employment concentrations, the more likely the proportion of users taking transit will rise in that neighborhood.

5.4 ACCESSIBILITY AND ECONOMIC DEVELOPMENT

While there is widespread agreement that the initial construction of the Interstate system had significant national and regional economic benefits, impacts of

---

[114] Cervero, Robert, *The Transit Metropolis,* New York: Island Press, 1998.

[115] Cervero, R., *America's Suburban Centers: The Land Use–Transportation Link,* Boston: Unwin-Hyman, 1989.

[116] Center for Transit-Oriented Development, *Transit-Oriented Development (TOD) and Employment,* May 2011, http://www.reconnectingamerica.org/assets/Uploads/TOD-EmploymentFINAL20111122.pdf.

incremental expansion of the highway network are not as clear. Banister and Berechman[117] argue that:

> *"…where there already is a well-connected transport infrastructure network, further investment will not on its own result in economic development. Transport infrastructure investment acts as a complement to other more important underlying conditions, which must be met if further economic development is to take place."*

Banister and Berechman suggest that improved accessibility is less important to economic development today than it was even 20 years ago for the following reasons: 1) the work trip accounts for a smaller share of all travel than in the past; 2) decentralized development patterns have resulted in commuting times remaining the same in major metropolitan areas; 3) new information and telecommunications technologies are considered more vital to improved production and distribution processes than improved transport; and 4) environmental and climate change concerns will increasingly require that households and firms reduce the amount of travel.

Banister and Berechman illustrate their view of the connection between transport investment and economic development in the figure below. Relationships in this figure are quite similar to those discussed by other authors, but the point that Banister and Berechman make is that "allocative externalities" such as agglomeration, labor market effects, and transportation network effects that lead to economic growth do not occur equally in all locations and may not occur at all in some locations. They cite examples of highway and transit projects that were expected to have economic development effects which never materialized. The Buffalo Light Rapid Rail Transit project was constructed in part to revitalize the Buffalo CBD but a study of that system by Berechman and Paaswell[118] concluded that improved rail transit accessibility was neither a necessary nor a sufficient condition to revitalize the CBD, and that conflicting highway, parking, transit and zoning policies worked against attempts to revitalize downtown Buffalo. Similarly, they cite a ring road around Amsterdam that was expected to have a significant effect on office location and rents that never materialized. A study of that road concluded that other factors like building amenities had a greater impact on office location decisions than improved accessibility. Many other Linkages between Transport Investment and Economic Development examples

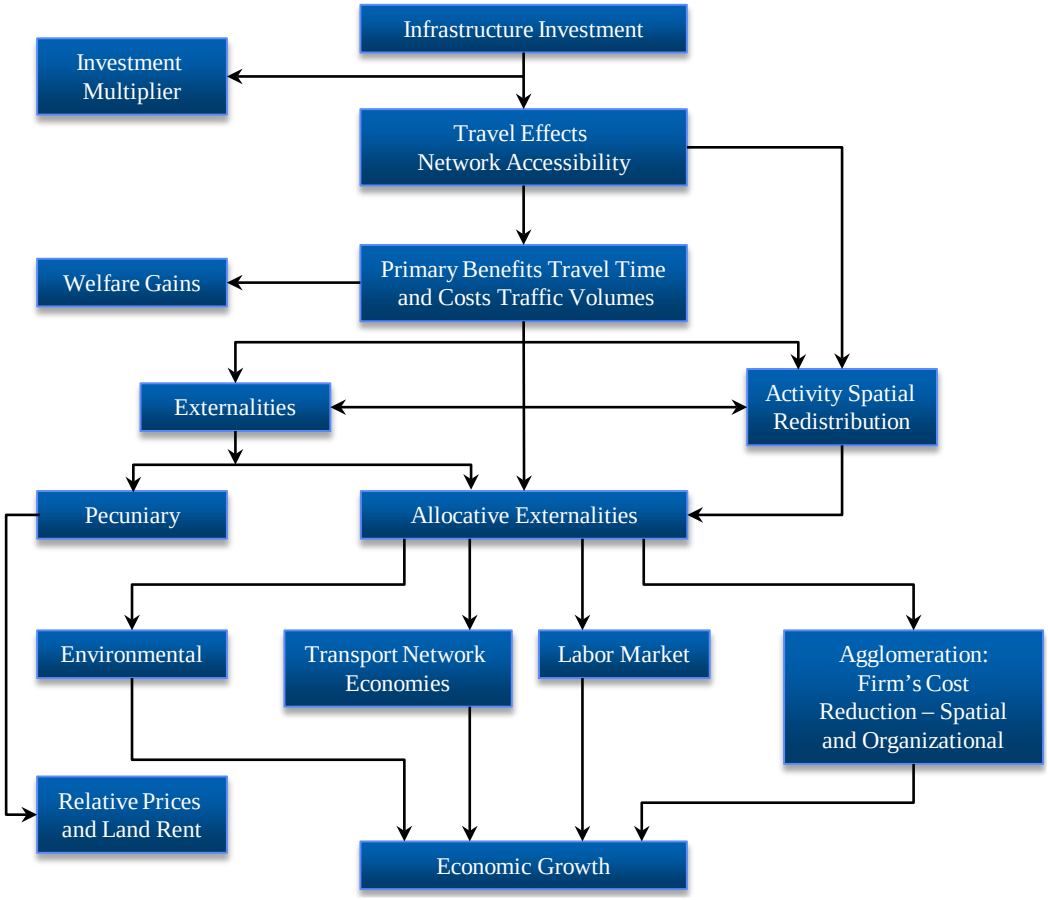
---

117 Banister, David and Yossi Berechman, *The Economic Development Effects of Transport Investment,* Paper presented at the TRANS-TALK Workshop, Brussels, 2000, http://www.iccr-international.org/trans-talk/docs/ws2-banister.pdf.

118 Berechman, J., and Paaswell, R, 1983, "Rail Rapid Transit Investment and CBD Revitalization: Methodology and Results," *Urban Studies*, 20(4), pages 471-486.

can be cited where development occurred in some places but not in others because of differences in local economic and political conditions.

Figure 5.1 Linkages between Transport Investment and Economic Development



Source: Banister and Berechman, "The Economic Development Effects of Transport Linkages."

The authors conclude that "transport accessibility must be seen as part of a much wider concept of accessibility that includes availability of skilled labor, good quality locations, the necessary supporting infrastructure, and local road and rail networks." They suggest three factors are important if transport investment is to contribute to achieving economic development objectives: 1) the design of the transportation facility itself and its integration with other elements of the transportation network; 2) regional economic policies that support economic development; and 3) a mechanism for resolving conflicts among stakeholders. If the necessary market conditions are present along with a supportive regional economic development policy, transportation improvements can promote local and regional economic development.

5.5 REGIONAL APPLICATIONS

The linkages between transportation and economic competitiveness have become more important to transportation planning at the regional level. Long-term transportation planning now frequently incorporates economic considerations in addition to traditional performance objectives relating to pavement, congestion, bridge conditions, and safety. Today, transportation planning also may address business considerations such as access to labor, the movement of inbound and outbound goods, and the ability to connect to distant markets to enable trips for goods and people. Regions that are capable of moving goods and people efficiently (in terms of time, reliability, and cost) gain competitive advantages over those that cannot. These advantages translate to more economic opportunities, stronger industries, and income for working people. As regions compete for jobs and investment, their transportation systems are increasingly seen as key tools for attracting business as well as workers.

Ozbay, Ozmen-Ertekin, and Berechman[119] examined how changes in accessibility affected economic development in 18 counties in the New York/New Jersey region. The authors used several different measures of accessibility to assess relationships between changes in accessibility and changes in employment and earnings, two measures of economic growth. Results of their analyses indicated that accessibility, as measured by travel times between different locations, is correlated with economic growth in the region. Ozbay, et al., caution not to use their results to predict impacts of individual projects, however, since many other factors affect economic growth.

Weisbrod summarizes several postproject evaluations that have been conducted to assess the impacts of transportation investment on regional economic development.[120] One study in the Mississippi Delta region found that regional employment increased 20 percent faster than national employment growth following a series of highway, seaport, and railroad improvements between 1990 and 1995. This study did not use statistical analysis or other techniques to try to isolate the impact of the transportation improvements from other factors occurring in the region, but relied primarily on opinions of key stakeholders and businesses in the region. Another study examined the impact of the Appalachian Development Highway System on economic development in the Appalachian region. In this study counties in Appalachia were matched with similar counties outside the region and income growth was compared for each of the county pairs

---

119 Ozbay, Kaan, Dilruba Ozmen-Ertekin, and Joseph Berechman, *Empirical Analysis of Relationship between Accessibility and Economic Development,* Rutgers, The State University, 2003, http://cait.rutgers.edu/files/CU-13-RU922.pdf.

120 Weisbrod, Glen, *Current Practices for Assessing Economic Development Impacts from Transportation Investments,* National Cooperative Highway Research Program Synthesis Report 290, Washington, D.C., 2000, http://www.edrgroup.com/pdf/synth290.pdf.

over time. The study found that income in the counties in the Appalachian region grew faster than similar counties outside the region. The greatest differences in income were found in those counties that had an Appalachian Development Highway. Again, no attempt was made to determine whether other factors in the Appalachia region may have been contributing to the faster growth in income.

In its 2009 report, a Boston nonprofit, "A Better City (ABC)," illustrated, from a regional perspective, the importance of transportation to support its economy and the relationship to these agglomeration benefits.[121] The study demonstrated the contributions of transportation to the functioning of the Massachusetts economy as well as the threats to the State's long-term competitiveness that may result from inadequate investments in infrastructure. The dense economic activity taking place in Boston and Cambridge is being fed with labor and freight traveling on the Massachusetts transportation system, including commuter rail, subway lines, air facilities, and highways. However, rising congestion as currently being experienced in Massachusetts can choke off the movement of goods and the inflow of people, undermining the State's competitive advantages and preventing it from reaching its full economic potential.

While talent and workforce are the fundamental factors that distinguish the Massachusetts economy, transportation services and infrastructure provide the foundations that the State's industries rely on to thrive. Good transportation strengthens the Massachusetts economy by connecting workers to employers, linking businesses with suppliers and markets, and fostering the face-to-face interactions that are pivotal to making an innovation economy operate. Public transportation plays a pivotal role in this process, supporting business and residential densities in the urban core of metropolitan Boston that would be otherwise unattainable. However, just as transportation allows businesses and institutions to function, problems in the transportation system manifested by lack of capacity, congestion, and poor connectivity threaten long-term competitiveness. Left unaddressed, deficient transportation infrastructure also may prevent Massachusetts from fully capitalizing on economic opportunities.

Congestion in the densely developed Boston area, in particular, can impede long-term growth of some of Massachusetts' most important growth industries. In life sciences and healthcare, for example, congestion can take a toll on employee retention and attraction efforts. As employees encounter lifestyle changes, such as shifting from postgraduate life in Cambridge or Boston to parenting in the suburbs, their commutes can become much longer with fewer public transportation options. The need to balance work and family time can entice some

---

[121] Economic Development Research Group, "Moving Forward: Transportation and the Massachusetts Economy," prepared for Our Transportation Future, Boston, 2010, http://www.ourtransportationfuture.com/media/2/20100720-OTF%20White%20Paper%20Final%207-20-10%20v%2023.pdf.

employees to other locations in the country where commutes are shorter. This demonstrates both the importance of public transportation to support agglomeration and that strategic investments can expand the transportation network (e.g., numerous public transportation projects are either under development or proposed in Boston that would enhance connectivity to make commuting and other trips more convenient), improving access for labor, the most important factor of production for innovative, technologically advanced industries.

Examples of metropolitan planning organizations that have incorporated economic benefits into their long-range plans include the following from the Hillsborough County (Florida) Metropolitan Planning Organization, the San Diego Association of Governments, and the Chicago Metropolitan Agency for Planning.

At the center of one of the fastest-growing regions in the country, Hillsborough County's transportation infrastructure has both fostered and accommodated the growth of West Central Florida's economy and population.

- The Port of Tampa and the rail system radiating from it have been instrumental in the successful development and marketability of Central Florida's phosphate deposits, and to bring in the steel and petroleum needed to support Florida's industries and drivers. Tampa International Airport provides Hillsborough County companies with access to business centers throughout the United States and brings in millions of visitors on an annual basis. Whether it is trucks carrying phosphates to the port, tourists driving to Busch Gardens, or workers commuting to financial services companies, all depend on Hillsborough County's transportation system to reach work, attract customers, receive supplies, or ship products to market.
- Although Hillsborough County, with much of the rest of the country, is confronting economic headwinds, long-term jobs and population projections predict that Hillsborough County will continue to grow at a rapid pace. This anticipated growth underlines the importance of planning for strong roadway and transit networks in conjunction with well-organized freight transportation services that will be able to keep up with the needs of the County's businesses and industries. If mobility in Hillsborough County becomes more onerous to businesses, tourists, and workers, both quality of life and the County's attractiveness to existing and prospective businesses will decline. Already, transportation accounts for a higher share of household spending in Tampa than all but four other U.S. metropolitan areas.[122] On the other hand, by improving the mobility of goods and people, the trans-

[122] According to the Bureau of Labor Statistics Consumer Expenditure Survey, transportation accounted for 20.4 percent of household expenditures in metropolitan Tampa in 2003, the fourth-highest transportation cost burden in the country following Houston, Detroit, and Cleveland.

portation strategies included in the LRTP can contribute to the long-term prosperity of Hillsborough County's and the Tampa Bay region's industries and population.

- HCMPO's 2035 Long-Range Transportation Plan demonstrates the importance of transportation to industries crucial to the long-term prosperity of the region, including business services and finance, advanced manufacturing, tourism, port activities, construction, and life sciences. Plans that are put in place by the 2035 LRTP to improve mobility, connectivity, accessibility, efficiency, and safety for the movement of people and goods will translate to economic benefits for Hillsborough County and the Tampa Bay region. By responding to the trends (listed below), as identified in the 2035 LRTP, Hillsborough County's transportation network and services can foster the growth of key industries, encourage economic diversification, and help the county capitalize on economic opportunities.

  Increasing demand for specialized services to support aging and a more diverse population. Demographically, Hillsborough County is becoming older like much of the rest of Florida and the United States. Improvements to the County's transit and paratransit services will help older people live independently, allowing them to remain economically active and commute to jobs. This will become more important as the number of people in their prime working years (25 to 64) experiences a declining share of the County's population. Transit services also are crucial to supporting younger, educated workers in the 25 to 34 age group who increasingly prefer living and working in or near dynamic commercial centers.

  Accommodating a more diverse industry mix that is leading to growth in demand for all modes. Hillsborough County is pursuing opportunities in high-end corporate business services, life sciences and healthcare, research and development, port/maritime, and advanced manufacturing (electronics, avionics, navigation, defense, medical, etc.) to diversify its economy and attract more sophisticated, higher wage jobs to the region. The growth of these industries, combined with continuing support for the County's tourism, construction, and natural resources-based industries, will require an integrated multimodal transportation network to ease the flow of people and goods within, into, and out of Hillsborough County. Life sciences, advanced manufacturing, and corporate business services, in particular, will require a transportation system that supports reliable small package freight deliveries, more business travel, and access to a highly educated labor pool, a factor that is enhanced by transit services.

  Increasing population and employment density is creating more demand for transit services to connect to activity centers. With increased development around major activity centers, including the University of South Florida, Downtown Tampa, Westshore/Tampa International Airport, Ybor City, MacDill Air Force Base, Hyde Park, and the port,

among others, strong transit connections will be needed to maintain mobility in the County between major job generators and residential areas. Improved transit services are key to long-term and more sustainable land-use strategies to encourage future growth in existing developed areas and along transportation corridors.

Increasing demand for moving people and freight. Meeting the needs to move more people and greater freight volumes on short trips within Hillsborough County and on longer trips to and from Central Florida, the rest of Florida, and other domestic and foreign markets will be a factor underlying Hillsborough County's ability to meet economic goals.

Within Hillsborough County. By improving mobility and mitigating congestion, Hillsborough County can expand labor markets and increase the reliability of freight movements and thus increase the competitiveness of its industries and businesses.

Within the increasingly integrated Tampa Bay region. Improved linkages for intercounty trips to and from Hillsborough County, the economic hub of the Tampa Bay region, will support a more robust regional economy in the future.

To/from other counties in Florida (e.g., I-4 Corridor). Institutional, academic, and business relationships fomented by the Florida High-Tech Corridor Council along I-4 and beyond depend on intercounty goods movements for production and the transport of people to promote innovation. Tampa Bay and Central Florida form a huge regional travel market, with visitors entering the area at different gateways and then traveling throughout the region to attractions, beaches, and meetings.

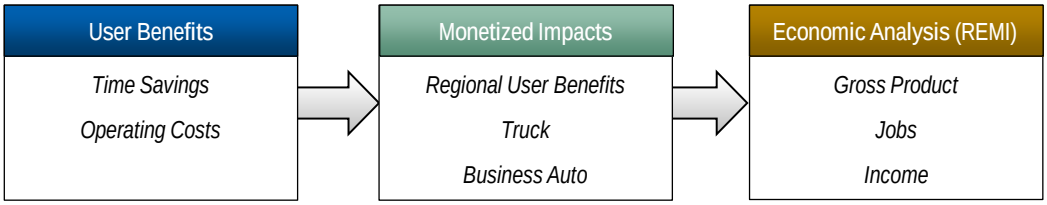
To/from markets in other states/nations. The ease of access to the Port of Tampa and to intermodal facilities will contribute to Hillsborough County's success in competing with other major ports throughout the country. Access to Tampa International Airport also will be crucial, not only for tourism and business travel, but for the Tampa Bay region's technology companies (e.g., pharmaceuticals, microelectronics, medical devices, etc.) that will depend on air freight to transport lightweight, high-value products.

In order to further quantify the economic benefits of transportation improvements, Hillsborough County conducted an analysis using the REMI model demonstrating the economic benefits of projects that would be possible through an increase in transportation funding. The analysis establishes the link between investments in roadways and transit and economic growth in Hillsborough County through 2035.

The general analytical framework to estimate and quantify the economic benefits of transportation investments in Hillsborough County is shown in Figure 5.2. Investments in transportation lead to increased

efficiency and capacity, such that vehicles have faster relative times between origins and destinations. This increase in efficiency and capacity improves travel conditions for cars and trucks. Roadway capacity and transit improvements contribute by reducing auto trips and vehicle miles traveled (VMT) which, in turn, lowers auto emissions and highway congestion.

Figure 5.2 Estimating Long-Term Benefits of Transit Investments



These user benefits, described above, reduce the costs of doing business and translate to an enhanced economy in terms of improved productivity, economic competitiveness, and greater growth potential. Long-term, the transit investments, and the productivity improvements they engender, result in appreciable increases in income, gross regional product, and jobs in Hillsborough County. The analysis in the LRTP found that a reduction in business travel costs and an increase in travel efficiency on the Hillsborough County roadway system resulting from the transit and roadway transportation investments associated with the increase in transportation investments would result in 2,102 more jobs in 2035 than Hillsborough County would have had without those improvements. The analysis also found that Hillsborough County's gross product, a measure of its economic size (the total value of goods and services produced), would increase by $320 million due to the transportation improvements.

San Diego's 2050 Regional Transportation Plan (RTP) explicitly references that the transportation system should play a significant role in raising the region's standard of living and includes "the support of a prosperous economy" as a vision for the plan. Objectives of the plan include "maximize the economic benefits of transportation investments" and "enhance the goods movement system to support economic prosperity." By comparing the RTP to a no-build scenario, SANDAG estimated the benefits of the projects included within the RTP to include more than 35,000 additional jobs and $4.4 billion in increased economic output. The benefits accrue from relative improvements in travel conditions and air quality. The plan estimates significant improvements in travel times for commuters and students compared to the no-build scenario. Network improvements included in the plan would encourage a greater use of public transit, carpooling, walking, and cycling. Rail capacity improvements and managed truck lanes are included in the RTP to ease the flow of freight in the San Diego region, including freight flows going to and from Mexico.

The capital projects recommended in the Chicago GOTO 2040 Plan were evaluated to improve operations, access, mobility, and economic opportunity. Today,

the annual costs of congestion in the Chicago region are estimated to be some $7.3 billion in lost time, excess fuel consumption, and wear on vehicles. The 2040 plan seeks to mitigate the negative impacts of congestion while ensuring greater mobility and the ability to accommodate future growth. In defining benefits, the 2040 plan lays out the difference between short-term benefits resulting from construction spending and the longer-term benefits resulting from increased competitiveness and improved transportation efficiencies:

- Infrastructure investment yields economic returns via long-term economic productivity, largely by reducing the costs of congestion and making the region more attractive to businesses and residents. While short-term job creation is an important goal particularly during economic downturns, wise investment in transportation infrastructure yields significant benefits for years to come. Careful targeting of investments is key to long-term economic vitality. Transportation infrastructure investments, including implementation of strategies to reduce congestion, increase the efficient movement of goods and people. The economic benefits of these transportation infrastructure investments include:

  Improved attraction and retention of businesses and skilled, innovative workers, who value a well-functioning transportation system;

  Greater efficiency of freight movement which can enhance just-in-time inventory management;

  Increased worker productivity due to fewer hours spent stuck in congestion; and

  Other positive effects on quality of life such as environmental benefits and enhanced access to jobs, education and medical care, and cultural and social interactions.

- CMAP's analysis of the economic impacts of GO TO 2040s recommended major capital projects estimates a $13.3 billion increase in long-term economic activity (as measured by Gross Regional Product) from a public-sector expenditure of $10.5 billion. Reducing the various costs of traffic congestion is what drives these positive economic impacts. They include not only decreased pollution, shipping costs, and time delays, but also increased productivity. In combination, these projects result in economic growth, reduced congestion, shorter commutes, and improved job accessibility. Example projects include roadway and transit extensions and improvements as well as the development of multimodal corridors.

- Achieving a modern, well-functioning system of roads and public transit simply makes good economic sense in light of the Chicago region's long-term goal to remain a vibrant and vital global destination. Surveys consistently indicate that businesses want good infrastructure systems, including rapid access to airports and efficient movement of goods. Residents want a more modern, world-class system for many similar reasons. The region should

strive toward fostering an environment to attract residents who will create innovative new technologies and industries – one where ease of mobility is ensured and where car ownership is not a requirement for living, working, and recreation.

- Public transit is identified as an important part of the transportation system in the GO TO 2040 Regional Vision, which calls for a "broad range of integrated and seamless transportation choices that are safe, accessible, easy to navigate, affordable, and coordinated with nearby land use." The primary economic benefits of transit come through the additional mobility that it permits. With a strong transit system, residents have more choices concerning where they can live and work and how they travel, and can avoid the harmful effects of congestion. In a 2007 report (*Time is Money, the Economic Benefits of Transit Investment*) on public transit's impact on the economy, Chicago Metropolis 2020 found that simple maintenance of the current transit system would provide a 21 percent return on investment (i.e., a $1 investment would yield $1.21 in saved jobs, new jobs, and time saved for commuters), while greater levels of funding could return up to 61 percent if the funding was tied to land use policies that encourage transit use. Essentially, the more money that is invested in the public transportation system, the greater the potential return on investment for the region. Much of this economic benefit is due to reduced congestion, because providing transit options improves travel even for people who continue to drive.
- Lower-income households, particularly those without access to cars (either because they do not own a car, cannot afford fuel prices, or other reasons), depend heavily on public transit, and it often provides their only link to jobs, health care, education, or other important assets. The same is true of disabled or elderly residents without the ability to drive. This is both an equity and economic consideration; the inability to travel has negative impacts on individuals, but also prevents them from participating fully in the Chicago region's economy.
- The GO TO 2040 Plan also includes a freight component that underlines the importance of transportation infrastructure to the movement of goods and the competiveness of Chicago's industries.
- The prosperity of other industry sectors, including but not limited to manufacturing and both wholesale and retail trade, is closely tied to Chicago's position as a transportation and logistics center. These industries account for more than 30 percent of the region's private sector employment, resulting in nearly $80 billion in personal income for residents of northeastern Illinois. Metropolitan Chicago's position as the nation's freight hub also has impacts beyond direct jobs and income for the region's residents. The railroads move $350 billion and trucks move $572 billion in goods to, from, or through the region each year. An efficient freight system enables a global supply chain to provide goods at lower costs and gives Chicago-area businesses an advantage in today's globally competitive economy.

- Since nearly all of the Chicago region's freight travels by trucks and trains, improvements to the efficiency of the region's freight system will help to alleviate congestion from the area's roadway network. Slow trains, blocked grade crossings, and other "costs of congestion" are real and serious; they include lost time and fuel, decreased productivity, inefficient freight movements, and pollution. Goods moving more efficiently through the region also can lead to more efficient inventories and thus lower prices for consumer goods.

5.6 FUTURE RESEARCH ON THE BROADER ECONOMIC BENEFITS OF TRANSPORTATION INVESTMENT

The Eddington Report sets out four principles to inform transport decision-making:

- Clear articulation of policy objectives and transport outcomes required;
- Consider the full range of policy options for meeting objectives;
- Prioritize resources on policies which most cost-effectively deliver all government's objectives; and
- Collect evidence on performance of network, needs of users, and effectiveness of policies.

Each of these principles requires improved understanding of relationships between transportation infrastructure and economic outcomes. For instance, without such an understanding it is impossible to link potential transport outcomes to the government's broader policy objectives. On the one hand, unrealistic expectations of transportation's potential contribution to economic development might be suggested but, on the other hand, complementary policies in other areas that could help achieve the desired policy objectives might be overlooked. Without an understanding of how the different modes, both individually and jointly affect economic activity, a thorough and balanced analysis of the various transportation policy options is impossible. This has been a frequent criticism of transportation planning studies in the past and will continue to be a problem until our understanding of the impacts of the various modes is improved. Without an understanding of the relationship between the benefits and costs of alternative transportation policies, it is impossible to prioritize investments to meet broad policy objectives as cost-effectively as possible. The last principle is perhaps the most important because without a fundamental understanding of network performance, user needs, and the effectiveness of policy options, sound transportation decisions cannot be made.

The Eddington Report notes the importance of linking performance indicators as closely as possible to the transportation outcomes expected to influence broader policy objectives – to measure what is important. Of special note is the need for improved evaluations of major transportation investments. Other countries

routinely evaluate the benefits of major projects to determine if the outcomes predicted when the project was approved actually materialized. This is rarely done in the U.S., and consequently there is no opportunity to improve the analytical tools that will be used to assess future projects. This, in turn, means that transportation officials are likely to be making investment decisions involving very large sums of money on the basis of potentially faulty information.

The issue of the wider economic benefits of transportation investment that are not captured in traditional benefit-cost analysis and cannot be linked to individual projects in macroeconomic analyses has received considerable attention recently. There appears to be a consensus that at least some of these benefits are not reflected in benefit-cost analysis, but there is concern by some analysts that a portion of the benefits are simply reflections of time savings and to include them in benefit-cost analyses would be double counting. Several previous research efforts, including the Eddington Report, have indicated that more research is needed to understand the mechanisms through which these wider economic benefits arise. Eddington identified several other areas where further research is needed, including:

- **Valuations of time savings**. Valuation of time based on local wages is essential to capture the true economic gain from a transport improvement in a particular region and to correct for the current anomaly between the calculation of costs and benefits in appraisal.
- **Freight valuations**. The full GDP benefits realized from freight traffic could be considerably higher than currently assumed, reflecting the wider impact of transport on business operations and logistics. There is a strong case for exploring whether the current valuation of freight time fully reflects the benefits to this sector.
- **Reliability**. It is clear that the performance of the transport network in terms of reliability often matters just as much, if not more, than any direct time savings from a transport journey. Evidence seems to suggest that these are considerably higher than has been appreciated in the past. There is a strong case for reliability valuations to reflect developing evidence in this field.
- **Agglomeration economies**. Thinking on transport's relationship with agglomeration economies is relatively new. There is very little literature that attempts to explain and measure this relationship, particularly in the context of service agglomerations. The UK is at the forefront of establishing techniques on how this relationship can be modeled. However, it is clear that there is merit in better understanding this relationship, not least because of the continuing importance of urban agglomerations to the future prosperity of the UK. The DfT's (Department for Transport) developing methodology on agglomeration economies should be applied to the appraisal of all transport schemes. This could increase the assessed value of schemes, especially in urban areas.

- **Gains from trade**. The contribution of transport policy in supporting trade is not well understood or quantified. But it is clear that acknowledging this relationship and quantifying its scale through appraisal, is pivotal to informing good transport policy, particularly around ports and airports, and surface access routes. These are not captured currently in appraisal. New research would need to be undertaken to consider how such gains could be captured and reflected.
- **Globally mobile activity**. Additional GDP gains are difficult to quantify for individual schemes, but analysis suggests that it will be important for transport policy to reflect this driver at relevant times.

Weisbrod summarized the development and evolution of models that estimate economic development impacts of transportation projects. While models have become increasingly sophisticated over the years, he notes:[123]

> *"…there is a substantial remaining need to improve the structure, dynamics and interaction of factors within transportation economic impact models. For instance, integration of a static travel demand model with a dynamic economic model can lead to clear biases in impact forecasts. This can occur because static travel demand model generally do not forecast time-of-day schedule shifts for commuters and truck deliveries in response to rising congestion, which can lead economic models to overestimate business and household relocation responses. On the other hand, travel demand models that use only daily average data can underestimate impacts associated with dramatically more severe peak-period conditions. The use of a general analysis framework that distinguishes critical benefit and cost elements is useful, as it can aid in addressing these problems."*

Experience with the U.S. Department of Transportation's new Transportation Investment Generating Economic Recovery (TIGER) program provides some useful insights into the state of the practice in benefit-cost analysis. In its report, *Surface Transportation: Competitive Grant Programs Could Benefit from Increased Performance Focus and Better Documentation of Key Decisions,* the U.S. Government Accountability Office (GAO) noted the poor quality of many benefit-cost analyses submitted in connection with TIGER applications, especially the first round of TIGER projects.[124] This led the U.S. DOT to conduct webinars and provide

---

123 Weisbrod, January 2008, op. cit.

124 United States Government Accountability Office, *Surface Transportation: Competitive Grant Programs Could Benefit from Increased Performance Focus and Better Documentation of Key Decisions,* GAO-11-234, Washington, D.C., 2011, http://www.gao.gov/new.items/d11234.pdf.

additional guidance on the use of benefit-cost analysis.[125] This experience points to the need for the development of additional resource materials on how to conduct benefit-cost analyses for different types of projects involving different transportation modes.

Another area where addition research could be worthwhile is to document through case studies how mutually supporting transportation, land use, and economic policies have been coordinated to achieve development objectives. As Banister and Berechman point out, it is difficult for transportation projects alone to have a significant impact on development when a mature transportation system already exists. Transportation, however, can be an important contributor to economic development and revitalization when coupled with other supporting policies.

As noted above many other countries do far more evaluation of completed projects than is done in the U.S. A primary objective of these *ex post* evaluations is to determine whether projected benefits upon which investment decisions were made actually materialized, and if not to try to ascertain why not. Understanding why a project failed to generate the expected benefits can inform future decisions for similar types of projects. There is an obvious reluctance to spend scarce resources evaluating completed projects when those resources could be used to fund other projects, but these other countries apparently believe that improved information upon which to make future investment decisions is worth the cost of conducting the *ex post* evaluations.

The U.K. is one of the most advanced countries in terms of their appraisal process for major investments. They have developed "value for money" analysis procedures and guidelines that attempt to capture many of these wider economic benefits identified by Eddington and others. Future research could be undertaken in the U.S. to determine whether similar guidance could be developed for assessing the full benefits of transportation projects in this the U.S.

Data and previous research noted above suggest several potential areas for future research particularly related to the emerging BRT, light rail, and streetcar systems:

- With the growing interest in BRT and light rail systems, further research on the ability of those systems to promote higher-density, mixed-use development around stations should be considered. Such development often occurs around heavy rail stations, but can the lower volume BRT and light rail systems promote higher density development patterns that increase system ridership and generate economic benefits to areas around the stations?

---

[125] Texas Transportation Institute, *Benefit/Cost Analysis for Transportation Infrastructure: A Practitioner's Workshop,* Workshop Proceedings, Washington, D.C., May 2010, http://tti.tamu.edu/group/tec/files/2011/09/benefit-cost10-proceedings.pdf.

- There is a general understanding of factors that make BRT, light rail, and streetcars more attractive to riders than traditional bus service, but it is unclear how ridership would be affected by changes in local bus service that attempted to provide attributes that more closely resemble those of the more attractive transit services. Transit systems and private operators in many cities are offering commuter bus service, downtown circulator service, and other specialized services targeted at specialized market segments. What has been the experience with those services and what lessons might be learned for traditional bus service?
- One of the main objectives of new and planned streetcar systems is to promote revitalization and economic development of downtown areas. Case studies of how new streetcar systems have been planned in conjunction with broader economic redevelopment plans would be of use to other cities considering new streetcar systems. For those systems that have been operating for several years of more, case studies could include actual impacts of the redevelopment initiatives and assessments of the role of streetcars in supporting new economic development. Case studies should include both systems that have been a success and those that have not achieved their objectives so that lessons can be learned from each.

6.0 Summary and Conclusions

Significant research has been conducted on the economic benefits of transportation investment. Most has focused on benefits of highway improvements, in part because more public investment goes to highways than other surface transportation modes, and in part because highway investment has a greater impact on economic growth and productivity than investment in other modes. But research has demonstrated the economic benefits of investment in other modes and from a multimodal perspective as well.

Research on quantifying the benefits of transportation investment generally has taken two tracks. The first is to value benefits that accrue directly to transportation system users, especially travel time savings, reduced vehicle operating costs, and improved safety resulting from a transportation improvement. These benefits are key components of benefit-cost analyses used to support investment decisions. Considerable attention also has been paid to the valuation of air pollution, noise, greenhouse gas emissions, and other adverse impacts associated with transportation projects.

The second track is to estimate the impact of transportation investment on economic activity. Research has examined impacts on general measures of economic activity, such as output and productivity, and also has examined impacts on employment, residential and business location, and the benefits of broader access to labor and markets. Many of these benefits are directly related to travel time savings included in benefit-cost analysis so the impacts on businesses cannot simply be added to direct user benefits with significant double counting.

In recent years, however, there has been increasing recognition that the user benefits included in traditional benefit-cost analysis underestimate the overall benefits of many transportation investments. Researchers have more thoroughly examined the mechanisms through which businesses benefit from transportation improvements to identify benefits that are more than just direct reflections of user benefits. Findings here and in other countries have shown that the broader economic impacts of transportation improvements can be large, increasing overall benefits of some transportation improvements by as much as 50 percent.

Despite the large body of prior research, much is not well understood about the economic benefits of transportation investment, especially investments made within the context of a mature transportation system. Communication of what the research does have to offer decision-makers is a particularly important element of that research. Numerous areas of future research have been identified in the body of this paper that could yield improved information on the benefits of and need for future transportation improvements to serve the needs of the nation's growing population and to keep the U.S. competitive with other countries that are investing heavily in their transportation infrastructure.