A Synthesis of Economic Impact Assessment of Transit Services

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Disclaimer

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16. Abstract

This report provides an in-depth synthesis of the economic impact assessment of transit services in the United States from 2003 to 2023, focusing on Benefit-Cost Analysis (BCA) and Economic Impact Analysis (EIA) methodologies. It examines their application in public transit systems and highlights geographical variations and trends. The report analyzes themes, trends, and gaps in existing research through extensive literature review, bibliometric mapping, and case studies from key metropolitan areas. Primary findings reveal a consistent use of BCA and EIA models across U.S. regions, supported by established assessment software. BCA, while prevalent for quantifying project effects, faces accuracy challenges, particularly in measuring intangible factors. EIA, relying on input-output models, tends to oversimplify complex economic interdependencies. The study also identifies a gap in the comprehensive evaluation of new transit modes like microtransit and micromobility, where traditional methods prevail but lack depth in analysis using both BCA and EIA. Concluding, the report advocates for an integrated approach to BCA and EIA in Florida, emphasizing the need for a comprehensive framework, reliable data and tools, and adaptable methodologies to capture the dynamic landscape of public transit and its multifaceted impacts effectively.

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Executive Summary

This report provides a detailed synthesis of the economic assessment of public transit services in the United States, covering the period from 2003 to 2023. It investigates the prevalent methodologies for conducting economic benefit-cost analysis (BCA) and economic impact analysis (EIA) of public transit systems, delves into geographical variations in economic assessments, identifies evolving trends in the literature, and discusses the application of recent advancements in Florida and across the nation.

In developing this report, a meticulous and holistic strategy was adopted, aimed at capturing a wide spectrum of insights and data:

1. The foundation of this approach was an extensive literature review, analyzing a diverse array of technical reports and academic journal articles over the past 20 years. Special emphasis was given to understanding how these methodologies have evolved over time, particularly in the context of emerging transit modes like microtransit and micromobility.
2. Another critical aspect of our approach was bibliometric mapping of the collected literature using CiteSpace. This process involved systematic categorization and analysis of the themes, trends, and gaps within the existing body of work, helping us to identify and focus on the most pertinent and influential studies, ensuring our report accurately reflects the current state of research in the field.
3. Additionally, our research included four case studies that examined the economic assessments of public transit projects in major metropolitan areas: New York, Chicago, Los Angeles, and Miami. These case studies were strategically chosen to represent a diverse range of geographical locations and economic contexts, offering a multi-perspective view of the impacts of public transit in various settings.

Primary findings and research limitations of previous literature identified by the report are summarized below:

1. BCA and EIA remain essential in transit assessment. BCA is widely used to quantify tangible and intangible project effects by calculating the benefit-cost ratio (BCR). EIA, on the other hand, evaluates broader economic consequences, including direct, indirect, and induced impacts, using input-output (I-O) models.
2. There have been slight evolutions in these assessments, particularly in the scientific categorization of benefit and cost types.
3. Across various U.S. regions, there is a consistent use of EIA models supported by matured assessment software packages such as RIMS-II, IMPLAN, and TREDIS. These software packages, mainly based on I-O models, feature customized multiplier matrices for different regions, states, and industries.
4. Despite its widespread use, BCA faces accuracy challenges due to its sensitivity to data availability and timeliness. Besides, the lack of standardized formulas and recommended monetized values for measuring intangible factors can lead to potential misestimations of a project's value.

5. EIA heavily relies on input-output (I-O) models, emphasizing changes in key indices like revenue, tax, and employment. This approach may oversimplify complex economic interdependencies.
6. The USDOT has provided standardized measures for certain benefits and costs associated with transit projects; however, these are intended as guidelines or references, not being comprehensive or enforceable.
7. EIA and BCA reports typically present a single numeric value rather than a range of possible values, which can lead to false precision.
8. In the case of emerging transit modalities like microtransit and micromobility, traditional assessment methods, such as measuring ridership or service area increases, are still common. These are sometimes supplemented with techniques like agent-based simulation. However, there is a lack of formal analysis using both BCA and EIA for these new transit modes. Currently, no specific formulas or monetized values are available for their thorough evaluation.

In response to the findings and identified limitations, this study recommends that the Florida Department of Transportation (FDOT) adopt an integrated approach combining EIA and BCA. Proposed to provide an in-depth evaluation of transit projects' economic, social, and environmental impacts, this method is particularly suited to Florida's varied demographic and economic landscape. It aims to facilitate more informed decision-making by FDOT, harmonizing financial feasibility with long-term societal and environmental benefits.

Specifically, we suggest developing a standardized model that synthesizes key elements from EIA and BCA literature. This model comprises both fundamental and customizable factors. The former includes a set of standard factors commonly used in EIA and BCA, ensuring consistency and reliability across projects. The latter contains elements that can be tailored to the specific needs of individual projects, thus enhancing the model's precision and relevance. It is crucial to list multiple formulas and sources for obtaining recommended monetized values, aiding the execution of multi-scenario assessments.

The model's development could ideally involve collaboration with external experts to integrate best practices and current assessment criteria. Establishing robust data management practices and utilizing various benchmark datasets and methodologies are vital to maintaining accuracy. Regular evaluations and updates, informed by feedback and evolving best practices, are essential for the sustained effectiveness of these economic analyses.

In conclusion, applying EIA and BCA in tandem, supported by creating an integrated, standardized model, will provide FDOT with a comprehensive toolkit for assessing the complex impacts of transit projects, ultimately fostering sustainable and beneficial outcomes for Florida.

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1 Introduction

1.1 Research Background

Public transit is a vital conduit interlinking socio-economic mobility, environmental resilience, and communal harmony. Every day, millions of residents and visitors in the United States step onto the platforms of trains, buses, ferries, and subways, epitomizing a nation actively in motion (American Public Transportation Association [APTA], 2020). Through its far-reaching network, public transit offers an option to individual vehicle trips. It provides crucial mobility options for the elderly, who may find modern driving in increasingly computerized vehicles overwhelming, and the low-income households burdened by the car ownership costs (Berg & Ihlström, 2019). Meanwhile, it stands as a precious asset in our collective fight against traffic congestion.

On the other hand, operating such sophisticated civic systems presents formidable challenges for municipalities, especially as the urgency to gauge its economic impact intensifies. Recognizing the broader economic advantages beyond just farebox revenues has become a shared understanding among investors, government officials, scholars, and other stakeholders. The APTA (2020) asserts that public transit's merits not only pertain to transportation domain per se but also extend to areas like job creation, increased business revenues, and rising property values. For example, every $1 billion public transportation investment can generate five times in economic returns, supporting and creating 50,000 jobs (APTA, 2023). According to Litman (2023), public transit annually saves the U.S. an estimated $19 billion by alleviating traffic congestion-related costs, plus $8 billion by diminishing the necessity for extensive road and parking infrastructure developments.

In short, while the value of public transit in enhancing community vibrancy, bolstering economic growth, advancing social equity, and building environmental sustainability is undeniably clear, the challenge lies in converting these diverse benefits into quantifiable economic metrics. Conventional metrics contain four types of primary limitations, as detailed below (refer to **Figure 1-1**).

First, the limitations of the farebox recovery ratio method must be acknowledged: using the farebox recovery ratio as the sole metric for assessing transit's economic viability can be misleading. This historically popular metric considers only the fraction of operating expenses covered by passenger fares. Additionally, given that a low farebox recovery ratio is common in almost all cities (e.g., the County of Miami-Dade reported a ratio of 8.58% in 2020), relying on this metric as the only criterion for economic viability could incorrectly label most systems as unworthy of investment (Federal Transit Administration, 2021). Underestimating these indirect benefits might potentially lead to inadequate investment in this transformative resource.

Second, the evolving landscape of transit options should be considered: advancements in mobile devices and cellular networks have spurred the emergence of new public transit modes including microtransit, micromobility, and mobility as a service (MaaS). Microtransit offers flexible routes and schedules utilizing smaller-sized vehicles, while micromobility involves the use of small, lightweight vehicles (e.g., e-scooters and shared bicycles) designed for short distances (Federal Transit Administration, 2020). The MaaS proposition refers to a one-stop travel management platform that digitally unifies trip creation, purchase, and delivery (Wong et al., 2020). Consequently, earlier studies focusing on traditional public transit systems are becoming outdated and less representative of today's dynamic transit environment. For example, microtransit can fill the void in communities poorly served by traditional bus service. Therefore, there is a need to explore how to apply and tailor economic impact evaluation methods to assess these emerging public transit modes.

Third, there is an absence of evolutionary review of economic assessment methodology: In recent years, economic evaluation techniques have evolved as scholars harnessed more sophisticated statistical analysis models and simulation tools. Nevertheless, a noticeable gap exists in the literature concerning systematic reviews to determine whether these advancements and novel methods have been applied to assess the economic impacts, benefits, and costs of public transportation in the United States. This limitation hinders our ability to ascertain whether the prevailing mainstream evaluation approach used by transportation agencies has kept pace with these advancements. A systematic review can further provide valuable insights to inform future decision-making and investment strategies.

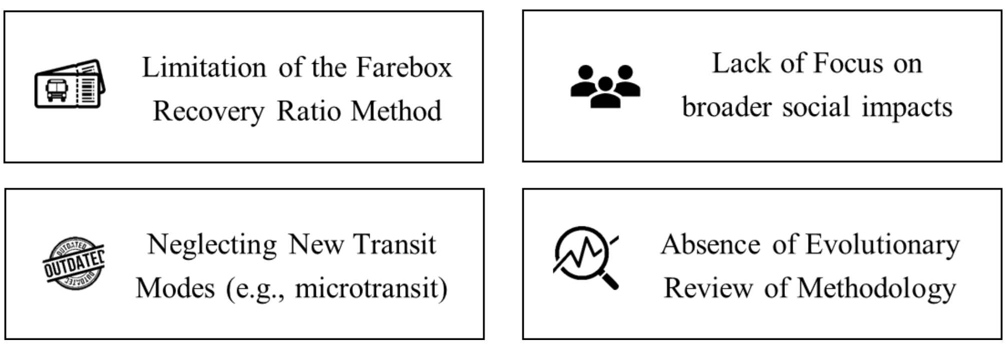


Figure 1-1. Four research limitations of studying economic influences of public transit services in the United States.

1.2 Research Questions

Given the identified research limitations and the transformative potential of public transit, it is crucial to revisit, refine, and recalibrate the methods used by scholars over the past years to measure the economic impacts of transit services across different states and regions in the United States. The main research questions are as follows:

1. Which methodologies have been prevalent in the literature from 2003 to 2023 for conducting economic benefit-cost analysis (BCA) and/or economic impact analysis (EIA) of public transit systems in the United States?
2. How do the economic assessments of public transit investments differ across geographical locations within the United States?
3. What notable trends have emerged in BCA and EIA literature over the past 20 years, particularly considering the rise of microtransit and micromobility?
4. What are the key advancements in public transit BCA and EIA studies in recent years, and how might they be applied to both Florida and the broader nation?

1.3 Research Objectives

Based on the research limitations and questions, this project aspires to achieve the following objectives:

1. To undertake a holistic review of the latest literature, including both technical reports and academic journal articles, on BCA and EIA of public transit services, with a focus on methodologies prevalent in the United States.
2. To conduct a thorough quantitative case study analysis of the economic effects of public transit projects, differentiating the analysis based on geographical areas within the United States.
3. To investigate the influence of emerging public transit modes, especially microtransit and micromobility, on both the economic outcomes of public transit services and the methodologies used to evaluate these impacts.
4. To summarize and analyze the advancements in methodologies from the literature review, subsequently discuss their policy implications and potential application in Florida and at a national level.

The final deliverable of this research will be a holistic literature review report, detailing existing studies on the benefit-cost and economic impact of public transit in the United States, and updating the outdated methodologies. It will also provide insights from case studies grouped by state. The ultimate goal is for the report to serve as a vital reference for the FDOT and transit agencies nationwide, aiding them in applying BCA or EIA more scientifically in the future.

1.4 Research Framework

This report aims to examine studies conducted since 2003 on the economic assessment of public transit projects or investments in the United States. The core research themes are "benefit-cost analysis (BCA)" and "economic impact analysis (EIA)," both of which are prominent forms of economic analysis recommended by the USDOT (2015).

Specifically, "benefit and cost" studies identify and quantify the positive and negative effects of transportation, and the associated societal and environmental influences. "Economic impact" studies evaluate the impacts on the regional or local economy, including aspects like jobs, income, and value added, as well as more profound ripple effects. It is critical to clarify that these two analytical forms and studies neither contradict each other nor act as substitutes. Instead, they can be applied separately or serve as complementary concepts, jointly supporting economic assessments for public transit investments and grant applications (Economic Development Research Group, Inc., 2017).

To ensure a thorough and unbiased review without compromising inclusivity, we implemented a bifurcated approach, examining both technical reports from government or transportation agencies and academic journal articles. For the technical reports, we employed a keyword-focused search strategy, capitalizing on the precision and easy identification of official government or DOT publications through keyword inputs. Among the technical reports reviewed, four city, county, and state-level benefit-cost and economic impact studies were dissected as case studies, summarizing the project objectives, economic analysis methodologies, tools or software used, and the final numeric outcomes. Conversely, for the academic journal articles, we utilized CiteSpace, a systematic bibliometric tool equipped with co-citation algorithms. Given the continually expanding corpus of academic papers, using CiteSpace allowed us to efficiently navigate literature, discovering the most frequently researched and cited themes, along with their publication timelines. **Figure 1-2** delineates this bifurcated approach.

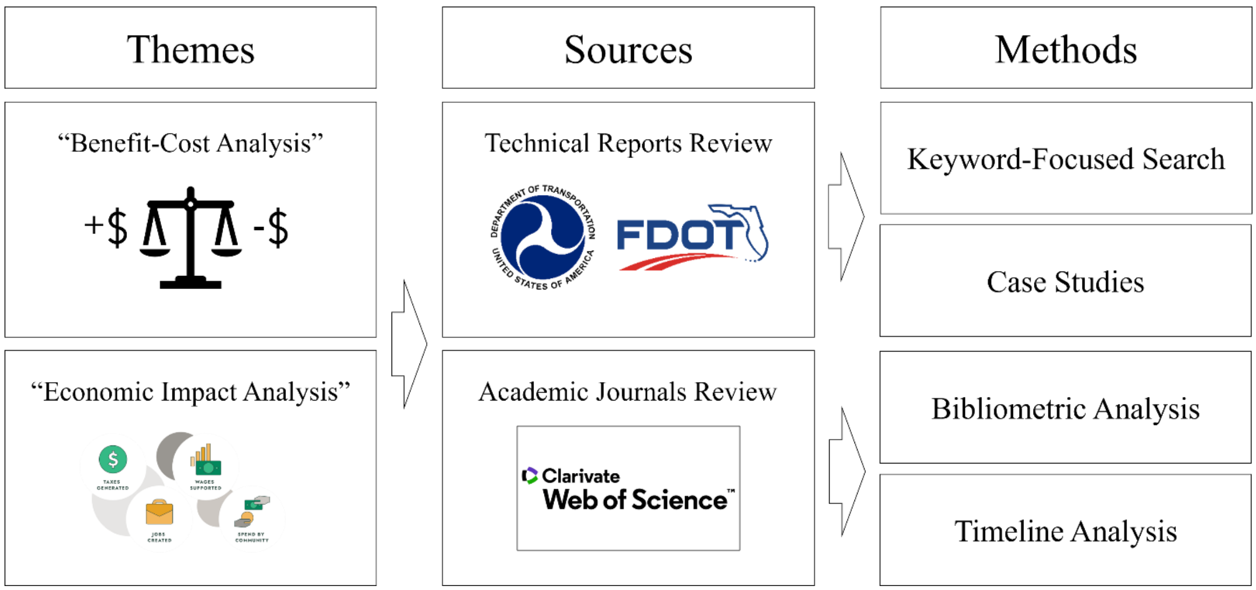


Figure 1-2. Framework of the research.

1.5 Organization of the Report

In the subsequent sections of this report, Chapter 2 presents a literature review of technical reports sourced through keyword-focused searches. Key sources include the USDOT and the Transit Cooperative Research Program (TCRP). This chapter delves into both BCA and EIA studies, tracing the evolution of these analytical methods over the past two decades. Chapter 3 employs the CiteSpace bibliometric tool to analyze and visualize academic journal papers, complementing the findings of Chapter 2. Chapter 4 introduces case studies that highlight economic assessments conducted by various states or regions. Chapter 5 offers a discussion of the findings and implications and provides answers to the research questions posed. Chapter 6 summarizes the recommendations for FDOT regarding future public transit project’s economic assessment approach. Finally, Chapter 7 draws the conclusion.

2 Literature Review of Technical Reports

2.1 Chapter Overview

Navigating the vast realm of literature, which includes government reports and academic journal articles, is indeed a task that demands meticulous strategy. Applying keyword-focused searches in library databases and web-based search engines holds foundational significance, as keywords can directly represent the theme and the author's perspective on a research's essence (Pesta et al., 2018). Although conventional, this method proves to be effective, particularly when analyzing government reports where topics are clearly defined, and the issuing agencies, such as the DOTs, are well-recognized for publishing subject-related studies and documents.

This chapter will leverage the keyword-focused searches, targeting investigations and discussions on the "benefit-cost analysis" and "economic impact analysis" of public transit systems in the United States, by mainly reviewing official technical reports from the USDOT, the Transit Cooperative Research Program (TCRP), local transportation agencies, research institutes, and universities. Moving forward, the next two chapters will employ a bibliometric tool to analyze academic journal articles and quantitative analyses of additional state DOT reports by major geographic regions.

2.2 Benefit-Cost Analysis (BCA)

A benefit-cost analysis (BCA) is a classic and popular analytical method used to evaluate the economic efficiency of a project, investment, or policy. This analysis involves a systematic process of itemizing, monetizing, and measuring a project's expected costs and benefits. It can also serve as a benchmark for comparing different project proposals (USDOT, 2023; Drèze & Stern, 1987). A BCA's objective is to determine whether a project's overall benefits surpass its total costs, i.e., whether it offers value for money, thus justifying the investment.

In the context of public transportation in the United States, BCA is one of the most vital evaluation tools. According to the USDOT (2023), the following discretionary grant programs (**Table 2-1**) are required to have a BCA when acquiring federal funding:

	Program Name	Department
1	Rebuilding American Infrastructure with Sustainability and Equity (RAISE) Grant Program	DOT
2	National Infrastructure Project Assistance program (Mega)	DOT
3	Nationally Significant Multimodal Freight and Highway Projects Grants Program (INFRA)	DOT
4	Rural Surface Transportation Grant Program (Rural)	DOT
5	Reconnecting Communities Pilot (RCP) Program	DOT
6	Bridge Investment Program - FHWA	FHWA
7	Promoting Resilient Operations for Transformative, Efficient, and Cost-Saving Transportation Program (PROTECT) (Resilience Improvement Grants and Community Resilience and Evacuation Route Grants only)	FHWA

8	Port Infrastructure Development Program (PIDP) Grants (Large Projects only)	MARAD
9	Consolidated Rail Infrastructure and Safety Improvements (CRISI) Program	FRA
10	Federal-State Partnership for Intercity Passenger Rail (FSP-National Grants only)	FRA

Table 2-1. List of discretionary grant programs that need a BCA when acquiring federal funding. FHWA refers to the Federal Highway Administration. MARAD refers to the United States Maritime Administration. FRA refers to the Federal Railroad Administration.

The BCA does not adhere to a universally standardized or accepted procedure. Despite minor variations, a BCA generally entails four steps (Hayes, 2023; Stobierski, 2019):

1. Identifying the project scope.
2. Determining the benefits and costs.
3. Monetizing each benefit and cost.
4. Tallying the total value to make a comparison.

The first step is to identify the project scope. The key is to establish clear goals that the project or investment aims to achieve. Defining these goals clarifies which aspects to emphasize in later BCA stages. Concurrently, building a timeline and allocating resources are other critical tasks in this step.

The second step is to determine the project's costs and benefits. While traditional BCAs may usually exclude broader economic and intangible factors not typically found on an income statement, modern BCAs tend to monetize and incorporate these societal impacts, enhancing the evaluation's comprehensiveness and accuracy (FHWA, n.d.; Rouwendal, 2012).

Benefits of a BCA can be categorized as:

1. *Direct Benefits:* Immediate revenue or cost savings resulting from a project. For instance, increased ticket sales and the rider's fuel savings brought by a newly introduced public transit route.
2. *Indirect Benefits:* Secondary benefits that might not translate directly into revenue but lead to other favorable outcomes. An example is the boost in local tourism and employment resulting from the accessibility provided by a new public transit line.
3. *Intangible Benefits:* Positive outcomes that cannot be directly quantified but contribute to the overall user experience or system reputation, such as heightened commuter satisfaction, safety, and enhanced employee morale. Many BCAs group indirect and intangible benefits together because of their overlapping characteristics.
4. *Competitive Benefits:* Advantages derived from pioneering or innovating in the industry, leading to a market share gain. For example, if a city launched a successful bus rapid transit program, it could gain a larger market share of commuters switching from other transit modes.

Costs of a BCA may include the following components:

1. *Direct Costs:* Expenses directly related to the implementation of the product or service. For example, labor costs for construction of transit infrastructure; expenses for raw materials and inventory like the electronic system and vehicles.
2. *Indirect Costs:* Overhead expenses from managerial operations, facility rent, and utilities that support daily operations of a public transit system.
3. *Opportunity Costs:* The lost opportunities or benefits caused by pursuing a project over an alternative, such as constructing a new public transit line over renovating an existing one.
4. *Intangible Costs:* These are current or future costs intricate to measure, e.g., potential negative impacts on commuter satisfaction that may lead to less repeated ridership.
5. *Cost of Potential Risks:* Considerations for competition costs, and regulatory risks.

The final two steps involve monetizing each identified cost and benefit and then tallying their anticipated total values. A BCA requires a uniform metric and unit, typically expressed in monetary terms (e.g., a dollar amount) with an applied discount rate, to enable comparison. The benefit-cost ratio (BCR) and net present value (NPV) are the two primary methods for executing a BCA, as depicted in equations (1) and (2):

$$BCR = \sum PV_{Benefits} \div \sum PV_{Costs} \tag{1}$$

$$NPV = \sum_{t=1}^{n} \frac{benefit_t - cost_t}{(1+i)^t} \tag{2}$$

Direct benefits and costs are straightforward to quantify and integrate into equations. However, assigning dollar values to indirect and intangible costs and benefits becomes more complex due to the absence of a standardized quantification method. We have summarized the key parameters and quantification methodologies for transportation projects, drawing principally from, but not limited to, the following reports or documents:

1. *Benefit-Cost Analysis Guidance for Discretionary Grant Programs by USDOT (2023)*. The USDOT updates this document each fiscal year. The January 2023 version is the latest official guide assisting users in drafting BCAs when applying for a federal grant. The document covers benefit and cost categories closely related to public transit projects and investments, which will be investigated in-depth in the later part of this section.
2. *Benefit-Cost Analysis Guidance for Rail Projects by FRA (2016)*. This is an earlier version of the 2023 USDOT's guide, tailored to align with rail projects, focusing on travel time, reliability, safety, and environmental impacts.
3. *Tiger Benefit-Cost Analysis (BCA) Resource Guide by USDOT (2016)*. This is another earlier version of the 2023 USDOT's guide supporting applicants of the Transportation Investment Generating Economic Recovery (TIGER) grants by recommending dollar values for each cost/benefit category.
4. *Measuring the Impacts of Freight Transportation Improvements on the Economy and Competitiveness by FHWA (2015)*. This report has a chapter on BCA and relevant

software tools, such as the RIMS-II, IMPLAN, and TREDIS, which will be elaborated in the EIA section.

5. *Indirect Benefits of State Investment in Public Transportation by the National Cooperative Highway Research Program (2015)*. This NCHRP research report summarizes indirect benefits, including employment, educational opportunities, reducing government service expenditures, and health care cost savings.
6. *TCRP Report 78 – Estimating the Benefits and Costs of Public Transit Projects: A Guidebook for Practitioners (2002)*. An early guidebook for conducting a CBA. Benefit and cost categories introduced in this book will be compared to the 2023 USDOT Guidance.
7. *TCRP Report 128 – Practices for Evaluating the Economic Impacts and Benefits of Transit (2017)*. A synthesis report and reference book for analysts to learn how the nation and local transportation agencies conduct economic assessments and analyses.

The common benefit and cost categories recommended by the USDOT (2023) for public transportation projects are presented in **Table 2-2**. Applicants seeking USDOT grants can choose specific benefit and cost types that align with their project's dimensions and objectives to compose a BCA.

	Benefits
	USDOT's BCA guidance
1	Safety benefits*
2	Travel time savings*
3	Vehicle operating cost savings*
4	Emission reduction*
5	Improved comfort or journey quality
6	Health benefits*
7	Reduced noise pollution
8	Emergency service response time improvement
9	Reductions in stormwater runoff and wildlife impacts
10	Reductions in operations and maintenance costs
11	Reductions in damages or outage impacts from improved resilience
	Costs
1	Capital expenditures*
2	Operating and maintenance expenditures (O&M) *
3	Residual value and remaining service life
4	Innovative technologies and techniques

Table 2-2. Benefit and cost types suggested by the USDOT (2023). The * denotes that the item is commonly used in a BCA.

To execute a BCA, users need to find recommended formulars and monetized values of the selected benefit or cost types in relevant documents. We will expound the safety benefits and travel time savings from the USDOT's official guide for demonstration and explain emission reduction in the next section.

Safety Benefits

Safety benefits in transportation infrastructure projects emphasize the reduction of fatalities, injuries, and property damage resulting from crashes. The evaluation of safety benefits considers the types of crashes the project might affect and its anticipated effectiveness in reducing their frequency or severity. The Crash Modification Factor (CMF) is a tool that can use historical crash data to calculate potential effects of a transit project's safety treatments (e.g., building a designated bike lane to protect cyclists), which are the estimated annual lives saved and injuries prevented, shown in Equations (3) and (4), respectively.

$$Estimated\ Annual\ Lives\ Saved = Current\ Annual\ Fatality\ Estimate \times (1 - CMF) \tag{3}$$

$$Estimated\ Annual\ Injuries\ Prevented = Current\ Annual\ Injury\ Estimate \times (1 - CMF) \tag{4}$$

Equation (5) below measures the overall safety benefits of introducing a new public transit project or safety treatment. "BR" stands for baseline risks (e.g., number of accidents per year), "RR" represents risk reductions (in percentage), estimated by equations (3) and (4), and "EC" refers to the expected consequences. EC is calculated as the sum of the number of accidents for each type (ranging in severity from no injury to fatalities) multiplied by the cost associated with each type.

$$Safety\ Benefits = BR \times RR \times EC \tag{5}$$

Table 2-3 presents the recommended monetized values of reducing accidental fatalities in transportation incidents (the "value of a statistical life", or VSL), injuries, and property damage in 2015 (USDOT).

Value of Injuries (2015)		
Severity	Fraction of VSL	Unit Value ($2015)
Minor	0.003	$28,800
Moderate	0.047	$451,200
Serious	0.105	$1,008,000
Severe	0.266	$2,553,600
Critical	0.593	$5,692,800
Not survivable	1.000	$9,600,000
Value of a Statistical Life (VSL)		
9,600,000 per fatality ($2015)		
Auto Property Damage Only (PDO) Crashes		
$4,198 per vehicle ($2015)		

Table 2-3. Recommended safety related monetized value of injuries in 2015. Adapted from the TIGER Discretionary Grants Benefit-Cost Analysis (BCA) Resource Guide (2016).

The latest 2023 version has made a few updates by adopting the KABCO injury scale, and the recommended monetized values are shown in **Table 2-4**.

Value of Injuries (2021)	
KABCO Level	Monetized Value ($2021)

O – No Injury	$4,000
C – Possible Injury	$78,500
B – Non-incapacitating	$153,700
A – Incapacitating	$564,300
K – Killed	$11,800,000
U – Injured (Severity Unknown)	$213,900
# Accidents Reported (Unknown if Injured)	$162,600
Auto Property Damage Only (PDO) Crashes	
$4,800 per vehicle ($2021)	

Table 2-4. Recommended monetized value of reduced fatalities and injuries in 2021. Adapted from the USDOT's Benefit-Cost Analysis Guidance for Discretionary Grant Programs (2023).

Travel Time Savings

Travel time savings are a fundamental aspect of BCA for transportation infrastructure projects. These savings, which involve reductions in both in-vehicle travel time and passenger waiting time, arise from efforts to enhance traffic flow, increase travel speeds, or establish more direct connections between destinations. Estimating travel time savings involves meticulous engineering calculations based on traffic forecasts and simulations, as well as considerations for potential induced demand effects, varying travel distances, travel purposes (business or leisure), and the attraction of new passengers. Nonetheless, a simplified method for calculating the value of travel time savings ($VTTS$) is often utilized to provide a reference point, as illustrated by Equation (6).

$$VTTS = Value\ of\ Time \times Change\ in\ Trip\ Time \times Affected\ Trips \tag{6}$$

Recommended monetized VTTS values can be sourced from the USDOT's Departmental Guidance on Valuation of Travel Time in Economic Analysis, initially published in 1997 and subsequently revised five times, with the latest ones summarized in **Table 2-5**.

Recommended Hourly Values of Travel Time Savings	
Category	$2021 per person-hour
General Tavel Time	
Personal	$17.00
Business	$31.90
All Purposes	$18.80
Walking, Cycling, Waiting, Standing, and Transfer Time	$34.00
Commercial Vehicle Operators	
Truck Drivers	$32.40
Bus Drivers	$35.00
Transit Rail Operators	$58.40
Locomotive Engineers	$57.40

Table 2-5. Recommended monetized hourly values of travel time savings. Adapted from the USDOT's Benefit-Cost Analysis Guidance for Discretionary Grant Programs (2023).

2.3

Regarding methodology, a straightforward way is to count how many low-wage jobs are generated due to improved transit access. For example, a case study conducted by Fan et. al. (2010) in Twin Cities, Minnesota, found that the addition of the Hiawatha light-rail line and related transit network improvements resulted in several noteworthy effects. During morning peak hours, there was a significant increase in the accessibility of low-wage jobs within a 30-minute transit travel radius. Light-rail station areas saw 14,000 additional accessible jobs, and areas with direct bus connections had 4,000 more jobs available. The construction of the light-rail system prompted the relocation of 907 low-wage workers closer to station areas and created over 5,000 low-wage job opportunities. The main data sources were the Metro Transit and the Longitudinal Employer-Household Dynamics (LEHD) database, U.S. Census Bureau.

Another approach involves providing a “what-if” scenario to estimate the number of trips to jobs, services, and education that would be forgone if a public transit project did not exist (Porter et al., 2015). For instance, a study conducted in Michigan by HDR Decision Economics (2010) found that over 34% of trips in the state were for work, while 26% were for educational purposes. Without access to public transportation, approximately 19% of work-related trips and 23% of education-related trips would be missed. When converted into dollar values, the economic cost of these missed work or medical trips would be around $67.6 million in 2008, or $96.6 million in 2023. It’s worth noting that HDR developed a spreadsheet-based tool to conduct the BCA, which will be discussed in the subsequent section.

Regarding other environmental impacts, USDOT used to include noise reduction but later categorized it as a health impact. For example, Müller-Wenk and Hofstetter (2003) monetized the annual costs of sleep disturbance caused by noise, which ranged from CHF 1,500 (USD 2,761) to CHF 15,000 (USD 16,567) in 2000. Besides, the 2023 guidebook mentioned stormwater runoff, although it currently lacks a recommended methodology for valuing the cost.

2.3 Evolution of BCA in Transportation Technical Reports

When comparing technical reports published around 2003 or earlier with recent ones, it becomes evident that traditional BCA and contemporary BCA share a common foundation in their core concepts and framework, which is to calculate the Benefit-Cost Ratios (BCR) and Net Present Value (NPV). Surprisingly, the range of benefit and cost categories has not expanded significantly. However, the notable evolution lies in the scholarly refinement of grouping various benefit and cost types to align with specific objectives of public transit projects. This refinement makes it more straightforward to select the relevant ones when constructing a new BCA. In essence, the BCA literature has matured and become more comprehensive over the years through practical experience and meticulous categorization, enhancing its effectiveness and efficiency in application.

Reviewing both old and recent reports can testify to the observations mentioned above. For instance, Litman published a guidebook titled “Evaluating Public Transit Benefits and Costs” in 1999, which synthesized benefit and cost categories identified in transportation literature during the 1990s (see **Table 2-7**). Remarkably, all these categories remain applicable in 2023, as evidenced by his updated version (see **Figure 2-1**). A similar finding emerges when examining the categories listed in TCRP Report 78 (2002).

Regarding the difference, the 1999 version only grouped the categories into mobility benefits, efficiency benefits, and costs, while the 2003 version expanded to include four objectives: improved transit service, increased transit travel, reduced automobile travel, and transit-oriented development. The grouping effort offers a more nuanced and holistic framework for assessing the multifaceted impacts of public transit projects. This increased granularity allows for a more thorough and precise analysis, better equipping policymakers to evaluate the diverse dimensions of these projects and make informed decisions.

Category	**Description**
Mobility Benefits	*Benefits from travel by transit that would not otherwise occur*
1. Economic	Economic benefits of increased employment
2. Personal	Benefits to users from increased employment, education, recreation, and social activities
3. Option Value	Maintaining transportation options in case of changes in individual or social needs
Efficiency Benefits	*Benefits resulting from reduced motor vehicle traffic*
4. User Cost Savings	Users' vehicle and time savings
5. Economic Development	Increased regional economic activity due to the larger portion of local inputs in transit expenditures compared with automobile expenditures
6. Congestion Reduction	Reduced traffic congestion resulting from reduced vehicle traffic
7. Parking Cost Savings	Reduced parking problems and parking facility cost savings from reduced automobile use
8. Safety Benefits	Relative safety of bus travel compared with automobile travel
9. Reduced Roadway Facility & Service Costs	Reduced costs for roadway construction, maintenance, traffic police, and related services
10. Reduced Roadway Land Requirements	Reduced need to use land for roads, increased tax revenue
11. Land Use Impacts	Reduced urban sprawl, loss of greenspace and negative aesthetic impacts of roads
12. Air Pollution Reductions	Reduced vehicle air pollution
13. Noise Impacts	Changes in vehicle noise emissions
14. Water Pollution	Reduced vehicle water pollution due to reduced automobile use
15. Resource Conservation	Reduced use of energy and other natural resources
16. Reduced Barrier Effect	Improved mobility for pedestrians and bicyclists due to reduced vehicle traffic
Costs	*Costs of transit service (not incorporated in benefit analysis)*
1. Fares	Fares charged to transit users
2. Travel Time	Additional travel time costs for transit users
3. Subsidies	Financial subsidies to provide transit service

Table 2-7. Categories of public transit benefits and costs in 1999. Adapted from Porter et al. (2015) and the original version was from Litman (1999).

Porter et al. (2015) provided another way (**Figure 2-2**) of grouping benefits of public transit investments, Box A represents the traditional economic impact analysis, which will be elaborated in the next section. Box B represents social cost savings resulting from reducing automobile use. Box C represents indirect benefits from improved access to jobs and services by public transit users, which complements Box B and USDOT's BCA guidance. Box D adds secondary benefits gained from transit-facilitated land use changes.

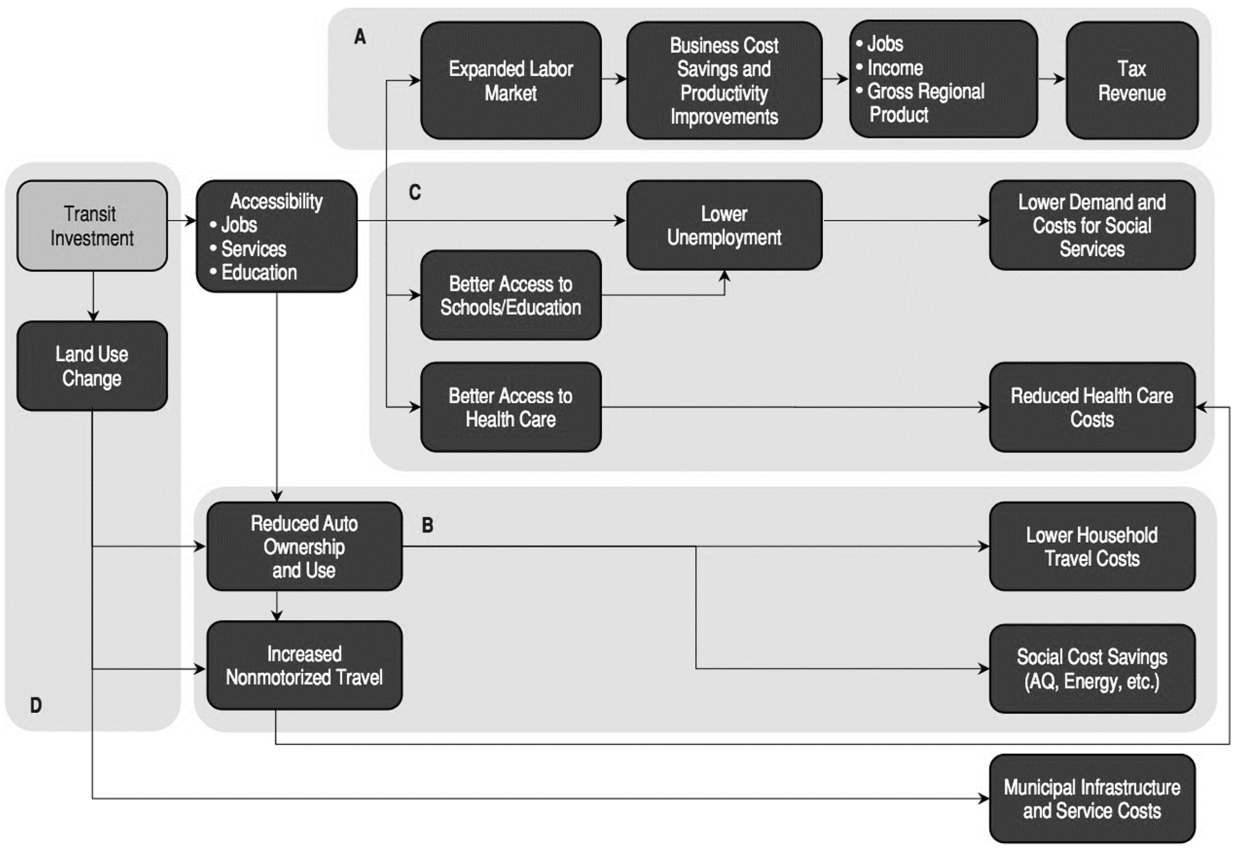


Figure 2-2. Direct and Indirect benefits and economic impacts of public transit investments. Adapted from Porter et al. (2015).

While the fundamental BCA formulas remain unchanged, new tools have been developed to streamline the data input process and expedite the calculation of economic effects for specific categories of benefits and costs. As mentioned in Section 2.3, HDR developed a transit benefit model using Microsoft Excel to calculate the difference in transportation costs between two scenarios: with and without the presence of a public transit service. The model aimed to measure:

1. *Transportation cost savings*, which are out-of-pocket cost savings (e.g., vehicle ownership and operating cost savings), travel time cost savings, accident cost savings.
2. *Low-cost mobility benefits*, which are affordable mobility benefits (i.e., the economic value to access work, healthcare, and educational services for transit dependent

people) and cross-sector benefits (budget savings for welfare and social services, e.g., unemployment and homecare).

The framework of the HDR transit benefit model is illustrated in **Figure 2-3**. Data inputs can be obtained from transit data at the agency level and from on-board passenger surveys that ask respondents whether they would still undertake work, retail, medical, and education trips if public transportation were unavailable. **Figure 2-4** displays the interface of the spreadsheet used to navigate the tool. This model has been employed for statewide economic analysis in Michigan and regional analysis in San Diego, CA.

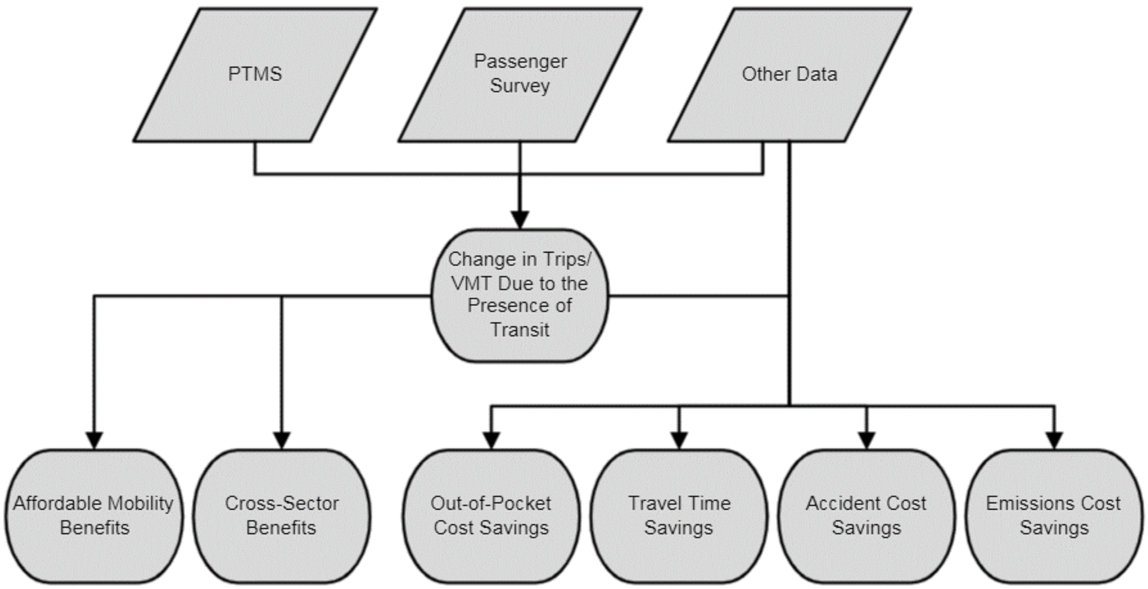


Figure 2-3. The framework of the HDR transit benefit model. Adapted from HDR (2010).

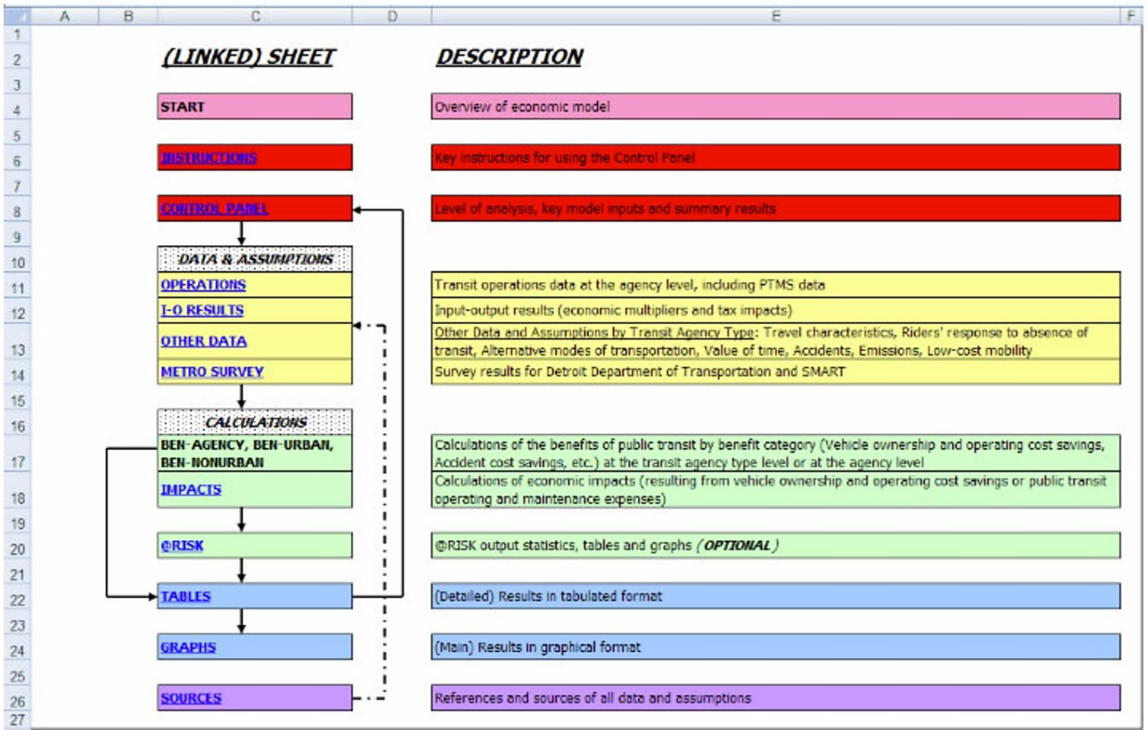


Figure 2-4. The user interface of the HDR transit benefit model. Adapted from HDR (2010).

2.4 Economic Impact Analysis (EIA)

Economic Impact Analysis (EIA) evaluates the total changes in the local economy resulting from a new project or investment, which bolsters the local economy by generating new jobs and enhancing business activities. Specifically, an EIA assesses the total employment creation, value added, taxes, business expenditure, worker income, and contributions to the gross domestic product (GDP) or gross state product (GSP) that such projects or investments induce, as illustrated by Box A of **Table 2**. (Market Street Services, Inc., 2004).

A traditional EIA focuses on quantifying the monetary influx into the economy in dollar terms and the corresponding multiplier effects arising from a transit project (Lyon-Hill et al., 2023). However, EIA and BCA are compatible approaches. For instance, the FHWA (n.d.) suggests that an EIA can quantify economic impacts on regions, land values, and businesses.

EIA only contains three components or types of economic effects: direct, indirect, and induced impacts, as detailed in **Figure 2-5** (Morton, 2019; Lyon-Hill et al., 2023):

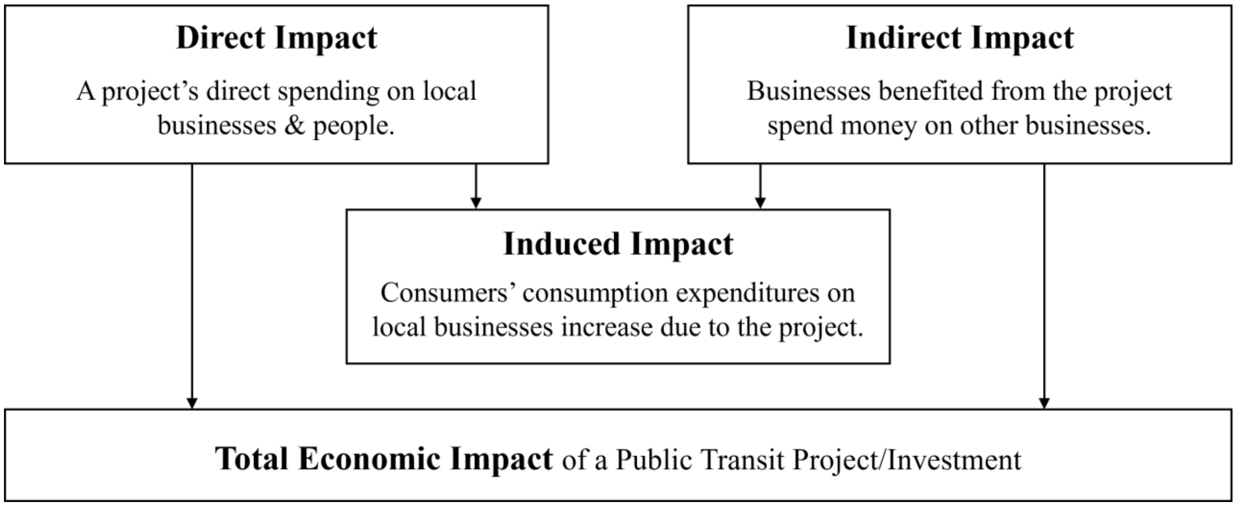


Figure 2-5. Model of Economic Impact Analysis (EIA).

1. *Direct Impacts:* These refer to the initial money influx or immediate jobs introduced into the local economy of the study area by a new project or investment. In the realm of public transportation, examples include funds allocated for hiring contractors and workers or purchasing raw materials to construct a new transit system.
2. *Indirect Impacts:* The income or employment generated by business-to-business transactions indirectly caused by the direct effects. When a business benefits from direct effects, it may, in turn, engage other local businesses for its needs by purchasing their products or services. For example, if money is spent to commission an IT team to establish a data security framework for a public transit system (a direct effect), and that IT team subsequently procures software or hardware from other suppliers (secondary sources), that procurement constitutes an indirect effect.
3. *Induced Impacts:* These represent the additional local consumption or spending made possible by the income generated through the direct and indirect impacts of the project or investment. An example would be employees, who, after being hired by a new transit project and receiving their salaries, might then increase their expenditure on consumer products or food. This multiplier effect sets EIA apart from BCA.

EIA primarily uses the Input-Output model (I-O) to measure these three impacts of an economic activity. The I-O model, initially developed by Leontief, examines how the output of one sector becomes the input for another, providing a detailed representation of the flow of goods and services (and the associated monetary values) throughout an economy (Kenton, 2021). Equation (8) represents the fundamental I-O model:

$$x = Ax + y \tag{8}$$

Here, x is the output vector, representing the total production of each industry. A is the technical coefficient matrix, also known as the input coefficient matrix or consumption matrix, illustrating the relationships among producers in an economy. Ax denotes the intermediate demand, which indicates the portion of the output of an industry consumed as inputs by other industries. Lastly, y is the final demand vector, representing the demand for goods and services intended for end consumers (Faruzzi, 2021).

Equation (9) is the other version, where I is the identity matrix of the same dimension as A. $(I - A)^{-1}$ is known as the Leontief inverse, which captures the direct and indirect input requirements to produce a unit of output.

$$x = (I - A)^{-1} y \quad (9)$$

Over the past two decades, most transportation agencies and research institutes have conducted EIAs using I-O modeling software or tools. These software or tools come with embedded multipliers specific to different regions and industries, eliminating the need for users to gather them independently. The multipliers are derived from a vast set of industry accounts, which measure the commodities produced by various industries and their consumption by both other industries and final users (Bess & Ambargis, 2011). There are two main I-O modeling tools: RIMS-II and IMPLAN.

RIMS-II

The Regional Input-Output Modeling System (RIMS-II) is a spreadsheet tool developed by the U.S. Bureau of Economic Analysis (BEA). It measures the effects of transportation activities on local jobs, income, and business sales across various industries. RIMS-II offers I-O multipliers for 372 detailed industries or 64 aggregate industries, available down to the county level (BEA, 2020; USDOT, 2015). Users can directly order the desired multipliers to conduct an EIA. Equation (10) demonstrates how to apply a multiplier. Types of multipliers are summarized and explained in **Table 2-8**.

$$Cost \times Multiplier = Economic\ Impact \quad (9)$$

Multiplier	Definition
Direct-effect earnings	Total household earnings per $1 initial change in household earnings
Direct-effect employment	Total number of jobs per initial change in jobs
Final-demand output	Total industry output per $1 change in final demand
Final-demand earnings	Total household earnings per $1 change in final demand
Final-demand employment	Total number of jobs per $1 million change in final demand
Final-demand value-added	Total value added per $1 change in final demand

Table 2-8. Types of multipliers used by RIMS-II. "Final demand" refers to the demand for goods and services that are consumed and not used in the production of other goods and services. Adapted from (Bess & Ambargis, 2011).

For example, assume that a light-rail transit construction project had an initial investment of $20 million. If its final-demand output and final-demand earnings multipliers were 1.96 and 0.71, respectively, then the total output would be $39.2 million, and the total earnings would be $14.2 million.

Regarding pros and cons, RIMS-II is standardized, reliable, and easily obtainable, especially for projects seeking federal oversight or funding. Yet, it is less user-friendly, given that all data and information are presented in a spreadsheet without a distinct user interface. Moreover, since the data and multiplier values remain static until BEA's subsequent update (the most recent being based on BEA's 2018 regional data), its capacity to reflect dynamic changes in the economy is constrained (BEA, 2020; USDOT, 2015).

IMPLAN

The Impact Analysis for Planning (IMPLAN) Cloud is a professional software tool designed to measure economic impacts using the I-O model. Initially launched by the USDA Forest Service, IMPLAN was later enhanced by the Minnesota IMPLAN Group (MIG, Inc.). The software provides comprehensive data for 440 sectors, aligning closely with the 4-digit North American Industry Classification System (NAICS) industry codes. Furthermore, its datasets and models can be tailored to various geographic scales, from the national level down to state and county levels. Such flexibility facilitates convenient statewide and countywide EIA for users (BEA, 2020; USDOT, 2015).

IMPLAN comprises both a descriptive and a predictive model. The descriptive model delineates the regional economy, tracing the flow of dollars from purchasers to producers within the region and capturing the movement of goods and services both internally and externally (including regional exports and imports). It also considers the Social Accounting Matrices (SAM) which detail the flow of money between institutions, such as transfer payments and taxes. The predictive model, on the other hand, leverages local-level multipliers – direct, indirect, and induced – to analyze changes in final demand and their subsequent ripple effects throughout the local economy. Applicants of the FHWA's TIGER Grant Program frequently turn to IMPLAN to conduct EIAs (USDOT, 2015).

One merit of IMPLAN is its user-friendly interface. Users simply select the geography they wish to assess, the industries to evaluate, and the activities to analyze (e.g., changes in industry output or employment). The system then taps into the local economic data stored in the cloud to estimate economic impacts in monetary terms. Another advantage is IMPLAN's capability to conduct multi-regional I-O analysis, enabling the simultaneous study of multiple adjacent regions or counties for deeper comparisons (IMPLAN, 2022).

The 2020 APTA report titled "Economic Impact of Public Transportation Investment" utilized IMPLAN to determine the effects of investment in public transportation on the U.S. economy in terms of wages, business income, and employment. Key metrics in the IMPLAN system used were total business output, overall GDP or value added, total labor income, and the total number of jobs linked to that labor income. The findings indicated that over a 20-year span, an annual $1 billion investment in public transit could yield approximately $5 billion in GDP, with $3 billion attributed to productivity gains from cost savings and $1.8 billion derived from the pattern of public transportation investment spending. Based on 2020 wage rates, this was tantamount to generating 49,700 jobs. For those transitioning to transit and forgoing a car, the annual savings could be roughly $9,797 (APTA, 2020).

TREDIS

The Transportation Economic Development Impact System (TREDIS), created by the Economic Development Research Group (EDR), is an integrated economic modeling system specifically designed to evaluate the broader economic impacts of transportation projects, policies, and service changes. The latest version TRDIS 6 has four separate modules to conduct BCA, EIA, financial impact analysis, and freight and trade flows analysis. These functions together may build a more holistic picture of how transportation activities or policy interventions affect economic growth, mobility, market access, and overall regional economic development (TREDIS, 2023). **Figure 2-6** illustrates the key elements of TREDIS.

There are six types of technical reports commonly incorporate TREDIS, which include transportation plans and policies (e.g., Texas Long Range Plan by Texas DOT), prioritization (e.g., North Carolina Project Prioritization by North Carolina DOT), corridor alternatives (Mid-States Corridor by Indiana DOT), freight (e.g., Nevada Statewide Freight Program Assessment by Nevada DOT), transit and passenger rail (e.g., Ultra High-Speed Ground Transportation by AECOM for Washington State DOT), and highways (e.g., Resilience – Highway 101 (CA) by California DOT).

Compared to other EIA tools, TREDIS stands out as a specialized transportation EIA software. It utilizes data sources that are tailored to transportation, distinguishing it from tools with a broader industry focus. Additionally, its prediction models are crafted for transportation analysts. While it integrates foundational frameworks like the I-O model, it also leverages other predictive or statistical models such as the econometric and travel cost models, backed by peer-reviewed publications and approved by public agencies. Beyond measuring generic impacts such as economic outcomes, employment, and value-added, TREDIS is adept at assessing changes in travel time, operational costs, business productivity, and household spending resulting from transportation projects or policies. Moreover, TREDIS has a dynamic simulation capability, allowing key parameters to be adjusted annually based on projections from the preceding year (USDOT, 2015). Although another EIA software REMI, or Regional Economic Models, Inc., has dynamic simulation functions, it was often applied to gauge a broader range of policy changes or economic activities on regional and level economics.

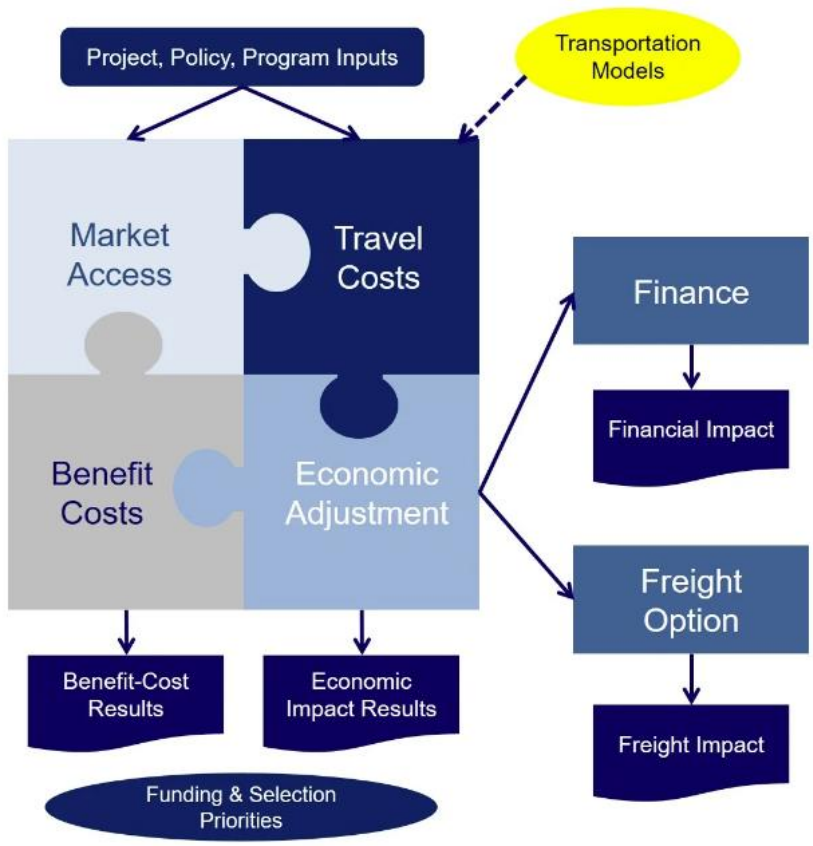


Figure 2-6. Key elements of the TREDIS model. Adapted from TREDIS (2023).

3 Literature Review of Journal Articles

3.1 Chapter Overview

Compared to technical reports, academic literature boasts a more extensive volume and diverse themes. With the increasing complexity of selecting journal papers relevant to a research topic, recent software advancements enable scholars to conduct quantitative literature analyses, including precise data extraction, track the evolution of disciplines, identify research hotspots, and map topic distributions. Amid these developments, CiteSpace has emerged as a popular bibliometric tool for analyzing patterns, spotting emerging trends, and mapping research domains in various scientific landscapes (Chen, 2016). By leveraging co-citation analysis theory and the PathFinder algorithm techniques, CiteSpace processes vast literature datasets, transforming them into visual narratives for easy interpretation (Liu et al., 2022).

For our research into the economic effects on public transit in the United States, the integration of CiteSpace proves essential. It allows for a comprehensive examination of a broad array of academic publications, spotlighting top-cited works that have left significant imprints on the discourse. By adeptly utilizing CiteSpace's unique features – from co-citation analysis to thematic clustering and research frontier detection – we can provide a panoramic view of the subject and discover areas that warrant further exploration.

In summary, this chapter presents our use of CiteSpace in the literature review process. We'll begin by discussing the data sources and methodology, then proceed to apply the tool. We will present and interpret the visual outcomes of the analysis, including cluster diagrams (which capture groups of thematically connected articles through co-citation patterns) and timelines illustrating the publication years of these clusters. By synthesizing insights from both this and the previous chapter, we aim to understand the methodologies and emerging trends related to the economic dimensions – specifically, the benefit-cost and economic impact – of public transit in the United States, addressing corresponding research questions.

3.2 Data Sources and Methods

Data Source: The Web of Science (WoS)

Central to our methodology is sourcing data obtained from the Web of Science (WoS), a renowned scientific database. Researchers can use it to monitor the citation frequency of specific articles, identify the individuals and institutions citing them, and pinpoint the exact publications where these citations are located. With its expansive coverage across disciplines, WoS places a special emphasis on the natural sciences (Birkle et al., 2020).

A distinctive feature of WoS is its stringent selection criteria for indexing articles, which are strictly peer-reviewed ones. This approach contrasts with platforms like Google Scholar, of which some articles may not undergo such rigorous scrutiny (Falagas et al., 2017). The inclusion of an article in WoS highlights its high reference worthiness, indicating the integrity and significance of its content.

WoS Search: Benefit Cost Analysis (BCA) & Economic Impact Analysis (EIA)

In conducting this bibliometric analysis, we executed an in-depth search through the WoS Core Collection search engine, employing two sets of keywords. The first set (referred to as Query 1) integrated "public transportation," "benefit cost," and "United States," while the second set (Query 2) integrated "public transportation," "economic impact," and "United States." To ensure precision, we included variations of the keywords that have the same meanings, which were "cost benefit," "public transit," "America," and "U.S." To maintain the rigor and relevance of our selections in the context of transportation, we focused on articles indexed in both the Science Citation Index Expanded (SCIE) and the Social Sciences Citation Index (SSCI) within WoS. The timeline spanned from January 1st, 2003, to October 1st, 2023. The specific inputs of the two queries with operators are shown below:

1. *Query 1*: (ALL = (benefit cost) *OR* ALL = (cost benefit)) *AND* (ALL = (public transportation) *OR* ALL = (public transit)) *AND* (ALL = (United States) *OR* ALL = (America) *OR* ALL = (U.S.))
2. *Query 2*: (ALL = (economic impact)) *AND* (ALL = (public transportation) *OR* ALL = (public transit)) *AND* (ALL = (United States) *OR* ALL = (America) *OR* ALL=(U.S.))

As of October 1st, 2023, Query 1 yielded a total of 238 relevant journal articles, while Query 2 yielded 316 (**Figure 3-1**).

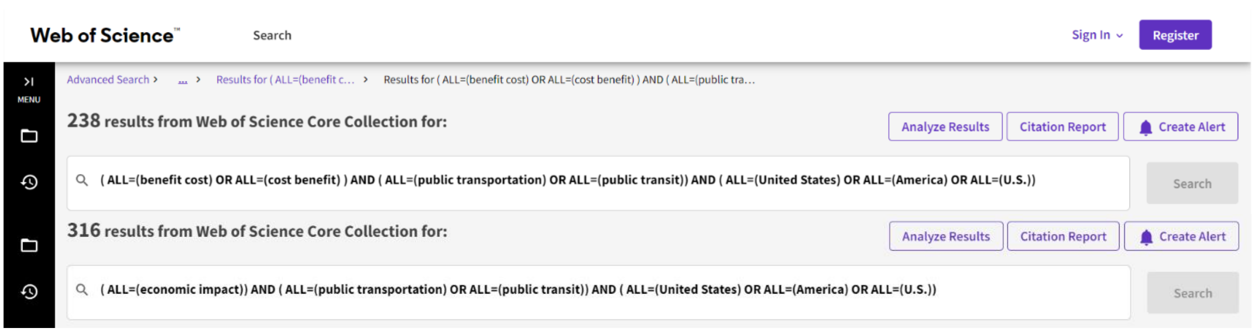


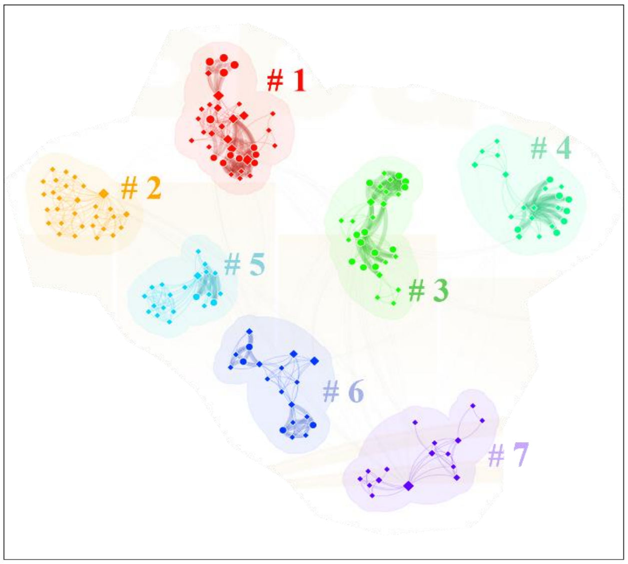
Figure 3-1. Relevant journal articles found in WoS based on the queries.

Methods

After obtaining journal articles relevant to our research topics, we downloaded and inputted them into CiteSpace to apply quantitative co-occurrence network analysis for each query. As previously mentioned, CiteSpace enabled us to categorize the selected articles to create scientific knowledge maps that could showcase the principal clusters and seminal research studies pivotal to our research theme. These maps could highlight potential connections and overarching interrelationships among nodes, which contained information like authors, institutions, articles, and foundational principles (Driessen et al., 2007; Freilich et al., 2010). Simultaneously, we generated timelines associated with these publications to reveal the progression and dynamism of research interests and themes over time. By analyzing the clusters of themes and keywords in relation to their positions on the timeline, we could gain a more thorough understanding of the scholarly perspectives on how researchers have assessed the economic effects of public transit in the United States since 2003.

3.3 Query 1: Benefit Cost Analysis

Figure 3-2 displays the outcomes from Query 1 in cluster map format. Each color within the map represents a cluster of articles with closely related themes. CiteSpace automatically extracted critical information from the articles' abstracts and keyword lists to identify mutual themes. The cluster at the top contains more frequently cited papers, indicating the popularity of the theme. For example, cluster 1 (in red) encompasses articles with high citations studying light-rail transit and healthcare costs.



	By Title	By Keywords
# 1	Light rail transit	Health care cost
# 2	Health benefit	Air pollution
# 3	Urban light rail line	Greenhouse gas emission
# 4	Literature review	Economic Impact
# 5	Auto & transit	Planning & analysis
# 6	Metro bus system	Greenhouse gases
# 7	Adults with disabilities	Transportation voucher

Figure 3-2. Clustering map of Query 1 articles.

Figure 3-3 displays the clusters identified by Query 1 on a timeline, visualizing the evolution of research themes over time. The nodes on the axis represent entities, such as articles or their keywords. The size of a node can indicate its importance or the frequency of the associated entity. Lines, or links, connect nodes and represent relationships between them, such as co-authorship frequency or the co-occurrence of keywords.

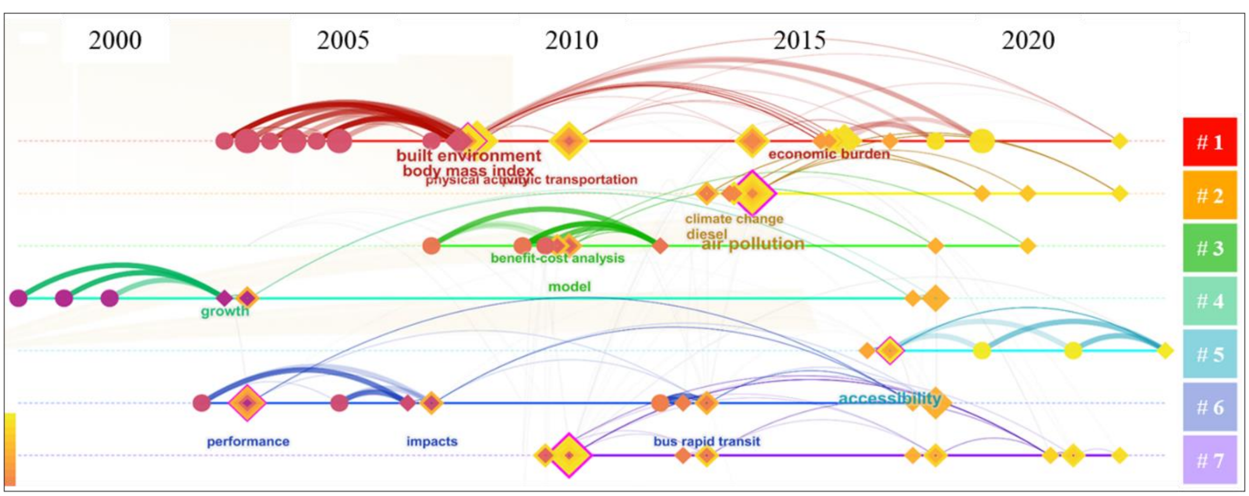


Figure 3-3. Timeline of Query 1 articles published.

By comparing and grouping the fourteen terms, we found that academic literature over the past 20 years emphasized assessing health and environmental impacts of public transit projects, especially urban light rail-services and buses. Major citing articles include:

Stokes et al. (2008). *Estimating the effects of light rail transit on health care cost*. The study applied the BCA to assess potential public health savings resulting from reduced obesity through Charlotte, NC's proposed light rail system. By computing factors including projected ridership, local obesity rates (23%), direct ($458) and indirect ($429) medical costs, and the transit system's influence on physical activity, the research indicated a cumulative health cost savings of $12.6 million over a 9-year period from the transit project. The cost reduction calculation is expressed in Equation (10), where N is the number of riders, O is the percentage of obese, R is percentage of riders that sufficiently exercised, and C is the cost of being obese.

$$Obesity\ Cost\ Reduction = N \times O \times R \times C \tag{9}$$

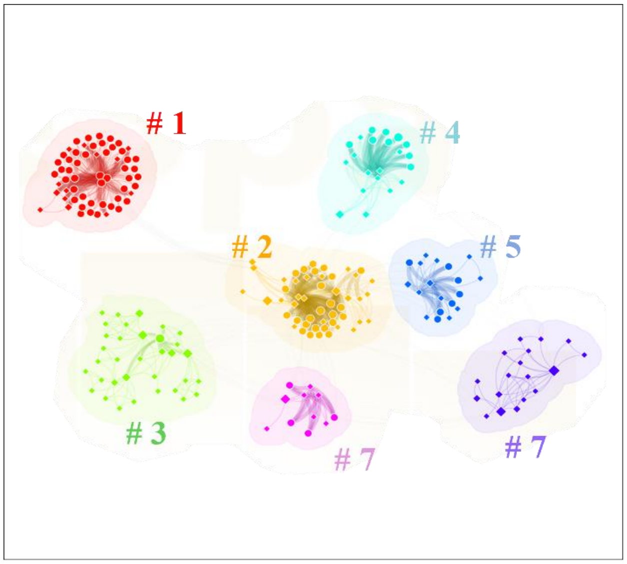
Olawepo & Chen (2019). *Health benefits from upgrading public buses for cleaner air: a case study of Clark County, Nevada, and the United States*. This research assessed the health benefits of a program in Clark County to power buses with compressed natural gas (CNG) instead of diesel. As of 2017, the study estimated that completing the transition could result in annual savings of $0.88–2.24 million. Nationwide, if 20% of buses switched to CNG, health benefits could amount to $0.98–2.48 billion per year. In terms of methodology, the study employed the Co-Benefits Risk Assessment (COBRA) model. Compared with BCA, COBRA is more specialized, emphasizing health impacts from changes in air quality. It utilizes a source–receptor (S–R) matrix that can simulate both the dispersion of primary PM2.5 and the formation of secondary PM2.5 from precursors. However, the monetary value of the pollutants suggested by the USDOT BCA guidebook could still be applied to both methods.

Nguyen-Hoang & Yeung (2010). *What is paratransit worth*? Using regression analysis and BCA, the authors studied the impact of paratransit services provided by US public transit agencies at the national level. Instead of quantifying the monetized values of benefits and costs, the study delved into the concept of "worth." The findings revealed that paratransit is extremely price-inelastic (approximately -0.02), meaning the benefits significantly outweigh the costs.

Bhatta & Drennen (2003). *The Economic Benefits of Public Investment in transportation: A review of recent literature.* It was an early attempt to group various categories of benefits, costs, and economic impacts tied to transit investments. These categories include output, productivity, production costs, income, property values, employment, real wages, rate of return, and non-commercial travel time.

3.4 Query 2: Economic Impact Analysis

Query 2 results are visualized in **Figure 3-4** (cluster map) and **Figure 3-5** (timeline).



	By Title	By Keywords
# 1	Health care cost	Light rail transit
# 2	Light rail transit	TOD
# 3	Public transit service cut	Health impact assessment
# 4	Border	Public transit demand
# 5	Literature review	Economic impact
# 6	Bike-sharing system	Health impact
# 7	Unionization	Transit operation cost

Figure 3-4. Clustering map of Query 2 articles.

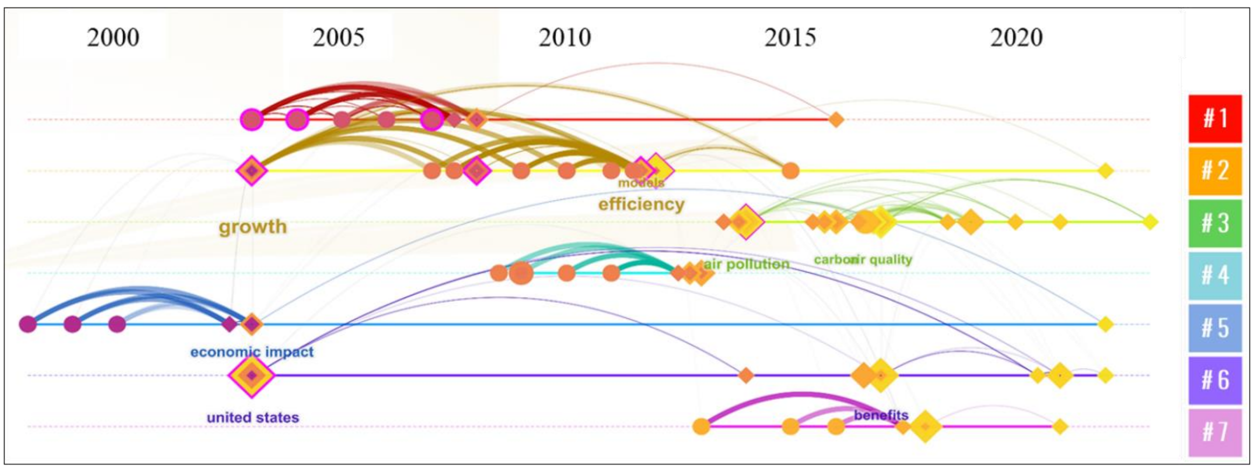


Figure 3-5. Timeline of Query 2 articles published.

After comparing and grouping the fourteen terms from Query 2, the findings were consistent with those of Query 1. Academic literature on public transit economic impacts predominantly centered on health and environmental aspects, such as health care costs and air pollution. Light-rail and bike-sharing emerged as the top transit modes studied. The major articles citing these topics include:

Lavery & Kanaroglou (2012). *Rediscovering light rail: assessing the potential impact of a light rail transit line on transit-oriented development and transit ridership*. In the case of the City of Hamilton, Ontario, Canada, the Integrated Urban Model (IUM) was used to assess the economic impact of a Light Rail Transit (LRT) system. The IUM analyzed the relationships between land use, transportation, and activities. Three model scenarios were developed for this study: a base case scenario that represented the existing relationship between transportation and land use as a projection for 2026 to 2031; a second scenario that estimated the reserved right of way anticipated for the LRT; and a third scenario that evaluated the effects of public policy options encouraging Transit-Oriented Development (TOD) along with the LRT's impact. Results showed that by 2031, the transit mode share would be 4.4% across all scenarios, with a slight increase from 35% to 37% for school trips. The auto-driver mode would contribute 86% of all trips, primarily because of its larger constant coefficient in the modal choice model. All these findings suggested that while a single LRT might not have significantly stimulated economic development or shifted modal share, the IUM proved to be a valuable tool for testing LRT-related public policies.

James et al. (2014). *A health impact assessment of proposed public transportation service cuts and fare increases in Boston, Massachusetts (USA).* The study conducted an 8-week Health Impact Assessment (HIA) to examine the health and economic implications of the public transit system in Boston by utilizing BCA models that integrated transportation with critical health and economic pathways. In this analysis, it was estimated that approximately 30,000 to 49,000 individuals switched from public transportation to driving, resulting in an additional 18,500 to 25,100 hours of driving per year under two scenarios proposed by the Massachusetts Bay Transportation Authority. Scenario 1 involved a 43% fare increase and service reductions affecting 34 to 48 million annual trips. Scenario 2 proposed a 35% fare increase and service reductions impacting 53 to 64 million annual trips, with a significant elimination of regional bus routes. The results indicated that Scenario 1 could have led to about 70 new obesity cases, 10 preventable deaths, and various morbidity outcomes per year. Meanwhile, Scenario 2 would result in roughly 120 new obesity cases and 15 preventable deaths annually. The proposed changes could have isolated 550 to 2,200 public transportation-dependent households from essential healthcare resources.

Fullerton Jr & Walke (2013). *Public transportation demand in a border metropolitan economy*. To investigate the level of demand for municipal bus services in El Paso, Texas, USA, the study incorporated factors such as price, income, and weather conditions to evaluate the possible effects of cross-border economic conditions on ridership in the El Paso region. The results obtained using a Linear Transfer Function (LTF) modeling technique indicated that ridership levels in this metropolitan region, situated near the border, were impacted by economic conditions both domestically and internationally. Furthermore, the study showed that El Paso transit riders were more responsive to changes in service levels than to fare adjustments, at least in the short term.

Clockston & Rojas-Rueda (2021). *Health impacts of bike-sharing systems in the U.S.* This study aimed to quantitatively assess the health hazards and benefits associated with Bike-sharing systems (BSS) in the United States, specifically in New York City (NYC), in 2019 using a Health Impact Assessment methodology. This approach involved quantifying the health effects related to physical activity, air pollution, and traffic incidents by utilizing data on transportation, traffic safety, air quality, and physical activity. The health effects were then simulated for adult individuals, considering variables such as death rates, occurrence of diseases, disability-adjusted life years (DALYs), and the economic consequences related to health due to illness and death. The findings suggested that the implementation of bike-sharing systems was associated with a decrease of 4.7 in premature mortality, 737 disability-adjusted life years (DALYs), and $36 million USD in health-related economic consequences, underscoring the positive health effects of bike-sharing systems.

Additional Findings

The research themes of Query 1 and Query 2, as extracted by the CiteSpace algorithm, were strikingly similar. Both focused on studies assessing health benefits and reductions in air pollution due to public transit improvement. However, these journal articles predominantly concentrated on identifying correlations through empirical data and statistical models to signify the importance of a public transit system rather than directly monetizing the impacts. This trend is largely attributable to the nature of academic research, which often places higher emphasis on theoretical contributions.

It's also worth noting that the total research output from both Query 1 and Query 2, amounting to 238 and 316 papers respectively over two decades, seems relatively modest. This might indicate the specialized or niche character of the research topics. One possible explanation could be that BCAs and EIAs mainly appear in governmental reports instead of in academic journals, where the technical reports prioritize practical applications. Moreover, the perceived lack of novelty in economic assessment methods might be directing researchers towards fresher, emerging research fields.

4 Case Studies

4.1 Chapter Overview

To better understand how different U.S. regions carry out public transit economic assessments through BCA and EIA, this chapter delves into four technical reports and plans as case studies. It focuses on the software/tools used, the direct, indirect, and induced economic impacts quantified, and the categories of benefits and costs that were monetized. These reports stem from public transit projects in Florida and three other megaregions.

As defined by the Regional Plan Association, a megaregion is a vast area containing two or more metropolitan areas that are in rough proximity, along with their surrounding hinterlands (Hagler, 2009). For example, the Florida megaregion includes cities such as Miami, Orlando, and Tampa Bay. The three other examined cases are drawn from Los Angeles (representing the Southern California megaregion), Chicago (from the Great Lakes Megaregion), and both New York City and the state of New York (representing the Northeast Megaregion), as illustrated with red circles in **Figure 4-1**.

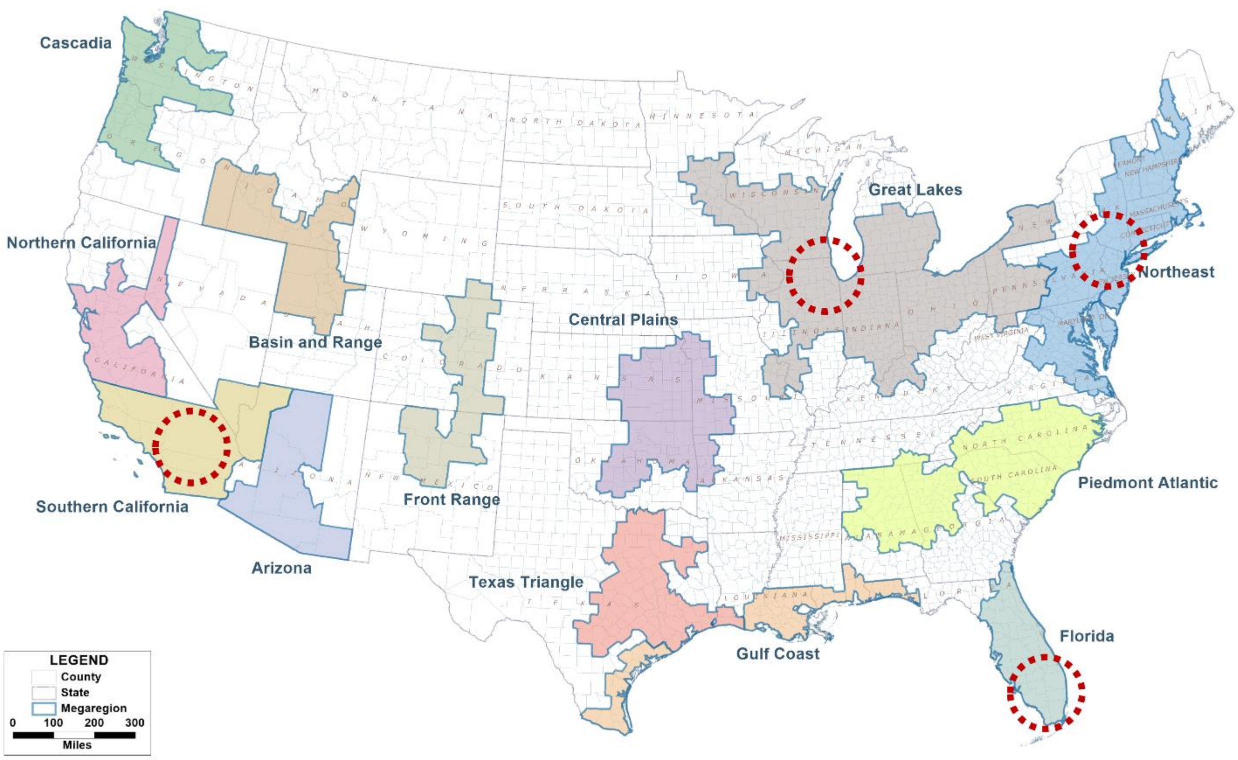


Figure 4-1. The 13 U.S. megaregions identified by the Lincoln Institute. The four case study sites are indicated by the red circles. Adapted from Jenkins (2022).

The cities chosen for this study stand out due to their significance within their respective megaregions. Each city functions as a global commercial center, with New York, Chicago, Los Angeles, and Miami consistently ranking among the top 30 global commerce hubs (Robinson & Scott, 2016). These cities confront shared urban transportation challenges, such as congestion, pollution, notable subway or light-rail ridership, and intricacies related to international trade and tourism (Ross et al., 2012). Moreover, by 2025, these four megaregions are projected to boast populations over at least 20 million and GDPs surpassing the national average, showing their communal demographic and socio-economic characteristics (Illsley, 2019). As such, these case studies provide invaluable insights into the complex interplay of public transportation within the megaregion framework.

4.2 Case Study 1: Los Angeles County's Traffic Improvement Plan

Program Background

To alleviate transportation issues and combat traffic congestion, Los Angeles County introduced the Los Angeles Transportation Improvement Plan in 2016. The plan aimed to enhance freeway traffic flow, expand the rail and rapid transit system, repave local streets, repair potholes, synchronize signals, maintain the safety of transit and highway systems, make public transportation more accessible, convenient, and affordable, embrace technological innovations, create jobs, reduce pollution, and bolster local economic benefits while ensuring accountability and transparency (LA Metro, 2016).

Specifically, the plan outlined nine construction regions (**Figure 4-2**), distributed across nine distinct subregions: Arroyo Verdugo, San Fernando, Central City, Gateway Cities, San Gabriel, South Bay, Westside, Las Virgenes-Malibu, and North County. These construction initiatives, supported by the proposed Ordinance No. 16-01 Measure M, were set to be financed through a retail transaction and a 0.5% tax rate within the boundaries of LA County.

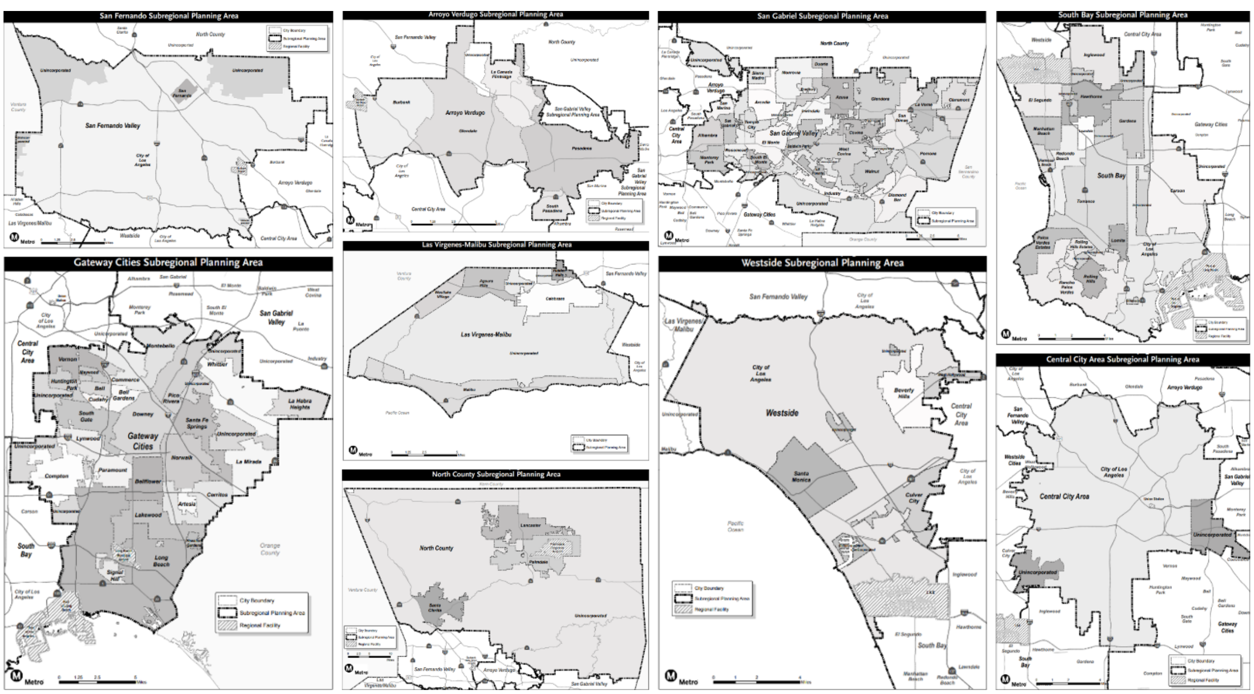


Figure 4-2. The subregions map for the LA County Traffic Improvement Plan. Adapted from LA Metro (2016).

While the primary employment and economic activity would be concentrated within LA County, the significance of its role as a connectivity hub in Southern California amplified the broader impact. Hence, the assessment of total economic effects extended to the regional level, influencing nearby counties of Los Angeles, Orange, Riverside, San Bernardino, and Ventura (LA Metro, 2016). To gather a full extent of the aggregate economic effects, the calculations contained the one-time increases in total output, employment, and labor income in Southern California that arose from construction activities, while subtracting measure-related expenditures. According to the EIA by the Los Angeles County Economic Development Corporation, or LAEDC (2016), the expected total expenditure exceeded $42.7 billion, thereby projected to generate an impressive $79.3 billion in economic output across the five-county Southern California region. This boost was predicted to create 465,690 job opportunities, leading to a significant labor income totaling $26.1 billion. Moreover, the increased economic activity was expected to result in higher tax revenues. The total tax revenue was estimated to reach $9.5 billion, comprising a substantial $6.1 billion for federal taxes, with another $3.3 billion allocated for state and local taxes. A summary of the fiscal impact can be found in **Table 4-1**.

Economic and Fiscal Impact of Metro Construction Projects			
	Highway	Transit	Total *
Total Project Spending ($ millions) **	$ 14,720	$ 27,982	$ 42,701
Less Right of Way and Vehicle Purchases	*736*	*1,399*	*2,135*
Net budgeted spending ($ millions) **	13,984	26,583	40,566
Total Economic Impact			
Output ($ millions)	$ 28,215	$ 51,116	$ 79,331
Employment (jobs)	149,390	316,300	465,690
Direct	*73,580*	*169,860*	*243,440*
Indirect	*37,830*	*68,850*	*106,680*
Induced	*37,980*	*77,590*	*115,570*
Labor income ($ millions)	$ 8,583	$ 17,542	$ 26,125
Total Fiscal Impact ($ millions)			
Federal taxes	$ 2,029	$ 4,114	$ 6,143
State and local taxes	1,088	2,225	3,313
Total Fiscal Impact	$ 3,117	$ 6,339	$ 9,457

* May not sum due to rounding
** All values expressed in 2015 dollars

Table 4-1. Summary of economic and fiscal impact of the Metro Construction Project in LA County. Adapted from LAEDC (2016).

Methodology

To evaluate the economic impact, the plan applied IMPLAN and analyzed three metrics: employment, income, and output value. For employment, the focus was on the number of jobs (full-time, part-time, permanent, seasonal employees, and the self-employed) rather than the hours worked throughout the year. Regarding labor income, both payroll wages and benefits such as health insurance received by employees and the self-employed were taken into consideration. The output value was determined by the combined value of commodities produced as goods and services. Expenditures were represented as nominal figures for the year of expenditure. All monetary values were expressed in terms of 2015 dollars. In this assessment, expenditures related to right-of-way and land acquisition were excluded, as the process itself didn't generate economic activity. Similarly, expenditures related to vehicle purchases and finance charges were omitted due to the activities occurring outside of the economic region.

The transportation improvement construction involved a range of projects, including the establishment of new highways and transit systems, ongoing operations and maintenance of buses and rail networks, demographic enhancements like ADA paratransit services, and various other initiatives. These projects could be classified into two main groups: highway and freeway projects, and transit projects. The comprehensive budget allocated for the realization of these endeavors amounted to $42.7 billion.

Economic Impacts

The IMPLAN assessment found that the aggregate budgeted spending amounted to $40.6 billion. Consequently, this investment was projected to yield a total economic output of $79.3 billion across the five-county region of Southern California and anticipated to generate a workforce of 465,690 individuals, contributing to a cumulative labor income of $26.1 billion. For a comprehensive breakdown of the economic impacts, please refer to **Table 4-2**.

Metro Transportation Improvement Construction Projects Economic and Fiscal Impact of Metro Construction Projects			
	Highway	Transit	Total *
Project Spending			
Total Project Spending ($ millions) **	$ 14,720	$ 27,982	$ 42,701
Less Right of Way and Vehicle Purchases	*736*	*1,399*	*2,135*
Net budgeted spending ($ millions) **	13,984	26,583	40,566
Total Economic Impact in Southern California			
Output ($ millions)	$ 28,215	$ 51,116	$ 79,331
Employment (jobs)	149,390	316,300	465,690
Direct	*73,580*	*169,860*	*243,440*
Indirect	*37,830*	*68,850*	*106,680*
Induced	*37,980*	*77,590*	*115,570*
Compensation ($ millions)	$ 8,583	$ 17,542	$ 26,125

* May not sum due to rounding
** All values expressed in 2015 dollars

Table 4-2. Economic and fiscal impacts of LA county's metro transportation improvement and construction projects in Southern California. Adapted from LAEDC (2016).

In addition to the employment and compensation generated within the transportation project sector, the projects would also contribute to regional, state, and federal tax revenues. This revenue stream originated from income taxes on the earnings generated by the employment and from taxes on the procurement of materials, services, and other transactions associated with the projects. These tax contributions (**Table 4-3**) were anticipated to yield a total tax revenue of nearly $9.5 billion.

Fiscal Impact of Transportation Improvement Projects			
	Highway	Transit	Total *
State and Local Taxes ($ millions)			
Income taxes	$ 309	$ 628	$ 937
Sales taxes	336	689	1,025
Property tax	291	596	887
Social insurance	23	47	71
Fees and fines	74	151	225
Other taxes	55	113	168
Total state and local taxes	**$ 1,088**	**$ 2,225**	**$ 3,313**
Federal Taxes ($ millions)			
Incomes taxes	$ 736	$ 1,505	$ 2,241
Social insurance	901	1,832	2,733
Corporate income taxes	277	542	819
Other taxes	115	236	351
Total federal taxes	$ 2,029	$ 4,114	$ 6,143
Total *	**$ 3,117**	**$ 6,339**	**$ 9,457**

* May not sum due to rounding
All values expressed in 2015 dollars
Sources: Metro; Estimates by LAEDC

Table 4-3. Fiscal impact of LA county's metro transportation improvement projects. Adapted from LAEDC (2016).

4.3 Case Study 2: Chicago's High Speed Rail Program

Program Background

The Midwest High-Speed Rail Association (MHSRA) has been actively promoting an efficient high-speed rail (HSR) system in the Midwest. Their ambition is to enhance public transit efficiency for all major metropolitan areas within a radius of 350 to 450 miles from Chicago. To realize this vision, the Economic Development Research Group, Inc. (EDRG) and AECOM prepared a study titled "The Economic Impacts of High-Speed Rail: Transforming the Midwest" for MHSRA in 2011. This research provided a metropolitan-level overview of the land use, economic factors, and infrastructure prerequisites for creating a regional high-speed intercity passenger rail hub in Chicago (EBP, 2023).

The Chicago metropolitan area's extensive transportation matrix serves as a pivotal link, connecting six of the Midwest's primary urban centers: Chicago, Detroit, Minneapolis/St. Paul, St. Louis, Cincinnati, and Cleveland. As illustrated in **Figure 4-3**, this expansive network comprises four main corridors in a "four-spoke" structure, with Chicago as its anchor. Each corridor has potential locations for strategically positioned stations to bolster long-distance connectivity. Trains are planned to operate at 220 mph on dedicated tracks, without any grade crossings (EBP, 2023). **Table 4-4** details the ridership, travel time, frequency, and revenue projections for these corridors. The project's forecast year is 2030, with revenue figures adjusted to 2010 dollars.

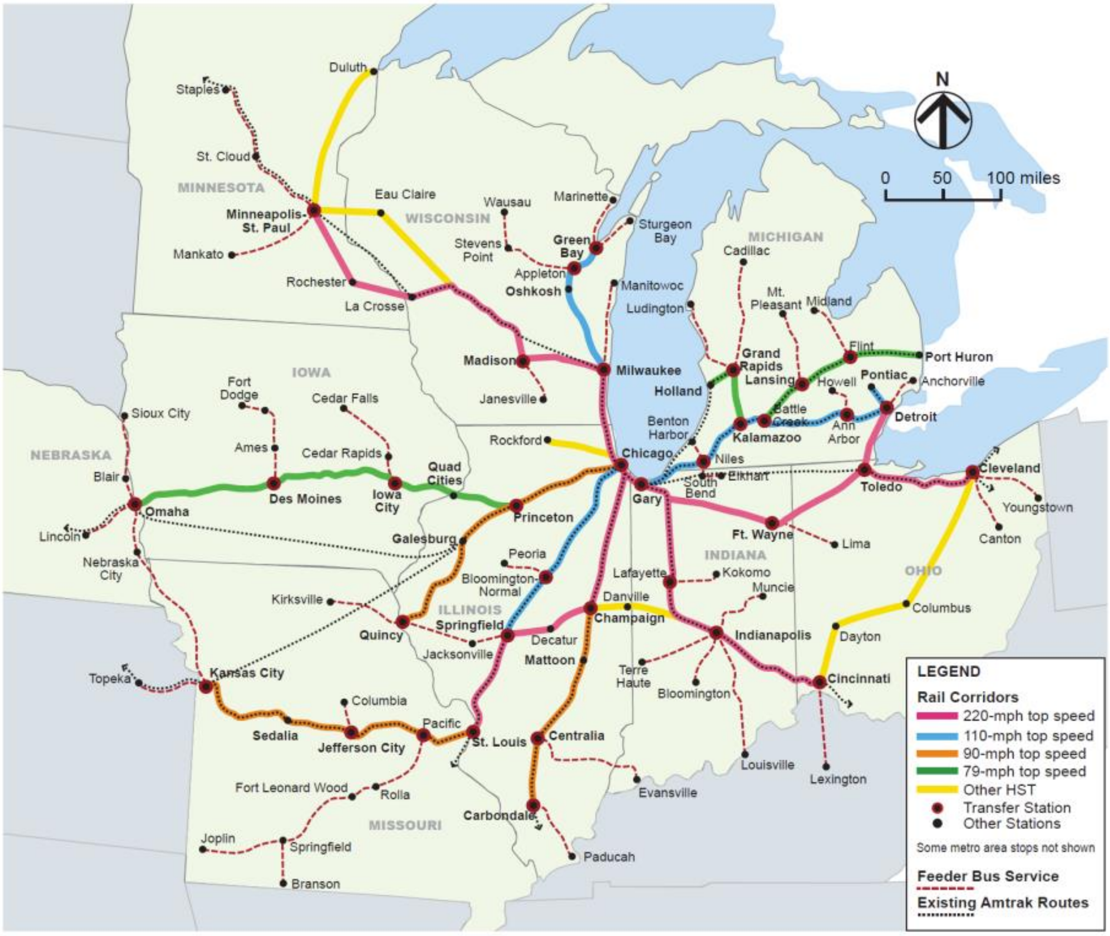


Figure 4-3. Concept plan for the Midwest region's high speed rail network. Adapted from MHSRA (2011).

	Annual Riders	Annual Revenue	Travel Time	Daily Roundtrips
CHICAGO – MINNEAPOLIS / ST. PAUL				
110 mph (MWRRI)	4,362,404	\$158,030,000	6:29	6
150 mph	12,537,000	\$634,220,000	3:30	25
220 mph	15,884,000	\$842,150,000	2:30	25
CHICAGO – ST. LOUIS				
110 mph (MWRRI)	1,757,123	\$65,760,000	4:27	8
150 mph	5,999,000	\$249,090,000	2:40	25
220 mph	7,904,000	\$336,750,000	1:55	25
CHICAGO – CINCINNATI				
110 mph (MWRRI)	894,669	\$55,420,000	4:08	5
150 mph	5,877,000	\$285,660,000	2:30	25
220 mph	7,226,000	\$374,280,000	1:55	25
CHICAGO – DETROIT / CLEVELAND				
110 mph (MWRRI)	4,795,048	\$179,360,000	4:24 / 4:48	9
150 mph	10,661,000	\$561,770,000	2:25 / 2:50	25
220 mph	12,650,000	\$685,190,000	1:55 / 2:15	25
TOTALS				
110 mph (MWRRI)	11,809,244	\$458,570,000	–	28
150 mph	35,074,000	\$1,730,740,000	–	100
220 mph	43,664,000	\$2,238,370,000	–	100

Table 4-4. Ridership forecast summary of the four corridors. Adapted from MHSRA (2011).

Methodology

While the AECOM and EDR's Chicago HSR report used the TREDIS model for BCA and EIA, many of their findings and data sources came from other Midwest Regional Rail Initiative (MDRRI) plans and DOT reports (e.g., Michigan, Iowa, Wisconsin, and Ohio) that covered the same study area. For example, both the "Midwest Regional Rail Initiative Benefit Cost & Economic Analysis" (Transportation Economics & Management Systems, Inc., 2007) and the "Economic Impacts of the Midwest Regional Rail System" (Midwest Interstate Passenger Rail Commission, 2007) utilized the RIMS-II model.

Figure 4-4 illustrates the mechanism of the I-O model (used by RIMS-II and TREDIS) in measuring the economic impacts of spending a single dollar on auto production. The blue lines represent the initial outcomes of the spending, e.g., 14 cents going towards plastics, 5 cents for electricity, 0.11 cents for instruments, and 0.07 cents for rubber. The red lines show the secondary ripple effect: the 14 cents spent in the plastic industry is further distributed as 9 cents to the chemical industry, 2 cents to local employees, and 3 cents as leakage. Similarly, from the initial spending, 21 cents allocated to other local industries re-circulate in the economy in various ways, such as 1 cent for utilities, 5 cents on autos, and 4 cents as income for local employees. (Transportation Economics & Management Systems, Inc., 2007).

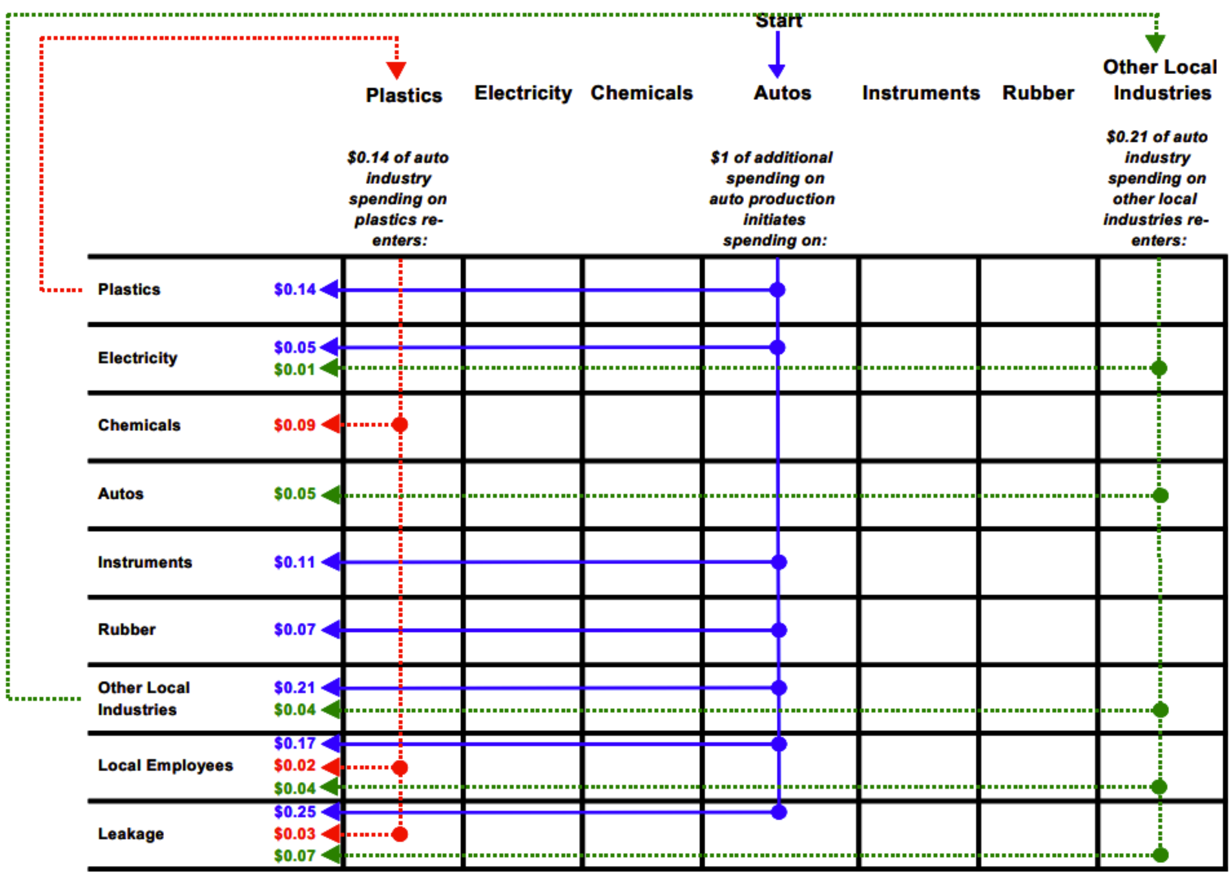


Figure 4-4. Multiplier mechanism example of spending $1 on auto production. Adapted from Transportation Economics & Management Systems, Inc. (2007).

Economic Impacts

Regarding the Chicago study, the economic impacts of the proposed high-speed rail service were gauged by the transit's impact on metropolitan economic growth. This impact integrated the combined effects on productivity, tourism, labor markets, other business activities, and advancements in research and technology brought about by the high-speed connection. These outcomes signified the extra economic activities in the area, which wouldn't have happened without the high-speed rail. While the high-speed trains had instant impacts during construction, the focus here was on the long-term impacts triggered by launching the project and grew in response to rising population, travel demand, and enhanced service performance.

Table 4-5 displays these overall effects on the Chicago metropolitan area, including the ripple effects. Beyond the expected employment, output, value-added, and wages, ridership patterns would also see significant changes. For the HSR system set at a 220-mph speed, approximately 21.2 million of the estimated 43.6 million (one-way) riders would be traveling to or from Chicago. In contrast, the 150-mph setup would see Chicago accounting for 16.7 million out of an estimated 35.1 million annual riders.

Measure	**Unit**	**150-mph scenario**	**220-mph scenario**
2030 Employment	Jobs	58,049	103,610
2030 Output (business sales)	$billion per year	$7.6	$13.8
2030 Value-Added (GRP)	$billion per year	$4.3	$7.8
2030 Wages	$billion per year	$3.0	$5.5

Table 4-5. Estimated annual total economic impacts of Chicago-based HSR service in 2030. Adapted from MHSRA (2011).

On the other hand, for this 4-corridor, 1,430-mile HSR network, its projected investment or infrastructure capital cost for the 220-mph speed scenario was $83.6 billion, while the 150-mph scenario came in at $74.7 billion, adjusted to 2010 U.S. dollars (MHSRA, 2011).

In the entire Midwest region, the BCA and EIA results from the MDRRI reports indicated a projected benefit-cost ratio (BCR) of 1.8 for the HSR system, meaning that for every dollar invested, there would be a return of $1.80. This BCR was among the highest for any regional railroad systems in the U.S. at the time. Furthermore, the completion of the entire Midwest Regional Rail system was projected to result in $23 billion in overall benefits, approximately 58,000 new permanent jobs, and an increase in earnings of $5.3 billion over the construction period (Midwest Interstate Passenger Rail Commission, 2007).

Besides the conventional economic impact metrics and benefit and cost categories, the MHSRA and other regional reports suggested that High-speed rail (HSR) could offer four additional mechanisms:

1. *Improved Business Efficiency*: HSR would significantly reduce travel times, allowing business travelers to cover distances quickly. This time-saving aspect boosts business productivity, as executives could now cover what used to be long trips in a fraction of the time. Therefore, the 220-mph speed would have more benefits.

2. *Reduction in Road Congestion*: HSR could offer an alternative to car and truck travel, easing road congestion. This could save travel time caused by congestion and reduce costs, enhancing the overall movement of goods and services.
3. *Relief for Air Travelers*: With HSR in place, there would be less congestion and waiting time at airports and traffic on routes leading to them. This means fewer air travel delays, making the overall journey smoother and more efficient.
4. *Increased Accessibility:* For those without cars, HSR would open up new destinations, democratizing travel and bringing broader societal benefits.

However, these reports didn't offer methods or monetized figures that could convert the four benefits of the HSR system into tangible economic gains. For instance, **Table 4-6** estimates the potential time savings resulting from the HSR network's construction, yet it doesn't translate these benefits in monetary terms. In essence, current research tends to emphasize directly measurable impacts, neglecting the more elusive or intangible effects.

City Pairs	Current Service	MWRRS	Time Reduction
Chicago-Detroit	5hr 38min	3hr 46min	1hr 52min
Chicago-Fort Wayne	(no service)	1hr 43min	(NA)
Chicago-Cleveland	6hr 24min	4hr 22min	2hr 02min
Chicago-Indianapolis	4hr 50min	2hr 41min	2hr 29min
Chicago-Cincinnati	8hr 10min	4hr 08min	4hr 02min
Chicago-Carbondale	5hr 30min	4hr 22min	1hr 08min
Chicago-Springfield	3hr 20min	2hr 29min	51min
Chicago-St. Louis	5hr 20min	3hr 49min	1hr 31min
St. Louis-Kansas City	5hr 40min	4hr 14min	1hr 26min
Chicago-Des Moines	(no service)	5hr 04min	(NA)
Chicago-Quincy	4hr 15min	3hr 44min	31min
Chicago-Omaha	8hr 37min	7hr 02min	1hr 35min
Chicago-Milwaukee	1hr 29min	1hr 04min	25min
Chicago-Madison	(no service)	2hr 15min	(NA)
Chicago-St. Paul	8hr 05min	5hr 31min	2hr 34min

Table 4-6. Example train travel times. MWRRS stands for the Midwest Regional Rail System. Adapted from Midwest Interstate Passenger Rail Commission (2007).

4.4 Case Study 3: MTA's 2020-2024 Capital Investment Strategy

Program Background

This study, conducted by Ernst & Young Infrastructure Advisors, LLC (EY), explored the potential economic impacts of the Metropolitan Transportation Authority's (MTA) preliminary 2020-2024 Capital Investment Strategy on New York State (NYS) and its 10 economic regions, as depicted in **Figure 4-5**. The goal of the investment was to renovate and enhance the region's subways, buses, railroads, and the authority's nine vehicular bridges and tunnels over the next five years, aiming for a faster, more accessible, and more reliable public transportation system (MTA, 2019). The six priorities of the MTA's 2020-2024 Capital Plan are:

1. Upgrade stations and improve accessibility.
2. Invest in new buses and train cars.
3. Modernize signals on the busiest subway lines and commuter rail lines.
4. Build the region's megaprojects.
5. Keep bridges & tunnels in good working condition.
6. Keep the MTA's other infrastructure in good working condition.

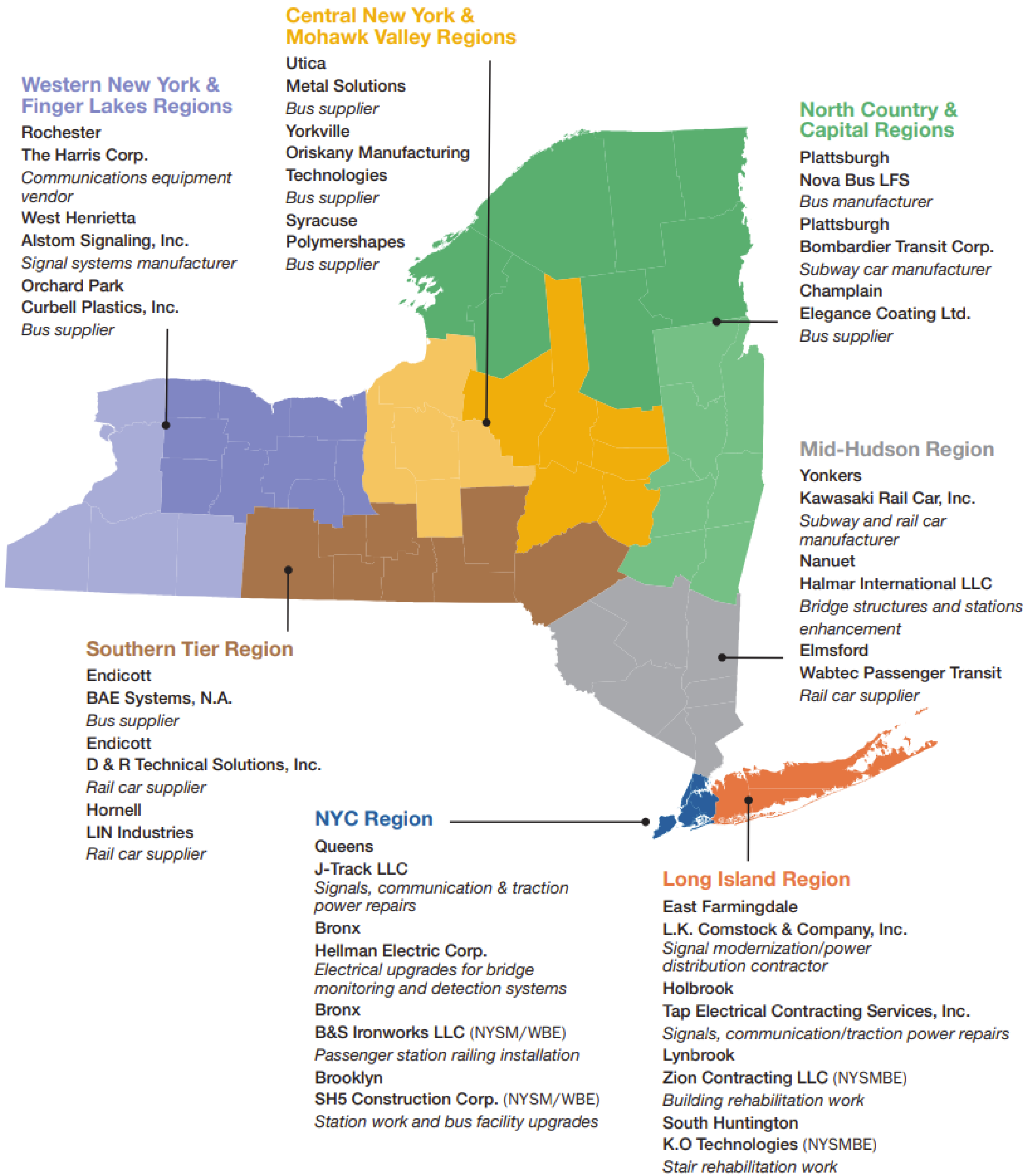


Figure 4-5. Economic regions of the MTA's Capital Program. Adapted from MTA (2019).

Methodology

This EIA utilized IMPLAN with all data and multiplier indices designated for analyzing New York regions. The scope of analysis included estimating potential impacts on income, employment, GDP, and economic outputs through the classic EIA effects: direct, indirect, and induced. Direct impacts were from MTA labor and capital spending and purchases from NYS vendors. Indirect impacts were generated through the supply chain of MTA and its vendors. Induced impacts were household spendings derived from the incomes of direct and indirect employees. The EIA estimated statewide, regional, and MTA impacts.

The report did not use a full BCA as a complementary method. Nevertheless, it provided an overall value of the investment, which was an unprecedented $51.5 billion, including more than $40 billion for New York City Transit.

Statewide Impacts

Table 4-7 displays the estimated statewide economic impacts of the 2020-2024 Capital Investment Strategy. For the three types of EIA effects, direct spending amounted to $12.7 billion for construction services and materials associated with MTA's projects. This investment could potentially create close to 7,000 direct jobs annually. The ripple effects, both indirect and induced, would permeate throughout New York as MTA's vendors procure additional inputs and as their employees reinvest their incomes locally. This broader economic stimulation could reach $22.6 billion, resulting in the creation of 25,100 new jobs. Cumulatively, the capital investment might sustain 286,800 worker-years over a span of five years, producing $62 billion in total economic output within New York. Out of this, $34.1 billion would contribute directly to New York's GDP, inclusive of $25.4 billion as employee labor income.

Statewide impacts	Direct impacts	Indirect & induced	Total, Statewide
Average employment	32,300	25,100	57,400
Worker years	161,400	125,400	286,800
Labor income	$16.39	$8.97	$25.36
GDP	$19.42	$14.70	$34.13
Economic output	$39.31	$22.64	$61.95

Table 4-7. Statewide economic impacts of the MTA capital investment program over a 5-year period. The units are in billions of dollars. Adapted from EY (2019).

The statewide EIA further estimated that the economic output per worker would be $244,00. For every $1 billion of direct expenditure, the capital program could generate approximately 7,300 New York jobs through direct, indirect, and induced economic channels, with an employment multiplier (total jobs created per direct job) of 1.8.

Regional Impacts

The MTA's capital program could offer direct, indirect, and induced economic impacts across the 10 economic development regions through various facilities and supply chain networks (EY, 2019). As depicted in **Figure 4-6**, three regions — NYC, Long Island, and Hudson Valley — would benefit most significantly from the investment.

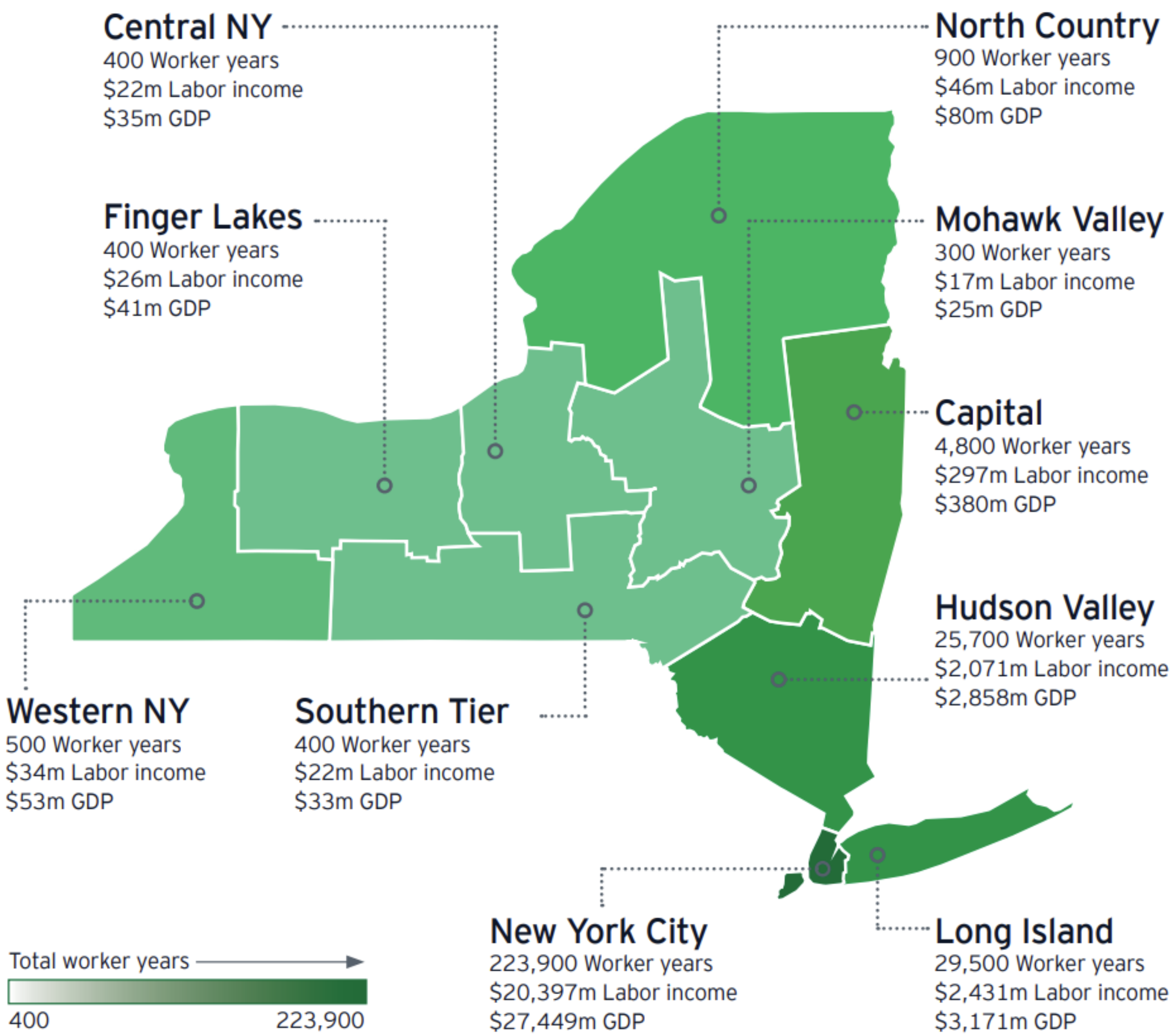


Figure 4-6. Total statewide economic impacts related to MTA's 2020-2024 capital investment strategy. Adapted from EY (2019).

The NYC job impact totaled 223,900 worker years, with a labor income of $20,397 million and a GDP of $27,449 million over the five years. In Long Island, there were 29,500 total worker years over five years, with $3.0 billion spent directly and a total economic output of $5.5 billion. The primary spending category there was $2.5 billion for construction, focused on enhancing LIRR passenger stations and track infrastructure. The Hudson Valley Region followed, with direct spending of $4.2 billion. This region housed the Kawasaki Plant in Yonkers (Westchester County), a key equipment provider for the MTA. The spending in this region was projected to have created around 25,700 worker years (averaging 5,200 jobs per year).

4.5 Case Study 4: EIA of the Miami-Dade County Airport System

Program Background

Miami International Airport (MIA) is widely recognized as the economic powerhouse of Miami-Dade County and the state of Florida, primarily due to its pivotal role in driving passenger and freight activity, as well as generating substantial increases in revenue. Functioning as a crucial hub for transshipment between the Americas, the Caribbean, and Europe, MIA serves approximately 135 cities across four continents. Notably, MIA holds a significant share of the Latin American and Caribbean passenger traffic market, solidifying its position as one of the two airports in the United States with the highest international-to-domestic passenger ratios.

In 2002, the county commissioners approved a capital improvement program (CIP) with a budget of $4.8 billion, aiming to increase MIA's annual passenger capacity to 39 million by 2015. This budget was revised to $5.237 billion by 2007 to account for potential costs and delays. By 2008, MIA had become a pivotal economic driver for South Florida, creating over 282,000 jobs, contributing $10.2 billion in income, and generating $26.7 billion in business revenue. The airport also funneled over $1 billion into state and local revenues and $654.5 million in federal aviation-specific taxes. By 2018, MIA managed 34 million passengers and 2 million tons of cargo, emphasizing its role as a central transportation and logistics hub.

In 2008, Miami-Dade conducted an updated economic assessment of MIA, using the same methodologies and conclusions as the 2006 evaluation, which will be analyzed as a case study here. This approach allowed for a direct comparison between the two years, illuminating the airport's evolving economic impact and contributions. While studying the aviation industry differs from examining the impact of constructing a freeway or light-rail network, it still provides insights into how an EIA is conducted and the various categories of effects under consideration.

Methodology

Although the report didn't specify which EIA tool it applied, some other aviation reports used RIMS-II. To detailed gauge the economic impact, the assessment examined factors including job numbers, total income, business revenue, local purchases, state tax, local tax, and federal tax. These effects were categorized based on their influence on the airport systems, both in terms of their intrinsic impacts and their contributions to the local tourism sector. The cumulative effects were then calculated by summing up these different dimensions. Detailed explanations are as follows:

1. Direct jobs pertain to employment opportunities that are directly generated by the activities taking place within the airport premises. That means these jobs would disappear if the operations at Miami International Airport and the General Aviation Airports were to come to a halt.
2. Induced jobs refer to employment opportunities that emerge across the local economy because individuals who are directly employed due to airport activity spend their earned wages on local goods and services, such as food, housing, and health care.
3. Indirect Jobs are employment positions that are generated due to the procurement of goods and services by firms that rely on airport-related activities. These jobs have a cascading effect on job creation throughout various sectors.
4. Personal Income quantifies the combined wages and salaries earned by individuals who are directly employed due to airport activities. This encompasses the wages of both indirect and induced jobs, as well as the wages of jobs directly created by the airport operations.

5. Business Revenue encompasses the income generated by firms that provide services at the airports, as well as by local businesses operating within the visitor industry.
6. Local Purchases refer to the expenditures made by businesses that are interdependent with airport activities. These purchases contribute to the overall economic vitality of the local area.
7. Tax Impacts comprises the tax payments made to federal, state, and local governments by both firms and individuals whose livelihoods are directly tied to the functioning of Miami International Airport and the General Aviation Airports.

Economic Impacts

Table 4-8 provides a detailed breakdown of the economic impact across various categories. In total, this initiative has resulted in 282,043 jobs, generating $10,167.3 million in wages. Business revenue increased to $26,746.1 million, with local purchases at $2,717 million. State and local taxes contributed $1,016.8 million, while federal taxes added $654.9 million.

IMPACTS	MIA-SITE GENERATED	MIA VISITOR INDUSTRY	GA-SITE GENERATED	GA VISITOR INDUSTRY	TOTAL IMPACTS
JOBS					
DIRECT	36,797	114,492	1,089	94	152,472
INDUCED	24,731	41,398	794	35	66,958
INDIRECT	21,888	38,747	1,947	31	62,613
TOTAL	83,416	194,637	3,830	160	282,043
PERSONAL INCOME (MILLIONS)					
DIRECT	$1,650.2	$2,358.6	$55.4	$2.1	$4,066.3
RE-SPENDING/CONSUMPTION	$2,464.6	$1,865.0	$82.8	$1.6	$4,414.0
INDIRECT	$784.4	$812.0	$89.9	$0.7	$1,687.0
TOTAL	$4,899.2	$5,035.6	$228.2	$4.3	$10,167.3
AVERAGE INCOME/DIRECT EMPLOYEE	$44,846.0	$20,601.0	$50,916.0	$21,883.0	
BUSINESS REVENUE (MILLIONS)	$12,144.3	$14,343.4	$247.0	$11.5	$26,746.1
LOCAL PURCHASES (MILLIONS)	$1,357.9	$1,216.7	$141.4	$1.0	$2,717.0
STATE AND LOCAL TAXES (MILLIONS)	$489.9	$503.6	$22.8	$0.4	$1,016.8
FEDERAL GOVERNMENT AVIATION SPECIFIC TAXES (MILLIONS)	$654.5	NA	$0.4	NA	$654.9

Table 4-8. Economic Impacts of the Miami-Dade County Airport System. Adapted from Miami-Dade Aviation Department (2008).

5 Discussions

5.1 Chapter Overview

This report has thoroughly examined both technical reports and academic journal articles published since 2003 pertaining to economic effects and assessments of public transit projects or investments in the United States. Building upon the literature review, bibliometric mapping, and cast studies results outlined in previous parts, this chapter will summarize the findings to answer the five research questions listed and provide implications correspondingly. The five research questions are:

1. Which methodologies have been prevalent in the literature from 2003 to 2023 for conducting economic benefit-cost analysis (BCA) and/or economic impact analysis (EIA) of public transit systems in the United States?
2. How do the economic assessments of public transit investments differ across geographical locations and over distinct time periods within the United States?
3. What notable trends have emerged in BCA and EIA literature over the past 20 years, particularly considering the rise of microtransit and micromobility?
4. What are the key advancements in public transit BCA and EIA studies in recent years, and how might they be applied to both Florida and the broader nation?

5.2 Question 1: Summary of BCA & EIA Methodologies

As analyzed in Chapter 2: Literature Review of Technical Reports, most transportation agencies and research institutions continue to use the classic benefit cost analysis (BCA) and economic impact analysis (EIA), or combing the two methods, to conduct economic assessment of public transit projects in the United States.

Findings from BCA Literature

Benefit-cost analysis (BCA) is still one of the most applied methods to quantitatively evaluate the economic viability of a project or investment by monetizing and then comparing the anticipated benefits to the associated costs. It essentially offers a systematic approach to determining the net present value (NPV) or benefit-to-cost ratio (BCR) of a project, assisting decision-makers in understanding the economic return on investment.

A primary advantage of BCA is its ability to provide clear and concise numerical values for multiple categories of benefits and costs, facilitating direct comparisons among alternative projects. For instance, in the context of public transportation, many key economic values, such as anticipated farebox revenue and construction costs, are straightforward to estimate and compare. The method also fosters a more holistic understanding of both tangible and intangible project effects, especially when considering factors like travel time savings and injury reductions, thus promoting thorough project evaluation.

However, a significant drawback of BCA is its extensive reliance on accurate, timely data sources, which can sometimes prove challenging. Firstly, BCA struggles to capture dynamic data; given the fast-paced changes in various sectors, the data sources utilized might become outdated by the time they're applied, leading to potential inaccuracies in the assessment. Secondly, the absence of standardized formulas and universally accepted monetized values poses another challenge. Different projects or regions might encounter unique factors that generic calculations fail to address adequately, implying that BCA results might often diverge based on the specific methodologies or values chosen. This can introduce inconsistencies and complicated comparisons across projects or regions. Additionally, BCA itself is not a method to measure induced impacts or the multiplier effect, meaning it might overlook the broader economic implications of a project on related industries or local economies.

Findings from EIA Literature

Economic impact analysis (EIA) evaluates the broader economic consequences of a project, specifically its influence on regional economics stimulated by an economic activity. Results are commonly presented in terms of job creation, local business impacts, and contributions to GDP.

One of EIA's strengths lies in its emphasis on the broader ripple effects, capturing the project's influence on local businesses, supply chains, and the overall economic fabric. The assessment of multiplier effects, which represents spending by those who gain financially from the project, complements BCA insights. Such a comprehensive view can better reflect the project's role in driving economic growth and community betterment, highlighting how stakeholders and residents benefited from the project or investment. Another advantage of EIA is the use of sophisticated, time-tested software and tools, such as RIMS-II, IMPLAN, and TREDIS. These tools, developed or endorsed by prominent government agencies like the EPA and various DOTs over the years, ensure that EIA reports crafted with their assistance are professional and reliable.

The reliance on the input-output (I-O) poses certain inherent challenges. Drucker (2016) claimed that the method was dependent on the assumption that the future will mirror the past. It would be problematic in situations of significant change. For example, the I-O model would often overlook capacity constraints or the potential for economic activities to restructure. This was evident when studying the expansion of Fort Lee in Virginia, where the model could not predict the inability of existing venues to cater to the anticipated boost in demand for services like lodging and food.

Combining BCA & EIA

Despite the uncertainties involved, BCAs and EIAs remain important and arguably irreplaceable (until the creation of more advanced software or methodologies) in economic assessment. Analysts over the past two decades have integrated EIA and BCA to leverage the advantages of both models. In practice, the BCA component should at least contain the categories identified in section 2.1, which are safety benefits, travel time savings, vehicle operating cost savings, capital expenditures, and operating and maintenance expenditures. Depending on the requirement, categories like emission reductio and health benefits can also be added. For EIA, economic impacts need to include output, employment, and income, and fiscal impacts need to include federal, states, and local tax revenues. **Figure 5-1** introduces the factors used by TREDIS in economic analysis (Weisbrod, 2014).

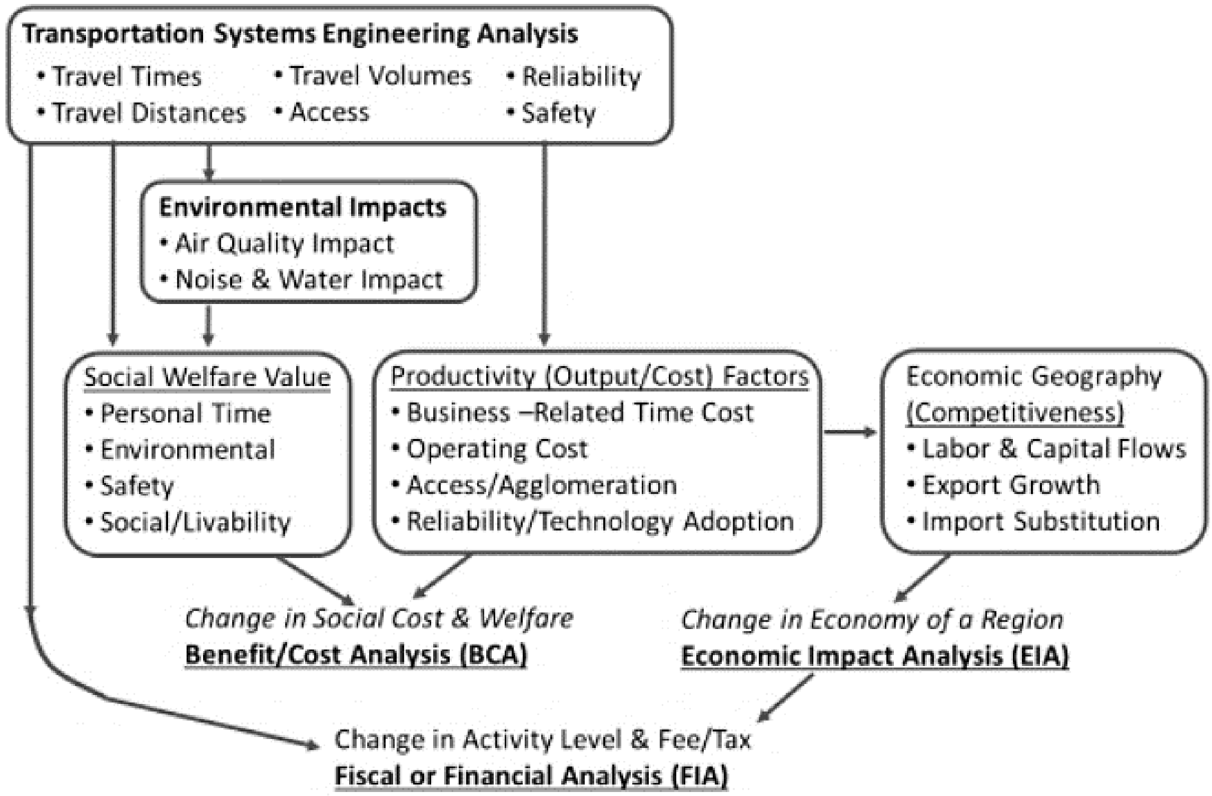


Figure 5-1. Key factors in conducting BCA and EIA. Adapted from Weisbrod (2014).

5.3

Another salient challenge is that, although impacts such as trip numbers or ridership can be quantified, there is a lack of standardized monetary values to serve as ideal references. Consequently, these values can't be incorporated into a BCR calculation. For instance, in the second case study, the Midwest Interstate Passenger Rail Commission estimated the travel time reduction resulting from the implementation of the high-speed rail network, but it did not provide a recommended dollar value for each minute saved. Additionally, sourcing such values from other reports might lead to inaccuracies, given that different states or regions possess distinct economic landscapes, and some data sources can become outdated within a short time span.

The methodologies still originated from the traditional benefit-cost analysis. Due to the nature of academic research, which prioritizes theoretical contributions and statistical correlations among factors over monetized values, these papers could only play a relatively minor referencing role in measuring economic effects.

5.4 Question 3: Geographic Variability of Transit Economic Assessments

Economic assessment of public transit programs across various geographical locations within the United States reveal strong similarities and relatively little disparities in their methodologies and emphases.

At both the city, regional, and state levels, all reports we reviewed have adopted the EIA model, where economic impacts are generally categorized into direct, indirect, and induced ones. Key metrics include total/net project spending, employment, personal income, business revenue, and federal, state, and local taxes, as summarized in **Table 5-1**. Note that the tax elements are sometimes attributed to fiscal impacts.

Economic and Fiscal Impact of Public Transportation Projects
Expenditures/Costs
Total Project Spending ($)
Net budgeted spending ($)
Total Economic Impact
Employment (jobs)
Direct
Indirect
Induced
Total
Personal income ($)
Direct
Indirect
Induced
Total
Business revenue ($)
Local purchases ($)
Total Fiscal Impact
Federal taxes
State and local taxes
Total Fiscal Impact

Table 5-1. A summary of elements commonly used in an EIA.

Once again, software tools utilizing the input-output (I-O) model – such as RIMS-II, IMPLAN, TREDIS, and sometimes REMI – have been predominantly adopted to calculate those terms reflecting direct, indirect, and induced effects. These tools have been either designated or endorsed by transportation agencies and thus reliable. The only noticeable issue is that different regions and industry sectors possess distinct multiplier indices. Therefore, when applying EIA, it's imperative to use those specific numbers to ensure consistency and accuracy. Also, for tools like IMPLAN, selecting the correct industry sector is also critical.

One distinction among the EIAs lies in the scale: some studies focus on local impacts of a single project, such as building an airport or a local bus line, while others evaluate the economic impacts across multiple states, like the Midwest high-speed rail network covering multiple states.

Another distinction is the time span, where some projects assess long-term impacts over decades rather than a shorter one.

Many reports also employed BCA in their analysis. However, it is self-explanatory that calculating a solitary benefit-cost ratio (BCR) isn't comprehensive enough to provide a holistic understanding, hence the necessity to apply these ratios individually for different categories of benefits and costs. Such savings, when properly computed, can offer a clearer insight into the broader implications and value of the initiatives in question. However, some other categories were harder to quantify. For example, finding the exact savings from increasing transit ridership often requires estimation based on other cases.

5.5 Question 4: Evolving Trends in BCA & EIA

When examining the evolution of BCA and EIA through literature review, the findings were not surprising: both models have witnessed minimal changes over the past twenty years. After decades of application and meticulous refinement, key elements such as the definitions, calculation methods, and data requirements of these models have reached maturity, making changes both unnecessary and unlikely. One minor change was that categories of benefits and costs have been grouped more scientifically based on project's requirement.

The stability is evident from the user's perspective. On one hand, it would be resource-intensive for government or transportation agencies to create or adopt a novel, unproven economic assessment model and develop software tools to implement the innovation, despite critiques of BCA and EIA. On the other hand, analysts familiar with existing software tools might find it more efficient and convenient to persist with their use, causing possible resistance and confusions.

To evaluate emerging transit modalities, such as microtransit and micromobility, the predominant methods remained on tallying ridership growth, measuring service area increased, and collecting users' feedback through surveys instead of offering monetary values. For example, Jiang (2023) analyzed the microtransit's improvements in several American cities:

1. *Birmingham, Alabama*. In December 2019, the city of Birmingham introduced On-Demand, a microtransit solution offering cost-effective shared rides, prioritizing certain marginalized neighborhoods. Before this service began, a mere 10% of the city's employment opportunities were reachable via public transit. This figure has now soared to 90%.
2. *Wilson, North Carolina*. This is an example of microtransit bridging transportation voids in less dense regions. RIDE – Wilson's citywide on-demand microtransit service – facilitates job-related commutes for regular day-shift employees and for those working during nighttime hours. Based on the users' feedback, relying only on fixed routes, riders can reach a mere 5% of local job sites; with the on-demand option, this accessibility expands to 80%.

Some researchers worldwide have combined transit data sources with survey results and then applied them to BCAs and EIAs to conduct economic assessments of existing microtransit and micromobility programs, while some others introduced innovations in simulation for assessing future impacts:

1. Félix et al. (2023). *Socio-economic assessment of shared e-scooters: do the benefits overcome the externalities?* This paper conducted a socio-economic assessment of shared e-scooters. Benefit and cost categories analyzed covered environmental (emissions and pollutants), social (physical activity, road safety and pollution exposure), and economic (vehicle operating costs and time savings) dimensions. This study utilized data from 1.4 million scooter rides in Lisbon obtained from a survey provider, complemented by a survey of 919 users. The findings indicated that shared electric scooters offer advantages, their safety concerns notably offset these benefits, leading to nearly €6M in yearly expenses.
2. Ongel et al. (2019). *Economic Assessment of Autonomous Electric Microtransit Vehicles*. The study employed the BCA method to evaluate the costs of electric autonomous vehicles used for microtransit in Singapore, contrasting them with the costs of traditional cars and buses. While considering both initial acquisition costs and life-cycle costs, the research determined that even though electric vehicles had a higher upfront cost than their traditional counterparts, they could reduce the total cost of ownership per passenger-kilometer by up to 75% in comparison to traditional vehicles and 60% when juxtaposed with buses.
3. Rodier et al. (2020). *Cost-Benefit Analysis of Novel Access Modes: A Case Study in the San Francisco Bay Area*. This research simulated the travel and revenue effects of deploying an autonomous vehicle fleet for transit access in the San Francisco Bay Area, considering various fare structures and three service types: home-based drop-off and pick-up for single passenger service (e.g., Uber and Lyft), home-based drop-off and pick-up for multi-passenger service (e.g., microtransit), and meeting point multi-passenger service (e.g., Via). An agent-based modeling framework was utilized for the simulation, which could capture both traveler and vehicle behaviors and estimate shifts in travel patterns, mode selections, and congestion, resulting in calculated reductions in travel time, enhanced accessibility, and prospective cost savings. Simulation findings indicated service costs ranging from $0.30/mile to $0.50/mile, with revenues peaking at $2 to $3 per ride in different scenarios.

5.6 Question 5: Applying Recent Advancements of Transit BCA & EIA in Florida

In short, transit economic assessment methods have seen little advancement over the past two decades. Transportation agencies, research institutions, and analysts still predominantly rely on BCA guidebooks from the USDOT or TCRP, as well as classic EIA I-O modeling software tools with their included multiplier indexes. As a result, performing an economic analysis in Florida mirrors similar processes in other regions.

While the methodology might appear straightforward, many analyses to date have encountered the “black box” problem due to lacking a clear definition in determining the scope of project impacts, appropriate time frames, impact zones, and stakeholders. This can impair the credibility and quality of economic analysis methods, making the results difficult to elucidate or comprehend (Weisbrod, 2014). Another challenge is that the static BCA or EIA approaches, along with frequently outdated data sources, may not adequately capture or promptly respond to dynamic economic environments.

To break down the “black box” and make economic impact and benefit/cost studies more holistic and explicitly when investigating a new transit project or investment, analysts may apply the following recommended strategies (Weisbrod, 2014; Drucker, 2015):

First, incorporate BCA and EIA. Since the two classic assessment tools complement each other in many respects, it’s crucial to combine them to leverage their strengths, offering more robust results including monetized values of economic output or expenditures, benefit-cost ratios, multiplier ratios, and employment numbers.

Second, build a framework. Establishing a comprehensive framework at the beginning of the project, which specifies the categories of benefits or costs to be analyzed, the types of direct, indirect, and induced effects included, the time span of the analysis (short-term or long-term), and the stakeholders involved, is essential. It aids in identifying the appropriate categories of assessments to apply, minimizes the time of allocating needed data, and prevents the omission of key categories.

Third, use trusted tools and datasets and update frequently. Although users can obtain data from surveys or by referring to benchmark data from regions with similar socio-economic characteristics, software tools like RIMS-II, IMPLAN, and TREDIS, along with guidebooks published by USDOT featuring recommended monetized values, remain the most reliable and standardized measures for transit economic assessment. Yet, increased uncertainty exacerbated by the dynamic economic environment and inevitable incidents has challenged the accuracy of these methods. Therefore, maintaining updated data timely and regularly and tracking economic conditions is paramount for better estimates and forecasts, outweighing the need for complex methodologies.

Fourth, reduce false precision and present results in ranges. Policymakers often desire precise, straightforward results in monetized values from researchers to inform policy decisions. However, analysts face the challenge of ensuring accuracy and avoiding overconfidence in their findings. It’s essential for them to convey the potential ambiguities and limitations of their analyses. Instead of providing overly precise numbers, they can present results in ranges, reflecting the true confidence they have in the data. When high accuracy is unattainable due to data or methodological limitations, analysts should be transparent about these shortcomings, possibly recommending alternative approaches or more suitable methodologies.

Fifth, provide impact categories. Disaggregating economic impacts into specific categories can provide clearer insights and help identify data gaps. This method allows for a separate assessment of each impact with induvial data sources and equations, thus improving accuracy. Instead of relying on a single point estimate, multiple categories can provide a more nuanced view, ensuring that errors in one area don’t compromise the entire assessment. Also, it offers flexibility for updates when new data is available.

Sixth, conduct benchmarking and comparisons. Comparative data can greatly enhance the interpretation of economic data for communities. While standardized metrics can be easily paired with national, state, or regional data for context, custom analyses are more challenging. One approach for projects serving multiple communities is to conduct analyses that benefit several regions, sharing the results with all relevant communities. Benchmarking new studies against past ones can also provide valuable context. However, there's no universal standard for comparisons in economic impact analyses. Analysts need to determine the relevance of each comparison, and while focusing on specific economic aspects, it's beneficial to briefly acknowledge impacts that are not detailed, suggesting further studies are needed. For Florida, the state could compare with other megaregions with similar income and investment scales, such as Southern California and the New York area.

Seventh, develop multiple scenarios. When estimating the effects of a project or investment that hasn't taken place, presenting multiple scenarios helps to underscore the inherent uncertainties, allowing audiences to grasp the ramifications of different assumptions and conditions, understanding the upper and lower boundaries of the potential outcomes, e.g., revenue and employment numbers. Engaging the community early on with these scenarios can also enhance public interest and consensus-building. In other words, scenarios not only allow planners to prepare for a diverse set of outcomes but also offer a clearer picture of how the public might react to certain policy moves.

6 Recommendations

In response to the findings of this report, it is recommended that the Florida Department of Transportation (FDOT) may consider adopting an integrated strategic approach for conducting Economic Impact Analysis (EIA) and Benefit-Cost Analysis (BCA) simultaneously for future statewide transit investments. The reasons for this recommendation are as follows:

EIA sheds light on immediate and broader economic effects, including job creation, revenue generation, and GDP contributions. BCA complements these insights by assessing the cost-effectiveness of these benefits and identifying potential cost reductions resulting from the investment.

The combined EIA and BCA approach is well-suited to Florida's distinct demographic and economic context. It effectively adapts to the state's diverse population and economic scenarios. The approach can be customized to regional needs, addressing different urban and rural transit requirements, the impact on tourism, and evolving economic priorities. Employing this strategy ensures that FDOT's transit investments are in line with statewide development objectives, such as alleviating urban traffic congestion and fostering rural economic expansion, thereby improving state-wide connectivity and prosperity.

Continuing with EIA and BCA is advantageous for its cost-effectiveness and practicality. This strategy utilizes established, widely recognized, and validated methodologies, saving FDOT from the expenses and complexities of devising new methods. These established frameworks offer proven guidelines and tools, ensuring straightforward and reliable implementation. Additionally, this approach minimizes potential disputes that might arise from introducing new evaluation frameworks or models, crucial in the public sector where transparency and accountability are key. Conducting EIA and BCA together also allows for resource optimization through shared data collection and analysis, leading to more efficient allocation of time and funds.

To optimize the implementation of the integrated approach, we propose a conceptual framework, envisioning a dual-component standardized model that synthesizes primary frameworks from EIA and BCA literature. This theoretical model is designed to include two distinct groups of factors, catering to both universal and project-specific requirements.

1. *Fundamental Factors*: The first group encompasses key factors commonly adopted in transit EIA and BCA reports. These would typically include elements with unified formulas and recommended monetized values, which have been established as industry standards, e.g., the USDOT guide. This set of factors ensures consistency, reliability, and comparability across a wide range of projects, serving as the foundation of the model.
2. *Customizable Factors*: The second group comprises factors that can be tailored to meet the specific needs and characteristics of each project. This element of the model provides the essential flexibility and adaptability required to address unique external impacts, cost considerations, and project-specific variables. It enables FDOT to precisely customize the analysis for each project, thereby enhancing the accuracy and relevance of the assessments. For instance, the model could include a comprehensive list of potential measures specific to microtransit and micromobility. Therefore, if the state or some regions decided to invest in these new transit systems, the model could be used as a reference.

In the development of this model, collaboration with external experts would be ideal to incorporate best practices and contemporary assessment criteria. Once established, it would be beneficial for FDOT to maintain and conduct regular reviews of the model, ensuring that necessary updates are implemented in a timely manner. This approach would further enable the department to refine and assure its quality over time. In summary, this strategy ensures that FDOT leverages established standards, while also maintaining the flexibility to adapt analyses to the unique aspects of individual projects statewide.

In addressing potential challenges, FDOT should set up robust data management practices to maintain high-quality, up-to-date data. While EIA software may update their database regularly and has the capacity to capture dynamic economic trends, BCA datasets require more rigorous and meticulous selection. Analysts are recommended to adopt various benchmark datasets and methodologies and give a range of results to avoid false accuracy. Moreover, regular evaluation and improvement of methodologies and outcomes based on feedback and evolving best practices will be vital in ensuring the effectiveness of these analyses.

We believe the simultaneous application of EIA and BCA and building a holistic standardized model will provide FDOT with a comprehensive toolset for evaluating the multifaceted impacts of transit projects. This will lead to more informed decision-making, ultimately fostering sustainable and beneficial outcomes for the state of Florida.

7 Conclusions

This literature review aims to bridge the gap between the tangible impacts of public transit and their economic representation, scrutinizing evolving methodologies and their relevance in the current transit landscape.

Our multifaceted approach began with a thorough examination of recent literature on BCA and EIA methods in the United States from 2003 to 2023. We discovered a predominant reliance on these methodologies, either separately or in combination. BCA, known for its quantitative evaluation, sometimes struggled with data timeliness and lacked standardized formulas. EIA captures a project's broader ripple effects. Analysts often integrated BCA and EIA to create a more encompassing economic assessment.

In our quantitative case study analysis, we selected transit projects from key U.S. metropolitan areas to understand their regional economic ramifications. Although there were geographical differences, the reports marked consistency in using the EIA model across various studies, with BCAs often providing more detailed insights into environmental and health benefits. However, challenges persisted in quantifying indirect benefits, such as converting increased ridership into monetized values, echoing the findings of the literature review.

Furthermore, our analysis highlights a significant gap in the assessment of emerging transit modes like microtransit and micromobility. In practice, traditional methods, such as measuring ridership increases or service area expansions, continue to be widely used, complemented by some research papers adopting techniques like agent-based simulation. Despite these efforts, a notable deficiency exists in the formal application of both BCA and EIA methodologies to these newer transit modes. The current lack of specific formulas or monetized values for a comprehensive evaluation of these modalities underscores the need for further development in transit economic assessment methodologies. Addressing this gap is crucial for accurately gauging the full spectrum of benefits and costs associated with these innovative, increasingly accepted transit methods.

In conclusion, our findings offer policy insights and practical applications for Florida and beyond. Key recommendations for conducting BCA or EIA include integrating both methods for a comprehensive view, establishing clear frameworks, using and updating reliable tools and datasets, presenting results as ranges to account for uncertainties, disaggregating economic impacts, benchmarking against other regions, and developing multiple scenarios. These steps aim to enhance the credibility, clarity, and applicability of transit economic assessments, fostering informed decision-making and beneficial outcomes.

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