FTA RESEARCH

FEDERAL TRANSIT ADMINISTRATION

TIGER II Urban Circulator Impact Assessment

AUGUST 2018

FTA Report No. 0122
Federal Transit Administration

PREPARED BY
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U.S. Department of Transportation
Federal Transit Administration

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Metric Conversion Table

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		NOTE: volumes greater than 1000 L shall be shown in m^3		
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
^oF	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	^oC

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13. ABSTRACT

Since the signing of the Transportation Investment Generating Economic Recovery (TIGER) grant program, the United States Department of Transportation (USDOT) invested substantial resources to fund streetcar projects in major urban areas. To assist USDOT in understanding the medium- to long-term impacts of streetcars, this research evaluated five systems that received TIGER grants and other federal funds. This study estimates impacts on property values, changes in business and employment growth, and changes in household job accessibility and travel times. The analysis reveals that streetcar investments have a positive impact on residential, commercial, and vacant properties. The magnitude of impacts is not equally distributed across the five systems and project phases (planning, construction, and operation). Panel data models on establishment and employment growth confirm the hypothesis that streetcars can be a catalyst for economic development. The impact on establishment and employment growth is greater at project announcement and during construction, with decreasing but lingering effects at opening and during operation. The accessibility analysis reveals that streetcars do not inherently result in marked gains to households and workers, especially if the study area is currently well-served by an extensive fixed-route bus system. Streetcars that integrate with a regional light rail or metro system provide minor added accessibility gains.

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ABSTRACT

Since the signing of the Transportation Investment Generating Economic Recovery (TIGER) grant program, the United States Department of Transportation (USDOT) invested substantial resources to fund streetcar projects in major urban areas. To assist USDOT in understanding the medium- to long-term impacts of streetcars, this research evaluated five systems that received TIGER grants and other federal funds. This study estimates impacts on property values, changes in business and employment growth, and changes in household job accessibility and travel times. The analysis reveals that streetcar investments have a positive impact on residential, commercial, and vacant properties. The magnitude of impacts is not equally distributed across the five systems and project phases (planning, construction, and operation). Panel data models on establishment and employment growth confirm the hypothesis that streetcars can be a catalyst for economic development. The impact on establishment and employment growth is greater at project announcement and during construction, with decreasing but lingering effects at opening and during operation. The accessibility analysis reveals that streetcars do not inherently result in marked gains to households and workers, especially if the study area is currently well-served by an extensive fixed-route bus system. Streetcars that integrate with a regional light rail or metro system provide minor added accessibility gains.

EXECUTIVE SUMMARY

Modern streetcars represent an emerging class of projects with objectives and expectations that are different from traditional transit projects. Since the signing of the Transportation Investment Generating Economic Recovery (TIGER) grant program, the United States Department of Transportation (USDOT) invested substantial resources to fund streetcar projects in major urban areas. During 2009–2016, the TIGER grant program awarded about 6 percent of the $5.1 billion total grant funds to streetcar projects.

A review of grant applications shows that the evaluation criteria and final selection of the projects took into account short- and long-term economic development objectives. The belief is that shovel-ready projects can stimulate short-term job growth through construction multiplier effects, and long-term growth can be realized if new businesses locate in proximity to streetcar stations or if existing businesses increase their gross sales and employment levels.

To assist USDOT in understanding the medium- to long-term impacts of streetcars, this research evaluated five systems that received TIGER grants and other funds under the Federal Transit Administration (FTA) Urban Circulator Program: 1) Cincinnati Bell Connector, 2) Charlotte CityLYNX Gold Line, 3) Sun Link Tucson Streetcar, 4) Atlanta Streetcar, and 5) Salt Lake S-Line. The projects are located in urban areas and cities that were most affected by the recent economic downturn of the Great Recession and urban areas that had already been economically-depressed. These projects were selected for evaluation because they were funded and built around the same time, allowing a consistent evaluation by using a minimum of three years of land-use and socioeconomic data before project announcement and a minimum of one year of operation after opening to the public for service. The study focuses on assessing the economic and development impacts of these systems.

The analysis estimates the streetcar impact on land-use values by property type, changes in business activity levels (establishment and employment), and changes in household job accessibility and travel times.

Impact on Property Values

This study employs statistical methods that allow distinguishing between changes in property values that would have occurred independent of the streetcar and changes attributable to the streetcar projects. The models isolate and quantify the effects that can be attributed to streetcar planning, construction, and operation. Across all case studies, the results show that streetcar investments have a positive impact on residential, commercial, and vacant properties. The magnitude of impacts is not homogenously distributed across the five systems and project phases. This is due to different local real estate market conditions and the concurrence of other transportation improvements and redevelopment initiatives.

Impact on Business Activity

This study hypothesizes that expected accessibility gains from the streetcar improvement affect firm location decisions. Increased accessibility leads to clustering of households in proximity to the streetcar. This leads to a larger pool of workers and customers, which, in turn, positively affects establishment and employment levels. The research tries to answer the question: Can streetcars serve as a catalyst for economic growth?

The analysis compares changes in employment levels and business growth within the streetcar influence area (SIA) to changes in comparable areas during planning, construction, and operation. The models net out the effects of confounding factors, such as unobservable firm-specific characteristics (e.g., business-specific management structure or practices) or secular trends (e.g., generalized economic conditions such as the Great Recession of 2008–2009). The dataset consists of primary and secondary fine-grain industry data collected over 2007–2016.

The empirical models confirm the hypothesis that streetcar investments contribute to economic development by exerting positive effects on firm location decisions and employment growth. Panel data models estimating changes in the number of business establishments show that streetcar investments tend to induce growth over time, starting at the announcement phase (6.8%), increasing during construction (23.5%), and stabilizing at opening and during operation (18.3%).

Across all streetcar projects, the impact on growth in firm employment ranges from 2.4 percent to 2.8 percent at announcement and during construction, with growth stabilizing at opening (1%). Over the long-run, the impact on employment is estimated to be about 4.2 percent annually.

When modeling each case study separately, there is some heterogeneity in the magnitude of these impacts. The range of impacts depends on the baseline industry composition and economic vitality of each study area.

Impact on Accessibility

Streetcar systems can provide additional accessibility gains to households and workers residing in the area, as well as to workers coming to the area while residing elsewhere.

To measure changes in job accessibility and household travel times, this study developed a series of multimodal network models that generate zone-to-zone travel time matrices. Using the network models, the analysis estimated two travel time sheds—(1) including all available transit modes and walking and (2) as in the first model but excluding the streetcar. The transit time sheds reflect average weekday peak and off-peak travel conditions specific to the SIAs.

The analysis revealed that streetcar investments do not inherently result in accessibility gains to households and workers. In general, streetcar alignments do not marginally increase accessibility if the study area is currently well-served by an extensive fixed-route bus system. On the other hand, streetcars that integrate with a regional light rail or metro system provide minor added gains.

Table ES-1 *Summary of Impacts by Type and Project Phase*

		Cincinnati Bell Connector	Charlotte CityLYNX Gold Line	Sun Link Tucson Streetcar	Atlanta Streetcar	Salt Lake City S-Line
Impact on Property Values	**Single-Family**					
	Announcement and Planning	—	—	19.2%	—	2.2%
	Construction	15.0%	—	14.5%	73.3%	3.6%
	Opening	27.0%	—	13.1%	48.4%	1.2%
	Condominium					
	Announcement and Planning	-13.1%	29.8%	—	—	5.3%
	Construction	13.5%	14.2%	13.4%	10.3%	9.9%
	Opening	17.7%	15.1%	19.2%	28.0%	15.4%
	Commercial					
	Announcement and Planning	-2.2%	1.4%	3.3%	—	3.5%
	Construction	1.4%	1.8%	10.1%	11.2%	5.6%
	Opening	5.6%	2.1%	13.3%	24.1%	5.1%
	Vacant					
	Announcement and Planning	6.9%	n.a.	2.3%	—	—
	Construction	17.7%	n.a.	2.5%	18.8%	8.4%
	Opening	25.9%	n.a.	12.4%	20.6%	10.5%
Impact on Business Activity	**Establishment Growth**					
	Announcement and Planning	6.4%	16.2%	9.1%	—	—
	Construction	23.0%	25.2%	19.8%	19.2%	24.4%
	Opening	12.7%	13.2%	—	12.6%	20.3%
	Employment Growth					
	Announcement and Planning	—	2.5%	—	3.8%	3.0%
	Construction	2.9%	2.5%	6.8%	3.0%	—
	Opening	—	3.8%	1.8%	—	2.3%
Impact on Accessibility	**Access to Jobs**	no change	no change	15,000 jobs within 25 min	1,350 businesses and 21,000 jobs within 12 min	no change
	Travel Time Savings	no change	no change	6–14 min	7–20 min	2–9 min on off-peak travel

n.a denotes data not available for statistical inference

— denotes lack of statistically significant evidence

Implications for Future Streetcar Project Evaluations

This study developed and implemented an evaluation framework to gauge the impact of streetcar investments. The results of the case studies can serve as general guidelines to FTA or other grant-awarding entities to assess future streetcar grant applications. In terms of fully capturing the long-term impacts of streetcars on economic development, it is worth noting some of the study limitations. The study relied on the complex fusion of multiple layers of data covering the period 2007–2016 to assess the impact of streetcars through planning, construction and opening. For some of the systems, this timeframe covers 1–2 years of operation. As the streetcar systems mature, continued data collection, monitoring, and analysis would ensure fully capturing the long-term benefits of streetcar investments. In addition, as streetcar operating data are collected (e.g., ridership and system reliability), the inclusion of these data in the empirical models could further refine the impact estimates and provide additional insight on the long-term impacts of these investments.

SECTION 1

Background

Project Background

Modern streetcars represent an emerging class of projects with objectives and expectations that are different from traditional transit projects. Since the signing of the Transportation Investment Generating Economic Recovery (TIGER) grant program, the United States Department of Transportation (USDOT) has invested substantial resources to fund streetcar projects in major urban areas [1].[1] During 2009–2016, the TIGER grant program provided a combined $5.1 billion to 421 projects in all 50 states, the District of Columbia, Puerto Rico, Guam, the Virgin Islands, and tribal communities. The TIGER grant program awarded about six percent of the total grant funds to streetcar projects.

A review of grant applications shows that the evaluation criteria and final selection of the projects took into account short- and long-term economic development objectives. The belief is that shovel-ready projects can stimulate short-term job growth through construction multiplier effects, and long-term growth can be realized if new businesses locate in proximity to streetcar stations or if existing businesses increase their gross sales and employment levels.

The limited experience with these projects means that USDOT, the Federal Transit Administration (FTA), and project sponsors face substantial limitations on their understanding of actual impacts of these projects or the conditions that are conducive to success of new projects, and of the need for and types of supportive policies [2]. Streetcar and urban circulator projects that are being funded through various USDOT funding programs provide a unique opportunity for FTA and project sponsors to learn from their actual implementation. The TIGER grant program provides a unique opportunity to assess the impact of streetcar systems on the built environment, the impact on economic development, and policies that lead to and result from projects of this type.

Several cities now have new streetcar systems under planning, construction, or recently-completed alignments undertaking extensions. With their resurgence, streetcars are fostering a lively debate among proponents and skeptics, although with limited academic work on their contribution to economic development growth. In fact, the vast majority of economic studies are preliminary evaluations conducted as part of the grant submission process and are performed by third-party consulting services (see, for example, [2–7]).

[1] https://www.transportation.gov/tiger.

The transportation research community is increasingly contributing by providing formal assessments of factors either driving or affecting patronage [8, 9], or in terms of ridership and service productivity measures [10–13]. Whereas proponents consider streetcars as the primary driver of economic growth [14], skeptics call for rigorous assessments to support such claims [15–17]. Prior to this study there was a lack of empirical evidence that this type of investment improves the transportation system or generates economic development impacts. Synthesis work on the role of streetcars as economic growth drivers points to a lack of formal analytical work to substantiate these claims and to the need to conduct research on the topic to better inform the public, particularly when existing systems are scheduled for expansion with significant local and federal funding commitments [18].

Research Objectives

The objective of this study was to determine whether federal investments in urban circulator projects have a significant impact in creating, supporting, or preserving jobs, spurring local business growth, and increasing transportation accessibility among certain households. The results of this research will serve to inform policymakers about the extent to which streetcar investments support USDOT strategic goals.

This objective is achieved via thorough documentation of each selected case study and a research design that allows assessing and measuring impacts consistently across a selected number of case studies.

Report Organization

The report begins by detailing the study research design, evaluation measures, and empirical modeling approach. Section 3 and Section 4 provide a detail description of each streetcar systems and the study area. Section 5 and Section 6 consist of a thorough historical assessment and econometric modeling of property values by land-use type, summarizing results by case study. Section 7 and Section 8 detail the analysis of changes in business and employment growth. Section 9 examines changes in job accessibility and travel time savings, and Section 10 summarizes the study findings and provides direction for further research. A separate appendix provides a technical overview of the statistical methods and dataset used.

SECTION 2

Research Design

Case Study Selection

The research focuses on a set of systems that received TIGER grants and other funds under the FTA Urban Circulator Program: 1) Cincinnati Bell Connector, 2) Charlotte CityLYNX Gold Line, 3) Sun Link Tucson Streetcar, 4) Atlanta Streetcar, and 5) Salt Lake S-Line. The projects are located in urban areas and cities that were most affected by the recent economic downturn of the Great Recession and urban areas that had already been economically-depressed. These projects were selected for evaluation because they were funded and built around the same time, allowing a consistent evaluation by using a minimum of three years of land-use and socioeconomic data before project announcement and a minimum of one year of operation after opening to the public for service. These projects will form the set of case studies for subsequent analytical work.

Evaluation Measures

The assessment measures the impact of streetcar planning, construction, and operation in terms of changes in:

- Property values by land-use
- Business activity levels, measured in terms of number of establishments and employment
- Accessibility measures, measured in terms of number of jobs accessible within the transit service area and travel time savings to local residents and system users

These evaluation measures are consistent with the TIGER grant application process and selection criteria. In particular, they are consistent with the primary selection criteria related to long-term outcomes of economic competitiveness, livability, and sustainability [19].

Changes in Property Values

Urban economic theory suggests that transportation improvements influence urban growth patterns through land prices. If new transit services improve accessibility, they generate a premium that is reflected in higher land and property prices. Empirical studies demonstrate that there is generally a positive relationship between accessibility improvements and property values, although results vary by area, investment type, and evaluation method. Proponents of transit-oriented development (TOD) argue that successful transit investments generate increases in property values that are resilient to exogenous economic shocks [20, 21].

This study employs statistical methods that allow distinguishing between changes in property values that would have occurred independent of the streetcar and changes attributable to the streetcar projects. Hedonic regression models estimate the differences in property values (sales and assessed values) before and after the project within a half-mile of the streetcar alignments and compares the results to the differences for the same before-after periods to a set of comparable parcels.

Changes in Business Activity Levels

TIGER II grant applications used generalized travel cost savings to measure increased economic competitiveness. Increased economic competitiveness can be achieved if businesses, by relocating in proximity to new streetcar stations, realize savings by reducing costs associated with congestion, such as workers' excess commuting time. To the extent that these cost reductions or savings can be realized, businesses will have an incentive to locate in proximity to newly-constructed streetcar stations. Businesses also will seek to reap the benefits of an expanded local employment base. In addition, increased residential and employment density around stations will help support long-term streetcar ridership. Economic competitiveness was measured in terms of:

- Spatial changes in businesses location patterns
- Changes in the number of establishments
- Changes in employment

Existing research shows that work proximity to transit stations is more relevant than residential proximity to ensure long-term ridership growth [22]. Employment densities at trip ends tend to have more influence on ridership than densities at trip origins.

The analysis compares changes in employment levels and business growth within the streetcars study area (SIA) to changes in comparable areas during planning, construction, and operation. Comparable areas are those selected using the selection methodology described in Appendix A. Dynamic panel data models were used to net out the effects of confounding factors, such as unobservable firm-specific characteristics (e.g., business-specific management structure or practices) or secular trends (e.g., generalized economic conditions such as the Great Recession of 2008–2009).

The dataset consists of fine-grain industry data covering the period 2007–2016. Each record in the business database was geocoded and includes business name, address, employee size, and actual sales volumes. Each business was classified using the North America Industry Classification System (NAICS) codes at the six-digit level, which allowed aggregating data by industry type. Firms have unique identifiers, allowing year-over-year comparisons to analyze industry changes and general economic trends over a certain period using advanced panel data methods.

Changes in Job Accessibility

To measure changes in job accessibility and household travel times, this study developed a series of multimodal network models that generate zone-to-zone travel time matrices employing General Transit Feed Specification (GTFS) data protocols. The network models estimate two travel time sheds—one with all available transit modes and one excluding the streetcar. The transit time sheds reflect average weekday peak and off-peak travel conditions specific to the SIAs.

Changes in Household Location Patterns

This study estimated changes in household location patterns by employing spatial kernel density methods. The analysis mapped changes in household location patterns by household income and life cycle cohorts. This information was used to conduct an analysis of household actual travel times with and without the streetcar using data from Google directions automated protocol interface (API). The data came from fine-grain residential databases that provide information on household residential location at the address-level location, socio-demographic, and life-cycle information over the 2007–2016 period.

Statistical Analysis

The case study analysis relied on a research design to evaluate longitudinally the impact of streetcars using a treatment vs. control evaluation and difference-in-differences estimation. The difference in growth in key impact measures around a transit station at each relevant phase (planning, construction, operation) was compared with the difference in growth during the same period for a comparable control area. The method hinged on the selection of a comparable area that was as similar as possible to the treatment area or the area around the new streetcar station. The goals was to substantially reduce the potential for biased results.

This study used propensity-score matching (PSM) methods to select control areas that closely match the treatment areas, using suitable socio-demographic and housing descriptors. PSM is a statistical method employed to select comparable units of observation for estimating intervention impacts using comparison group data. PSM has been applied in several fields of research, such as to study the impact of training on labor wage differentials and to estimate the impact of welfare programs. It also has been used to evaluate the impact of transportation investments [23, 24] on employment and population growth [25, 26]. The study's goal was to control and isolate all variability in the measures of interest that is not caused by the treatment itself from other causes, such as localized economic conditions. One method was suited to analyze and compare treatments to control relies on difference-in-differences estimation, as discussed below. Other approaches applied a pre-test and post-test approach using time-series analysis [27].

To study the impact of urban circulators on residential and commercial property values, the analysis adopted a differences-in-differences model specification developed by the principal investigator [28]. The model relied on a quasi-experimental design to test for the empirical evidence of property price differentials before, during, and after construction and operation of network improvements. This study used a generalized version of this model to study the impact of streetcars on property values, establishment, and employment levels. When applied to the study of residential and commercial property values, the empirical models account for spatial autocorrelation among parcel units. Failing to account for the presence of spatial factors affecting sales leads to omitted bias adversely impacting the reliability of parameter estimates. Appendix A details the PSM selection method, the datasets, and the econometric models used to conduct inference.

SECTION

3

Project Descriptions

Cincinnati Bell Connector

The Cincinnati Bell Connector (Figure 3-1) is a 3.6-mile-long modern streetcar system located in Cincinnati, Ohio (Figure 3-2). Cincinnati, located in Hamilton County, is one of the largest municipalities in Ohio and represents the core of the Cincinnati–Middletown–Wilmington (Ohio, Kentucky, and Indiana) Metro region, serving about 2.2 million people.[2] The system consists of 18 stops with up to 5 modern-style cars in service every 12 minutes during peak hour and every 15 minutes during off-peak.[3] Traveling on a loop from Second Street (on the riverfront) to Henry Street (north of Findlay Market), the streetcar links visitors, residents, students, and workers to popular attractions, employment centers, and public amenities. The system runs through Over-the-Rhine (OTR), one of the oldest historic districts in the U.S., dating back to the 19th century wave of German immigration, which has undergone drastic socio-demographic changes over the last 20 years.

Figure 3-1

Cincinnati Bell Connector

[2] American FactFinder, 2016 Population Estimates, https://factfinder.census.gov.

[3] http://www.cincinnatibellconnector.com/about-the-streetcar/about/faqs.

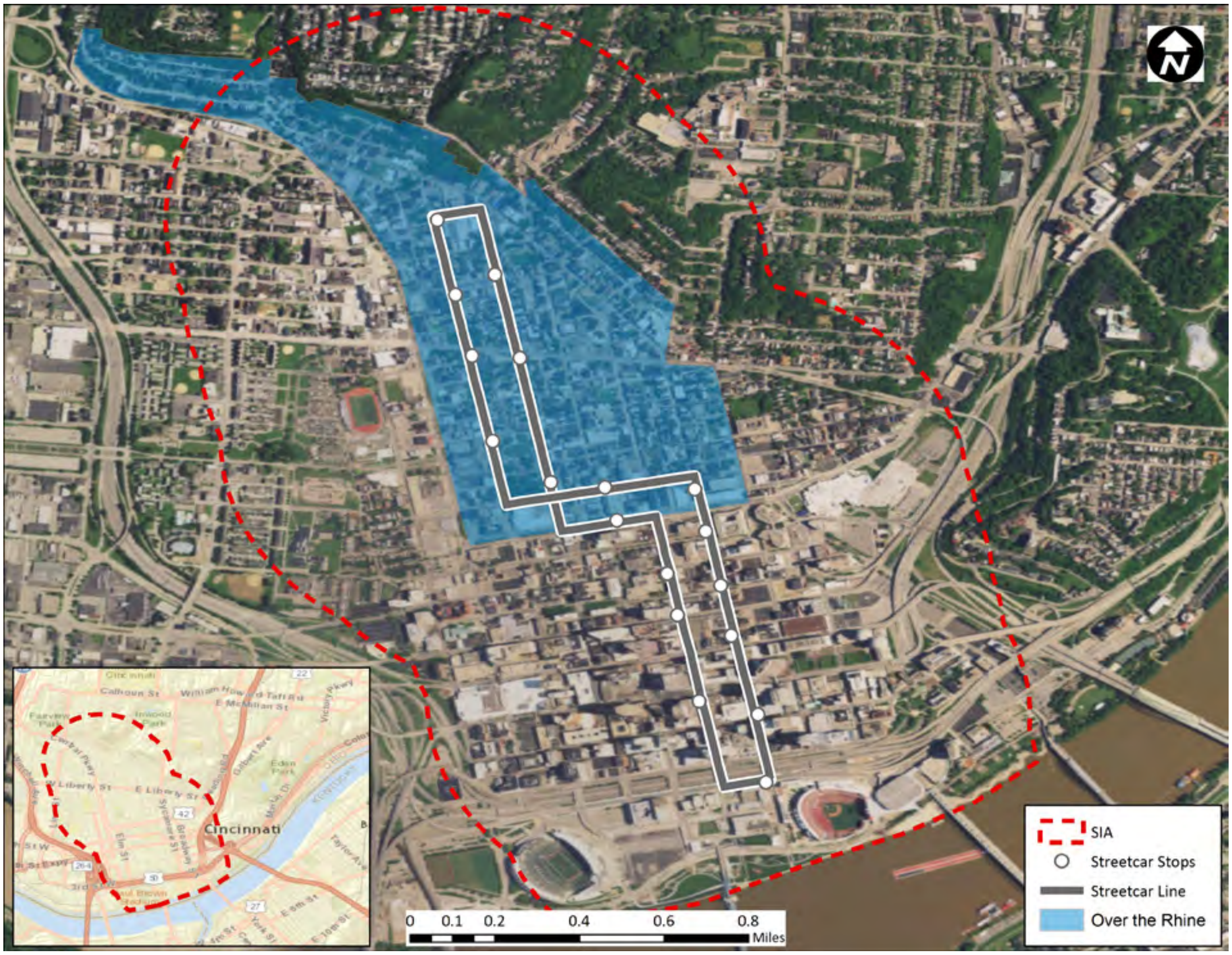


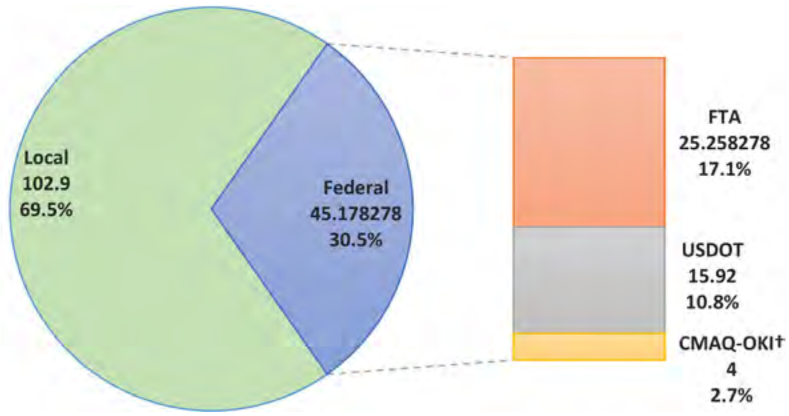
Figure 3-2 *Cincinnati Bell Connector Alignment*

Planning for the system dates back to 2007 when the City conducted a feasibility study; in 2008, the City approved a construction plan. In July 2010, FTA awarded the City of Cincinnati $24.99 million from the Urban Circulator Grant, followed by a $15.9 million Tiger 3 grant (Figure 3-3). About 69 percent of the total $148.1 million came from a variety of public and private local funding sources.[4] Construction started in February 2012, and the streetcar opened for passenger service on September 9, 2016. The streetcar fare is $1 for a two-hour pass or $2 for a day pass.

[4] http://www.cincinnati-oh.gov/streetcar/streetcar-funding/.

Figure 3-3

Cincinnati Bell Connector Capital Funding Breakdown ($148.1 million)



**Includes SORTA ROW Grant*
† Ohio-Kentucky-Indiana Regional Council of Governments Congestion Mitigation Air Quality Program
Source: City of Cincinnati Streetcar website

Charlotte CityLYNX Gold Line

The Charlotte Streetcar (renamed the LYNX Gold Line) (Figure 3-4) is a 1.5-mile-long streetcar system located in Charlotte, North Carolina (Figure 3-5). Charlotte, located in Mecklenburg County, is the largest municipality in North Carolina and represents the core of the Charlotte–Gastonia–Concord metropolitan statistical area (MSA), serving more than 2.3 million people.[5] The system consists of 6 stops with up to 6 vintage-style replica cars in service every 15 minutes during peak hour and every 20 minutes during off-peak.[6] Service runs from the Time Warner Cable Arena on the west to Novant Health Presbyterian Medical Center on the east. The service includes a connection to the LYNX Blue Line light rail system.

The streetcar is the first phase of a more extensive streetcar system consisting of multiple phases and currently under planning. The second phase of the Gold Line will extend service with the addition of 11 stops over a 2.5-mile extension designed to connect several academic, business, and activity centers located in the Metro region. Phase 2 is under construction, with a projected service start date in 2020.

[5] 2011–2015 American Community Survey (ACS) 5-Year Estimates.

[6] http://charlottenc.gov/cats/rail/cityLYNX/Pages/default.aspx.

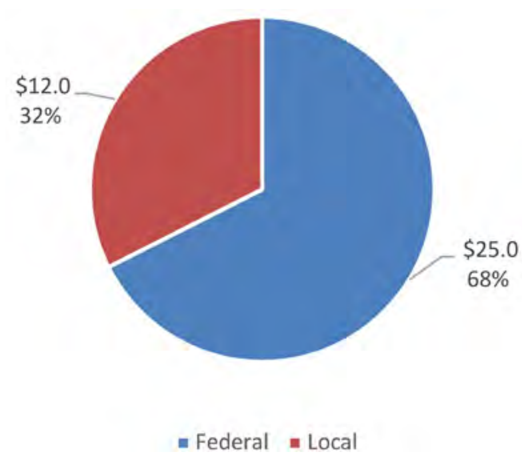
Figure 3-4 *Charlotte LYNX Gold Line*

Figure 3-5 *Charlotte LYNX Gold Line Alignment*

The Charlotte streetcar is the result of a public-private collaborative partnership that involves the City of Charlotte, City of Charlotte Engineering & Property Management, and Charlotte Area Transportation System (CATS), the agency responsible for operating and maintaining the streetcar. Planning dates back to 2006 when the streetcar was included in the 20-year regional transportation plan. In July 2010, FTA awarded the City of Charlotte $24.99 million from the Urban Circulator Grant to construct the first operational segment of the project. The remaining $12 million (32% of the total $37.0 million) came from the City of Charlotte (Figure 3-6). Construction started in December 2012, and the streetcar opened for passenger service on July 14, 2015. The streetcar is fare-free today, but CATS plans to charge Gold Line passengers the cost of a one-way bus or train ticket, which is currently set at $2.20.

Figure 3-6

Charlotte LYNX Gold Line Capital Funding Breakdown ($37.0 million)



Source: City of Charlotte website

Sun Link Tucson Streetcar

The Sun Link Tucson Streetcar (Figure 3-7) is a 3.9-mile-long modern streetcar system located in Tucson, Arizona. The streetcar connects the University of Arizona (UAZ) to the western portion of the study area by running through the 4th Avenue Business District and Tucson Central Business District (CBD) (Figure 3-8). The multimodal Luis G. Gutierrez Bridge is a vital link to the streetcar system, which crosses Interstate 10 to reach the western portion of the study area. The system consists of 22 stops with up to 6 cars in service every 7–10 minutes during peak hour and every 20 minutes during off-peak. From a regional perspective, the streetcar links tourists, residents, students, and workers to attractions, jobs, and public amenities. The system connects the following major destinations:

- Arizona Health Sciences Center
- Main Gate shopping and entertainment district

- 4th Avenue shopping and business district
- Tucson CBD
- Tucson Mercado San Augustin

Figure 3-7

Sun Link Tucson Streetcar

Figure 3-8

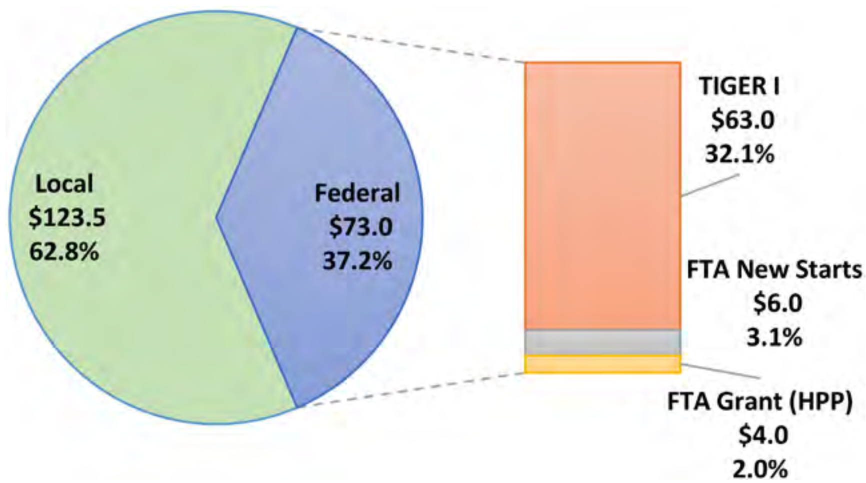
Sun Link Tucson Streetcar Alignment

The streetcar is the result of a collaborative partnership among the City of Tucson Department of Transportation (TDOT), Sun Tran, UAZ, the Regional Transportation Authority (RTA), and the Arizona Department of Transportation (ADOT). Planning dates back to 2006 when the streetcar was included in the 20-year regional transportation plan. In December 2010, the City of Tucson received notice of a $63.0 million TIGER I grant award to help fund the project. The funding breakdown for the project's total cost of $196.0 million also included $10.0 million from FTA New Starts and other grant funds and $75 million from RTA (†Includes $63 million TIGER I funds (Figure 3-9). Construction started in April 2012, and the streetcar opened for passenger service on July 25, 2014. One-way full cost trip fare is $1.50, and a daily pass costs $4.

Annual operating costs are about $4.2 million and are covered by fare box revenue ($1.2 million), an RTA allocation ($2.0 million), City of Tucson general funds ($0.9 million), and advertising revenue ($100,000). The streetcar system has a dedicated two-bay operation and maintenance facility located in proximity of 4th Avenue and 8th Street.

Figure 3-9

Sun Link Tucson Capital Funding Breakdown ($196 million)



†Includes $63 million TIGER I funds
Source: Sun Link Streetcar website

Atlanta Streetcar

The Atlanta Streetcar is a 2.7-mile-long modern streetcar system located in the core of the CBD of Atlanta, Georgia. The streetcar connects the Martin Luther King Jr. National Historic Site east of Interstate 75/85 to the Centennial Olympic Park on the western portion of the study area (Figure 3-10). The system consists of 12 stops with service every 10–15 minutes during peak hour and every 30 minutes during off-peak. Streetcars travel counterclockwise on at-grade tracks and converge in a pinched loop alignment at Woodruff Park. From Woodruff

Park, at the center of the loop, streetcars operate eastbound via Park Place, Edgewood Avenue, and Jackson Street to the Martin Luther King Jr. Historic Site. The loop continues westbound via historic Auburn Avenue, Peachtree Street, Ellis Street, Carnegie Way, and Andrew Young International Boulevard to Centennial Olympic Park Drive, then eastbound via Luckie Street to Woodruff Park.

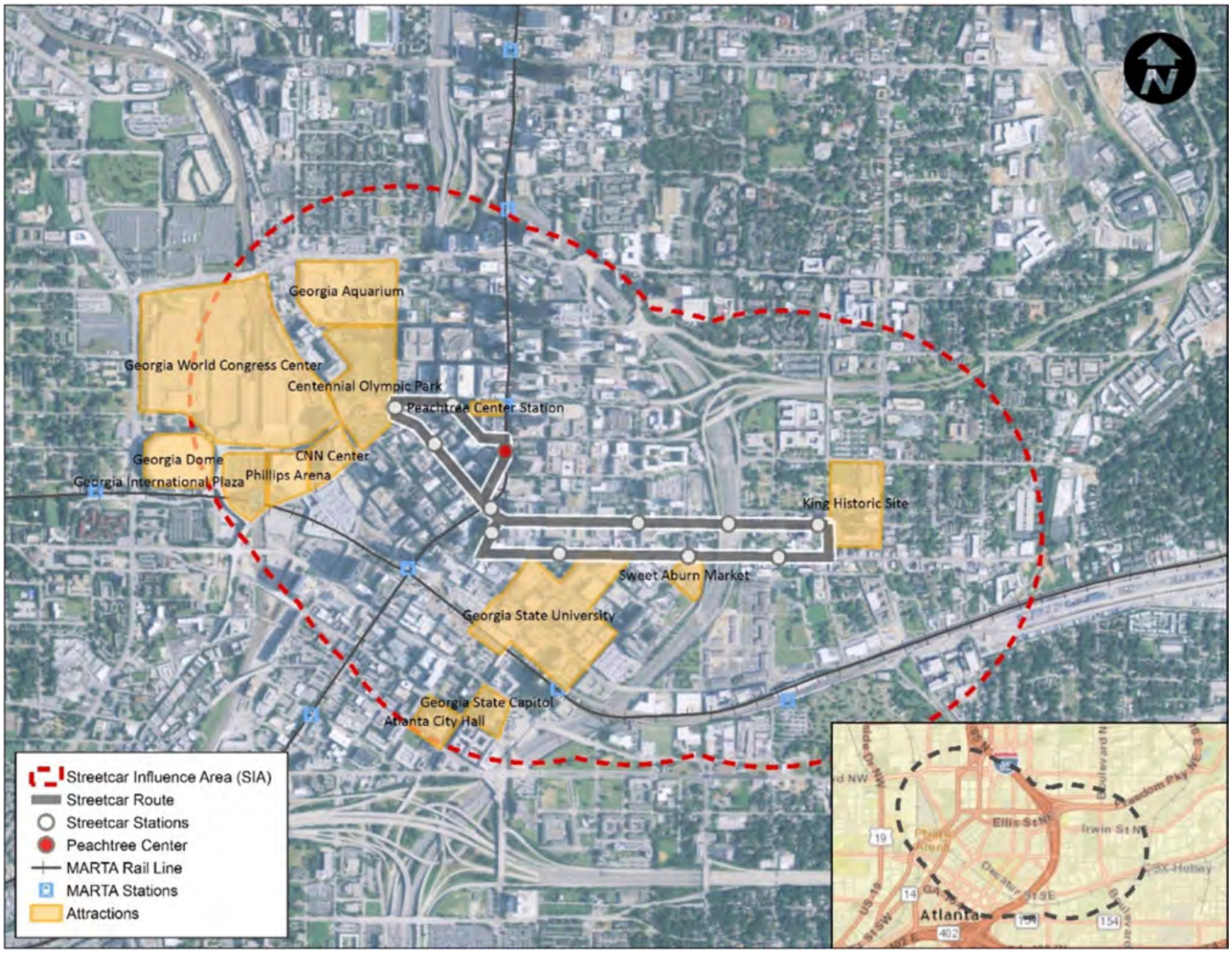


Figure 3-10 *Atlanta Streetcar System*

The streetcar is the result of a public-private collaborative partnership among the City of Atlanta (COA), the Atlanta Downtown Improvement District (ADID), the Midtown Improvement District (MID), and the Metropolitan Atlanta Rapid Transit Authority (MARTA). Planning dates back to 2003 with the formation of Atlanta Streetcar, Inc., a business-led effort to reintroduce the modern streetcar to Atlanta. Planning continued through 2008, when the streetcar was included in the 2030 Regional Transportation Plan. On October 15, 2010, COA received notice of a $47.6 million TIGER II grant award to help fund the project. Figure 3-11 shows the funding breakdown for the project's total cost of $98.9. Local funding included $32.6 million from COA Recovery Zone Bond funds and Department of Watershed Management Clean Water program, $6.0 million from ADID, and $12.7 million from the Atlanta Regional Commission (ARC) Livable Centers Initiative Program and Transportation Enhancement projects. The streetcar opened for passenger service on December 30, 2014.

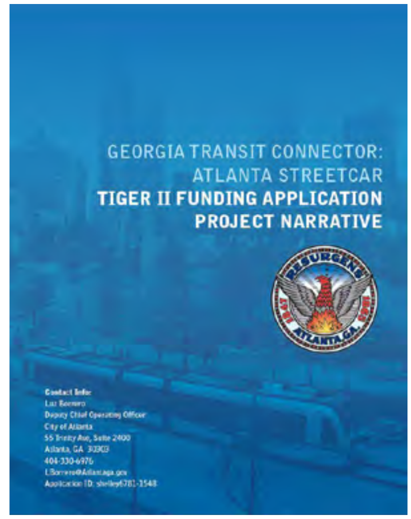
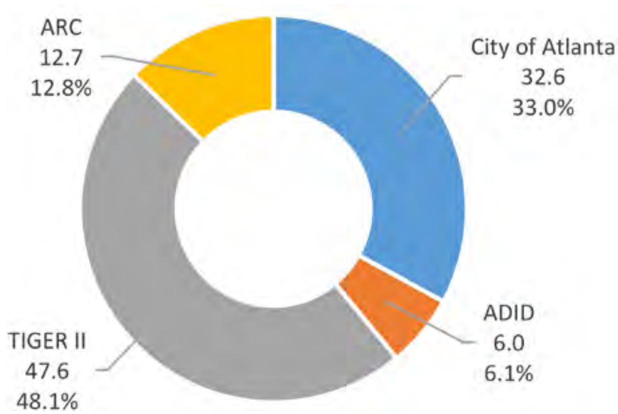


Figure 3-11

Atlanta Streetcar Capital Funding Breakdown ($98.9 million)



Source: streetcar.atlantaga.gov

Annual operating costs are about $1.7 million, with a 20-year operational fund commitment to be covered by fare box revenue, federal grant funds, and City of Atlanta rental and hotel/motel tax proceeds. Users pay a one-way trip fare of $1.00. A monthly pass costs $40.00. The system uses the same smart-card technology as MARTA bus and rail service.

From a regional perspective, the streetcar links tourists, residents, students, and workers to attractions, jobs, and public amenities. From a national perspective, the streetcar connects historic sites such as the Martin Luther King Jr. (MLK) National Historic Site on the east side of downtown Atlanta to Centennial Olympic Park on the west via historic Auburn Avenue. The project is located within an Economically Distressed Area and is intended to create new pedestrian-oriented development, support mixed-use projects, and reinforce existing land use and zoning plans. The system also reconnects the eastern and western sections of downtown Atlanta, which were divided by the construction of Interstate 75/85 in the mid-1950s, by removing the barrier of the I-75/85 overpass that affected the once vibrant local economy in the Auburn Avenue corridor. The Atlanta Streetcar is designed to restore this historic community and foster overall greater livability, social cohesion, and economic development in the Atlanta area.

Salt Lake Sugar House Streetcar

The Sugar House Streetcar (now called the S-Line) is a two-mile-long modern streetcar system located between South Salt Lake City and Salt Lake City, Utah. It consists of 7 stops spaced 0.3 miles apart with service every 15 minutes during peak hours and 30 minutes during off-peak. The system connects the Sugar House district, located on the eastern portion of the study area, and Utah Transit Authority (TRAX) Light Rail at Central Pointe Station (Figure 3-12). The system's tracks use existing right-of-way owned by TRAX running parallel to East 2100 South and Interstate 80.

Planning for the Sugar House Streetcar dates back to 2006, when South Salt Lake City and Salt Lake City sponsored a study of alternatives.[7] Since its inception, the project was touted as a means to reduce automobile congestion by improving connectivity between the existing light rail and bus networks and to stimulate economic development and growth in an economically depressed area of Salt Lake County.

Figure 3-12

Salt Lake City S-Line

The total capital cost of the project was $55.5 million, with $26 million funded by a TIGER II grant awarded in 2010. Construction of the streetcar began in 2012, and the project was completed in 2013. Upon opening on December 8, 2013, the Sugar House Streetcar was named the S Line to honor the two founding cities, Salt Lake and South Salt Lake, as well as the Sugar House neighborhood. Total annual operating and maintenance costs (2013) amounted to about $1.7 million.

The project is located within the Wasatch Front, a metropolitan region in the north-central part of Utah, consisting of a chain of cities and towns stretched along the Wasatch Mountain Range. The region contains the major cities of

[7] http://www.rideuta.com/files/Sugar_House_Final_Report_0808.pdf.

Salt Lake City, Provo, West Valley City, and West Jordan and is home to about 80 percent of Utah's residents. Salt Lake County is the most populous county, with a population of about 1.02 million, based on the 2010 U.S. Census. The county has one major research university, the University of Utah. Westminster College, located north of the study area, and Salt Lake Community College also have large, well-defined campuses. The Utah Governor's Office of Planning and Budget estimates that by 2030, approximately 1.46 million people will live in Salt Lake County. Recognizing this expected growth and the challenges to the transportation system, Salt Lake County has fully-embraced public transit as a travel option. The S-Line project represents the first phase of a locally-adopted regional transportation plan that also has the support of elected officials outside the project area.

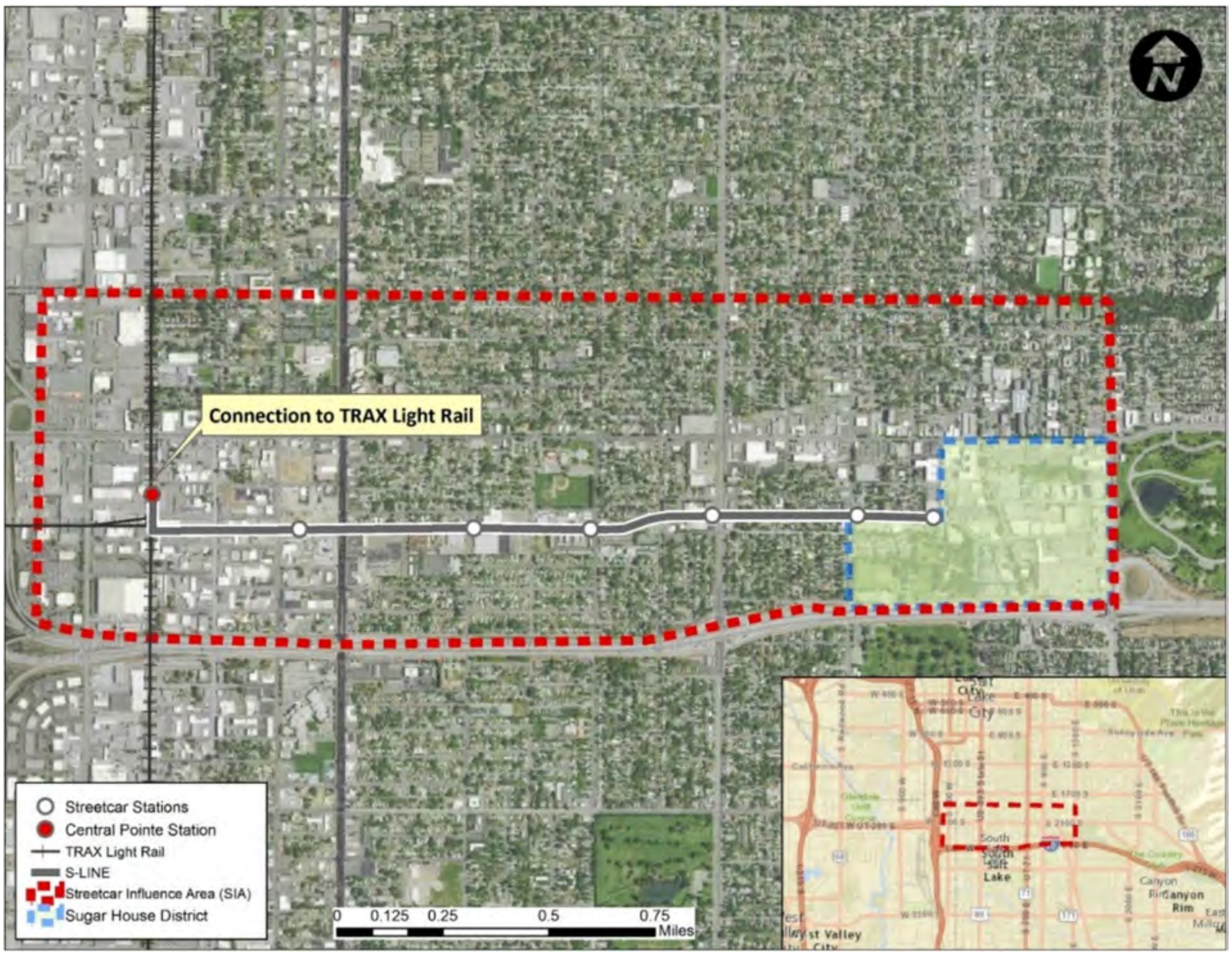


Figure 3-13 *Salt Lake City S-Line Alignment*

SECTION
4

Streetcar Influence Area

The streetcar influence area (SIA) consists of a 0.5-mile seamless buffer around the streetcar stations. The 0.5-mile buffer is consistent with the empirical literature investigating the relationship between time and walking distance and its influence on ridership. When structural barriers to walking are present, the SIA is digitally cropped using ArcGIS mapping tools.

Cincinnati Bell Collector

Figure 4-1 outlines the SIA, defining an area about 1.5 miles wide by 2.9 miles long, totaling 2.2 square miles in size. The truncation occurs south of the SIA along the Ohio riverbank. As of 2016, the SIA contains about 7,900 households, more than 2,900 businesses, and about 81,000 workers. The SIA is the site of Fortune 500 employers and several attractions and popular destinations.

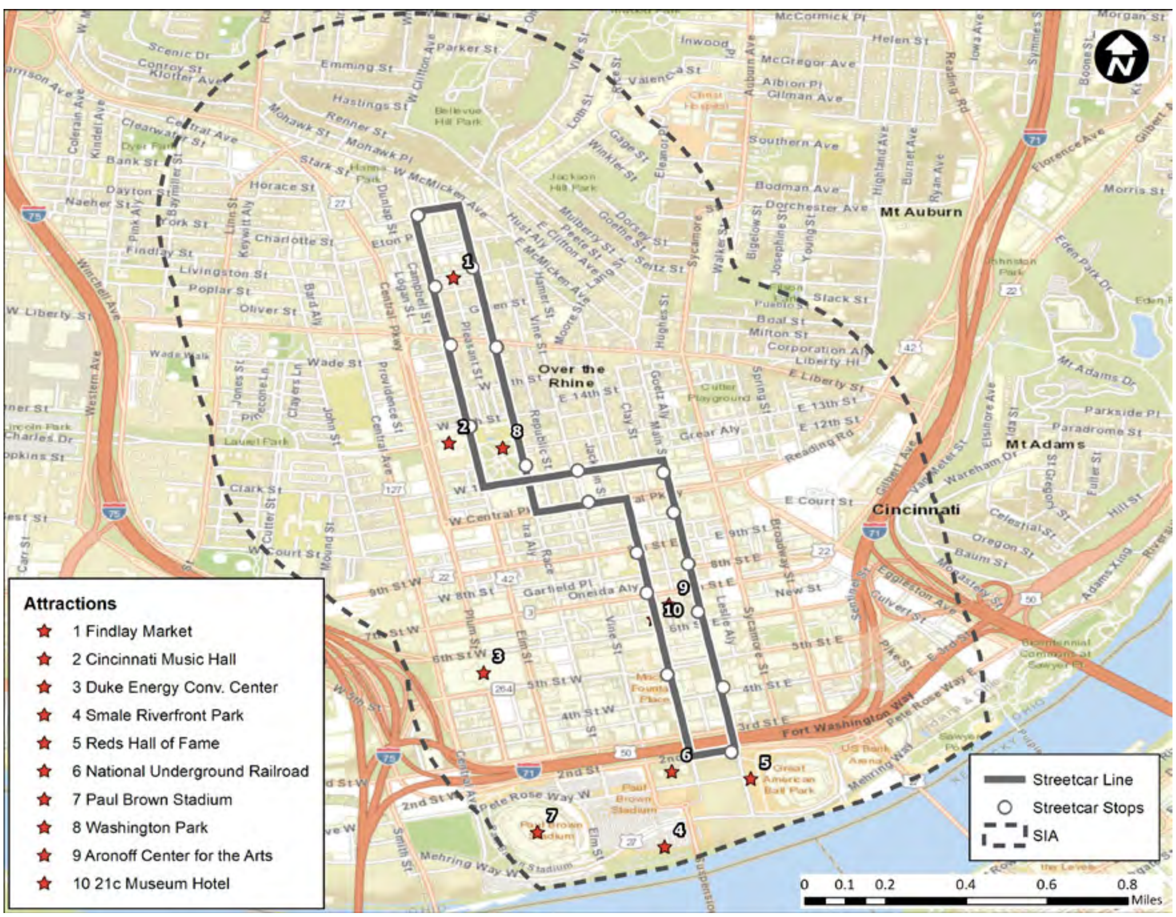


Figure 4-1 *Cincinnati Bell Connector SIA*

Table 4-1 provides detailed descriptive statistics of the study area. According to the U.S. Census American Community Survey (ACS) Five-Year Estimates, the study area is characterized by a high share of low-income households living below the poverty level (43%) compared to the rest of the county (11%). To measure race diversity, this analysis used an index of ethnic heterogeneity that varies from 0 (only one race in the neighborhood) to 1 (no race is prevalent), similar to Shannon's diversity index used in the ecological literature.[8] With a diversity index of 0.40, the SIA is less diverse in terms of race composition than the rest of the county (0.28). The percent of population of black or African American origin is about 49 percent, compared to 26 percent for the rest of the county.

Table 4-1 *Sociodemographic and Travel Descriptive Statistics – Cincinnati Bell Connector*

Variable	SIA Block Groups	Rest of County	Matched Block Groups†	Source
Persons per household	3.00	2.53	2.61	ACS
Percent households below poverty level	0.43	0.15	0.28	ACS
Percent of households with income <$10,000	0.28	0.11	0.20	ACS
Percent households with income <=$59,000	0.79	0.57	0.68	ACS
Percent households with income >$100,000	0.09	0.21	0.18	ACS
Diversity Index	0.40	0.28	0.27	ACS
Percent of block group population that is black	0.49	0.26	0.36	ACS
Percent of block group population that is white	0.44	0.70	0.60	ACS
Percent housing units owner-occupied	0.21	0.64	0.53	ACS
Percent housing units renter-occupied	0.79	0.36	0.47	ACS
Percent housing built on or before 1949	0.65	0.35	0.53	ACS
Percent housing built on or after 2000	0.10	0.05	0.05	ACS
Median housing value	160,982	166,575	192,545	ACS
Median housing age	64.56	53.37	60.97	ACS
Vehicles per household	1.04	1.60	1.41	ACS
Gross household density (households per acre)	6.25	2.76	3.76	HUD
Average household transport and housing cost (% of income)	35.65	45.41	44.87	HUD
Average household annual VMT	13,366	18,680	17,195	HUD
Average household annual transit trips	176.53	54.05	75.43	HUD
Intersection density (intersections/land area)	0.92	0.20	0.28	HUD
Block Density (blocks per acre)	0.41	0.08	0.12	HUD

†Identified using propensity-score matching as described in Appendix A.
Sources: U.S. Census ACS 2007–2011 5-Year average; U.S. HUD Location Affordability Index

[8] The Shannon Index compares diversity between habitat samples in terms of the proportion of individuals of a given species in the set (Begon, Harper, and Towsend, 1996).

The SIA housing stock reflects the historic nature of the Cincinnati CBD, with 65 percent of houses built on or before 1949, compared to the entire county (35%). Most of the residential properties are renter-occupied units (79%), another characteristic that differentiates it from the rest of the county (36%). Data from the U.S. Department of Housing and Urban Development (HUD) Location Affordability Index show substantial differences between the SIA and the rest of the county in terms of housing and transportation costs. With more than 176 transit trips per year, SIA residents rely more on public transportation and own fewer vehicles than the remainder of the county.

In the statistical modeling of property values (Section 6, Econometric Analysis of Property Values) and changes in business patterns and employment levels (Section 8, Econometric Analysis of Business Activities), the analysis employs a subsample of county block groups, defined as control block groups, to establish a more statistically representative baseline. The approach to select control block groups is detailed in the methodology section of Appendix A.[9] Using the variables described in Table 4 1, the control selection methodology reduces the bias introduced by using the entire Hamilton County data as a baseline for comparison. The approach identified 31 Census block groups that closely match the 41 block groups of the study area (i.e., treatment). The third column of Table 4 1 reports the control block groups sample mean values, which more closely match those of the SIA in terms of housing and socio-demographic characteristics.

Charlotte CityLYNX Gold Line

Figure 4-2 outlines the Gold Line SIA, which consists of a 0.5-mile seamless buffer around the stations defining an area about 1.5 miles wide by 2.9 miles long, totaling 2.9 square miles in size. As of 2016, the SIA comprised about 5,200 households, approximately 2,000 businesses, and about 13,000 workers. Running along Elizabeth Avenue, the streetcar links visitors, residents, students, and workers to attractions, jobs, and public amenities. The SIA is characterized by neighborhoods with socio-demographic and travel behavior characteristics that differ from the rest of the county.

[9] Appendix A is part of the main report summarizing findings of each case study.

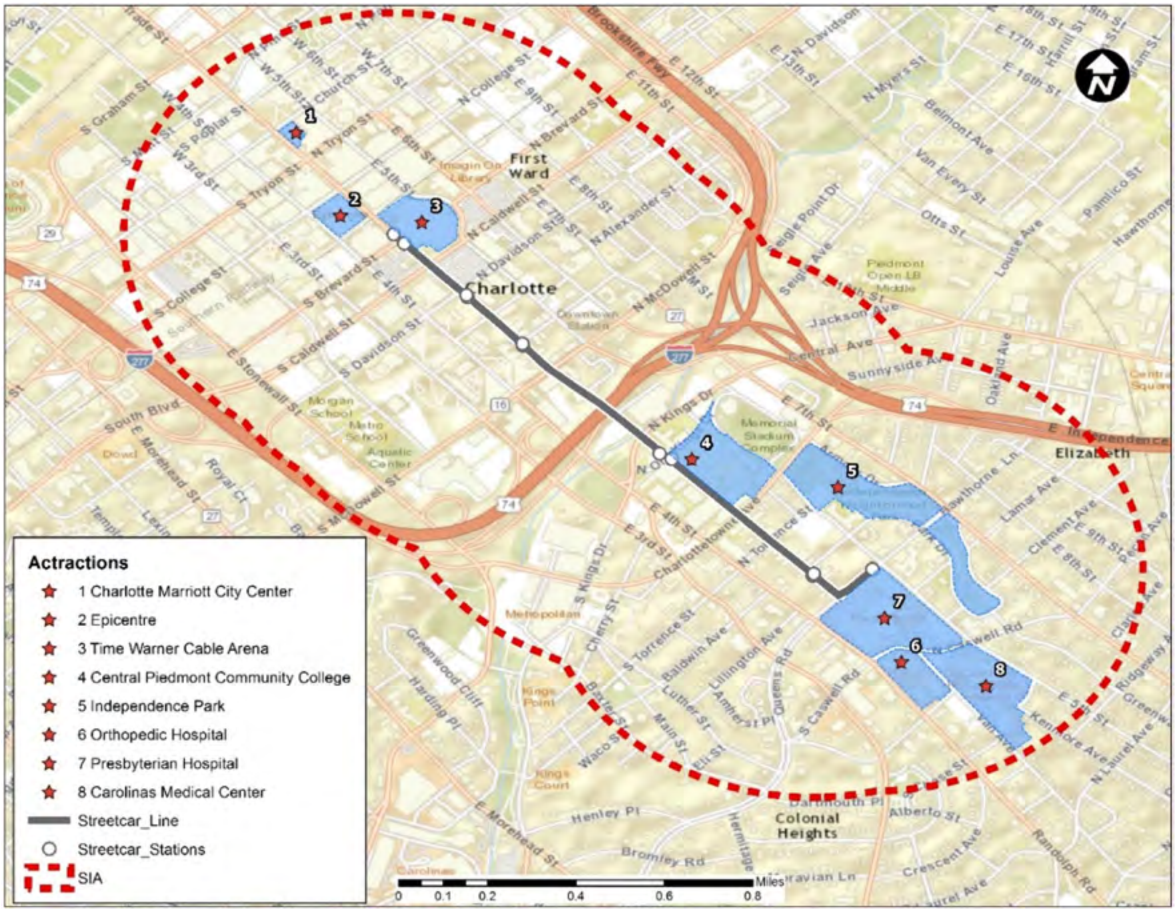


Figure 4-2 *Charlotte City LYNX Gold Line SIA*

Table 4-2 provides detailed descriptive statistics of the study area in comparison to the rest of the county and to the control block groups. According to the ACS 5-Year Estimates, the study area is characterized by a higher percentage of high-income households (31%) compared to the rest of the county (24%). To measure race diversity, this analysis used an index of ethnic heterogeneity that varies from 0 (only one race in the neighborhood) to 1 (no race is prevalent), similar to Shannon's diversity index used in the ecological literature.[10] With a diversity index of 0.35, the SIA is less diverse in terms of race composition than the rest of the county (0.43).

[10] The Shannon Index compares diversity between habitat samples in terms of the proportion of individuals of a given species in the set (Begon, Harper, and Towsend, 1996).

Table 4-2 *Sociodemographic and Travel Descriptive Statistics – Charlotte CityLYNX Gold Line*

Variable	SIA Block Groups	Rest of County	Matched Block Groups†	Source
Persons per household	1.84	2.55	2.14	ACS
Population 16 and older	670	1,258	895	ACS
Diversity Index	0.35	0.43	0.44	ACS
Percent households income >$100,000	0.31	0.24	0.24	ACS
Percent households income <=$59,000	0.49	0.54	0.53	ACS
Percent housing units owner-occupied	0.37	0.62	0.41	ACS
Percent housing units renter-occupied	0.63	0.38	0.59	ACS
Percent housing built on or before 1949	0.26	0.07	0.26	ACS
Percent housing built on or after 2000	0.40	0.25	0.33	ACS
Median housing value	354,479	223,748	270,496	ACS
Vehicles per household	1.29	1.65	1.55	ACS
Gross household density (households per acre)	3.77	1.86	2.86	HUD
Average household transport and housing cost (% of income)	42.39	47.13	44.70	HUD
Average household annual VMT	13,338	19,961	17,302	HUD
Average household annual transit trips	240.54	66.13	129.16	HUD
Intersection density (intersections/land area)	0.38	0.15	0.26	HUD

†Identified using propensity-score matching as described in Appendix A. Using the variables described in Table 4-2, the control selection methodology identified 22 Census block groups that closely match the 18 block groups of the study area (i.e., treatment). The third column of Table 4-2 reports the control block groups sample mean values, which more closely match those of the SIA.
Sources: U.S. Census ACS 2007–2011 5-Year Average; U.S. HUD Location Affordability Index

The SIA housing stock reflects the historic nature of the Charlotte CBD, with 26 percent of houses built on or before 1949, compared to the entire county (7%). Most of the residential properties are renter-occupied units (63%), another characteristic that differentiates it from the rest of the county (38%). Data from the HUD Location Affordability Index show substantial differences between the SIA and the rest of the county in terms of housing and transportation costs, and vehicle and transit trip making. The SIA is characterized by higher transit trip-making and lower vehicle miles traveled (VMT) than the rest of the county, which reflects a highly-dispersed, low-density urban landscape.

Sun Link Tucson Streetcar

Figure 4-3 maps the Sun Link Tucson SIA, consisting of an area about 1.5 miles wide by 2.9 miles long, totaling 4.0 square miles in size. As of 2016, the SIA contained about 4,850 households, approximately 1,900 businesses, and about 30,000 workers (including UAZ employees).

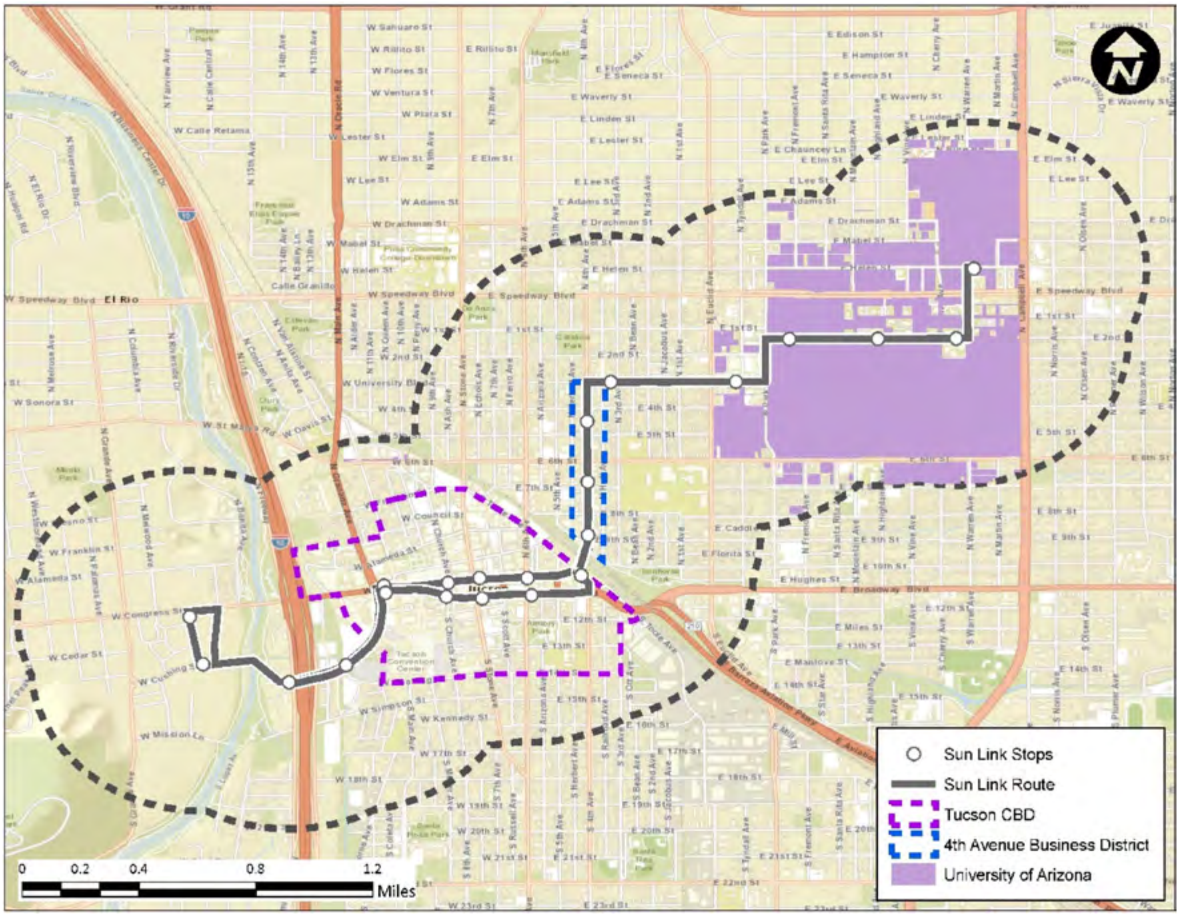


Figure 4-3 *Sun Link Tucson Streetcar SIA*

The study area is located in Tucson's CBD, Pima County, and is characterized by neighborhoods having socio-demographic and travel behavior characteristics that differ from the rest of the county. Table 4-3 provides detailed descriptive statistics of the study area and compares it to the rest of the county and to the control block groups. According to the U.S. Census ACS 5-Year Estimates, the study area is characterized by a lower percentage of high-income households (9%) compared to the rest of the county (15%). A higher percentage of households (76%) are in the median income range ($59,000 or less). To measure race diversity, this analysis used an index of ethnic heterogeneity that varies from 0 (only one race in the neighborhood) to 1 (no race is prevalent), similar to Shannon's diversity index used in the ecological literature.[11] With a diversity index of 0.34, the SIA is similar in terms of race composition to the rest of the county (0.33).

[11] The Shannon Index compares diversity between habitat samples in terms of the proportion of individuals of a given species in the set (Begon, Harper, and Towsend, 1996).

Table 4-3 *Sociodemographic and Travel Descriptive Statistics – Sun Link Tucson Streetcar*

Variable	SIA Block Groups	Rest of County	Matched Block Groups†	Source
Persons per household	2.76	2.59	2.55	ACS
Population 16 and older	1,068	1,233	838	ACS
Diversity Index	0.34	0.33	0.34	ACS
Percent households income >$100,000	0.09	0.15	0.07	ACS
Percent households income <=$59,000	0.76	0.64	0.80	ACS
Percent housing units owner-occupied	0.31	0.63	0.46	ACS
Percent housing units renter-occupied	0.69	0.37	0.54	ACS
Percent housing built on or before 1949	0.41	0.07	0.24	ACS
Vehicles per household	1.30	1.63	1.36	ACS
Gross household density (households per acre)	3.38	2.54	3.08	HUD
Average household transport and housing cost (% of income)	45.60	51.95	46.75	HUD
Average household annual VMT	13,488	19,204	16,049	HUD
Average household annual transit trips	141.64	55.82	94.83	HUD
Intersection density (intersections/land area)	0.42	0.23	0.33	HUD

†Identified using propensity-score matching as described in Appendix A.
Sources: U.S. Census ACS 2007–2011 5-Year Average; U.S. HUD Location Affordability Index.

The SIA housing stock reflects the historic nature of the Tucson CBD, with 41 percent of houses built on or before 1949, compared to the entire county (7%). Most of the residential properties are renter-occupied units (69%), another characteristic that differentiates it from the rest of the county (37%). Data from the U.S. HUD Location Affordability Index show substantial differences between the SIA and the rest of the county in terms of housing and transportation costs, and vehicle and transit trip making. The SIA is characterized by higher transit trip-making and lower VMT than the rest of the county, which is characterized by a highly-dispersed, low-density urban landscape.

Using the variables described in Table 4-3, the control selection methodology identified 48 Census block groups that closely match the 31 block groups of the study area (i.e., treatment). Table 4 3 reports the control block groups sample mean values, which more closely match those of the SIA.

Atlanta Streetcar

Figure 4-4 shows the Atlanta Streetcar SIA, consisting of an area about 1.5 miles wide by 2.9 miles long, totaling 2.0 square miles in size. The SIA is larger than the 0.25-mile buffer zone used in the original TIGER II grant application because this analysis took into account the connectivity between the streetcar system, the MARTA system in the southern section, and the Civic Center stop at the northern boundary. The 0.5-mile buffer is consistent with the empirical literature investigating the relationship between time and walking distance and its influence on ridership. As of 2016, the SIA contained about 5,200 households, approximately 3,500 businesses, and about 87,000 workers.

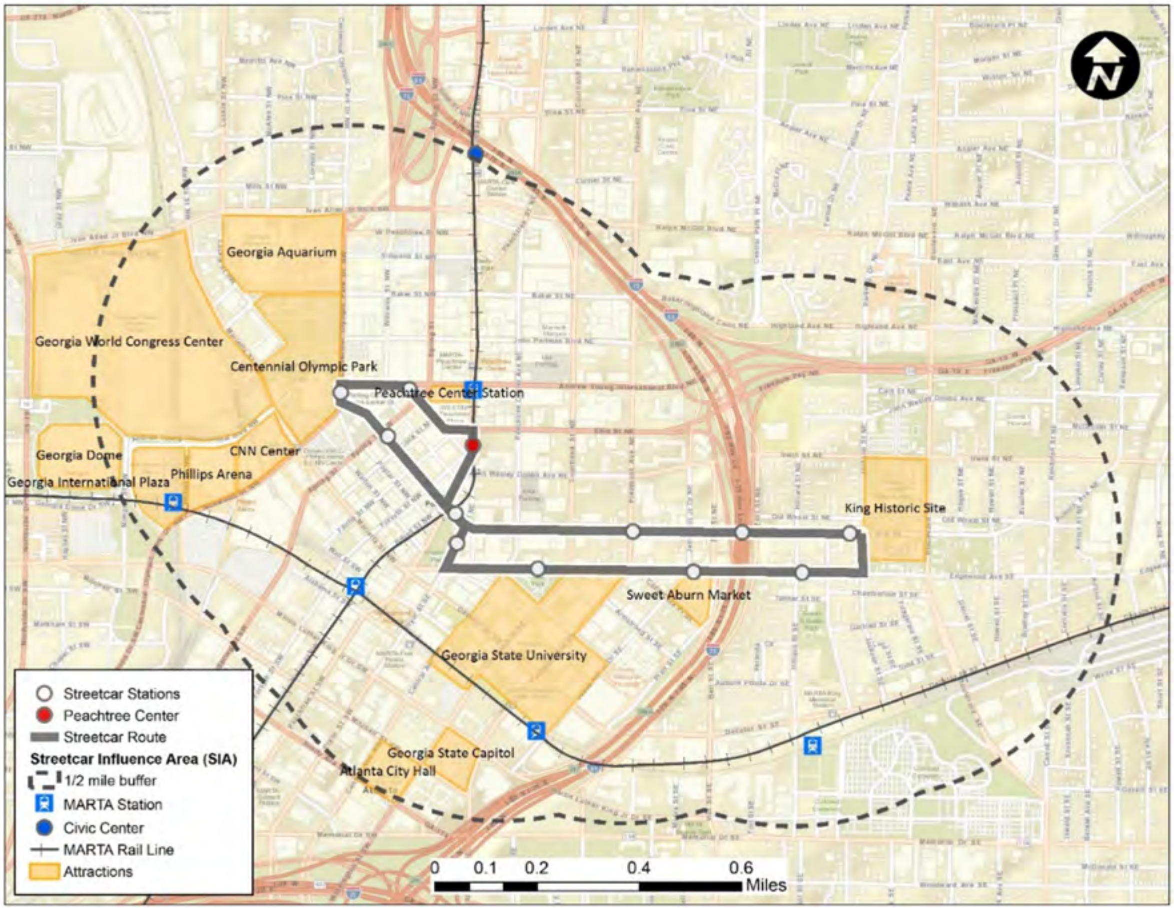


Figure 4-4 *Atlanta Streetcar SIA*

The study area is located in Atlanta's CBD, Fulton County, and is characterized by neighborhoods having socio-demographic characteristics that differ from the remainder of the county. Table 4-4 provides detailed descriptive statistics of the study area and compares it to the rest of the county and to the control block groups. According to the U.S. Census ACS 5-Year Estimates, the study area is characterized by a lower percentage of high-income households (17%) compared to the rest of the county (28%). A higher percentage of households (30%) are in the median income range ($49,000 or less). To measure race diversity, this analysis used an index of ethnic heterogeneity that varies from 0 (only one race in the neighborhood) to 1 (no race is prevalent), similar to Shannon's diversity index used in the ecological literature.[12] With a diversity index of 0.51, the SIA is relatively more diverse than the remainder of the county (0.31).

[12] *Ibid.*

Table 4-4 *Sociodemographic and Travel Descriptive Statistics – Atlanta Streetcar*

Variable	SIA Block Groups	Rest of County	Matched Block Groups†	Source
Persons per household	2.19	2.81	1.89	ACS
Population 16 and older	1,273	1,316	1,057	ACS
Diversity Index	0.51	0.31	0.44	ACS
Percent household income >$100,000	0.17	0.28	0.18	ACS
Percent households income <$10,000	0.30	0.13	0.28	ACS
Percent housing units owner-occupied	0.29	0.56	0.32	ACS
Percent housing units renter-occupied	0.71	0.44	0.68	ACS
Vehicles per household	1.35	1.73	1.40	ACS
Gross household density (households per acre)	4.90	2.75	8.35	HUD
Average household transport and housing cost (% of income)	39.60	48.26	40.25	HUD
Average household annual VMT	12,452	18,692	12,516	HUD
Average household annual transit trips	531.43	211.58	477.21	HUD
Intersection density (intersections/land area)	0.48	0.21	0.49	HUD

†Identified using propensity-score matching, as described in Appendix A.
Sources: U.S. Census ACS 2007–2011 5-Year Average; U.S. HUD Location Affordability Index.

The SIA housing stock reflects the historic nature of the Atlanta CBD, with 30 percent of houses built on or before 1949, more than twice the average housing stock for the entire county (13%). Most of the residential properties are renter-occupied units (71%), another characteristic that differentiates it from the rest of the county. Variables measuring household density, vehicle housing and transportation costs, ownership levels, and transit trip-making also illustrate differences between the SIA and the rest of the county, which is characterized by a highly-dispersed, low-density urban landscape. Data from the U.S. HUD Location Affordability Index show substantial differences between the SIA and the rest of the county.

In the statistical modeling of property values (Section 6, Econometric Analysis of Property Values) and changes in business patterns and employment levels (Section 8, Econometric Analysis of Business Activities), this analysis employs a subsample of county block groups, defined as control block groups and detailed in the methodology section of Appendix A.[13] Using the variables described in Table 4-3, the control selection methodology reduced the bias introduced by using Fulton County data in its entirety. The approach identified 37 Census block groups that closely match the 17 block groups of the study area (i.e., treatment). Table 4-3 reports the control block groups sample mean values, which more closely match those of the SIA.

[13] Appendix A summarizes the findings of each case study.

Salt Lake City S-Line

Figure 3-1 shows the SIA, consisting of an irregular polygon of 1.98 square miles. The SIA is similar in size to the default 0.5-mile seamless buffer used in the other case studies, but omits the blocks south of Interstate 80, which are physically separated from the roadway and unlikely to benefit from the streetcar system. The polygon size is consistent with the study area defined in the original environmental assessment study.[14] As of 2016, the SIA contained about 4,400 households, approximately 1,100 businesses, and more than 271 acres of retail and commercial land use.

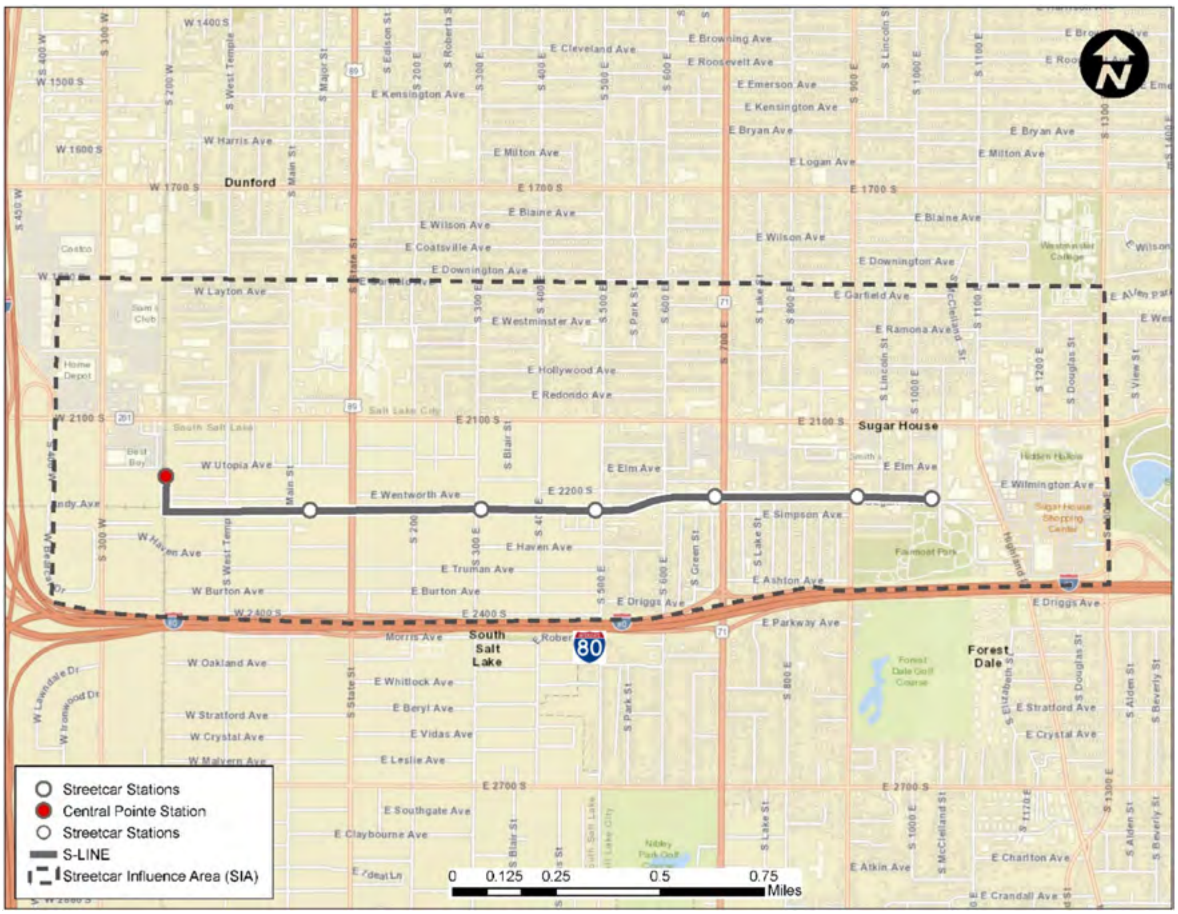


Figure 4-5 *Salt Lake City S-Line – SIA*

The study area is located approximately three miles south of the Salt Lake City CBD and is characterized by neighborhoods having socio-demographic characteristics that differ from the rest of the county. Table 4-5 provides detailed descriptive statistics of the study area and compares it to the rest of

[14] http://www.shstreetcar.com/files/SHStreetcarEnvironmentalAssessment_sm.pdf?page=Projects-OtherProjects-SugarHouseStreetCar.

the county and to the control block groups. According to the U.S. Census ACS, the study area is characterized by a higher percentage of households below the poverty level (16.0%) compared to the remainder of the county (10.0%). A lower percentage of affluent households (13.0%) reside in the study area than in the rest of the county (24.0%). This is also reflected in housing ownership levels, with more households renting (52.0%) compared to the remainder of the county (38.0%). In turn, SIA households rely more on public transportation and spend less of their income in housing and transport costs.

Table 4-5 *Sociodemographic and Travel Descriptive Statistics – Salt Lake City S-Line*

Variable	SIA Block Groups	Rest of County	Matched Block Groups†	Source
Persons per household	2.45	3.04	2.64	ACS
Population 16 and older	1,068	1,232	992	ACS
Diversity Index	0.30	0.25	0.31	ACS
Percent household income >$100,000	0.13	0.24	0.13	ACS
Percent households below poverty level	0.16	0.10	0.16	ACS
Percent households income <$10,000	0.11	0.07	0.10	ACS
Percent housing units owner-occupied	0.48	0.70	0.50	ACS
Percent housing units renter-occupied	0.52	0.30	0.50	ACS
Median housing age	59	38	56	ACS
Median housing value	227,057	256,716	222,052	ACS
Vehicles per household	1.56	1.95	1.59	ACS
Gross household density (households per acre)	4.14	3.17	4.41	HUD
Average household transport and housing cost (% of income)	40.69	45.53	40.41	HUD
Average household annual VMT	17,257	19,895	17,130	HUD
Average household annual transit trips	242.52	167.18	260.90	HUD

†Identified using propensity-score matching, as described in Appendix A.
Sources: U.S. Census ACS 2007–2011 5-Year Average; U.S. HUD Location Affordability Index

To measure race diversity, this analysis uses an index of ethnic heterogeneity that varies from zero (only one race in the neighborhood) to one (no race is prevalent), similar to Shannon's diversity index.[15] With a diversity index of 0.30, the SIA is relatively more diverse than the rest of the county (0.25).

Using the variables described in Table 4-5 the control selection methodology identified 50 block groups that closely match the 21 block groups of the study area (i.e., treatment). The table reports the control block groups sample mean values, which closely match those of the SIA.

[15] The Shannon index compares diversity between habitat samples in terms of the proportion of individuals of a given species in the set (Begon, Harper, and Towsend, 1996).

SECTION

5

Trend Analysis of Property Values

Cincinnati Bell Collector

The analysis is based on data from the Hamilton County Auditor's Office. Upon request, the Auditor's Office provided access to a comprehensive tax roll parcel database covering the entire study period (2007–2016).[16] The database reports yearly assessments of all real and tangible personal property in Hamilton County as produced by the Operations and Public Records Office. The tax roll database contains detailed parcel information, including parcel size, building size and structural characteristics, and the estimated taxable value. A separate database reports detailed information of property sales transactions. In Ohio, property taxes are levied against the assessed value, which is equivalent to 35 percent of the market value of the property. The market value of property is determined by the County Auditor.

The tax roll datasets contain a land use code, which allows creating property-type categories for subsequent analysis:

- Residential (vacant, single-family, multi-family, other)
- Commercial
- Industrial
- Government (federal, state, and local)
- Institutional (e.g., universities, schools)
- Other (e.g., public utilities, right-of-way, rivers, lakes, parks, etc.)

The Cincinnati Area Geographic Information System Office (CAGIS) office routinely publishes GIS shapefiles to plot the parcels (also containing detailed land-use information), allowing merging information from other sources.[17] Upon request, CAGIS provided separate files identifying condominium property attributes and sales. In addition, the GIS office provides public access to a variety of land-use GIS shapefiles that are used to augment the parcel dataset for subsequent empirical analysis. Upon request, the office provided separate shapefiles on condominium parcels and building attributes. These data were useful to estimate the impact of the streetcar system on condominium property sales.

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[16] http://www.hamiltoncountyauditor.org.

[17] http://cagis.org/Opendata/?.

The SIA map was superimposed on the parcel layers to identify the parcels located within 0.5 miles of the streetcar stations. Figure 5-1 shows the location of 12,177 parcels (2016 CAGIS parcel database), highlighting residential, commercial, and industrial land uses.

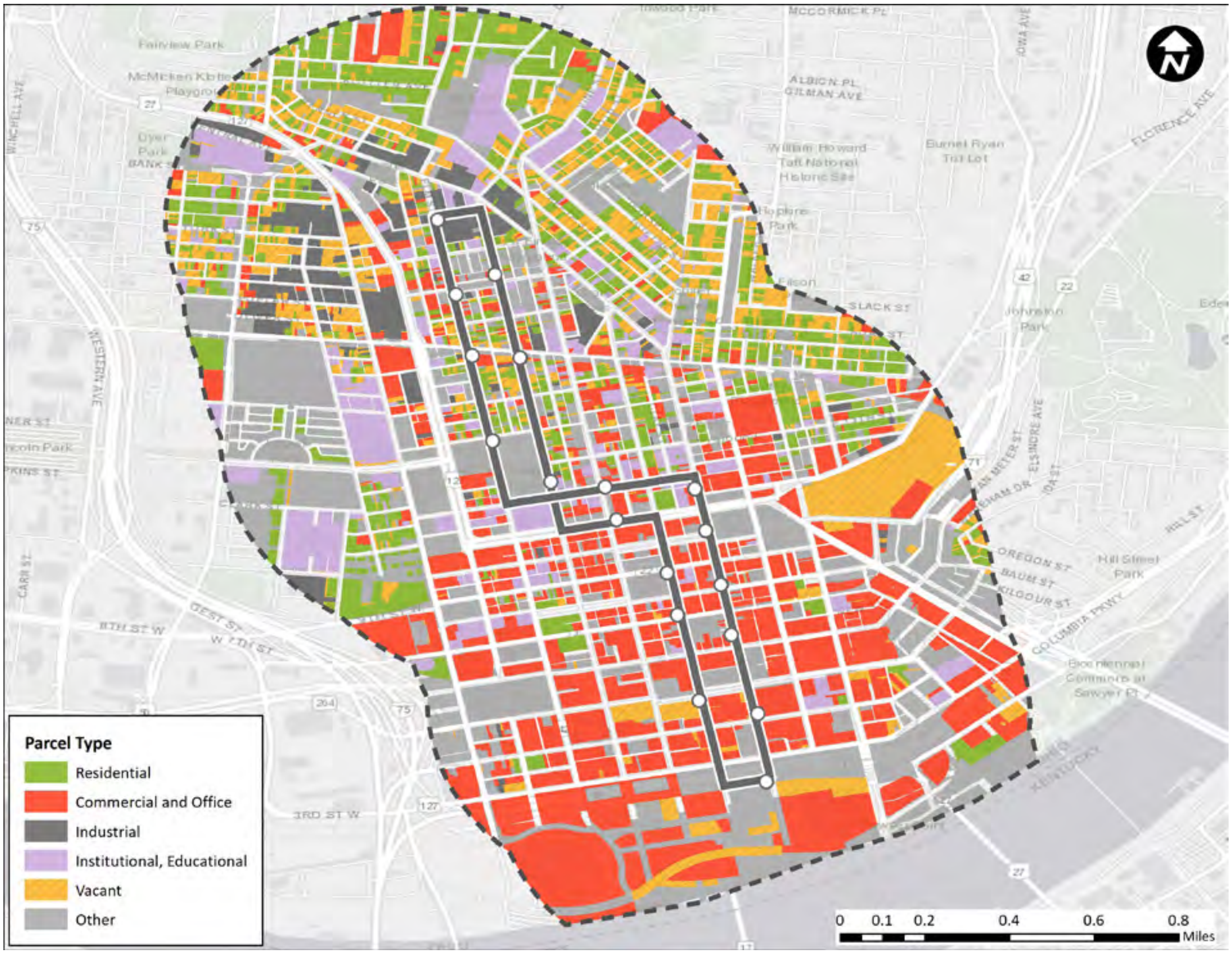


Figure 5-1 *Parcels by Land Use – Cincinnati Bell Connector*

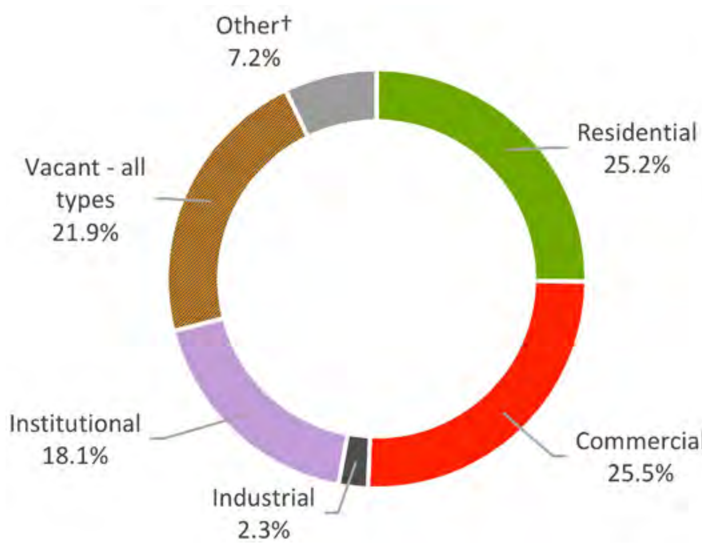
Figure 5-2 shows the property type breakdown in the SIA, and includes public utilities, government, religious, natural resources. Figure 5-3 shows the property type breakdown for Hamilton county. The breakdown is based on the CAGIS parcel database classification land use code (Class variable).[18] The SIA is characterized by a high share of vacant parcels (21.9%) compared to the rest of the county (12.0%). A later section of this report provides a detailed analysis

[18] The parcel dataset is available in the quarterly update parcel shapefile named *parcpoly*. CAGIS regularly updates this files for public use: http://cagis.org/Opendata/CagisOpenDataQuarterly.zip.

of vacant parcels. Consistent with the characteristics of a CBD, the SIA is characterized by a lower share of residential parcels and a higher concentration of commercial, government, and institutional parcels than the rest of the county.

Figure 5-2

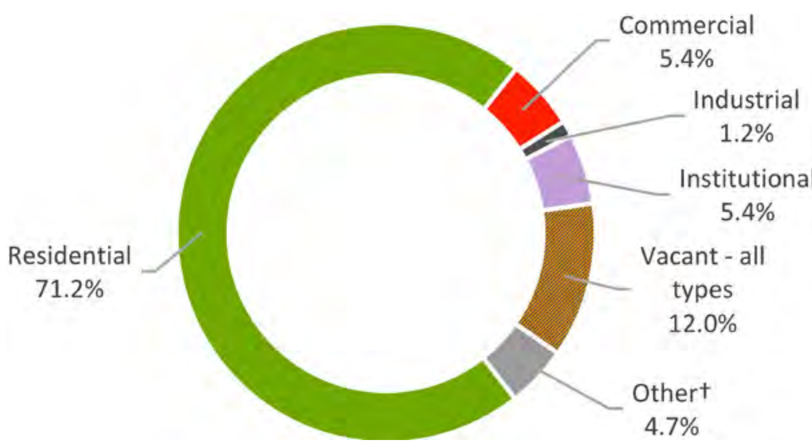
Parcel Counts by Property Type, Cincinnati Bell Connector – 2016



†Includes public utilities, government, religious, natural resources.

Figure 5-3

County Parcel Counts by Property Type, Hamilton County (OH) – 2016



†Includes public utilities, government, religious, natural resources.

Table 5-1 and Table 5-2 report historical parcel counts and total parcel acreage by major land-use types for 2007-2016, as provided by the County Auditor's Office.[19] Over this period, the SIA experienced a change in land use with a reduction of 85 commercial (a decrease of 4.3%) and 30 industrial parcels (a

[19] Tables do not include condominium parcel data and tax-exempt properties. As the County Auditor's Office tax roll data, the database does not discern between multi-family and condominium properties and does not include data on parcels that are tax-exempt.

decrease of 15.2%). At the same time, the number of vacant parcels increased by 50 units (3.2%). The pace at which these changes occurred increased during 2012–2016. Beside the decline in the number of industrial parcels, these trends mirror the trends for the remainder of Hamilton County.

Table 5-1 *Parcel Counts – Cincinnati Bell Connector*

Property Type	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Residential	1,824	1,838	1,848	1,839	1,838	1,830	1,837	1,841	1,851	1,860
Commercial	1,965	1,935	1,940	1,958	1,931	1,895	1,871	1,877	1,876	1,880
Industrial	197	196	194	188	186	180	173	171	166	167
Institutional	1,205	1,332	1,334	1,333	1,349	1,300	1,312	1,317	1,323	1,334
Vacant – all types	1,563	1,471	1,485	1,490	1,477	1,555	1,567	1,579	1,608	1,613
Other†	390	388	401	404	434	446	461	456	506	528
Total	*7,144*	*7,160*	*7,202*	*7,212*	*7,215*	*7,206*	*7,221*	*7,241*	*7,330*	*7,382*

†Includes education, religious, public utilities and natural resources.

During 2007–2016, whereas acreage dedicated to residential uses increased by about 2.9 acres (2.7%), commercial parcel acreage increased by 20.6 acres (5.9%). The growth in commercial acreage increased more rapidly over 2012–2016.

Table 5-2 *Parcel Acreage – Cincinnati Bell Connector*

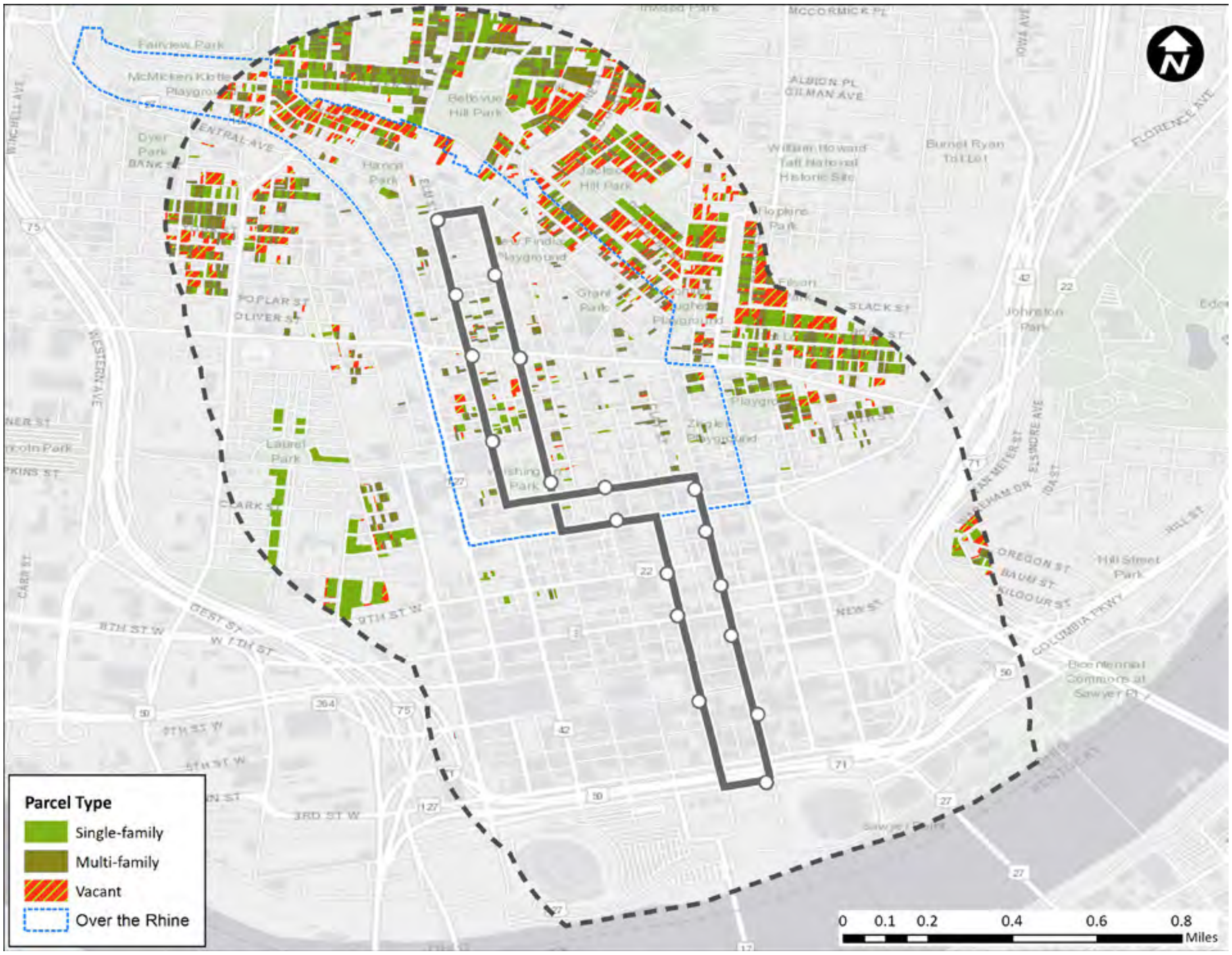
Property Type	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Residential	108.1	108.2	109.7	109.3	109.1	111.7	109.0	109.9	110.6	111.0
Commercial	349.7	355.2	369.7	371.8	375.7	345.1	352.3	2,861.0	381.5	370.2
Industrial	57.4	57.4	59.7	56.4	56.1	50.9	47.0	45.3	47.8	53.2
Institutional	165.4	168.0	166.9	164.0	172.0	172.2	180.2	181.7	191.7	206.3
Vacant – all types	102.6	111.6	113.5	109.8	106.6	131.5	133.4	134.0	131.9	131.4
Other†	74.9	76.3	77.6	83.4	83.9	89.3	89.8	82.8	91.9	94.2
Total	*858.0*	*876.8*	*897.0*	*894.6*	*903.5*	*900.8*	*911.7*	*3,414.8*	*955.5*	*966.5*

†Includes education, religious, public utilities and natural resources.

Residential Properties

As of 2016, there were 3,262 residential parcels in the SIA, with most single- and multi-family properties clustered on the northern portion (Figure 5-4) and most condominium parcels clustered within the OTR historic district. The map also shows a large presence of vacant parcels north of the streetcar line on the northeastern fringes of OTR. Figure 5-5 shows that as of 2016 single-family parcels represented 35.5 percent of the total 3,262 residential parcels, followed by vacant parcels (32.8%).[20]

[20] By direct request, CAGIS provided data on condominium parcels and condominium attributes.

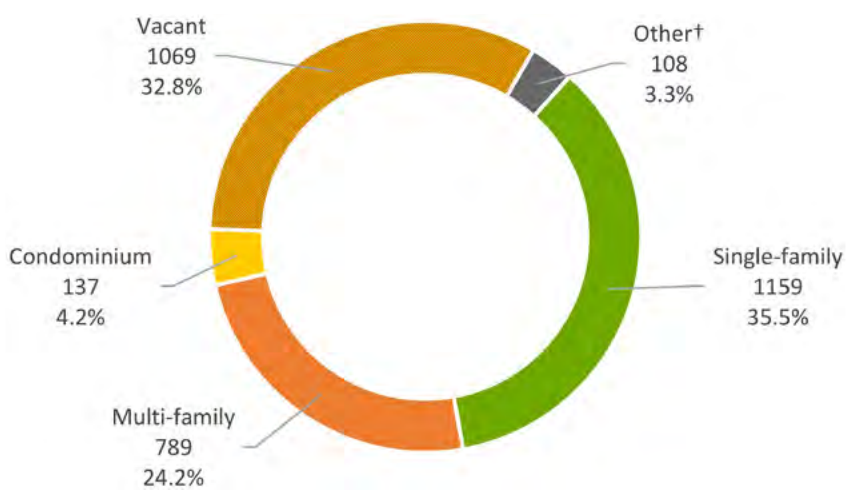


†Includes townhouse and condominium common areas.

Figure 5-4 *Map of Residential Parcels – Cincinnati Bell Connector*

Figure 5-5

Residential Parcels, Cincinnati Bell Connector – 2016



†Includes townhouse and condominium common areas.

The distribution of residential parcels fluctuated through the years, as indicated by the change in the number of residential parcel counts displayed in Table 5-3.[21] During 2007–2016, the number of single-family parcels increased by 12.3 percent, with the largest increases occurring during 2012–2016. The number of multi-family parcels decreased by 10.6 percent (reduction of 85 parcels). The number of vacant parcels declined over 2007–2012, with a reduction in terms of acreage and parcels. This trend reversed over 2012–2016, showing an increase of 40 parcels and an increase of about two acres of vacant land (Table 5-4).

Table 5-3 *Residential Parcel Counts – Cincinnati Bell Connector*

Parcel Type	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Single-family	926	950	975	978	982	986	1,003	1,015	1,031	1,040
Multi-family	800	784	770	760	753	742	732	724	718	715
Vacant	992	886	892	883	876	910	915	922	943	950
Other†	98	104	103	101	103	102	102	102	102	105
Total	*2,816*	*2,724*	*2,740*	*2,722*	*2,714*	*2,740*	*2,752*	*2,763*	*2,794*	*2,810*

†Includes mobile homes, garages, and other areas.

Table 5-4 *Residential Parcel Acreage – Cincinnati Bell Connector*

Parcel Type	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Single-family	52.1	53.2	54.6	54.7	54.8	54.9	52.9	53.4	54.1	54.6
Multi-family	46.0	45.3	44.4	43.9	43.5	42.9	42.1	41.7	41.3	41.1
Vacant	51.0	45.9	46.1	45.0	44.7	46.2	46.5	46.8	48.0	48.3
Other†	5.5	5.8	5.8	5.7	5.8	5.7	5.7	5.7	5.7	5.9
Total	*154.6*	*150.2*	*151.0*	*149.3*	*148.7*	*149.7*	*147.2*	*147.6*	*149.1*	*149.9*

†Includes mobile homes, garages, and other areas.

Table 5-5 reports average annual property values for the SIA, which reflect the property assessor's market evaluation (i.e., assessed value). The appraised values were adjusted using the Consumer Pricing Index to report all dollar amounts in 2016 dollars.

Table 5-5 *Residential Property Values – Cincinnati Bell Connector*

Parcel Type	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Single-family	236,884	231,151	224,963	220,616	181,045	185,247	197,405	222,762	238,466	250,871
Multi-family	173,083	160,084	150,979	144,938	119,906	123,763	129,805	149,737	159,367	166,812
Vacant	17,026	12,579	12,085	11,802	11,580	11,597	11,803	14,496	16,666	19,898
Other†	168,743	167,191	163,195	165,776	153,416	158,083	164,300	157,713	164,476	173,336

†Includes mobile homes, garages, and other areas.

[21] Tables do not report historical information on condominium parcels (*ibid.*, 19). Some observations lost when merging historical tax roll data with GIS parcel shapefile because historical tax roll data do not include tax-exempt parcels.

Figure 5-6 provides a historical perspective comparing assessed value trends in the SIA with the rest of the county and the control areas. The graphs show generalized upward trends in value starting in 2011. On average, single-family properties located in the SIA had lower values than comparable properties in the remainder of the county and properties located in the control areas, which share similar neighborhood characteristics. From these graphs, it is unclear if there is any correlation or causality between the streetcar and changes in land values, although the empirical literature provides evidence of anticipated impacts of rail investments on residential property prices. The statistical analyses in the next sections aim to uncover any causal relationship between the streetcar investment and changes in land-use and property values.

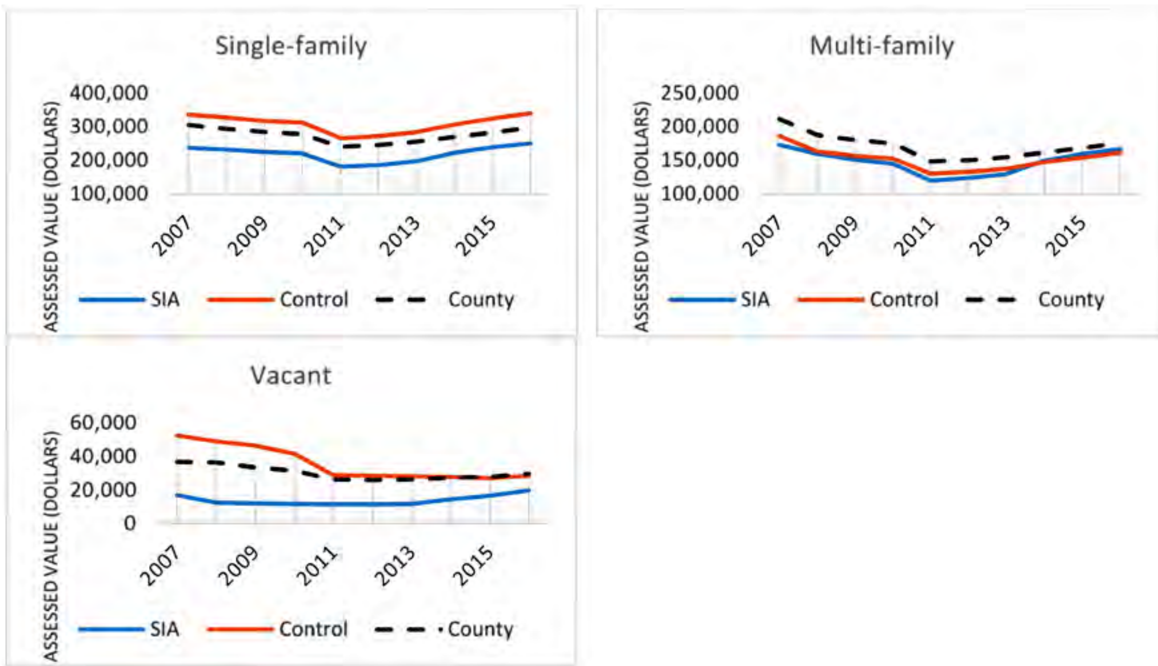


Figure 5-6 *Residential Properties Assessed Values, Cincinnati Bell Connector*

Figure 5-7 and Figure 5-8 provide spatial information about market values for residential properties, comparing 2007 (before streetcar announcement) to 2016 (opening phase). The maps employ the same appraised value ranges for the two-reference periods. Residential parcels include single-family, multi-family, and other residential properties.[22] The map shows evidence of increases in property values between the two reference periods.

The key question to ascertain is to what extent the value of these properties changed through time in response to the streetcar planning phases, after controlling for loss of value caused by the real estate market crisis and other influencing factors.

[20] Condominium properties are not included due to data constraints previously discussed.

Figure 5-7

Map of Residential Property Values, Cincinnati Bell Connector – 2007

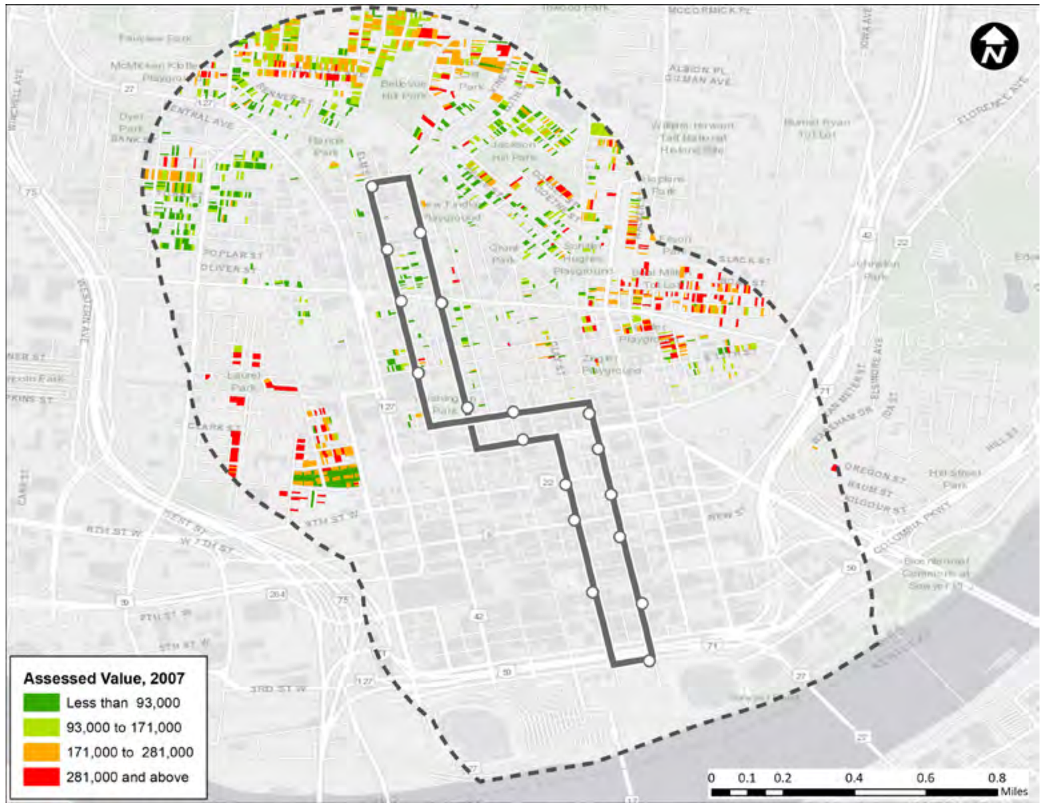
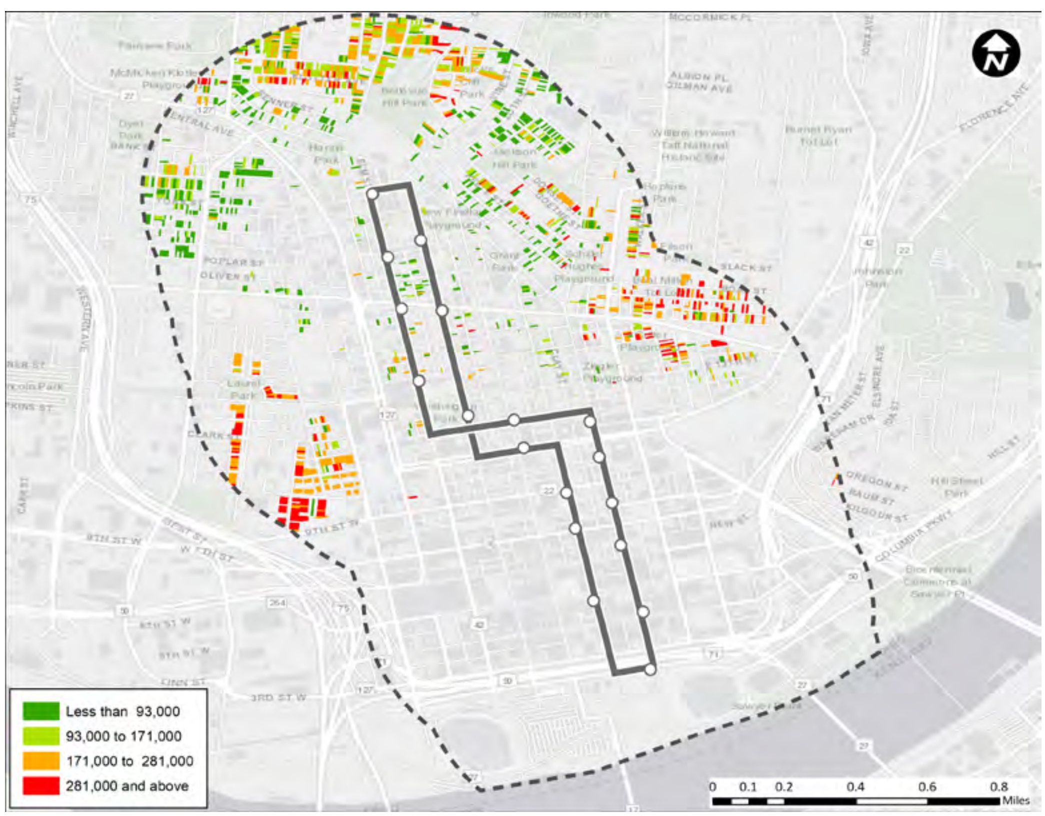


Figure 5-8

Map of Residential Property Values, Cincinnati Bell Connector – 2016



Commercial Properties

Figure 5-9 shows commercial properties, which include all parcels where business units are located. Businesses include commercial establishments, restaurants, shops, shopping centers, department stores, and food stores. Commercial parcels are located in the CBD core and along the streetcar route. As of 2016, there were 3,770 commercial parcels totaling 275.3 acres.

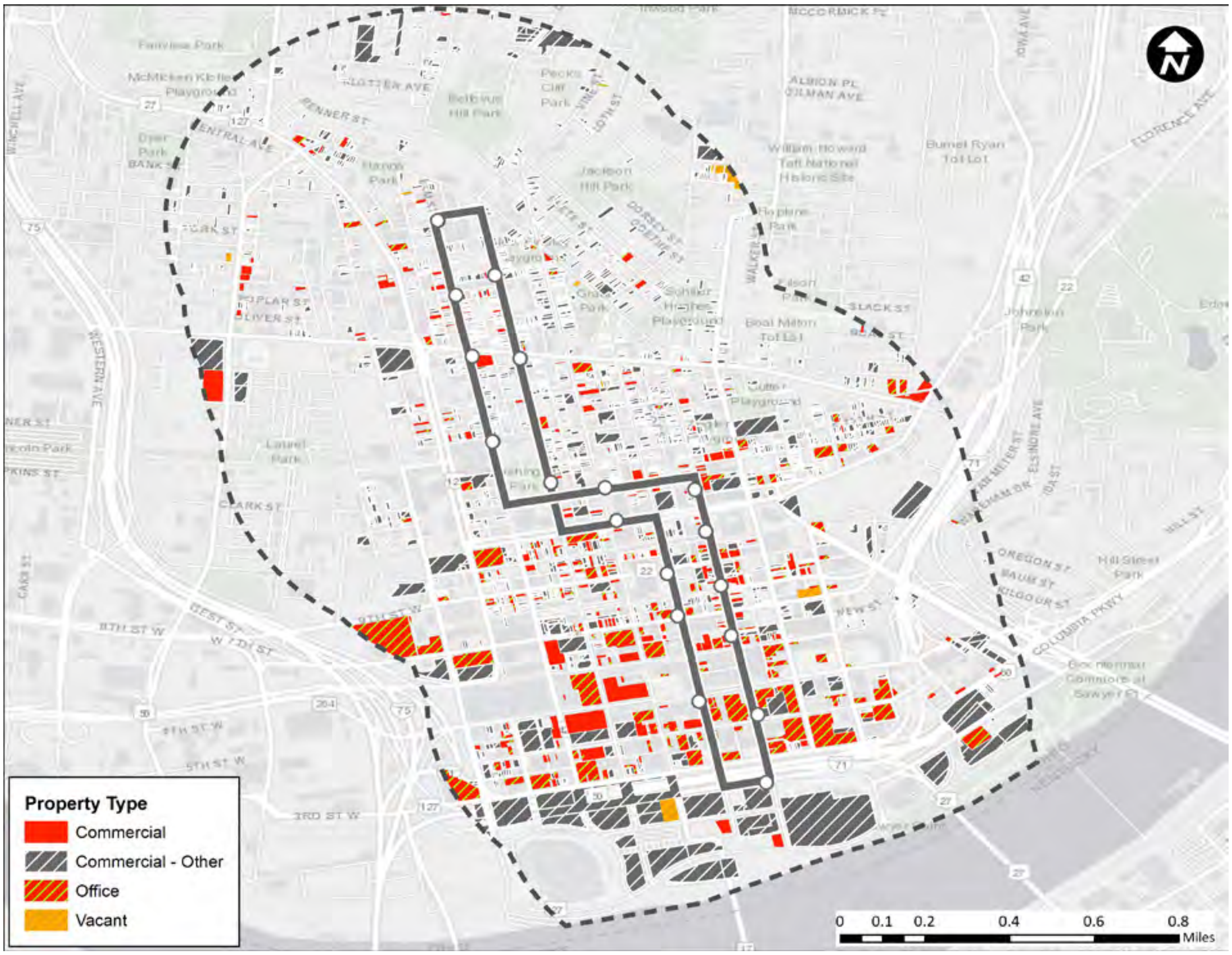
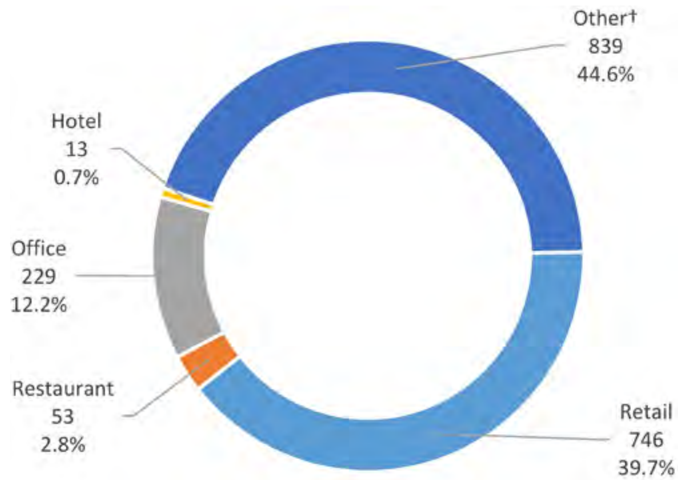


Figure 5-9 *Map of Commercial Parcels – Cincinnati Bell Connector*

Figure 5-10 reports the breakdown by property type (2016 tax roll) of the commercial parcels. About 21.7 percent of the parcels are used for offices, which include medical, banking, and savings institutions. Retail establishments represent 44.1 percent of the total and occupy 135.6 acres (about 49.3% of total commercial acreage).

Figure 5-10

Commercial Parcels Breakdown – Cincinnati Bell Connector



Looking at the historical trends of Table 5-6 and Table 5-7, parcels dedicated to office space steadily increased in number and total acreage during 2007–2016. Comparing 2016 to 2007, retail and restaurant parcels steadily increased in number and acreage.

Table 5-6

Commercial Parcel Counts – Cincinnati Bell Connector

Parcel Type	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Retail	749	750	762	783	774	751	741	743	742	746
Restaurant	61	58	51	53	53	54	55	56	52	53
Office	226	228	227	231	225	224	226	226	228	229
Hotel	8	8	8	8	9	9	11	12	13	13
Other†	921	891	892	883	870	857	838	840	841	839
Total	*1,965*	*1,935*	*1,940*	*1,958*	*1,931*	*1,895*	*1,871*	*1,877*	*1,876*	*1,880*

†Includes apartment complexes, country clubs, amusement parks and other commercial structures.

Table 5-7

Commercial Parcels Acreage – Cincinnati Bell Connector

Parcel Type	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Retail	127.3	127.6	130.3	137.0	144.1	120.0	120.3	130.3	141.2	135.6
Restaurant	4.1	4.0	3.6	3.7	3.7	4.0	4.4	4.4	4.1	4.2
Office	38.1	45.1	43.5	48.7	47.3	47.2	47.5	47.2	49.9	50.2
Hotel	2.7	2.7	2.7	2.7	2.7	2.7	2.9	3.3	3.4	3.4
Other†	77.4	74.5	75.4	75.2	74.3	73.7	73.3	73.8	82.0	81.9
Total	*249.7*	*253.9*	*255.5*	*267.3*	*272.1*	*247.6*	*248.3*	*259.1*	*280.6*	*275.3*

†Includes apartment complexes, country clubs, amusement parks and other commercial structures.

Figure 5-11 shows historical trends in mean assessed value for occupied parcels, comparing the study area to the rest of the county and to similar properties (controls). SIA parcels are located in the core of Cincinnati's CBD, and location premia result in relatively higher values.

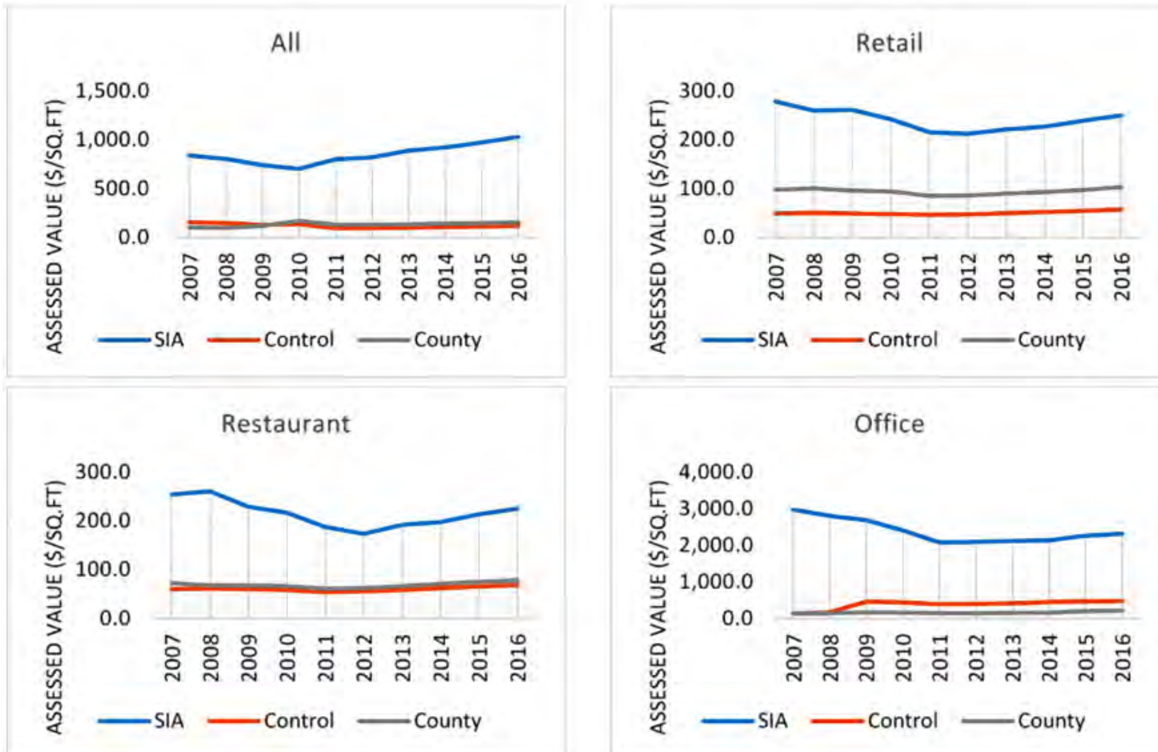


Figure 5-11 *Commercial Property Values – Cincinnati Bell Connector*

Figure 5-12 and Figure 5-13 illustrate the appraised valued for 2007 and 2016, highlighting clustering of commercial parcels in downtown Cincinnati CBD, with smaller size parcels in the OTR district showing appreciation over time.

Figure 5-12

Map of Commercial Property Values, Cincinnati Bell Connector – 2007

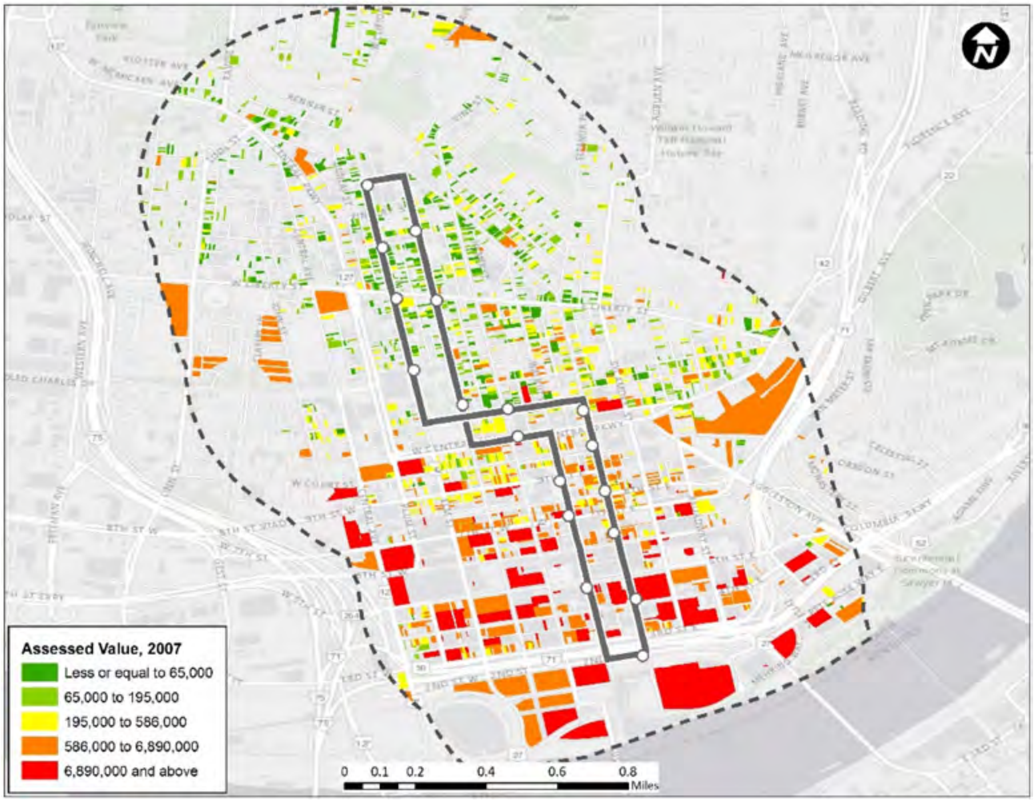
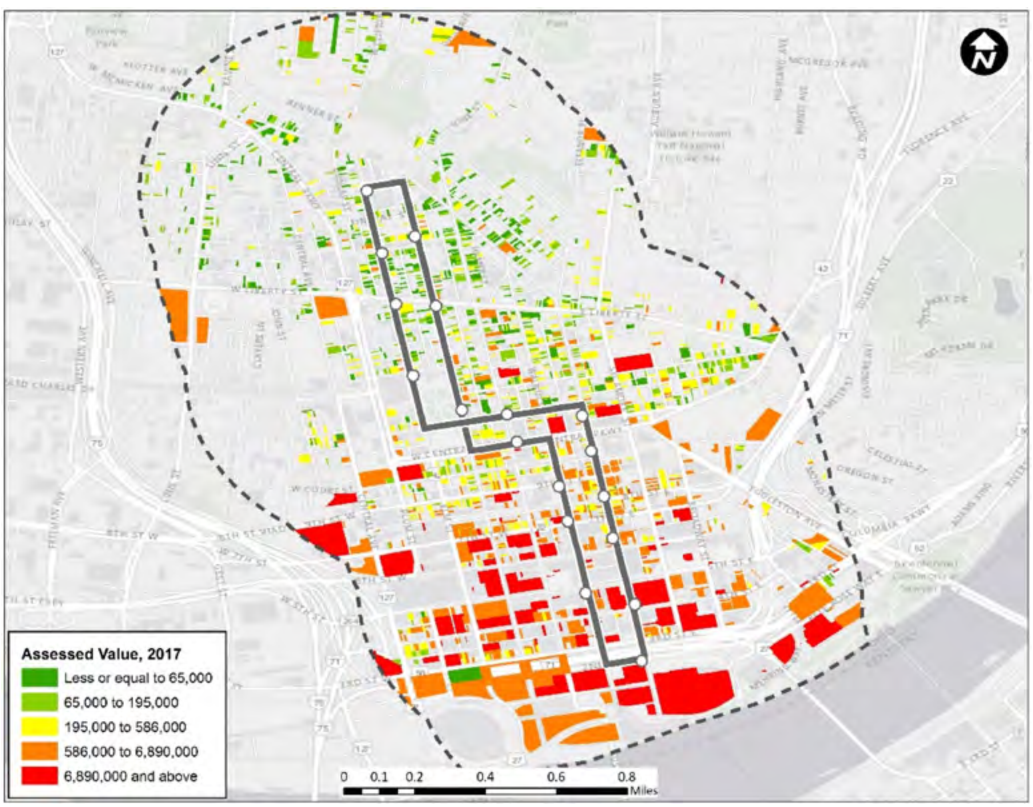


Figure 5-13

Map of Commercial Property Values, Cincinnati Bell Connector– 2016



Vacant Properties

As of 2016, there were about 2,000 vacant parcels, of which 1,069 (53.3%) were classified as residential, 834 (41.6%) were classified as commercial, and 103 (5.1%) were classified as industrial. Figure 5-14 maps the vacant parcels by major land use, showing that the vast majority of residential parcels were clustered on the northern portion of the SIA and on the northeastern edges of the OTR district. The industrial parcels were clustered on the northeastern portion of the SIA and outside the OTR district.

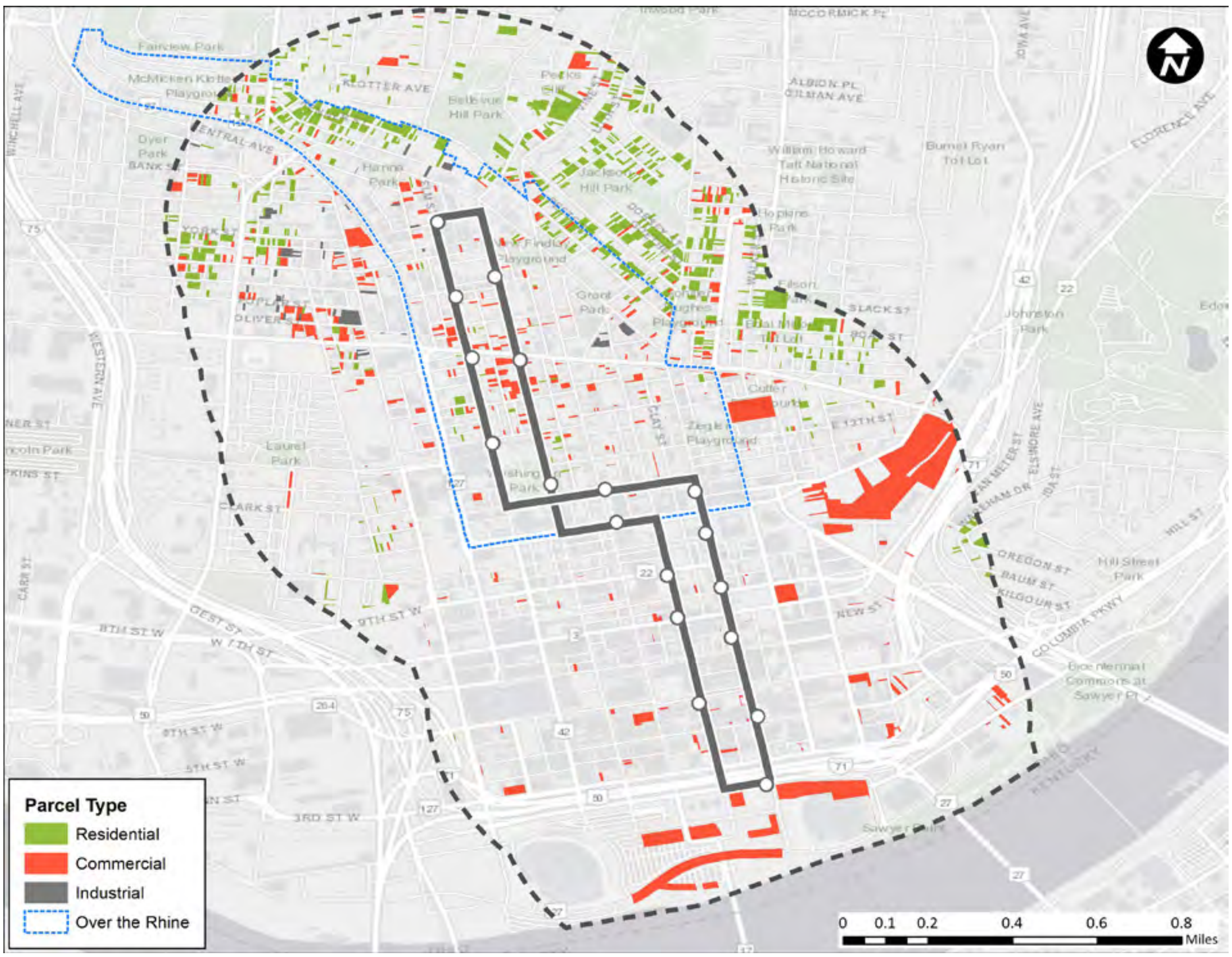


Figure 5-14 *Map of Vacant Parcels – Cincinnati Bell Connector*

Figure 5-15 shows historical parcel count and mean assessed values trends by land use. Overall, vacant parcels show increasing trends in terms of number of parcels and mean assessed values. It is not clear if this is due to a change of land-use over the reference period. Vacant residential parcels show a decline in number between 2007 and 2011, followed by a subsequent increase. Notably, vacant commercial parcels increased in value by 58.0 percent over the period of 2007–2016.

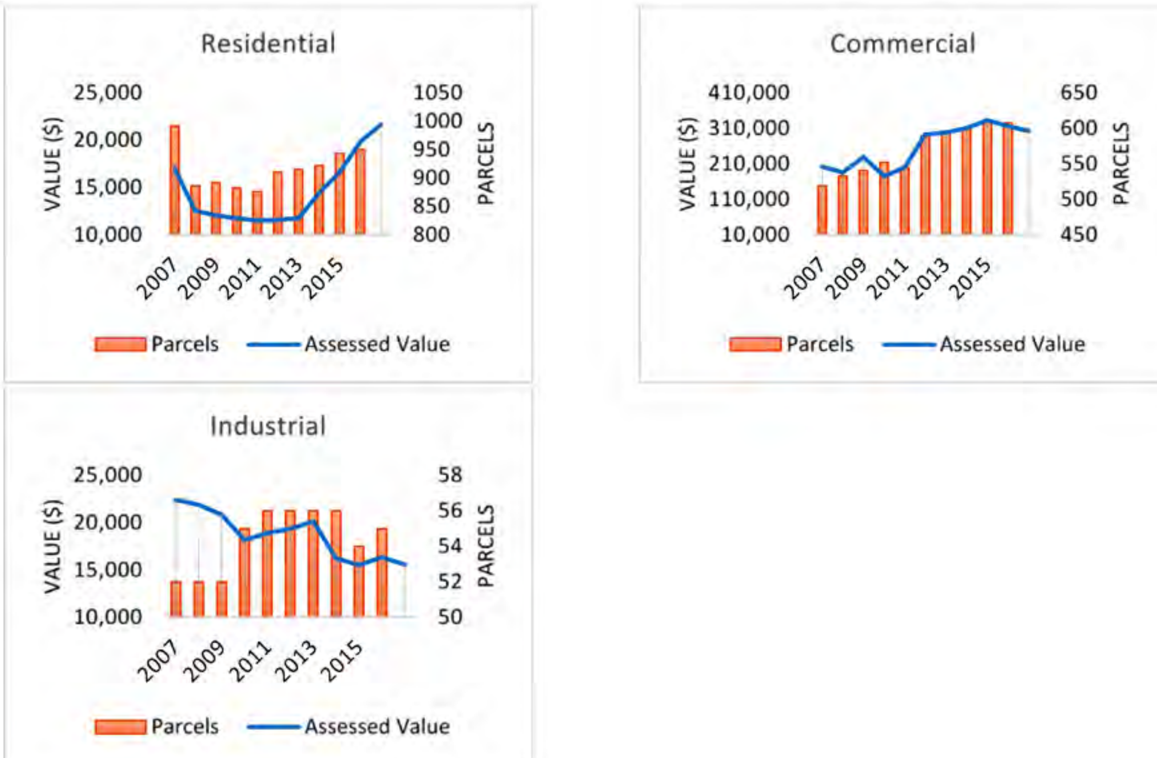


Figure 5-15 *Vacant Parcels Assessed Values – Cincinnati Bell Connector*

Charlotte CityLYNX Gold Line

The analysis was based on data from the Mecklenburg County Land Records Management tax parcels database, which provides current tax roll and property sales data.[23] The database reports yearly assessments of all real and tangible personal property in Mecklenburg County as produced by the Real Property Appraisal Division. The tax roll data provide detailed parcel information, including parcel size, building size and structural characteristics, the estimated taxable value, and the price and date of property sales transactions. North Carolina law requires that all real property be assessed at fair market value as of January 1st of a revaluation year. It is the function of the Real Property Appraisal Division to list, discover, assess, and process appeals for ad valorem tax purposes. Real estate taxes are based on the assessed valuation of the real property as of the date of the latest countywide reappraisal (2011) divided by 100 and multiplied by the tax rate.[24]

[23] http://charmeck.org/mecklenburg/county/LUESA/GIS/GeneralInfo/Pages/Land%20Records.aspx.

[24] http://charmeck.org/mecklenburg/county/AssessorsOffice/Pages/Real-Estate.aspx.

The tax roll datasets contain a land use code, which allows creating the following property-type categories for subsequent analysis:

- Residential (vacant, single-family, multi-family, condominium, other)
- Commercial
- Industrial
- Government (federal, state, and local)
- Institutional (e.g., universities, schools)
- Other (e.g., public utilities, right-of-way, rivers, lakes, parks, etc.)

The Mecklenburg County Geospatial Information Services (GIS) office makes available GIS shapefiles to plot the parcels, thus allowing merging information from other sources.[25] In addition, the GIS office provides public access to a variety of land-use GIS shapefiles that are used to augment the parcel dataset for subsequent empirical analysis.

The Gold Line SIA map was superimposed on the parcel layers to identify the parcels located within 0.5 miles of the streetcar stations. Figure 5-16 shows the location of 4,300 parcels (as of 2016 tax roll), highlighting residential, commercial, and industrial land uses. The map outlines the split caused by Interstate 277 that divides the downtown area from the eastern portion of the SIA, where most health clinics and residential parcels are concentrated.

Figure 5-16

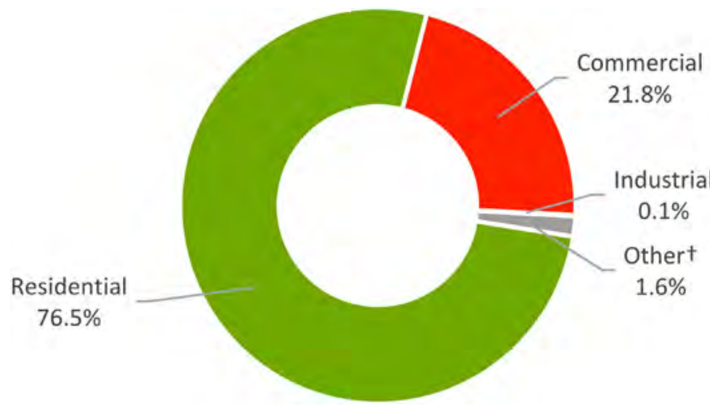
Parcels by Land Use – Charlotte CityLYNX Gold Line

[25] http://maps.co.mecklenburg.nc.us/openmapping/data.html.

Figure 5-17 shows the property type breakdown in the SIA, and includes public utilities, government, religious, and natural resources.

Figure 5-17

Parcel Counts by Property Type, Charlotte CityLYNX Gold Line – 2016

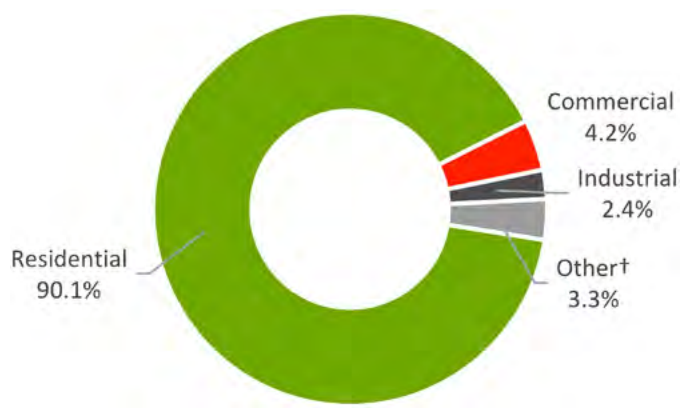


†Includes public utilities, government, religious, natural resources.

Figure 5-18 shows the property type breakdown in Mecklenburg county. The breakdown is based on the the database property land use code contained in the "Tax Parcel" file. The database was purged of redundant parcels, based on the sorting of the "Taxpid" variable, which represents a unique parcel identifier. The share of residential parcels in the SIA (76.5%) is substantially lower than the rest of the county (90.1%). This is because of a larger concentration of commercial properties within the SIA (21.8%) than in the remainder of the county.

Figure 5-18

County Parcel Counts by Property Type, Mecklenburg County (NC) – 2016



†Includes public utilities, government, religious, natural resources.

Table 5-8 and Table 5-9 report historical parcel counts and total parcel acreage by major land-use types for the period 2007–2016. Residential parcels increased by 416 units during this period (15.7%); commercial parcels did not show substantial growth. Use of the land-use code variable to identify commercial properties (code C700) defines a general category that includes parcels whose buildings include of a broad set of uses, such as government, retail, hotel, office, wharehouse, and other uses. When analyzing commercial properties in detail, a later section employs building categories (variable *cdebuldin* indicating building type).

Table 5-8 *Parcel Counts – Charlotte CityLYNX Gold Line*

Property Type	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Residential	2,645	2,823	3,014	3,044	2,954	2,953	2,957	3,030	3,060	3,061
Commercial	869	936	904	902	914	918	915	927	895	872
Industrial	4	4	4	4	4	4	4	4	3	3
Other†	269	145	65	69	69	64	69	71	63	66
Total	*3,787*	*3,908*	*3,987*	*4,019*	*3,941*	*3,939*	*3,945*	*4,032*	*4,021*	*4,002*

†Includes government, utilities, religious, education and miscellaneous uses, and new parcels (land use code "NEW).

Table 5-9 *Parcel Acreage – Charlotte CityLYNX Gold Line*

Property Type	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Residential	1,593.5	1,594.6	2,504.8	2,541.1	2,442.0	2,443.1	2,442.5	2,411.0	2,411.0	2,411.9
Commercial	558.4	910.2	596.7	600.3	610.3	612.0	609.9	619.2	600.7	595.6
Industrial	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	0.9	2.8
Other†	52.8	567.4	54.4	56.6	54.5	56.5	58.9	55.5	42.3	41.2
Total	*2,205.8*	*3,073.3*	*3,157.1*	*3,199.2*	*3,108.1*	*3,112.8*	*3,112.5*	*3,086.9*	*3,054.9*	*3,051.5*

†Includes townhouse and condominium common areas.

During 2007–2016, acreage dedicated to residential uses increased by about 818 acres (51.4%), and commercial parcel acreage increased by about 37 acres (6.7%). In 2008, the database shows a substantial increase in the number of commercial parcels and acreage. The category defined as "other" includes new parcels (as categorized by the land-use code "NEW" in the parcel database). In 2009, the acreage increase was allocated to new residential parcels.

Residential Properties

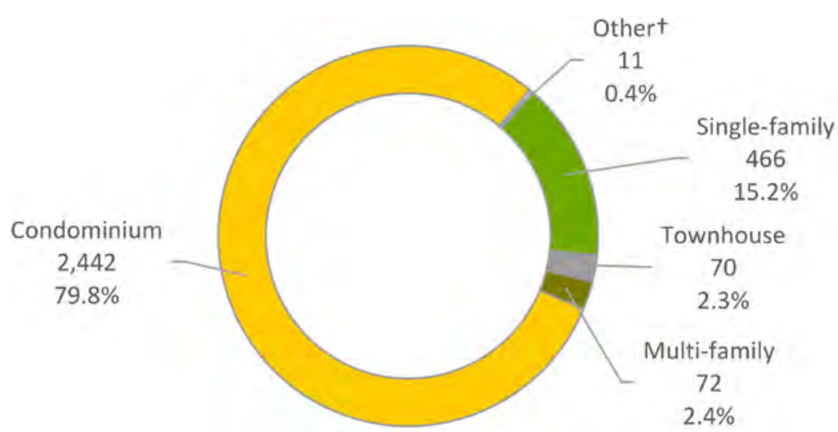
As of 2016, there were 3,061 residential parcels in the SIA, with most single-family properties clustered in the southern portion of Charlotte CBD (Figure 5-19). Condominium parcels were located in the northern area of the SIA (North of Tyron Street). Figure 5-20 shows that as of 2016, condominium parcels represented 79.8 percent of total parcels, followed by single-family (15.2%) parcels.

Figure 5-19

Map of Residential Parcels – Charlotte CityLYNX Gold Line

Figure 5-20

Residential Parcels, Charlotte CityLYNX Gold Line– 2016



†Includes townhouse and condominium common areas.

Parcel type fluctuated through the years, as indicated by the number of residential parcel counts displayed in Table 5-10 and residential parcel acreage in Table 5-11. During 2007–2016, the number of single-family parcels increased by 10 percent, with the largest increases occurring during the last two years. The number of condominium parcels significantly increased (18.0%), with the largest growth experienced between 2007–2010. The growth over this period in condominium parcels is coupled with a substantial increase in acreage (55.8%). The number of multi-family parcels remained constant.

Table 5-10 *Residential Parcel Counts – Charlotte CityLYNX Gold Line*

Parcel Type	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Single-family	424	424	423	425	424	423	430	436	464	466
Townhouse	70	69	70	72	71	71	70	71	71	70
Multi-family	71	72	73	78	77	77	76	76	73	72
Condominium	2,070	2,249	2,439	2,462	2,375	2,375	2,374	2,440	2,442	2,442
Other†	10	9	9	7	7	7	7	7	10	11
Total	*2,645*	*2,823*	*3,014*	*3,044*	*2,954*	*2,953*	*2,957*	*3,030*	*3,060*	*3,061*

† Includes townhouse and condominium common areas.

Table 5-11 *Residential Parcels Acreage – Charlotte CityLYNX Gold Line*

Parcel Type	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Single-family	83.9	84.7	84.7	87.5	86.7	86.7	88.9	88.0	88.9	89.2
Townhouse	3.0	3.0	11.0	11.7	11.1	11.1	11.0	11.1	11.1	3.1
Multi-family	41.2	44.0	43.9	48.6	43.0	44.0	41.7	41.8	40.6	41.9
Condominium	1,460.3	1,461.2	2,363.6	2,392.3	2,300.2	2,300.2	2,299.8	2,269.0	2,268.3	2,275.7
Other†	5.1	1.7	1.7	1.1	1.1	1.1	1.1	1.1	2.0	2.0
Total	*1,593.5*	*1,594.6*	*2,504.8*	*2,541.1*	*2,442.0*	*2,443.1*	*2,442.5*	*2,411.0*	*2,411.0*	*2,411.9*

† Includes townhouse and condominium common areas.

Table 5-12 reports average annual property values for the SIA, which reflect the Property Appraiser's market evaluation (i.e., assessed value). The appraised values have been adjusted by the Housing Pricing Index to report all dollar amounts in 2015 dollars. In 2016, residential parcels started showing signs of recovery from the real estate market crisis, in particular, single-family and condominium properties.

Table 5-12 *Residential Property Values – Charlotte CityLYNX Gold Line*

Parcel Type	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Single-family	210,331	209,388	213,330	241,088	321,009	332,294	241,353	295,629	276,813	278,534
Townhouse	194,521	200,089	210,078	215,932	292,681	294,134	269,818	265,903	250,659	247,019
Condominium	262,305	272,921	285,918	296,964	294,820	290,883	275,435	264,762	251,658	253,429

Figure 5-21 provides a historical perspective comparing assessed value trends in the SIA with the rest of the county and the control areas. The graphs show that single-family properties located in the SIA have higher values than comparable properties in the rest of the county and properties located in the control areas sharing similar neighborhood characteristics. Condominium prices experienced a rapid increase in market value preceding the crisis with average values greater than comparable parcels and the rest of the county. From these graphs, it is unclear whether the streetcar had a direct impact on the increase in land values, although, the empirical literature provides evidence of anticipated impacts of rail investments on residential property prices.

Figure 5-21 *Residential Properties Assessed Values, Charlotte CityLYNX Gold Line – 2007–2016*

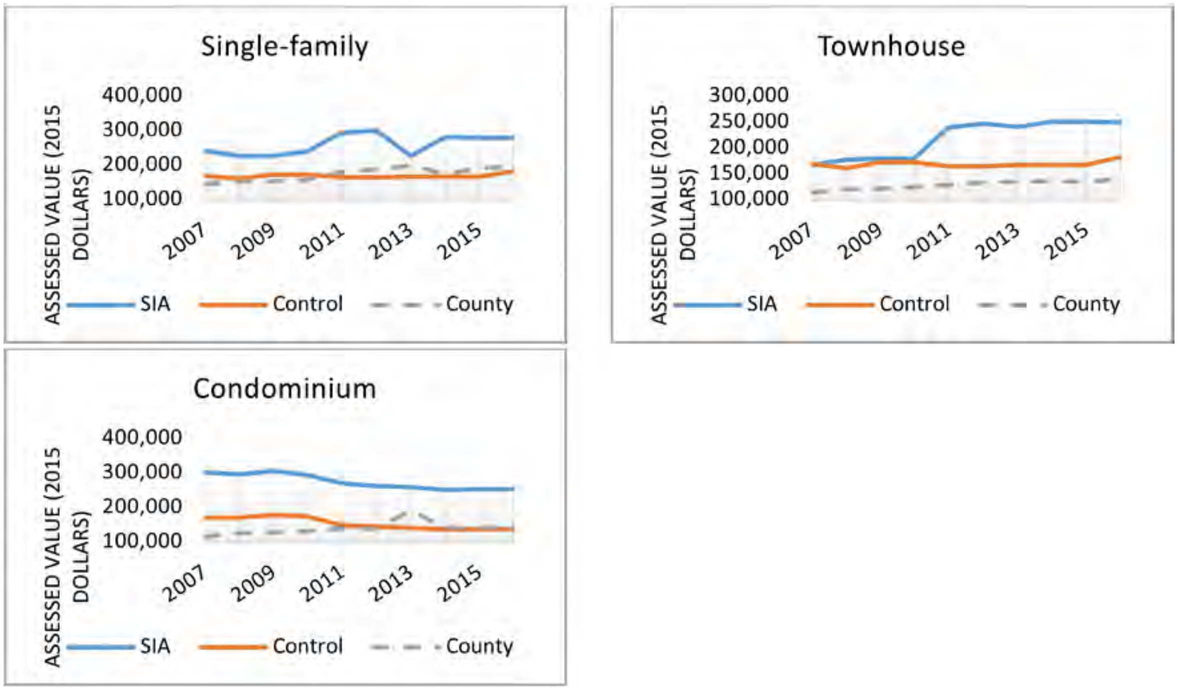


Figure 5-22 and Figure 5-23 provide spatial information about market values for residential properties, comparing 2007 (before streetcar announcement) to 2016 (opening phase). The maps employ the same appraised value ranges for the two-reference periods. Residential parcels include single-family, multi-family, and condominium properties. Figure 5 23 shows substantial increases in residential property values in 2016. The key question to ascertain is to what extent the value of these properties changed through time, and if knowledge of the streetcar project planning had an impact on property prices, either by increasing value of similar properties located outside the SIA or through market value preservation in response to loss of value caused by the real estate market crisis.

Figure 5-22

Residential Property Values, Charlotte CityLYNX Gold Line – 2007

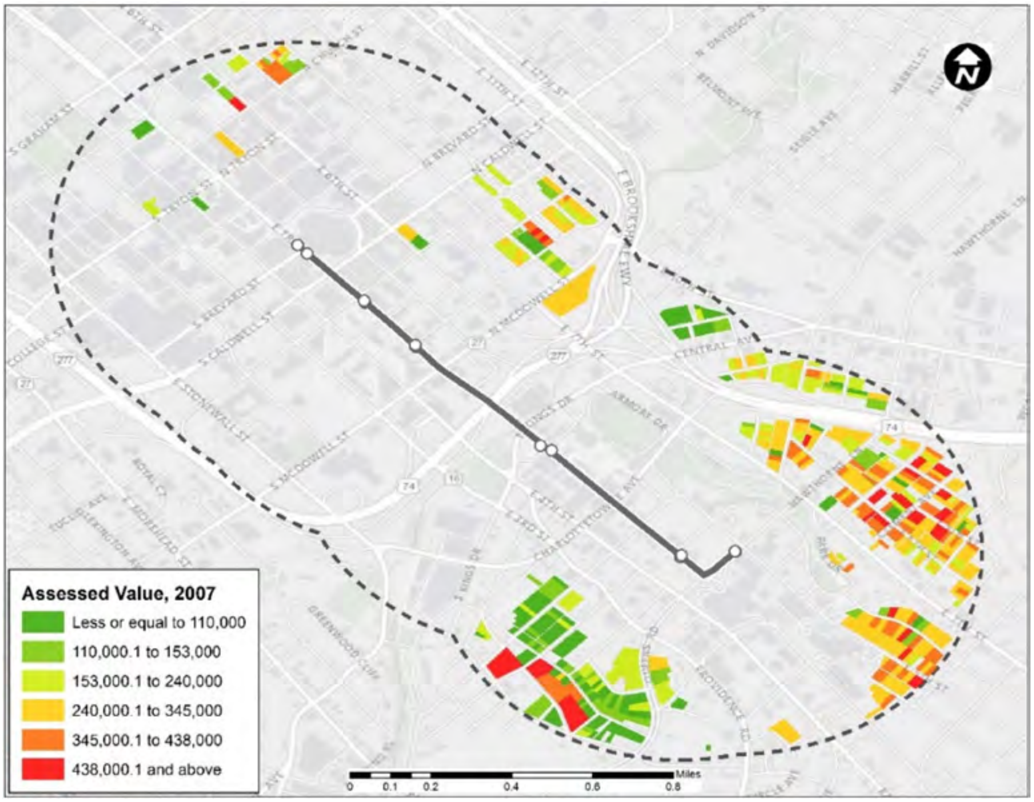
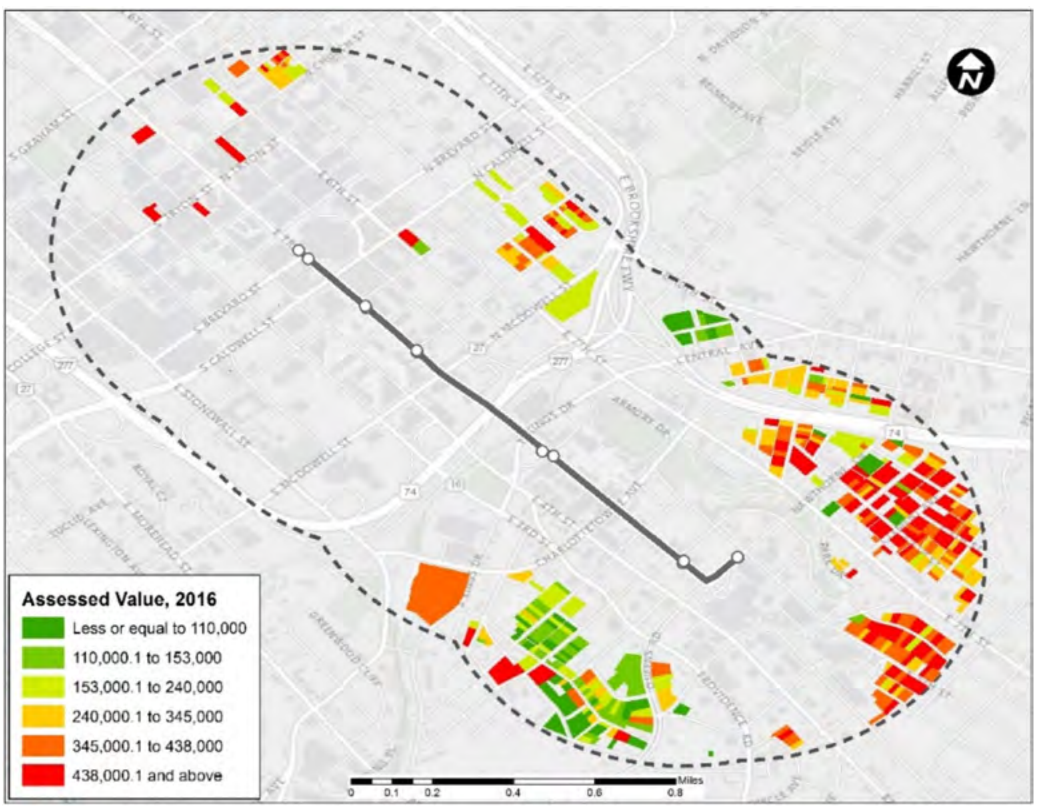


Figure 5-23

Residential Property Values, Charlotte CityLYNX Gold Line – 2016



Commercial Properties

As of 2016, the SIA was home to about 2,000 businesses. Figure 5-24 shows commercial properties, which include all parcels where business units are located. Businesses include commercial establishments, restaurants, shops, shopping centers, department stores, and food stores. Commercial parcels are located in the CBD core and along the streetcar route on Elizabeth Avenue. As of 2016, there were 531 commercial parcels totaling 94.1 acres. The total number of parcels and the breakdown are based on the use of any structure present in the parcel.[26]

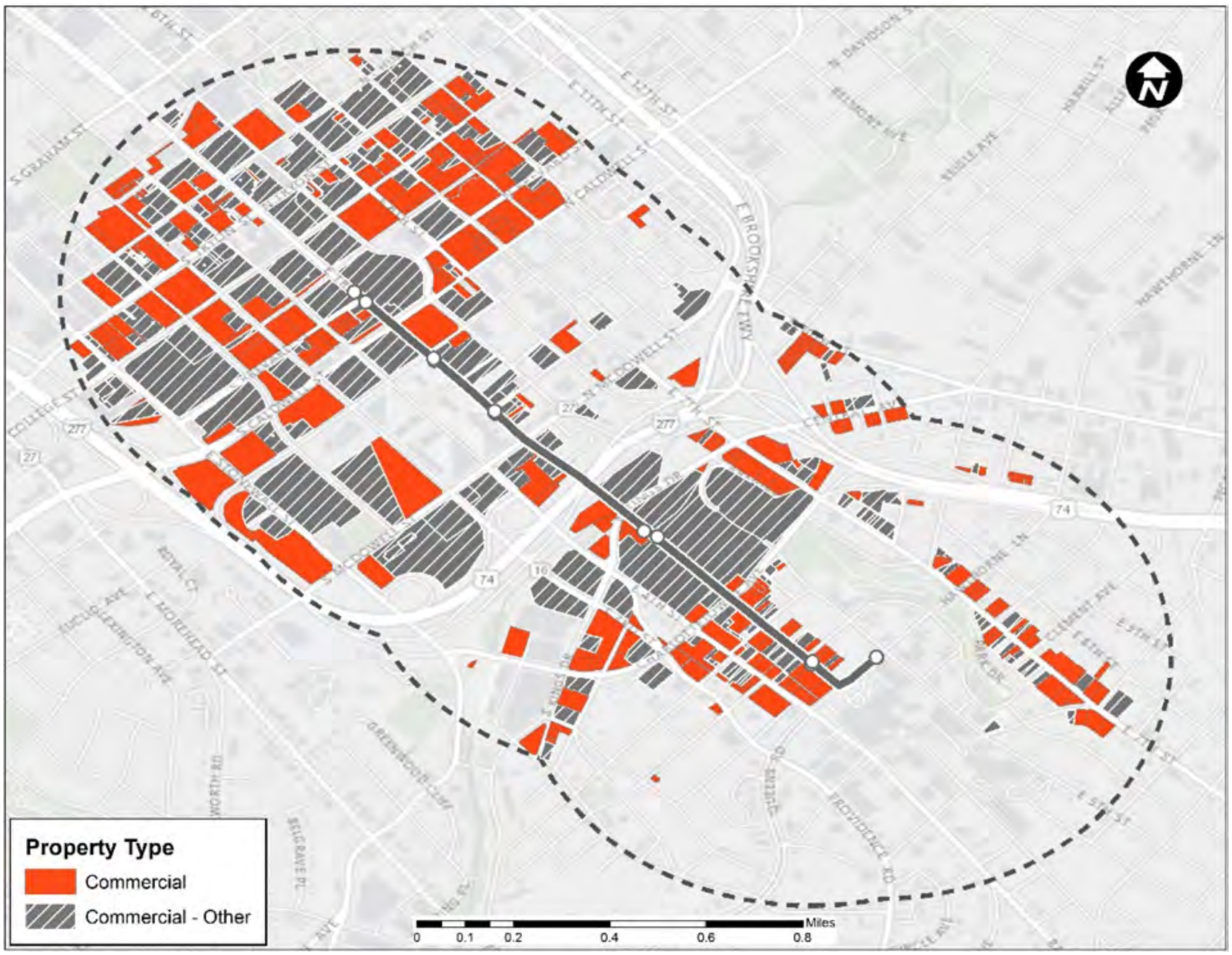


Figure 5-24 *Map of Commercial Parcels, Charlotte CityLYNX Gold Line*

Figure 5-25 reports the breakdown by property type (2016 tax roll) of the 531 commercial parcels. About 390 parcels (74.0%) are used for offices, which include medical, banking, and savings institutions. Retail establishments represent

[26] Breakdown is based on the variable "*cdebuildin*" included in the tax parcel file and only accounts for parcels with a structure.

10.4 percent of the total and occupy 7.4 acres (about 7.9% of total commercial acreage).

Looking at the historical trends presented in Table 5-13 and Table 5-14, parcels dedicated to office space increased in number and total acreage during 2007-2016.[27] Comparing 2016 to 2007, retail and restaurant parcels increased slightly in number. Hotel parcels increased in number (15.4%), but decreased in acreage by 0.5 acre (-9.8%).

Figure 5-25

Commercial Parcels Breakdown, Charlotte CityLYNX Gold Line

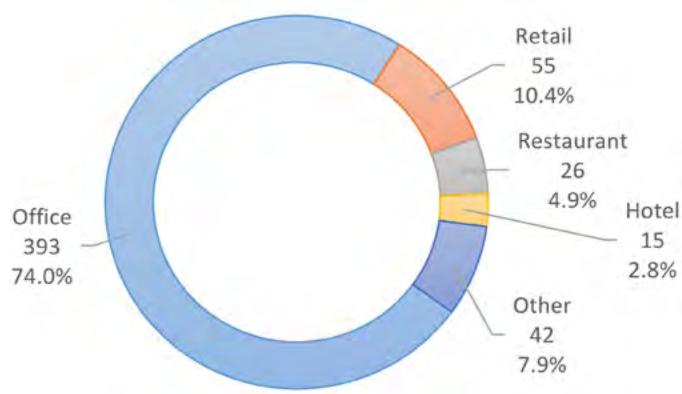


Table 5-13 *Commercial Parcel Counts – Charlotte CityLYNX Gold Line*

Parcel Type	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Office	351	378	386	390	387	392	391	398	394	393
Retail	54	51	51	51	61	62	61	61	56	55
Restaurant	23	22	23	24	24	23	23	25	26	26
Hotel	13	13	13	11	12	12	12	14	13	15
Other	24	32	46	52	47	50	49	49	42	42
Total	*465*	*496*	*519*	*528*	*531*	*539*	*536*	*547*	*531*	*531*

Table 5-14 *Commercial Parcels Acreage – Charlotte CityLYNX Gold Line*

Parcel Type	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Office	54.4	55.0	53.9	56.1	58.7	55.0	61.3	62.6	60.4	64.5
Retail	6.9	5.2	5.8	5.8	7.9	6.0	8.0	7.6	8.9	7.4
Restaurant	5.9	5.8	5.6	5.6	5.6	4.0	5.6	6.0	6.3	6.3
Hotel	5.1	5.1	5.1	4.5	4.9	4.0	5.6	5.6	3.5	4.6
Other	13.9	13.8	14.3	14.3	11.7	14.0	14.1	14.0	12.1	11.3
Total	*86.2*	*85.0*	*84.7*	*86.3*	*88.9*	*83.0*	*94.6*	*95.8*	*91.2*	*94.1*

[27] Totals in table are smaller than those in Table 5-9 because they comprise only parcels with a structure.

Figure 5-26 shows historical trends in mean assessed value for occupied parcels, comparing the study area to the rest of the county and to similar properties (controls). SIA parcels are located in the core of Charlotte's CBD and location premia result in relatively higher values.

Figure 5-26

Commercial Property Values – Charlotte CityLYNX Gold Line

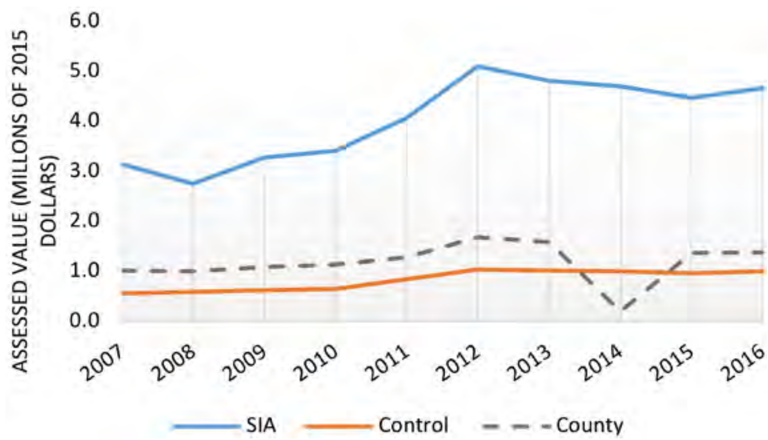


Figure 5-27 and Figure 5-28 illustrate the appraised valued for 2007 and 2016, showing clustering of commercial parcels in downtown Charlotte. Most notably, properties located on Elizabeth Avenue along the streetcar route show increases in assessed values.

Figure 5-27

Map of Commercial Property Values, Charlotte CityLYNX Gold Line – 2007

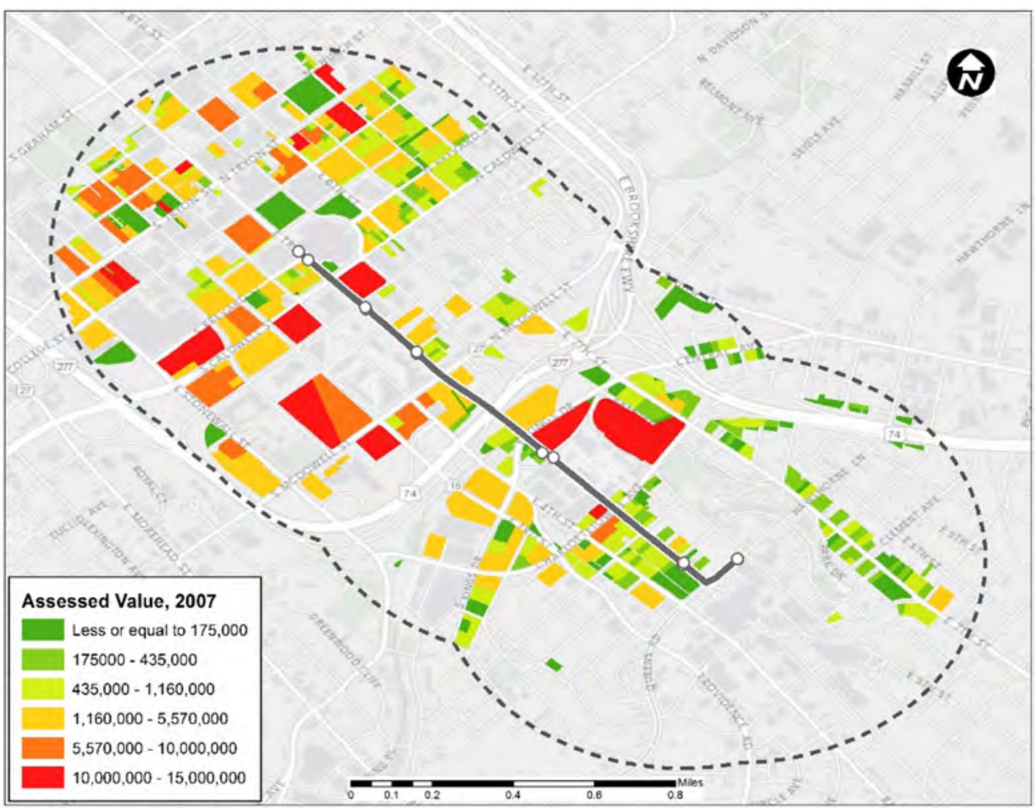
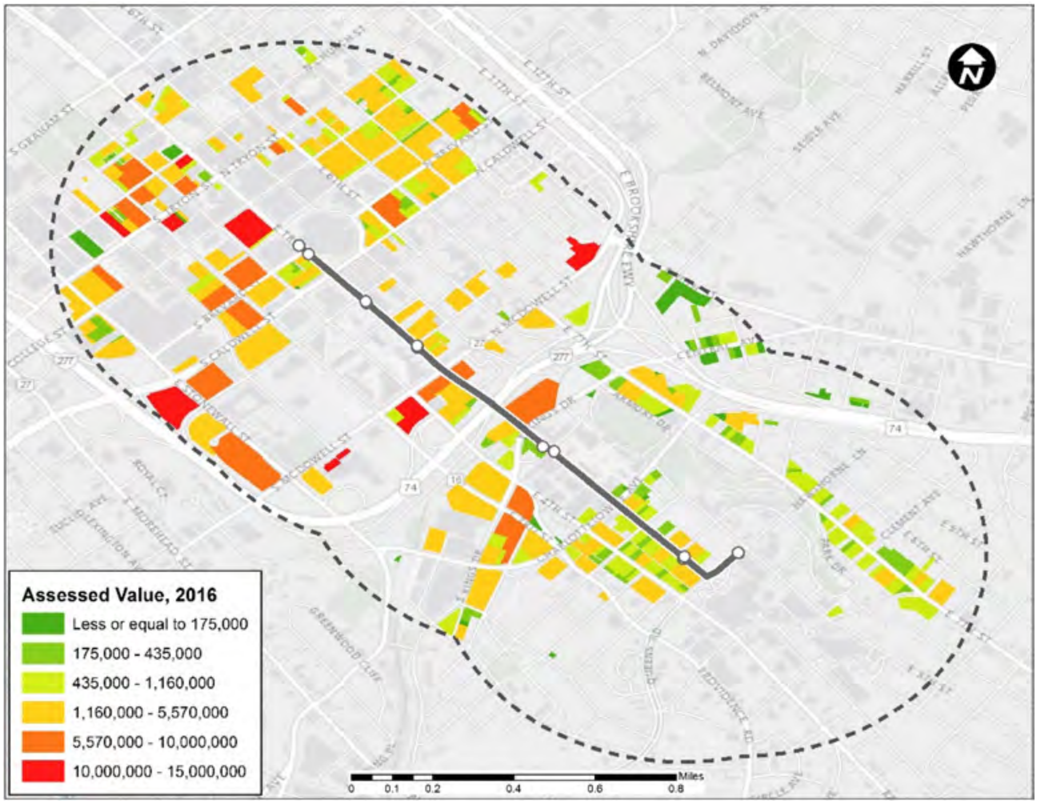


Figure 5-28

Map of Commercial Property Values, Charlotte CityLYNX Gold Line – 2016



Vacant Properties

The Charlotte Mecklenburg Property Appraiser database does not have a field that explicitly identifies vacant parcel by land use. There is only one field that allows identifying a change from vacant to improved at time of sales. Due to this constraint, this study does not include vacant parcels.

Sun Link Tucson Streetcar

The analysis is based on data from the Pima County Assessor's Office, which provides current tax roll and property sales data.[28] The Assessor conducts yearly assessments of all real and tangible personal property in Pima County. The tax roll data provide detailed parcel information, including parcel size, building size and structural characteristics, tax assessor estimated value, and price and date of property sales transactions. The Assessor adopts a market approach to value residential properties. In this approach, value is estimated by comparing sales and adjusting them for differences in characteristics to indicate a value for the subject property. In a single-property appraisal, typically 3–5 comparables are used to determine a value for the subject property.

[28] http://www.asr.pima.gov/links/resinfo.aspx#noticeinfo.

The tax roll datasets contain a land use code, which allows creating property-type categories for subsequent analysis:

- Residential (vacant, single-family, multi-family, condominium, other)
- Commercial
- Industrial
- Government (federal, state, and local)
- Institutional (i.e., UAZ)
- Other (public utilities, right-of-way, rivers, lakes, parks, etc.)

The Pima County Geographic Information Systems (GIS) office provides GIS shapefiles to plot the parcels, thus allowing merging information from other sources.[29] In addition, the GIS office provides public access to a variety of land-use GIS shapefiles that are used to augment the parcel dataset for subsequent empirical analysis.

The SIA map was superimposed on the parcel layers to identify the parcels located within 0.5 miles of the streetcar stations. Figure 5-29 shows the location of 5,964 parcels (as of 2016 tax roll), highlighting residential, commercial, and industrial land uses. The map outlines the divide caused by Interstate 10 that splits the downtown area from the western portion of the SIA, where the Mercado San Augustin development and most of the area vacant commercial and residential parcels are located. The map shows a large number of parcels labeled as education, because the UAZ main campus is located on the northern portion of the streetcar line.

Figure 5-30 shows the 2016 property type breakdown in the SIA, and includes public utilities, government, education, religious, natural resources.

[29] http://webcms.pima.gov/cms/one.aspx?portalId=169&pageId=25365.

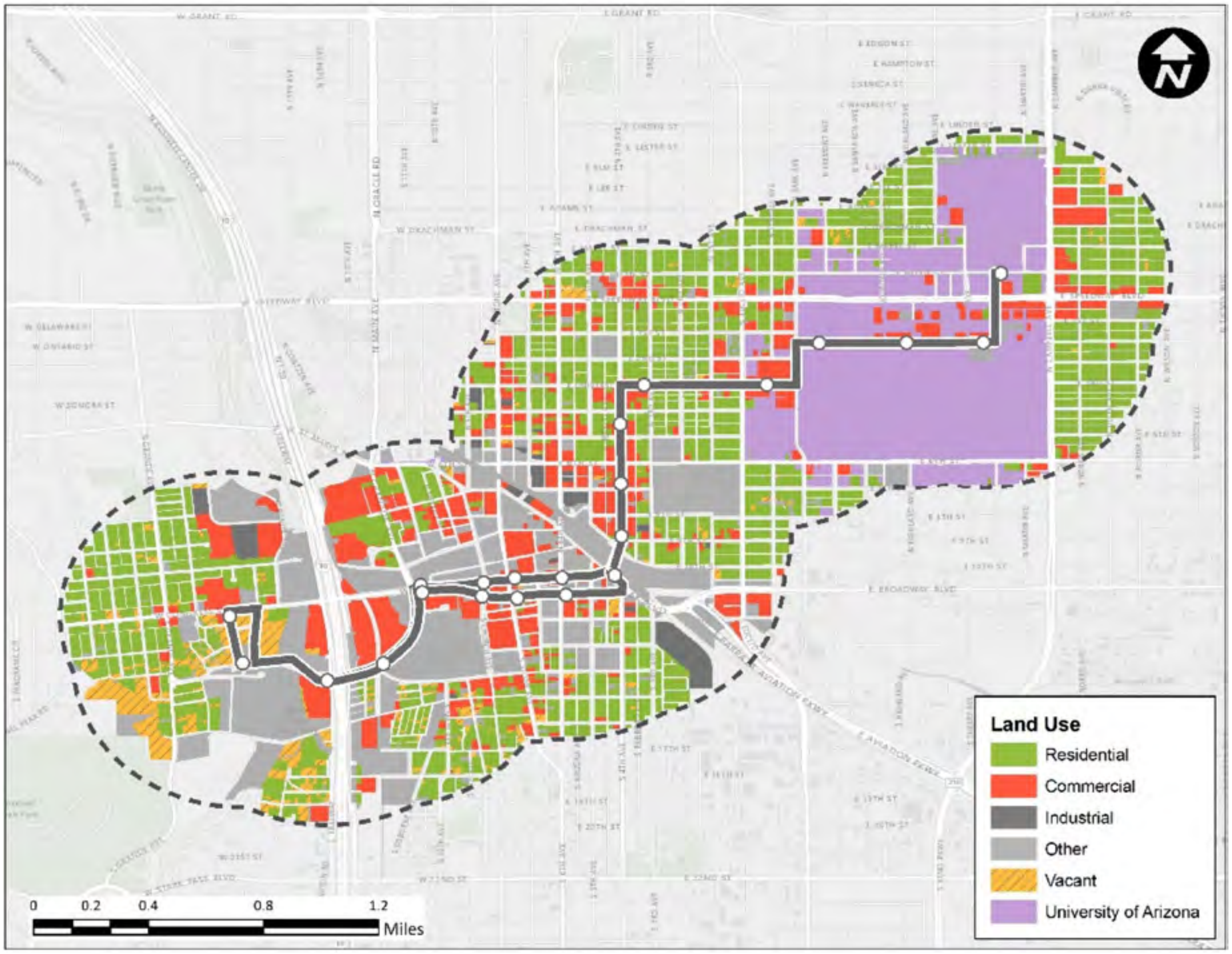
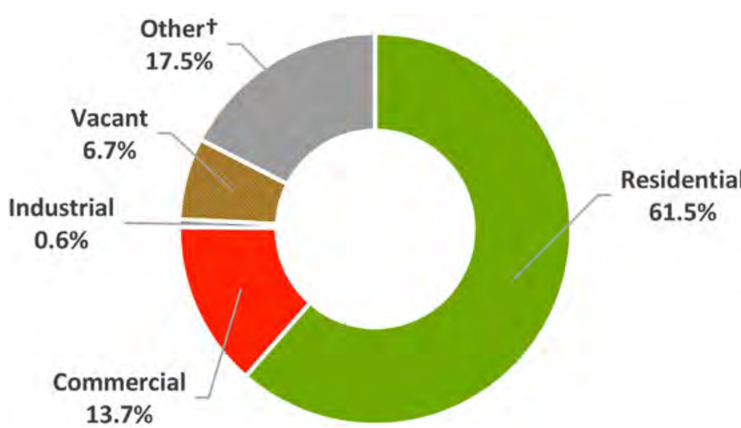


Figure 5-29 *Parcels by Land Use – Sun Link Tucson Streetcar*

Figure 5-30

Parcel Counts by Property Type – Sun Link Tucson Streetcar – 2016

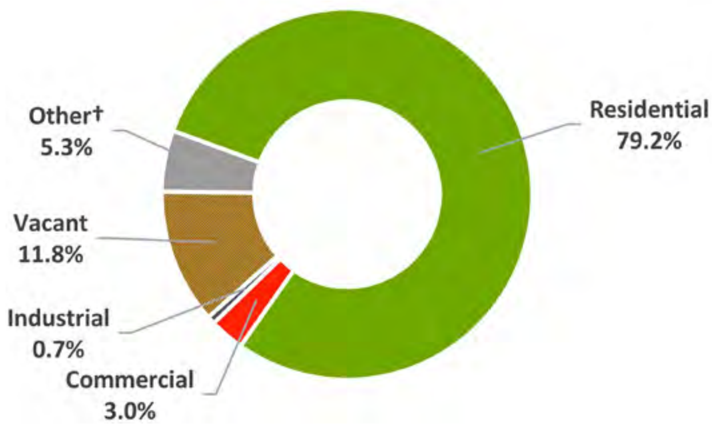


†Includes public utilities, government, education, religious, natural resources.

Figure 5-31 shows the 2016 property type breakdown in the county. The share of residential parcels in the SIA (61.5%) is lower than the rest of the county (79.2%). This is because of the larger concentration of commercial (13.7%) and government and other properties (17.5%) within the SIA, a characteristic of the Tucson CBD.

Figure 5-31

Parcel Counts by Property Type, Pima County (AZ) – 2016



†Includes public utilities, government, education, religious, natural resources.

Table 5-15 and Table 5-16 report historical parcel counts and total parcel acreage by major land-use types for the period 2007–2016. Residential parcels increased by 112 units during this period, following the Appraiser's conversion of vacant parcels for other land-uses to residential. Commercial parcels are characterized by consistent growth throughout the period, with an overall increase of 115 parcels (16.7%) and a 26.8 percent increase in acreage (78.3 acres). On the other hand, the number of industrial parcels decreased by 19.6, percent reducing total acreage to 32.2 acres. The number of vacant parcels decreased by 259 units and total vacant parcel acreage declined by 17.1 acres or 18.5 percent.

Table 5-15 *Parcel Counts – Sun Link Tucson Streetcar*

Property Type	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Residential	3,627	3,637	3,720	3,755	3,728	3,727	3,703	3,712	3,722	3,739
Commercial	690	699	695	779	789	812	815	828	828	805
Industrial	46	51	50	54	55	54	44	39	39	37
Vacant	557	562	567	586	584	415	446	429	408	298
Other†	1,265	1,232	1,245	1,102	1,124	1,086	1,052	1,054	1,058	1,085
Total	*6,185*	*6,181*	*6,277*	*6,276*	*6,280*	*6,094*	*6,060*	*6,062*	*6,055*	*5,964*

†Includes public utilities, government, religious, natural resources.

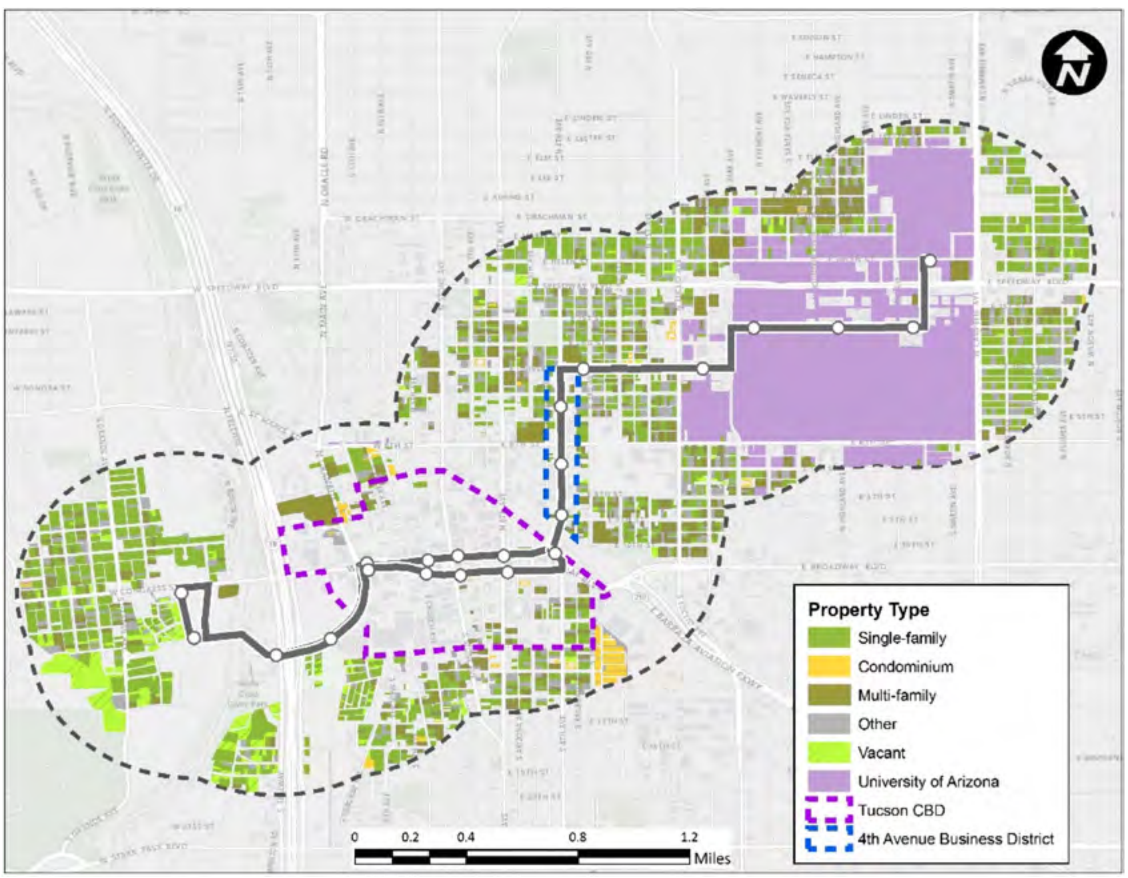
Table 5-16 *Parcel Acreage – Sun Link Tucson Streetcar*

Property Type	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Residential	606.4	609.4	599.0	609.1	602.9	599.7	602.5	604.8	608.6	610.8
Commercial	213.6	225.5	219.5	275.8	268.0	280.6	283.9	281.3	295.1	291.9
Industrial	33.0	34.9	34.5	35.4	35.4	37.1	32.3	31.1	31.1	32.3
Vacant	92.8	80.1	81.6	87.2	87.9	74.7	79.7	76.8	81.2	75.7
Other†	823.3	824.1	829.4	759.0	776.0	777.8	767.7	777.3	756.5	767.8
Total	*1,769.1*	*1,774.0*	*1,764.1*	*1,766.5*	*1,770.1*	*1,769.8*	*1,766.1*	*1,771.3*	*1,772.6*	*1,778.4*

†Includes public utilities, government, religious, natural resources.

Residential Properties

As of 2016, there were 3,739 residential parcels in the Sun Link SIA, with most single-family properties clustered primarily around UAZ, the southern portion of Tucson CBD, and the western end of the streetcar system.



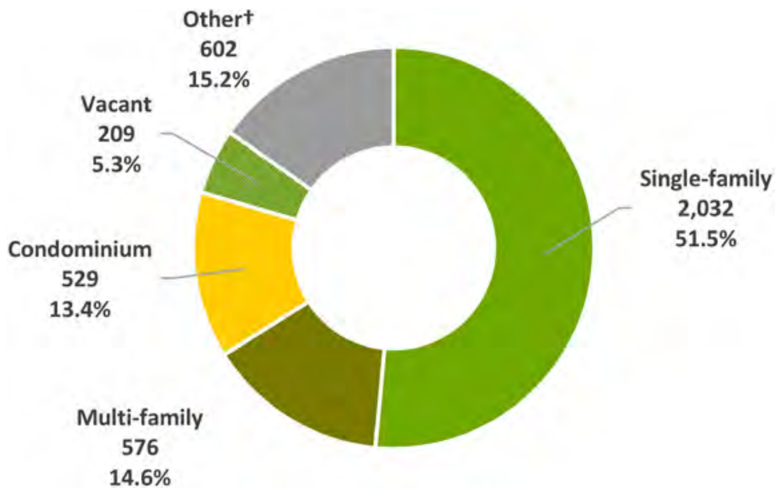
†Includes duplex, triplex, fourplex, and mobile homes.

Figure 5-32 *Map of Residential Parcels – Sun Link Tucson Streetcar*

Figure 5-33 shows that single-family parcels represent 51.5 percent of the total, followed by multi-family (14.6%), condominium (13.4%), and other (15.2%) parcels, which consist of mobile homes and other structures. Vacant parcels make up 5.3 percent of the sample and are clustered south of the western portion of the SIA, in proximity of the Mercado San Augustin development.

Figure 5-33

Residential Parcels, Sun Link Tucson Streetcar – 2016



†Includes duplex, triplex, fourplex, and mobile homes.

The distribution of residential parcels by type fluctuated through the years, as indicated by the number of residential parcel counts displayed in Table 5-17. During 2007–2016, the number of vacant parcels significantly decreased (-56.1%), while the number of condominium parcels increased by 26.3 percent, or about 110 units. The number of single-family parcels remained relatively constant.

Table 5-17 *Residential Parcel Counts, Sun Link Tucson Streetcar*

Property Type	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Single-family	2,082	2,134	2,123	2,106	2,073	2,024	2,016	2,014	2,021	2,032
Multi-family	657	595	592	604	600	597	592	588	589	576
Condominium	419	395	490	490	493	521	523	525	525	529
Vacant	476	483	486	496	493	338	344	344	331	209
Other†	469	513	515	555	562	585	572	585	587	602
Total	*4,103*	*4,120*	*4,206*	*4,251*	*4,221*	*4,065*	*4,047*	*4,056*	*4,053*	*3,948*

†Includes mobile homes, mobile home parks and other parcels categorized as residential.

Over the same period, vacant parcel acreage decreased by 18.2 acres, and parcels dedicated to condominiums increased 5.3 acres, an increase of 63.6 percent (Table 5-18).

Table 5-18 *Residential Parcels Acreage, Sun Link Tucson Streetcar*

Parcel Type	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Single-family	355.2	360.1	352.0	348.3	342.5	335.5	335.3	335.2	336.1	336.4
Multi-family	149.5	139.6	137.6	139.9	139.6	138.2	142.3	142.9	145.7	144.7
Condominium	8.4	8.0	10.7	10.7	10.7	13.2	13.3	13.5	13.5	13.7
Vacant	68.0	60.5	61.3	65.3	65.2	61.0	61.1	61.9	64.1	49.8
Other†	93.3	101.7	98.8	110.2	110.1	112.8	111.6	113.2	113.3	115.9
Total	*674.4*	*669.9*	*660.3*	*674.4*	*668.1*	*660.7*	*663.6*	*666.7*	*672.8*	*660.6*

†Includes mobile homes, mobile home parks and other parcels categorized as residential.

Table 5-19 reports average annual property values for the SIA, which reflect the Property Appraiser's market evaluation (i.e., assessed value). The appraised values have been adjusted by the Consumer Price Index (CPI) to report all dollar amounts in constant 2016 dollars. In 2016, residential parcels started showing signs of recovery from the real estate market crisis—in particular, single-family properties. Condominium mean values appear to be converging to pre-2009 levels.

Table 5-19 *Residential Property Values – Sun Link Tucson Streetcar*

Parcel Type	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Single-family	146,849	179,577	181,340	195,131	181,252	157,058	161,237	162,320	167,361	168,611
Multi-family	142,723	190,791	189,296	203,813	181,685	161,658	162,456	169,935	176,402	181,361
Condominium	96,367	116,959	103,227	113,330	107,092	100,000	105,593	109,299	96,755	112,816
Vacant	22,841	25,815	25,882	28,714	28,753	33,150	32,053	34,695	39,467	33,373
Other†	155,069	187,835	191,602	220,707	211,130	189,807	198,117	198,320	203,275	203,471

†Includes mobile homes, mobile home parks and other parcels categorized as residential.

Figure 5-34 provides a historical perspective comparing assessed value trends in the SIA with the rest of the county and the control areas. The graphs show generalized downward trends in value for the years following the real estate market crisis of 2008. On average, single-family properties located in the SIA have lower values than comparable properties in the rest of the county, but have higher values than properties located in the control areas sharing similar neighborhood characteristics. Starting in 2012, multi-family property values show an upward trend. Like single-family parcels, condominium prices experienced a rapid increase in market value preceding the crisis, and only recently are showing signs of recovery. Although residential vacant land prices in the entire county peaked in 2009 and declined after 2010, the SIA shows an upward trend that started at the streetcar Announcement phase (2010) and rapidly increased at the opening year (2014). From these graphs, it is unclear whether the streetcar had a direct impact on the increase in land values, although the empirical literature provides evidence of anticipated impacts of rail investments on residential property prices.

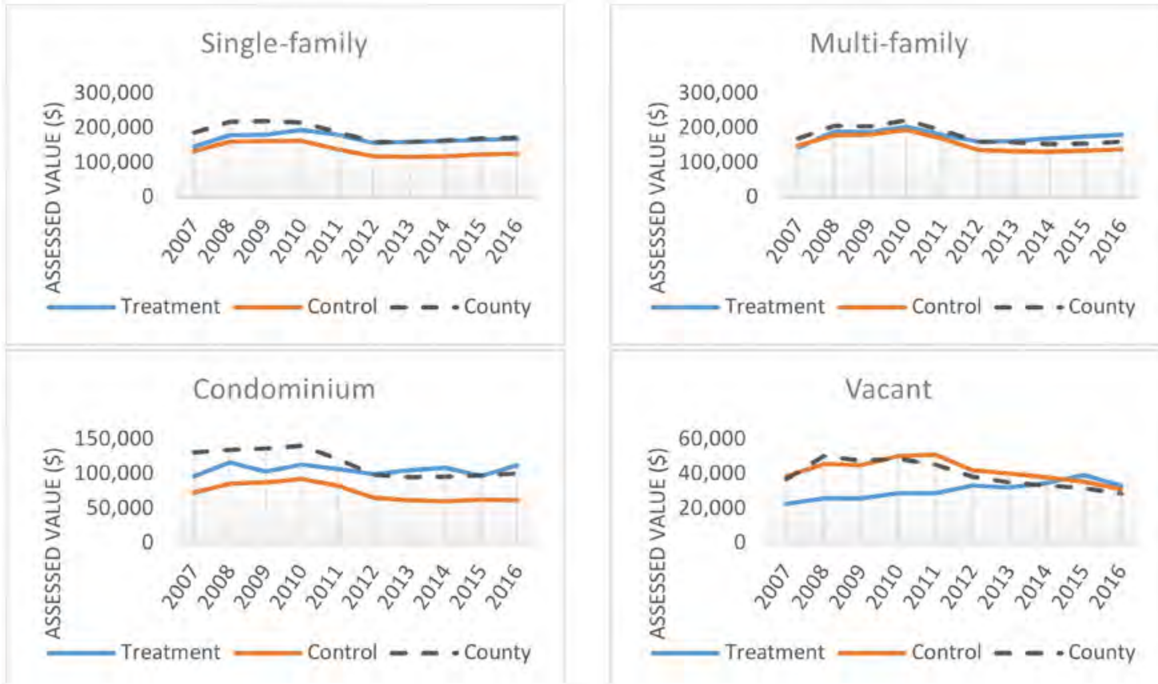


Figure 5-34 *Residential Assessed Values, Sun Link Tucson Streetcar – 2007–2016*

Figure 5-35 and Figure 5-36 display spatial information about market values for residential properties and compare 2007 (before streetcar announcement) to 2016 (opening phase). Residential parcels include single-family, multi-family, and condominium properties. These parcels are distributed over the entire study area, with clustering around the UAZ and the western portion. The maps employ the same appraised value ranges for the two reference periods. Parcels located around the North 4th Avenue/East 5th Street and the East University Boulevard/North 3rd Avenue stops show a marked increase in value. Properties located on the western portion of the SIA are characterized by lower average appraised values.

The key question to ascertain is to what extent the value of these properties changed through time, and whether knowledge of the streetcar project planning had an impact on property prices, either by increasing value of similar properties located outside the SIA or through market value preservation in response to loss of value caused by the real estate market crisis.

Figure 5-35

Map of Residential Property Values, Sun Link Tucson Streetcar – 2007

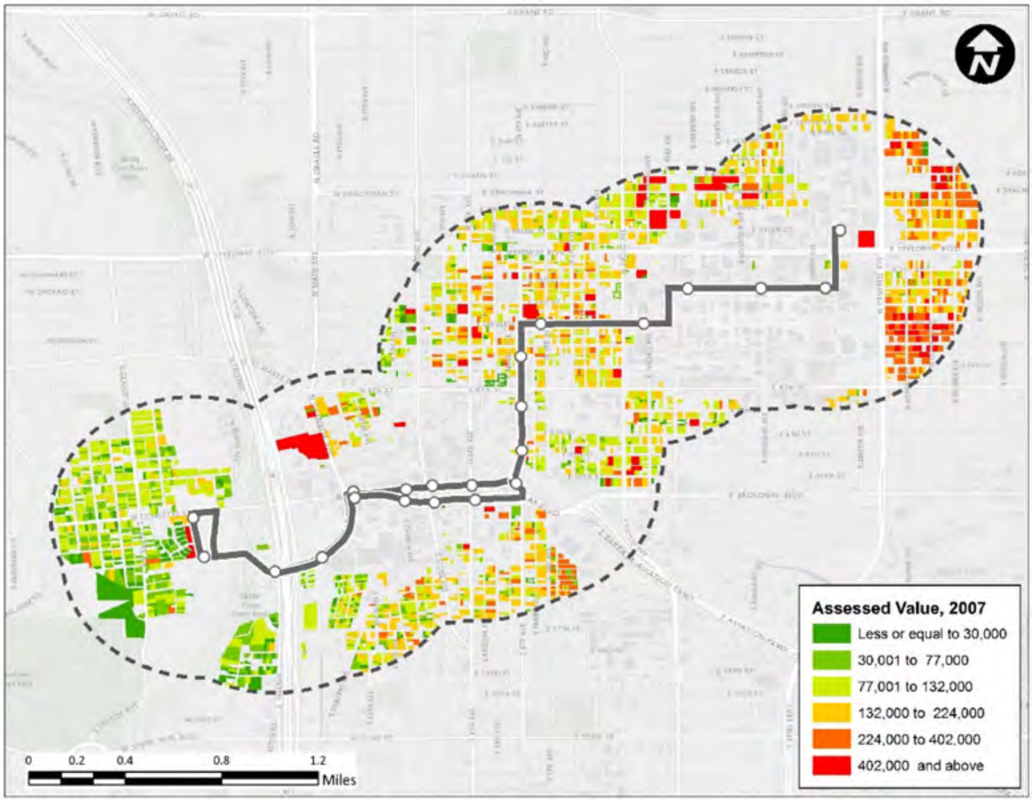
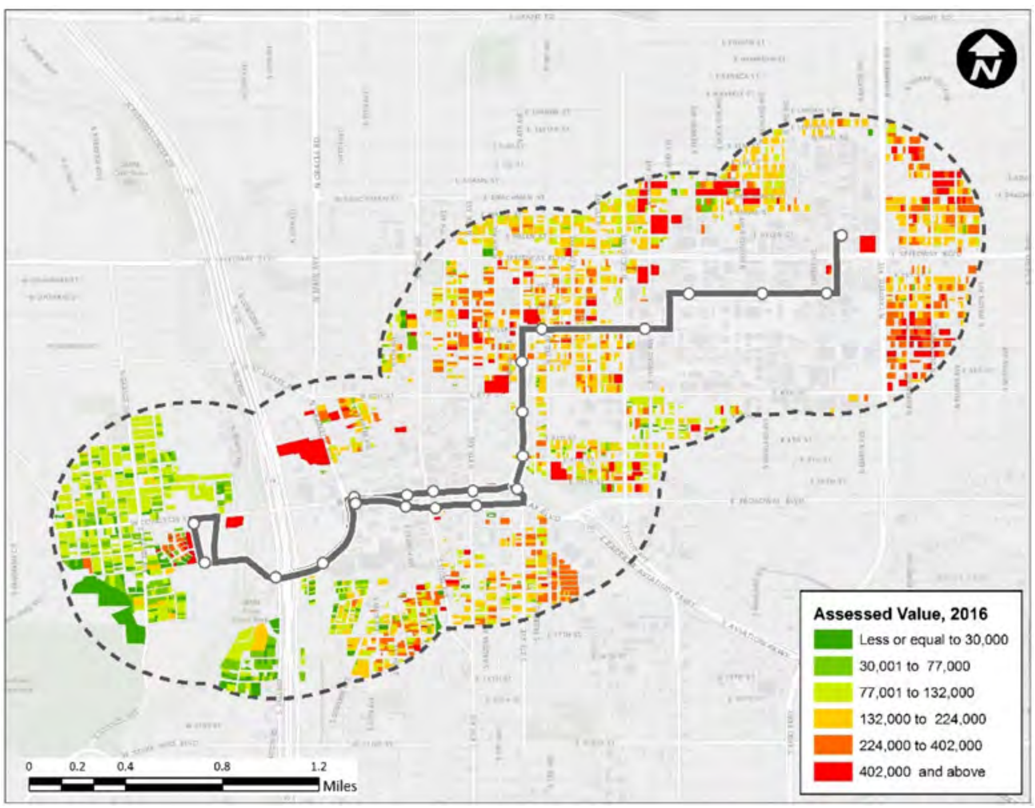


Figure 5-36

Map of Residential Property Values, Sun Link Tucson Streetcar – 2016



Commercial Properties

Figure 5-37 shows commercial properties in the SIA, including all parcels in which business units are located. Businesses include commercial establishments, restaurants, shops, shopping centers, department stores, and food stores. Due to their large representation, offices and hotels are reported separately. Commercial parcels are located in the CBD core, along the streetcar route, and in proximity to UAZ. In 2016, there were 805 occupied (291.9 acres) and 79 vacant (24.7 acres) commercial parcels.

Figure 5-37 *Map of Commercial Parcels – Sun Link Tucson Streetcar*

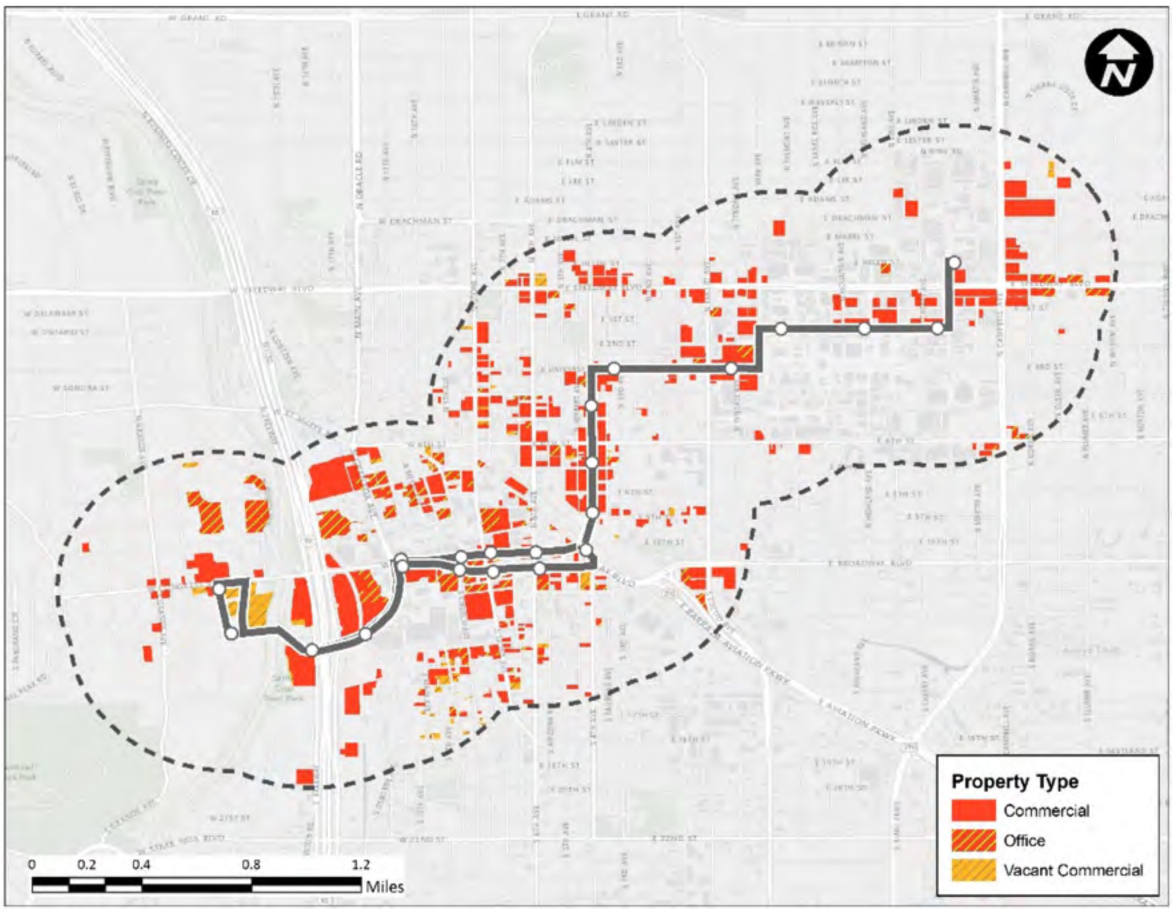
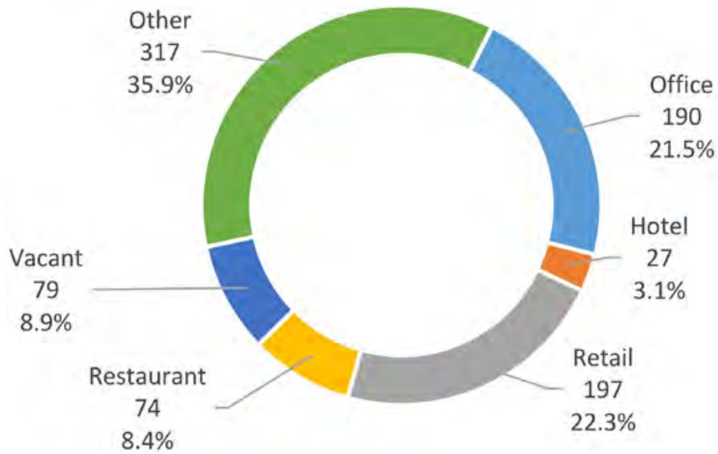


Figure 5-38 reports the breakdown by business category (2016 tax roll) of the commercial parcels. About 190 parcels are used for offices, which include medical, banking and savings institutions. Retail establishments represent 22.3 percent of the total and occupy 45.1 acres (about 14.3% of commercial acreage).

Figure 5-38

Commercial Parcels Breakdown – Sun Link Tucson Streetcar



Looking at the historical trends presented in Table 5-20 and Table 5-21, parcels dedicated to office space steadily increased in number and total acreage during 2007–2016, with an increase of 19.0 acres. Following a similar trend, parcels siting restaurants increased by 21 units (39.6%) and 3.4 acres (26.4%). The most marked reduction was experienced by retail, with a decrease of 46 parcels and 9.2 acres. Although the number of vacant parcels increased by 20 units, acreage decreased about 6.0 percent or 1.4 acres.

Table 5-20 *Commercial Parcel Counts – Sun Link Tucson Streetcar*

Parcel Type	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Office	146	154	158	173	175	171	179	189	187	190
Hotel	33	33	34	29	31	30	29	30	29	27
Retail	243	233	233	230	227	228	222	213	213	197
Restaurant	53	57	57	59	59	58	62	68	69	74
Vacant	59	58	60	69	71	63	75	71	63	79
Other	215	222	213	288	297	325	323	328	330	317
Total	*749*	*757*	*755*	*848*	*860*	*875*	*890*	*899*	*891*	*884*

Table 5-21 *Commercial Parcels Acreage – Sun Link Tucson Streetcar*

Parcel Type	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Office	47.3	44.9	46.5	53.3	54.8	58.3	61.1	66.2	68.3	66.3
Hotel	37.7	37.8	37.8	35.7	36.5	36.5	36.2	37.0	36.8	35.7
Retail	54.3	49.9	50.4	50.2	49.7	49.1	48.7	47.1	48.9	45.1
Restaurant	12.9	16.1	17.0	17.1	17.1	16.2	17.5	14.5	15.3	16.3
Vacant	23.3	18.3	18.8	20.3	21.3	12.7	16.3	13.5	15.6	24.7
Other	61.4	76.8	67.7	119.6	109.9	120.5	120.5	116.4	125.8	128.5
Total	*236.9*	*243.8*	*238.3*	*296.2*	*289.3*	*293.3*	*300.2*	*294.7*	*310.7*	*316.6*

Figure 5-39 shows historical trends in mean assessed value for occupied and vacant parcels, comparing the study area to the rest of the county and to similar properties (controls). SIA parcels are located in the core of Tucson's CBD and location premia result in relatively higher values. Although Pima County shows a generalized decrease in vacant property values in starting in 2014–2015, the SIA shows a marked increase in concurrence with the streetcar opening.

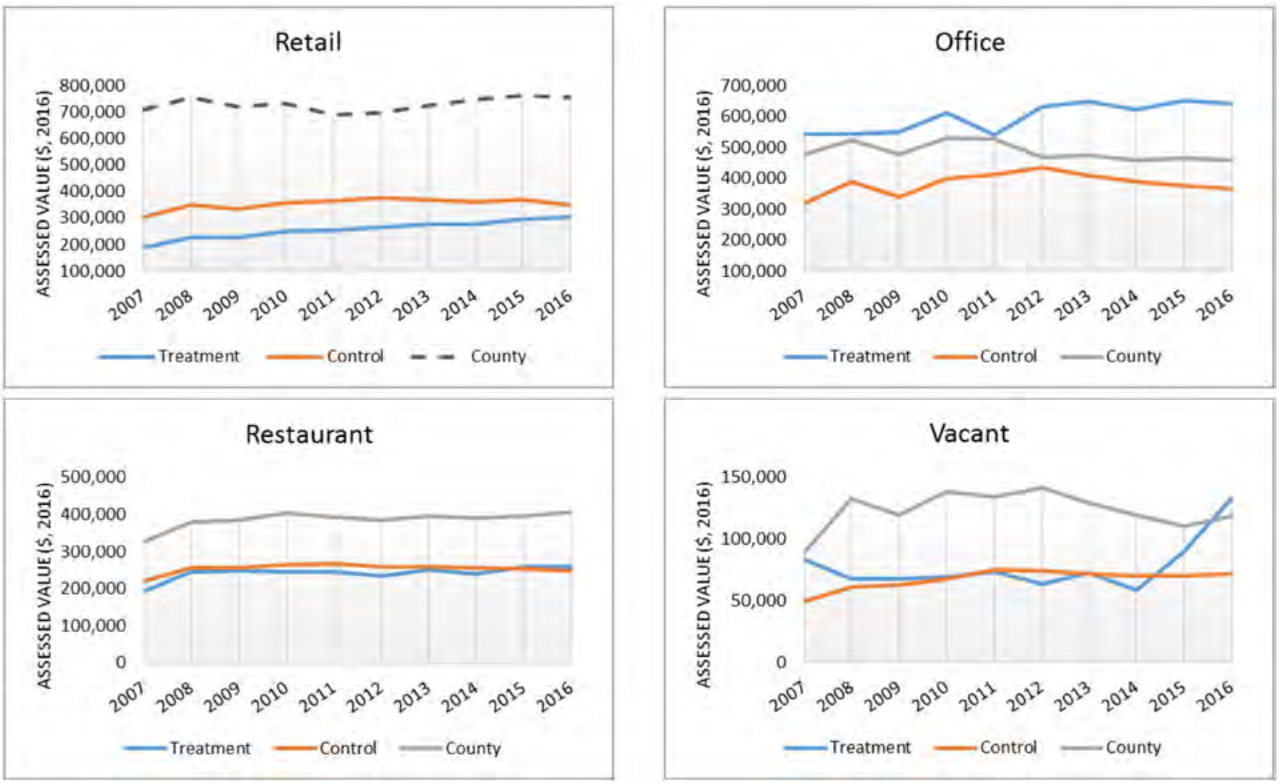


Figure 5-39 *Commercial Property Values – Sun Link Tucson Streetcar*

Figure 5-40 and Figure 5-41 illustrate the appraised valued for 2007 and 2016, showing clustering of commercial parcels in downtown Tucson, along the North 4th Avenue/East 5th Street and the East University Boulevard/North 3rd Avenue streetcar stops. The figures show that parcels in the CBD area tend to shift from yellow/orange in 2007 to orange/red in 2016, indicating an increase in property values.

Figure 5-40

Map of Commercial Property Values – Sun Link Tucson Streetcar – 2007

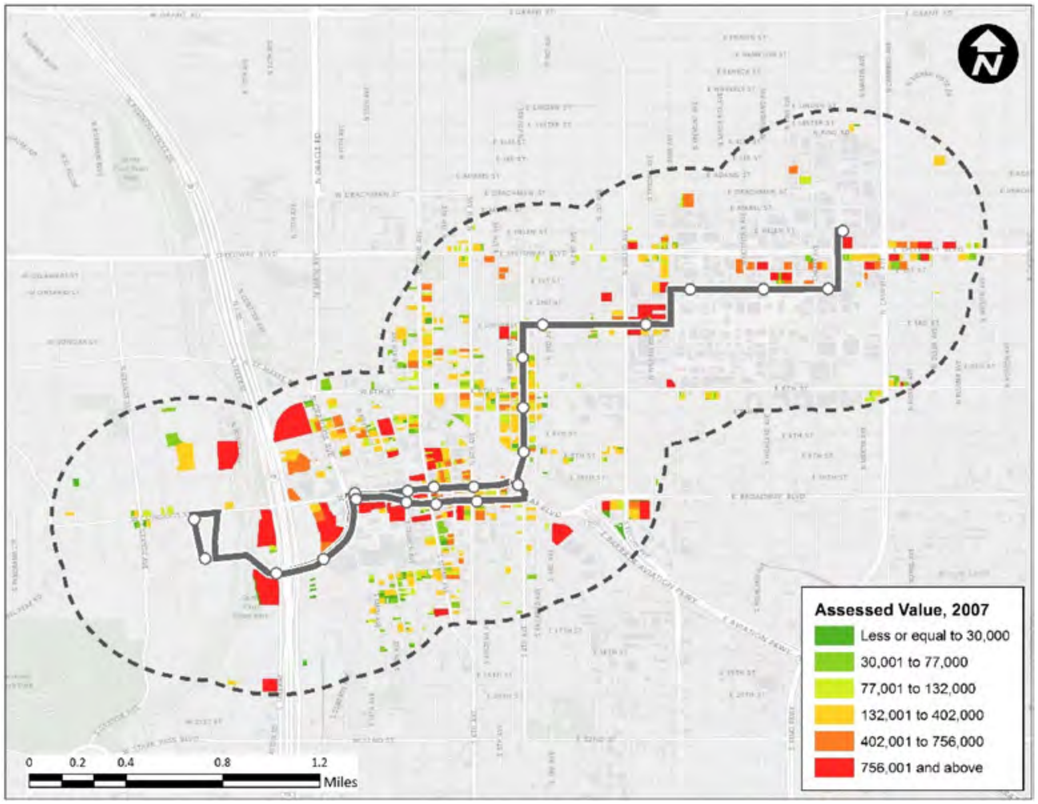
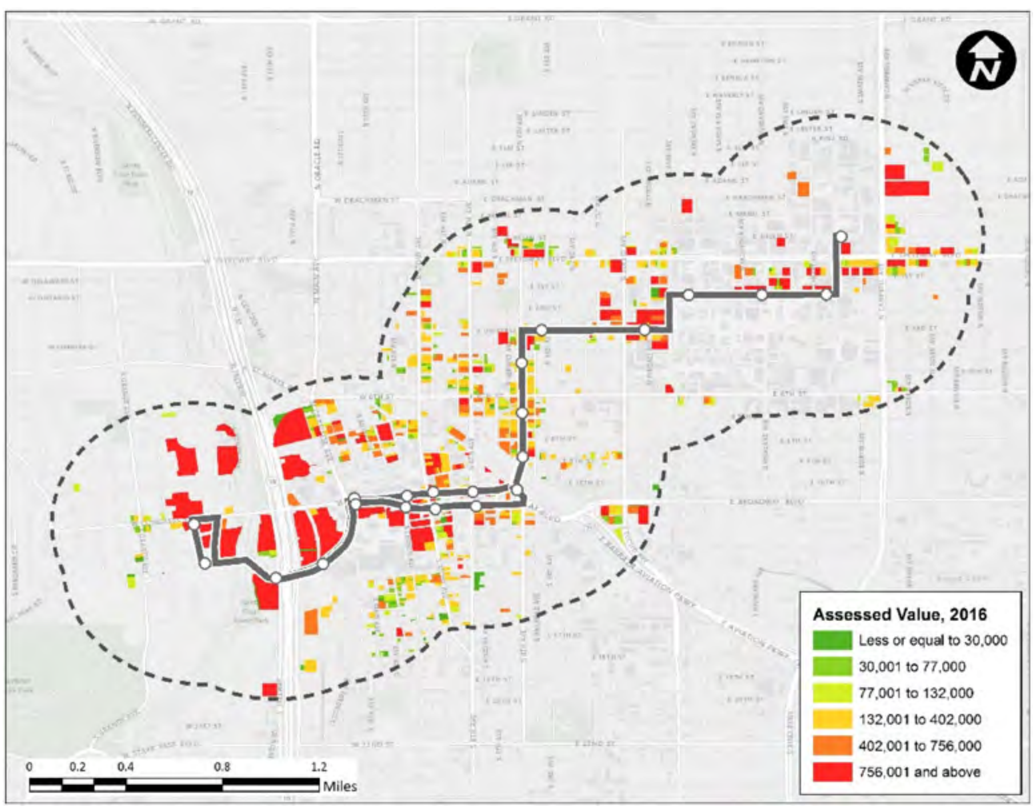


Figure 5-41

Map of Commercial Property Values – Sun Link Tucson Streetcar – 2016



Vacant Properties

In 2016, there were 298 vacant parcels, of which 209 (70.1%) were classified as Residential and 79 (26.5%) were classified as Commercial.

Vacant parcels are not uniformly distributed geographically but are clustered in the western portion of the SIA and in close proximity of the Mercado San Augustin area (Figure 5-42). The Mercado San Augustin is a public marketplace built in 2010 as part of Tucson's mixed-use transit oriented development planning and is part of the Rio Nuevo, a special taxing district designed to redevelop the west side of downtown Tucson. Vacant parcels within 1,240 feet of the Mercado Area amount to 21.0 acres of which 18.2 acres (75.8%) are classified as residential, and 2.6 (10.8%) acres are commercial.

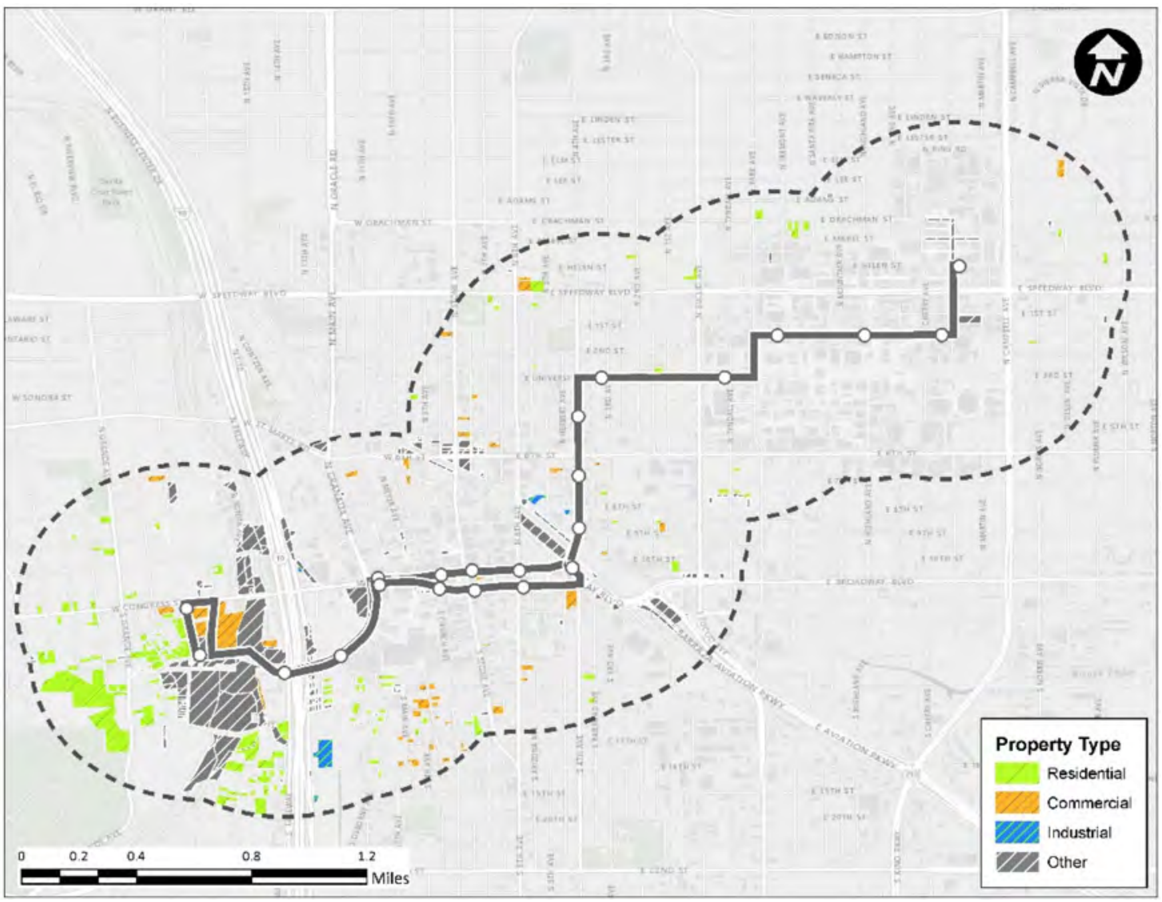


Figure 5-42 *Map of Vacant Parcels – Sun Link Tucson Streetcar*

The classication of vacant land by purpose in the Mercado San Augustin area changed over the study period. Figure 5-43 shows the land use for 2007, and Figure 5-44 the land use for 2016.

Figure 5-43

Vacant Parcels, 2007 – Mercado San Augustin

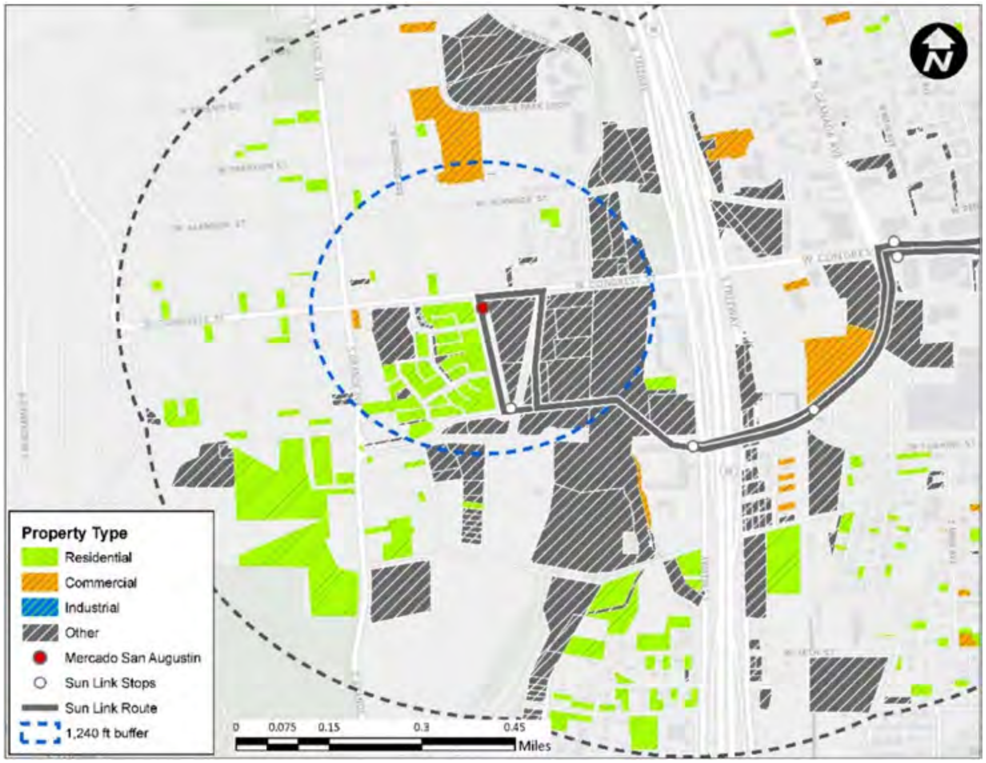


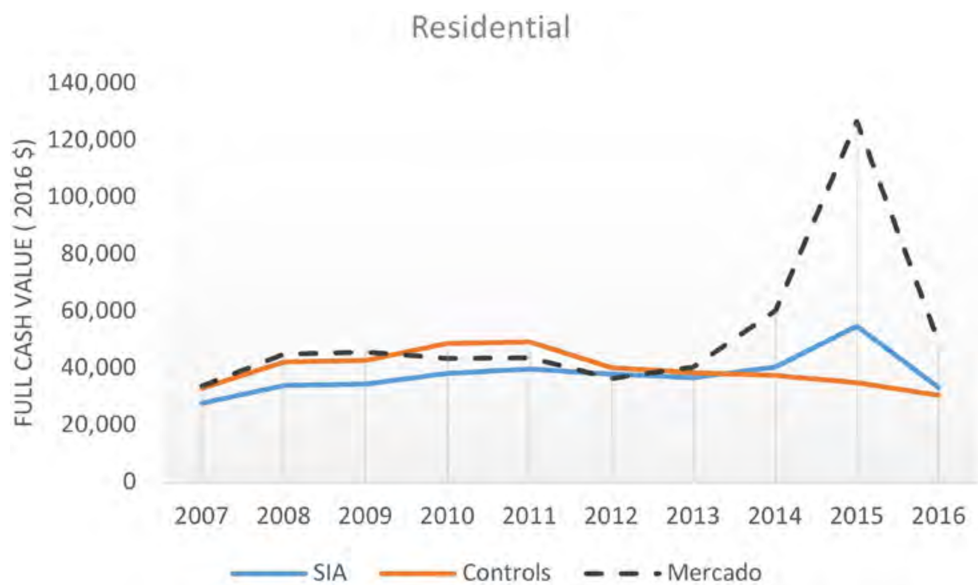
Figure 5-44

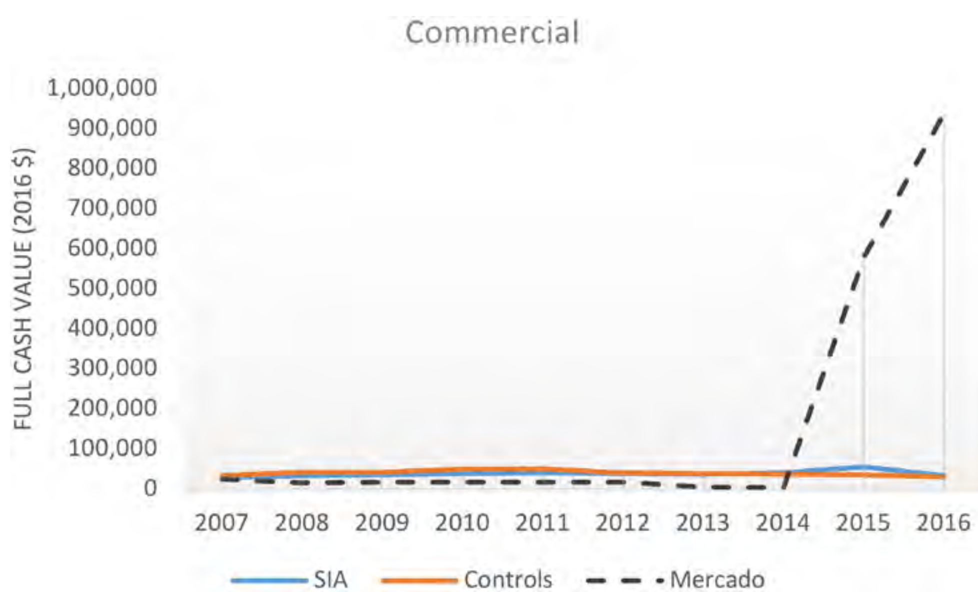
Vacant Parcels, 2016 – Mercado San Augustin

The appraised value of vacant parcels located in the SIA, using the Property Appraiser evaluation of land value (full cash equivalent), shows a marked increase starting in 2012 (Figure 5-45), in conjunction with the streetcar construction and concurring changes in land-use. While the control areas show a decline, which is in line with the rest of the county, the SIA, and, in particular, the Mercado area, show a marked upward trend.

Figure 5-45

Vacant Parcels Assessed Values – Sun Link Tucson Streetcar





Atlanta Streetcar

The analysis is based on data from the Fulton County Board of Assessors Property Records, which provide current tax roll and property sale data.[30] The Board of Assessors conducts yearly assessments of all real and tangible personal property in Fulton County. The tax roll data provide detailed parcel information, including parcel size, building size and structural characteristics, the tax assessor estimated value, and the price and date of property sales transactions.

The Atlanta Board of Assessors also provides GIS shapefiles to plot the parcels and to allow merging information from other sources. These data were complemented with data from public queries through the public portal to property records.[31] Additional geographical features and updates to the tax parcel shapefiles were obtained from the Fulton County Geoportal website.[32]

The datasets contain a land use code, which allows creating the following property-type categories for subsequent analysis:

- Residential (vacant, single-family, multi-family, condominia, other)
- Commercial
- Industrial
- Government (federal, state, and local)
- Institutional (i.e., Geogia State University)
- Other (public utilities, right-of-way, rivers, lakes, parks, etc.)

The SIA map was superimposed on the parcel layers to identify the parcels located within 0.5 miles of the streetcar stations. Figure 5-46 shows the location of 4,943 parcels (as of 2016 tax roll), highlighting residential, commercial, and industrial land uses. The map outlines the divide caused by the interstate network that split the downtown area from the eastern portion of the SIA, where the MLK historical site and most of the residential properties are located. The map shows a large presence of parcels labeled as education because the Georgia State University main campus is located south of the streetcar line.

Figure 5-47 shows the property type breakdown in the SIA and includes public utilities, religious, natural resources, parking and other parcels.

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[30] http://www.qpublic.net/ga/fulton/.

[31] http://qpublic9.qpublic.net/ga_search_dw.php?county=ga_fulton.

[32] http://share.myfultoncountyga.us:8080/geoportal/catalog/main/home.page.

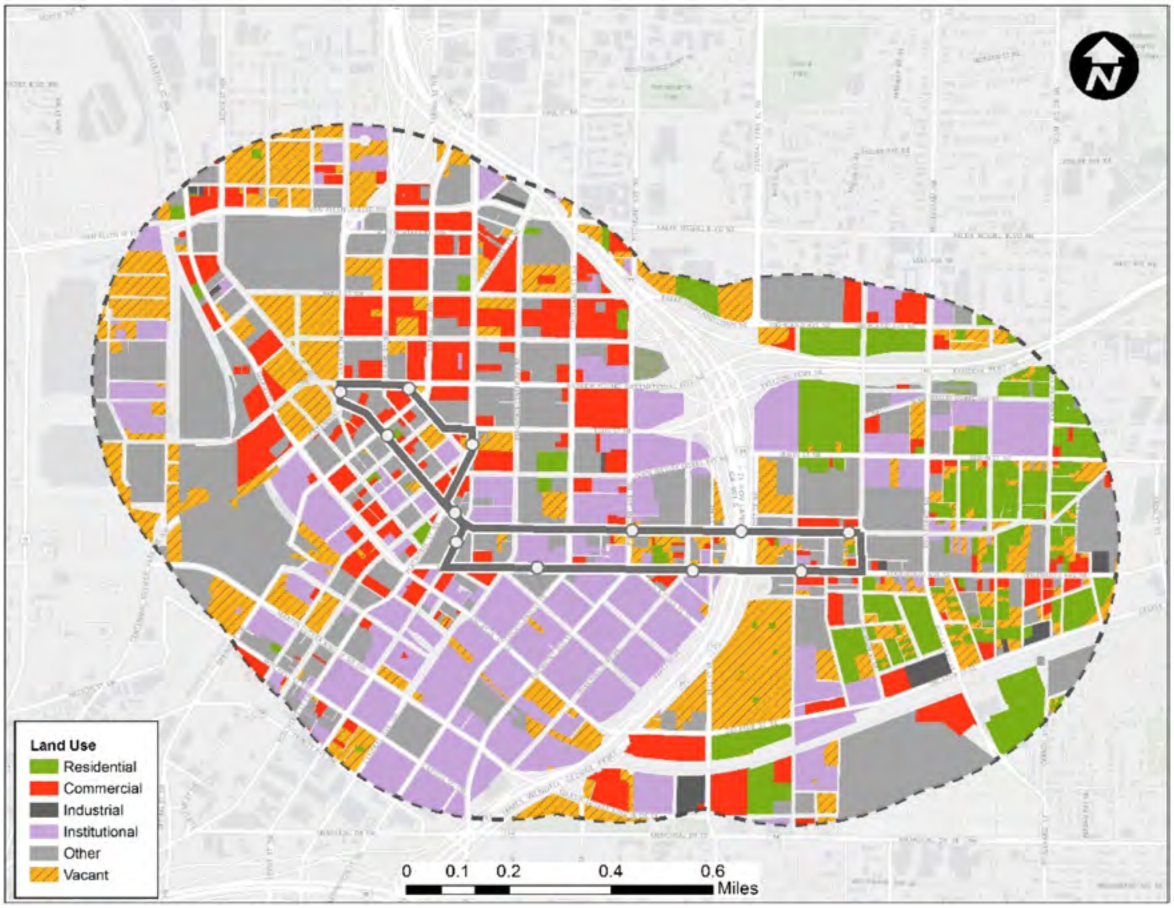
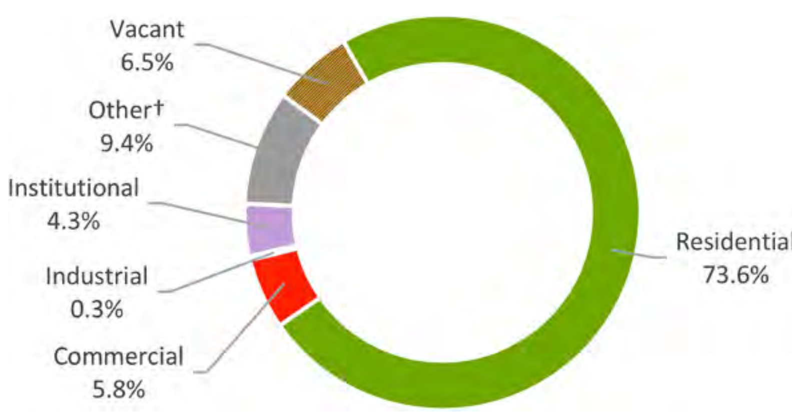


Figure 5-46 *Parcels by Land Use – Atlanta Streetcar*

Figure 5-47

Parcel Counts by Property Type – Atlanta Streetcar – 2016

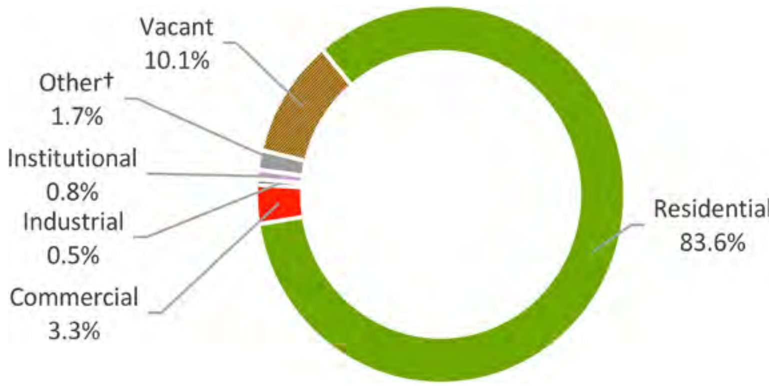


†Includes public utilities, religious, natural resources, parking and other parcels.

Figure 5-48 shows the property type breakdown in the county. The share of residential parcels in the SIA (76.3%) is lower than the rest of the county (83.6%), because of the larger concentration of commercial (5.8%) and institutional properties (4.3%), a characteristic of the Atlanta CBD.

Figure 5-48

Parcel Counts by Property Type – Fulton County (GA) – 2016



†Includes public utilities, religious, natural resources, parking and other parcels.

Table 5-22 and Table 5-23 report historical parcel counts and total parcel acreage by major land-use types for the period of 2007–2016. Residential parcels increased by 1,518 units during this period. A closer look at the Property Appraiser's data revealed that this is due to the appraiser splitting larger condominium parcels into smaller units. Commercial parcels increased by 5 units, but experienced a 25.7 percent reduction in acreage over the same period. On the other hand, the number of government and health parcels (institutional) increased by 16.7 percent, and their total acreage increased by 25.4 percent.

Table 5-22 *Parcel Counts – Atlanta Streetcar*

Property Type	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Residential	2,114	3,310	3,332	3,372	3,058	3,061	3,709	3,682	3,506	3,632
Commercial	282	295	289	291	276	277	280	283	286	287
Industrial	17	18	17	16	15	15	15	16	16	16
Institutional	180	173	176	194	205	199	217	215	207	210
Vacant	375	360	388	361	368	364	369	362	332	323
Other†	482	480	480	470	459	451	476	475	462	464
Total	*3,450*	*4,636*	*4,682*	*4,704*	*4,381*	*4,367*	*5,066*	*5,033*	*4,809*	*4,932*

†Includes public utilities, religious, natural resources, parking and other parcels.

Table 5-23 *Parcel Acreage – Atlanta Streetcar*

Property Type	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Residential	1,620.8	2,539.5	2,537.2	2,518.3	2,105.0	2,106.1	1,976.9	1,954.8	1,674.0	1,664.2
Commercial	164.6	165.8	153.6	161.3	143.5	144.5	135.1	128.0	126.2	122.3
Industrial	7.4	7.5	6.6	8.7	4.4	4.4	4.2	5.7	5.7	5.7
Institutional	152.2	179.7	181.2	168.2	177.2	176.5	186.0	190.1	190.1	190.8
Vacant	123.9	114.8	124.9	131.2	131.7	131.0	150.4	140.0	126.7	127.2
Other†	237.7	230.4	234.1	238.8	229.6	232.0	239.9	251.5	245.8	245.1
Total	*2,306.5*	*3,237.8*	*3,237.6*	*3,226.5*	*2,791.5*	*2,794.5*	*2,692.4*	*2,670.0*	*2,368.5*	*2,355.4*

†Includes public utilities, religious, natural resources, parking and other parcels.

Residential Properties

As of 2016, there were 3,732 residential parcels in the SIA (including vacant parcels), with most single-family and condominium properties clustered around King Historical District (Figure 5-49).

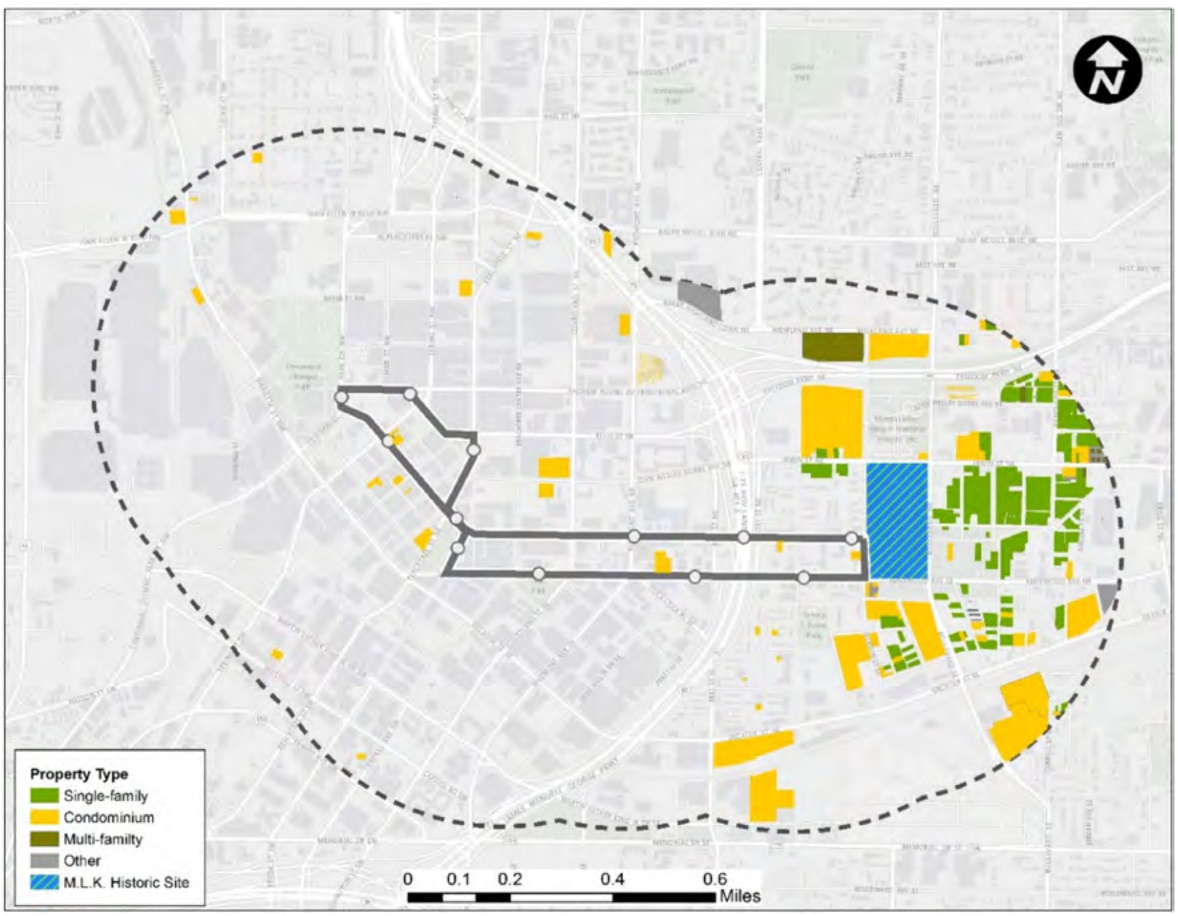


Figure 5-49 *Map of Residential Parcels – Atlanta Streetcar*

Figure 5-50 shows that condominium parcels represent 82.0 percent of the total, followed by single-family (7.8%) and multi-family (7.5%) parcels. Several vacant parcels, 2.7 percent of the sample, are clustered south of the historic site, along the MARTA rail line.

Figure 5-50

Residential Parcels – Atlanta Streetcar – 2016

The distribution reported in Figure 5-50 fluctuated through the years, as indicated by the number of residential parcel counts displayed in Table 5-24. During 2007–2016, the number of vacant parcels did not signficantly change, but the number of multi-family parcels more than doubled. The number of condominium parcels increased by about 1,360 units. This is due to splitting larger lots representing apartment complexes into single apartment units. After the Property Appraiser split the larger lots, the number of condominium properties increased above 3,000 units. The number of vacant parcels remained fairly constant, as did the number of single-family parcels.

Table 5-24 *Residential Parcel Counts – Atlanta Streetcar*

Parcel Type	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Single-family	280	288	285	286	283	285	277	278	287	290
Multi-family	131	274	274	276	278	278	278	279	280	279
Condominium	1,701	2,744	2,769	2,806	2,493	2,494	3,151	3,122	2,935	3,059
Vacant	122	121	139	128	118	126	122	119	107	100
Other†	2	4	4	4	4	4	3	3	4	4
Total	*2,236*	*3,431*	*3,471*	*3,500*	*3,176*	*3,187*	*3,831*	*3,801*	*3,613*	*3,732*

-†Includes mobile home park, single-family mobile home, co-ops, condo and homeowner association common area.

In terms of acreage (Table 5-25), during 2007–2016, condominium parcels increased by 2.7 percent, which corresponded to a 2.2 percent decrease in the acreage of vacant parcels.

Table 5-25 *Residential Parcels Acreage – Atlanta Streetcar*

Parcel Type	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Single-family	31.1	34.7	34.0	34.0	33.7	34.2	33.4	33.1	33.8	34.0
Multi-family	345.9	348.9	348.9	348.9	349.2	349.2	349.0	349.4	349.5	349.4
Condominium	1,243.4	2,151.8	2,150.3	2,131.3	1,718.1	1,718.7	1,591.0	1,568.9	1,286.3	1,276.4
Vacant	13.0	13.6	26.1	13.8	13.2	13.9	13.4	14.0	13.2	12.8
Other†	0.4	4.0	4.0	4.0	4.0	4.0	3.4	3.4	4.4	4.4
Total	*3,640.8*	*4,561.1*	*4,572.3*	*4,542.1*	*4,129.2*	*4,131.9*	*4,003.3*	*3,982.8*	*3,702.2*	*3,692.9*

†Includes mobile home park, single-family mobile home, co-ops, condo and homeowner association common area.

Table 5-26 reports average annual property values for the SIA, which reflect the Property Appraiser's market evaluation (i.e., assessed value). The appraised values have been adjusted by the CPI to report all dollar amounts in constant 2016 dollars. As of 2014, residential parcels started showing signs of recovery from the real estate market crisis, in particular, single-family properties. Condominium mean values appear to be converging to pre-2009 levels.

Table 5-26 *Residential Property Values – Atlanta Streetcar*

Parcel Type	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Single-family	222,079	226,976	250,013	175,171	128,002	127,748	225,814	233,760	238,582	244,337
Multi-family	222,601	254,952	246,533	206,115	174,547	161,206	128,251	133,216	162,659	162,671
Condominium	274,733	313,401	287,073	263,527	232,006	233,968	188,663	202,738	255,452	278,079
Vacant	46,225	88,407	127,586	34,311	20,422	19,846	68,217	78,638	75,811	74,371
Other	*112*	*1,118,777*	*625,730*	*626,361*	*601,774*	*595,372*	*48,542*	*47,551*	*202,730*	*198,675*

Figure 5-51 provides a historical perspective comparing assessed value trends in the SIA with the rest of the county and the control areas. The graphs show generalized downward trends in value for the years following the real estate market crisis of 2008. On average, single-family properties located in the SIA have lower values than comparable properties in the rest of the county, but have higher values than properties located in the control areas sharing similar neighborhood characteristics. Multi-family property values show a downward trend. Like single-family parcels, condominium prices experienced a rapid increase in market value preceding the crisis, and only recently, show signs of recovery.

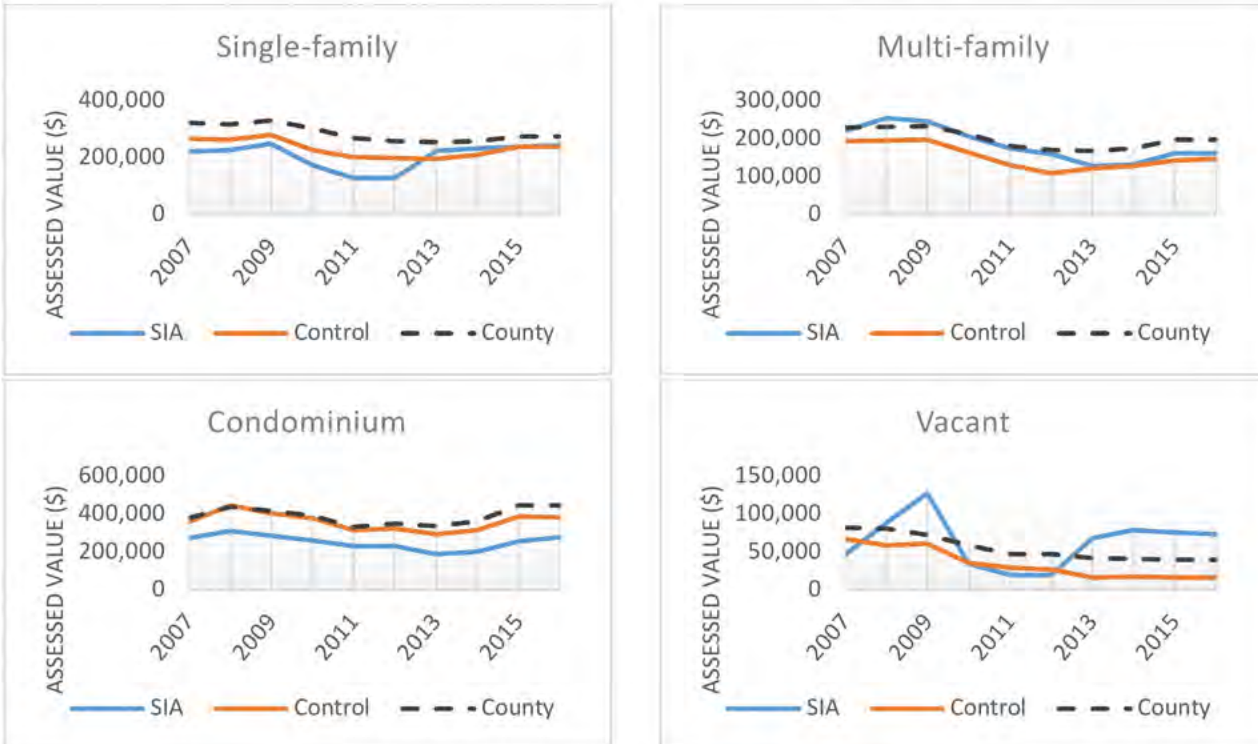


Figure 5-51 *Residential Assessed Values, Atlanta Streetcar – 2007–2016*

Residential vacant land prices in the SIA peaked in 2009, a year before the announcement of the streetcar investment, but gradually increased during 2012–2016. From these graphs, it is unclear if the streetcar funding announcement had an impact on the increase in vacant land values, although the empirical literature provides evidence of anticipated impacts of rail investments on residential property prices. Figure 5-52 and Figure 5-53 and display spatial information about market values for residential properties, comparing 2010 (announcement) to 2016 (opening). Residential parcels include single-family, multi-family, and condominium properties. These parcels are located primarily in proximity to the MLK Historical Site, east of Jackson Street. The maps employ the same appraised value ranges and illustrate a growth in value for the properties in proximity to King's Historic Site.

Figure 5-52

Map of Residential Property Values – Atlanta Streetcar – 2010

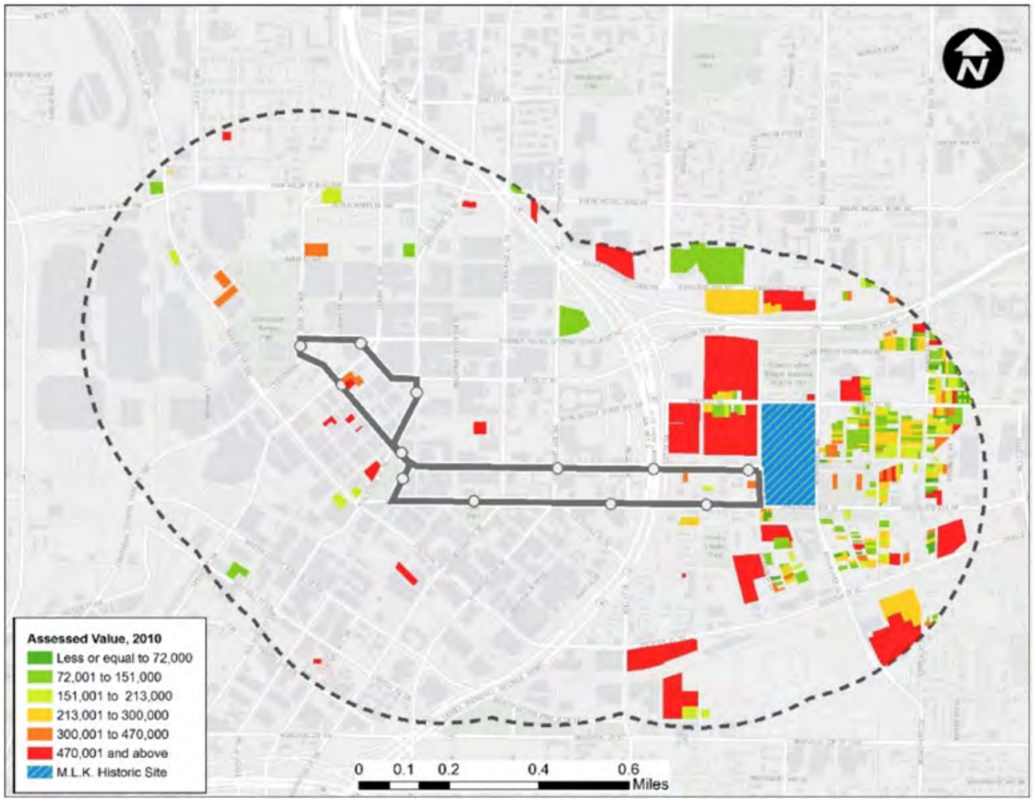
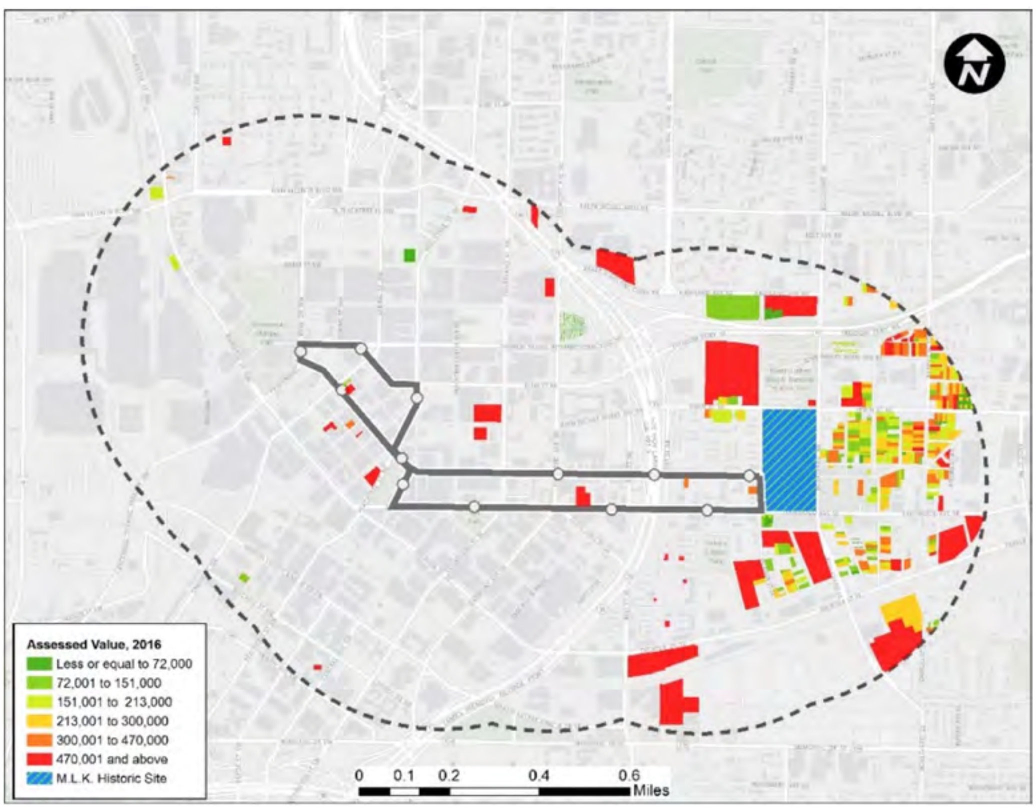


Figure 5-53

Map of Residential Property Values – Atlanta Streetcar – 2016



Commercial Properties

Atlanta serves as the regional hub for many federal offices, including the Federal Reserve Bank of Atlanta and the Centers for Disease Control and Prevention, along with the U.S. Court of Appeals for the Eleventh Circuit and the U.S. District Court for the Northern District of Georgia. Figure 5-54 shows commercial properties, including all parcels in which business units are located. Businesses include commercial establishments, restaurants, shops, shopping centers, department stores, and food stores. Due to their large representation, offices and hotels are reported separately. Commercial parcels are located in the CBD core, along the streetcar route, and in proximity to the MLK Historic Site. As of 2016, there were 287 occupied (122.3 acres) and 70 vacant (27.1 acres) commercial parcels.

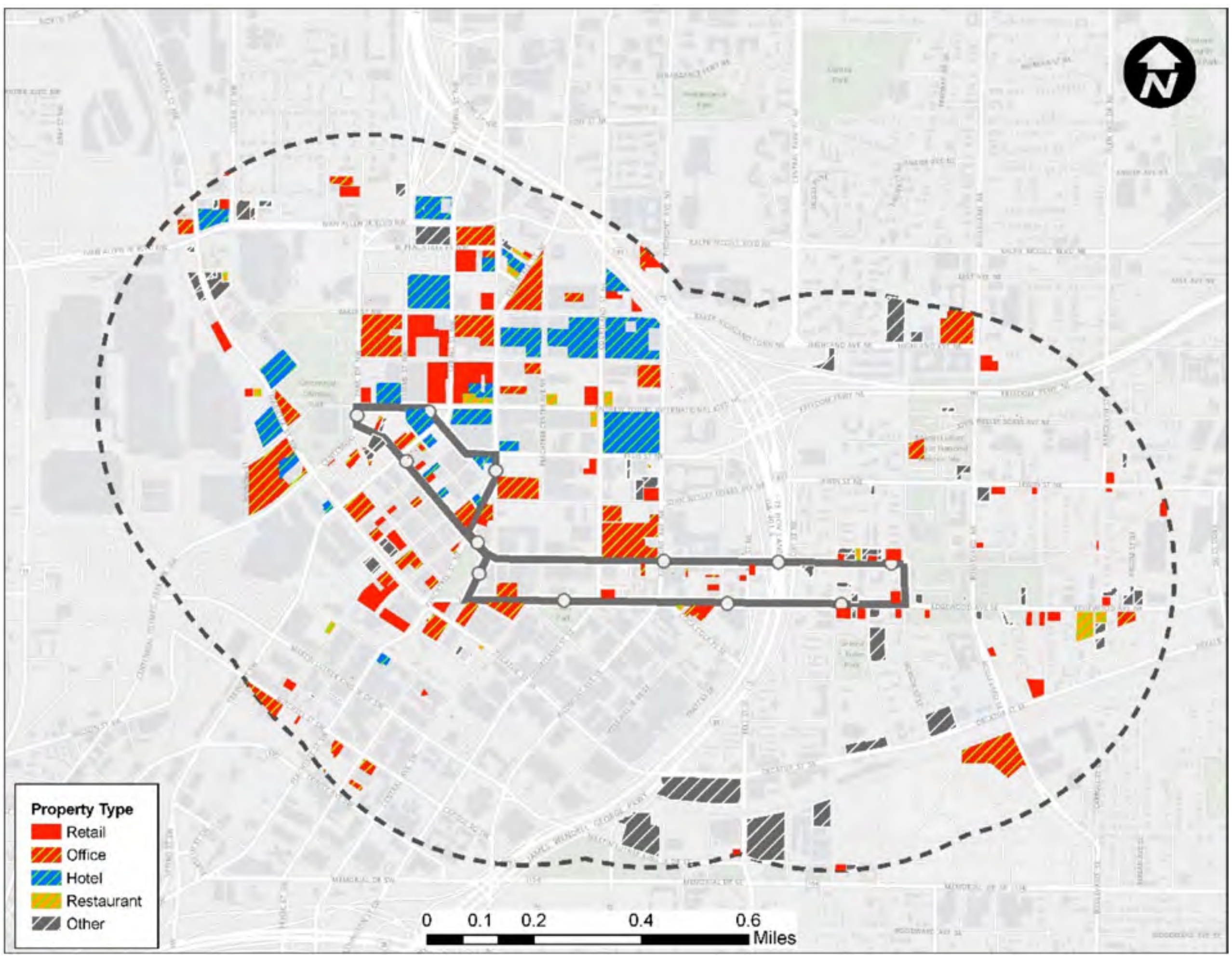
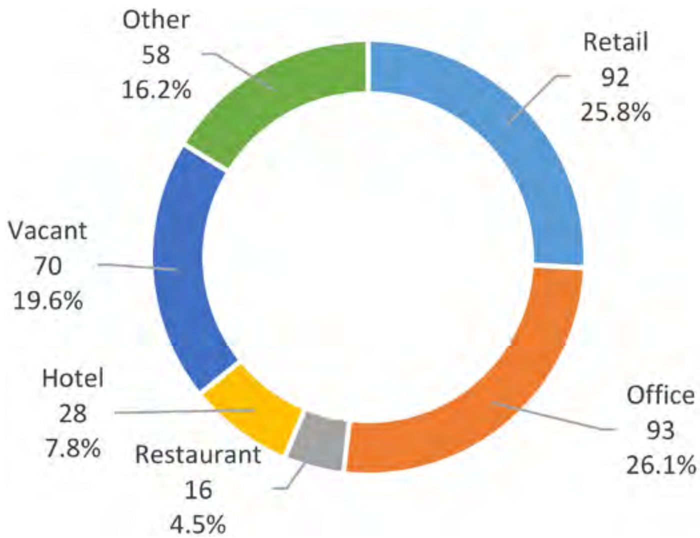


Figure 5-54 *Map of Commercial Parcels – Atlanta Streetcar*

Figure 5-55 reports the breakdown by property type (2016 tax roll) of the commercial parcels. About 100 parcels are used for offices, which include medical, banking and savings institutions, and low- and high-rise buildings. Retail establishments represent 25.8 percent of the total and include four parcels (about 6.3 acres) categorized as "super-regional shopping mall center," which is the site of AmericasMart, one of the world's largest wholesale trade centers.

Figure 5-55

Commercial Parcels Breakdown – Atlanta Streetcar



Looking at the historical trends of Table 5-27 and Table 5-28, parcels dedicated to office space steadily declined in number and total acreage during 2007–2016, with a reduction of 28.4 acres. Vacant parcels also showed a decline (33.3%), with a reduction in total acreage of about 42.2 percent.

Table 5-27

Commercial Parcel Counts – Atlanta Streetcar

Parcel Type	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Retail	75	78	78	85	81	81	83	87	89	92
Office	110	104	102	102	94	98	101	95	95	93
Restaurant	14	14	13	13	12	12	12	15	15	16
Hotel	27	26	25	27	27	27	25	27	27	28
Vacant	105	83	94	85	82	76	73	72	70	70
Other	56	73	71	64	62	59	59	59	60	58
Total	*387*	*378*	*383*	*376*	*358*	*353*	*353*	*355*	*356*	*357*

Table 5-28 *Commercial Parcels Acreage – Atlanta Streetcar*

Parcel Type	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Retail	29.76	28.2	27.14	29.18	26.52	25.36	23.29	21.32	21.34	21.49
Office	67.99	61.52	61.37	65.49	51.1	53.15	50.34	45.42	43.32	39.63
Restaurant	2.157	2.872	2.028	2.028	1.83	1.83	2.613	3.4	3.4	3.547
Hotel	35.72	34.97	33.83	36.36	36.39	35.65	31.65	31.77	31.38	31.76
Vacant	46.99	34.01	32.26	32.06	31.34	30.27	37.74	28.51	25.69	27.15
Other	28.96	38.24	29.18	28.21	27.68	28.52	27.21	26.13	26.79	25.88
Total	*211.6*	*199.8*	*185.8*	*193.3*	*174.9*	*174.8*	*172.8*	*156.6*	*151.9*	*149.5*

Figure 5-56 shows historical trends in mean assessed value for occupied and vacant parcels, comparing the study area to the rest of the county and to similar properties (controls). SIA parcels are located in the core of Atlanta's CBD, and location premia result in relatively higher values. The trends show the generalized increase in property prices during the years preceding the real estate crisis and the ensuing economic downturn post-2009.

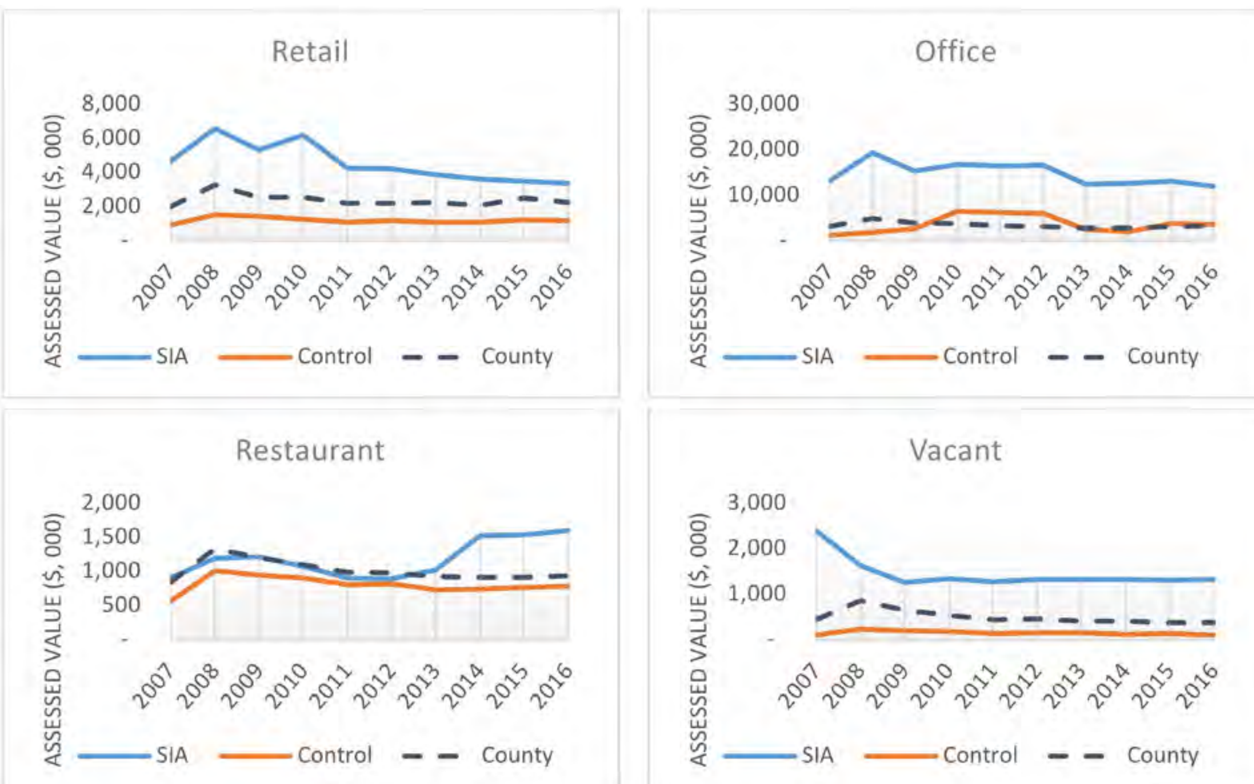


Figure 5-56 *Commercial Property Values – Atlanta Streetcar*

Figure 5-57 and Figure 5-58 illustrate the appraised valued for 2010 and 2016, showing clustering of commercial parcels along the streetcar route, in proximity of I-75/85 and MLK Historic District.

Figure 5-57

Map of Commercial Property Values – Atlanta Streetcar – 2010

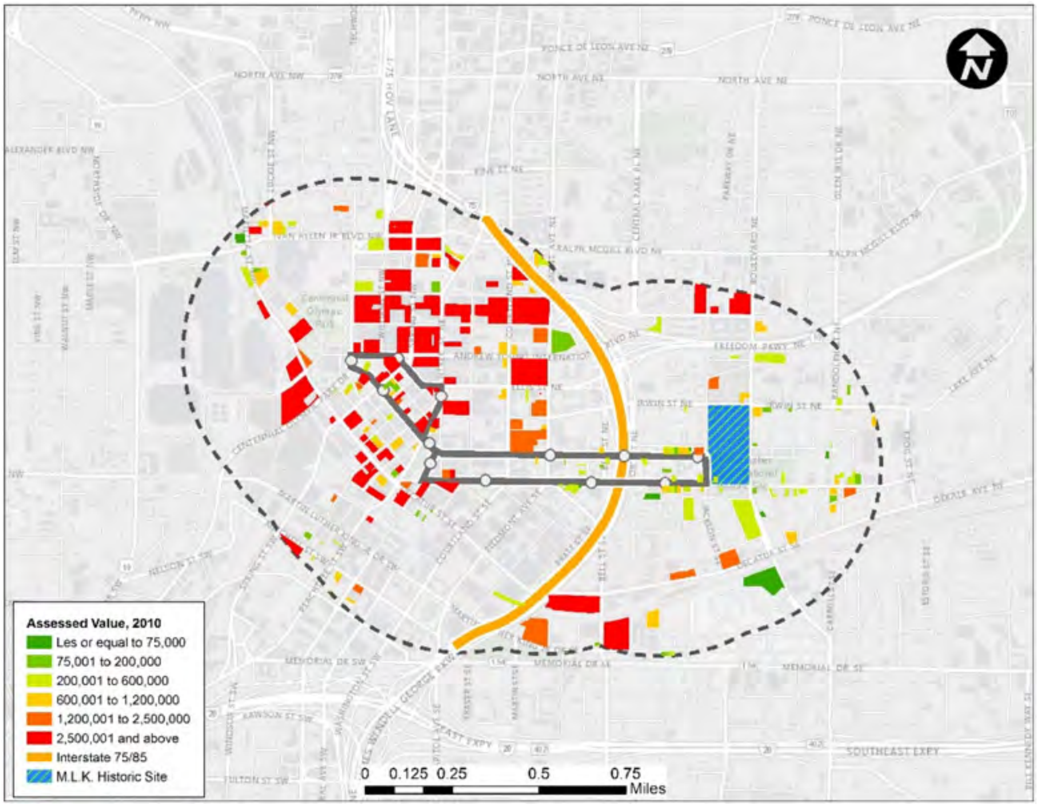
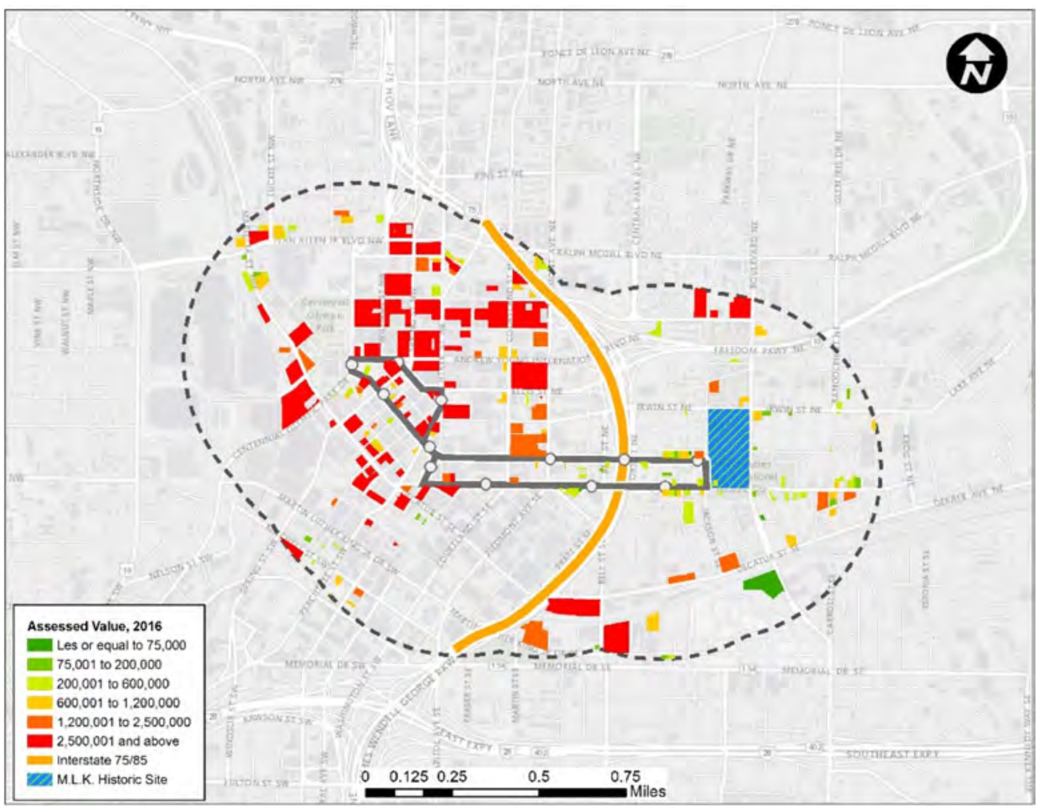


Figure 5-58

Map of Commercial Property Values – Atlanta Streetcar – 2016



Vacant Properties

In 2016, there were a total of 323 vacant parcels, of which 100 (31.0%) were classified as Residential and 70 (21.7%) classified as Commercial. Vacant parcels are not uniformly distributed geographically. Figure 5-59 shows a clustering of small size commercial parcels in proximity of the eastern portion of the streetcar alignment, and residential parcels clustered on the eastern portion of the SIA.

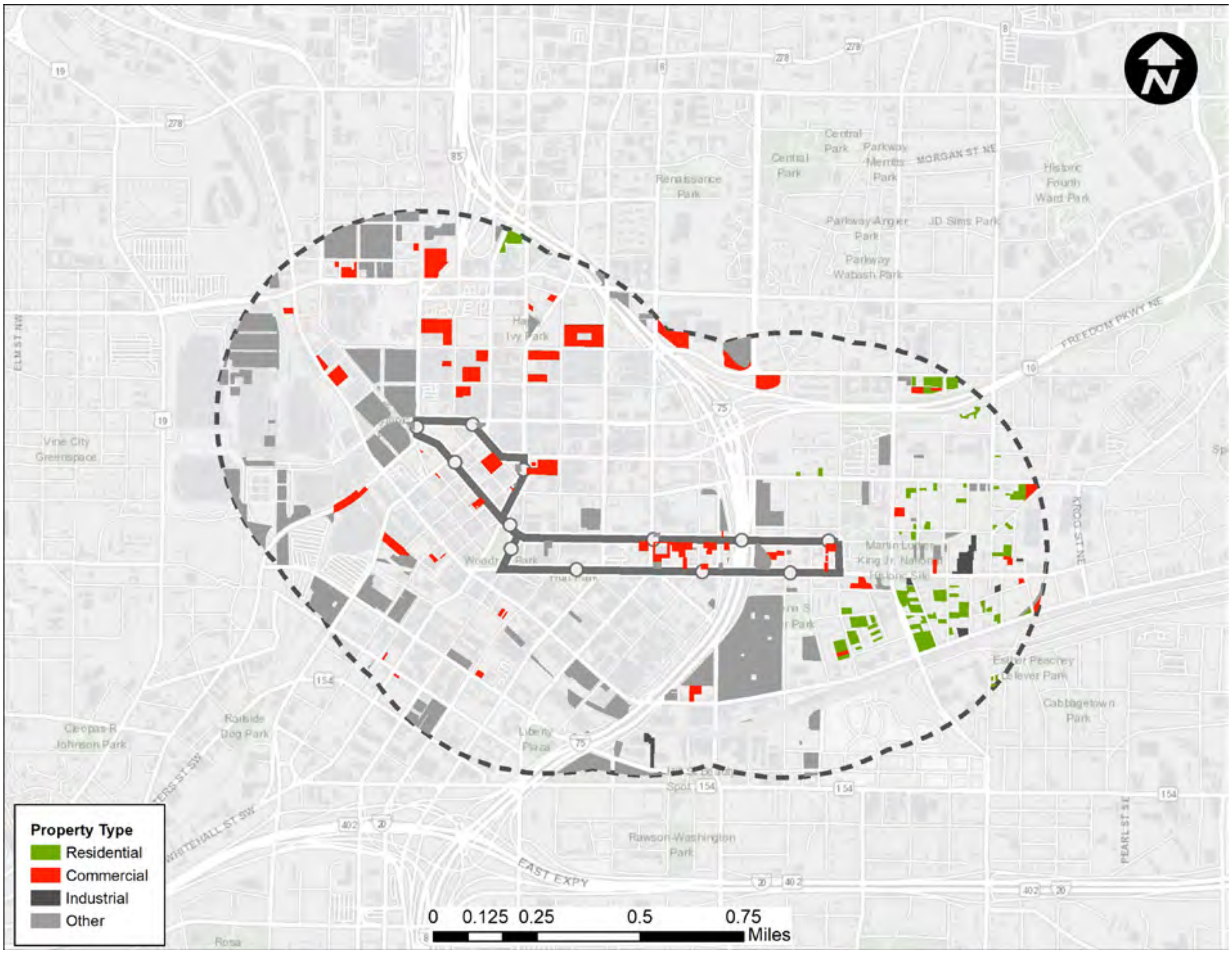


Figure 5-59 *Map of Vacant Parcels – Atlanta Streetcar*

The appraised value of vacant parcels located in the SIA, using the Property Appraiser's evaluation of land value, shows a marked increase starting in 2012, in conjunction with the streetcar construction and concurrent changes in land use (Figure 5-60). Although the control areas show a decline, which is in line with the rest of the county, the SIA shows a marked upward trend.

Figure 5-60

Vacant Parcels Assessed Values – Atlanta Streetcar

Salt Lake City S-Line

Utah is a nondisclosure state, making private sale information unavailable to the public. The Salt Lake County Assessor provides data on assessed values for tax roll purposes. The assessing procedure evaluates properties based on fair market value, which the Utah Property Tax Act equates to "the amount at which property would change hands between a willing buyer and a willing seller."[33]

The Salt Lake County Assessor provided assessed property information for the period 2007–2016, along with the ArcGIS parcel shapefiles. Through a set of relational datasets, the appraised data contain detailed parcel information, including parcel size, building size and structural characteristics, the assessed value, and the applicable tax rate. Additional geographical features and updates to the tax parcels were obtained from the Utah Automated Geographic Reference Center.[34] The assessed datasets provide information on the following parcels:

- Residential (vacant, single-family, multi-family, condominium, other)
- Commercial (office, retail, restaurant, etc.)

[33] https://le.utah.gov/xcode/Title59/59.html.

[34] http://gis.utah.gov/.

- Industrial (manufacturing, commercial/industrial)
- Government
- Other (public utilities, right-of-way, rivers, lakes, parks, etc.)

The SIA map was superimposed on the parcel layers to identify all parcels located within the SIA. Figure 5-61 shows the location of 3,843 parcels (2016 tax roll) and highlights residential, commercial, and industrial land uses. Most commercial properties were located in proximity to the Sugar House Shopping Center and along East 2100 South, occupying about 261 of the total 952 acres (27.4%). As of 2016, there were about 78 acres of vacant commercial parcels (8.2%). Industrial parcels occupied about 74 acres (7.7%) and were clustered around the TRAX rail line in proximity to the Central Pointe Station on the western portion of the SIA.

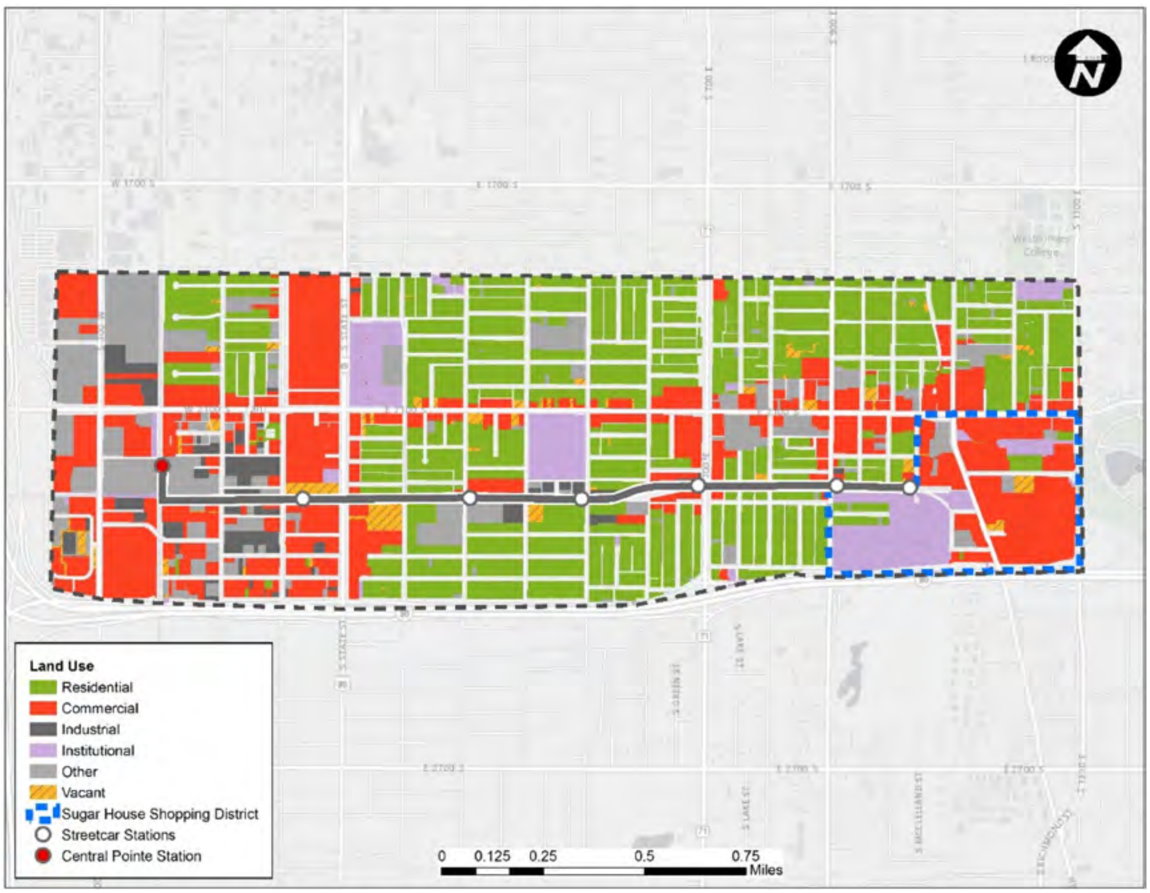


Figure 5-61 *Parcels by Land Use – Salt Lake City S-Line*

Figure 5-62 and Figure 5-63 show the breakdown by property type for the SIA and the rest of the county. The share of residential parcels (74.7%) is in line with the rest of the county (76.1%). The percentage of commercial parcels (14.3%) is higher than the rest of the county (4.3%), indicating that the SIA is a destination for recreational activities. The presence of industrial establishments near the Central Pointe Station is reflected in the 1.8 percent share of light industrial parcels.

Figure 5-62

Parcel Counts by Property Type – Salt Lake City S-Line – 2016

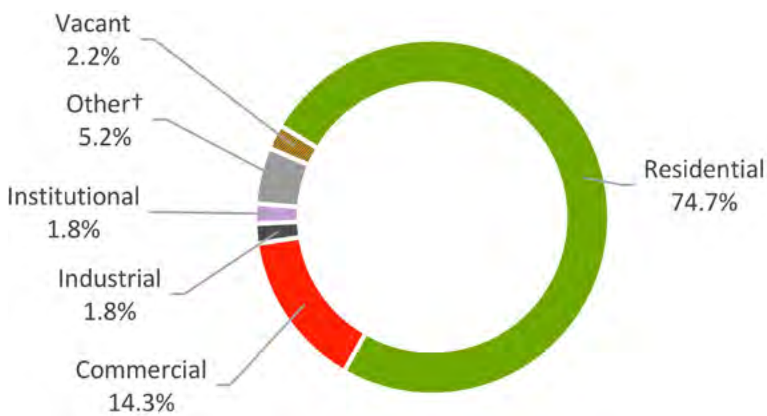
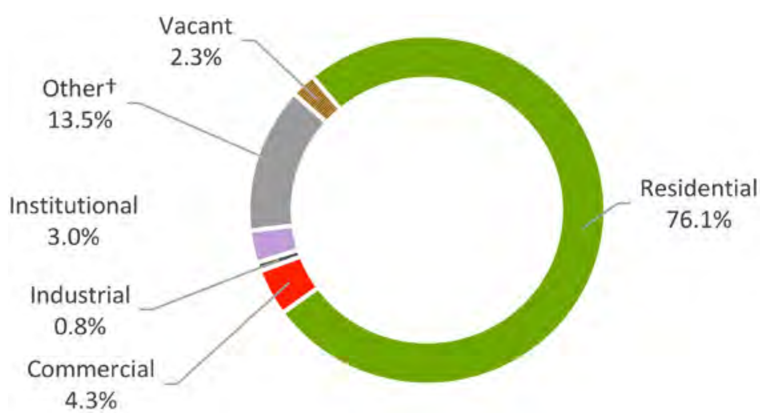


Figure 5-63

Parcel Counts by Property Type – Salt Lake County (UT) – 2016



To provide a perspective on how the SIA developed through the study period, Table 5-29 reports historical trends by parcel type for the period 2007–2016. The table shows that the total number of residential parcels remained relatively constant. Within the residential parcels, the number of single-family and condominium units changed, as detailed in Section 2. Vacant parcels declined by 60 units and by 10.0 acres (Table 5-30) during 2007–2016, with a marked change in trends occuring after 2010. As discussed in the residential parcel analysis below, most of this growth resulted from the construction of condominium units. During 2007–2016, the number of industrial parcels did not change, and the number of commercial parcels increased by 24 units.

Table 5-29

Parcel Counts – Salt Lake City S-Line

Property Type	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Residential	2,885	2,880	2,864	2,892	2,918	2,904	2,881	2,859	2,858	2,870
Commercial	526	523	519	524	535	537	549	573	546	550
Industrial	69	70	72	70	75	74	73	70	71	70
Institutional	55	51	51	52	62	67	71	77	77	69
Vacant	146	138	117	121	89	86	85	89	83	86
Other†	176	185	174	169	189	188	191	194	196	198
Total	*3,857*	*3,847*	*3,797*	*3,828*	*3,868*	*3,856*	*3,850*	*3,862*	*3,831*	*3,843*

†Includes agriculture, public utilities, dedicated parcels, parking and other parcels.

Table 5-30

Parcel Acreage – Salt Lake City S-Line

Property Type	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Residential	398.0	398.8	395.0	399.0	399.0	397.9	396.2	393.7	397.1	397.0
Commercial	276.8	271.9	276.4	291.4	293.7	285.6	272.7	289.6	269.9	271.3
Industrial	33.9	33.0	36.3	34.8	36.5	37.9	38.0	35.7	36.8	33.8
Institutional	62.0	57.9	57.8	58.0	73.2	82.0	82.6	102.2	82.5	73.9
Vacant	31.4	28.9	23.0	23.8	17.0	16.6	17.4	20.3	13.2	21.3
Other†	133.0	135.2	137.1	113.5	125.3	106.0	127.1	111.2	111.2	116.5
Total	*935.0*	*925.7*	*925.6*	*920.3*	*944.7*	*926.0*	*934.0*	*952.6*	*910.7*	*913.6*

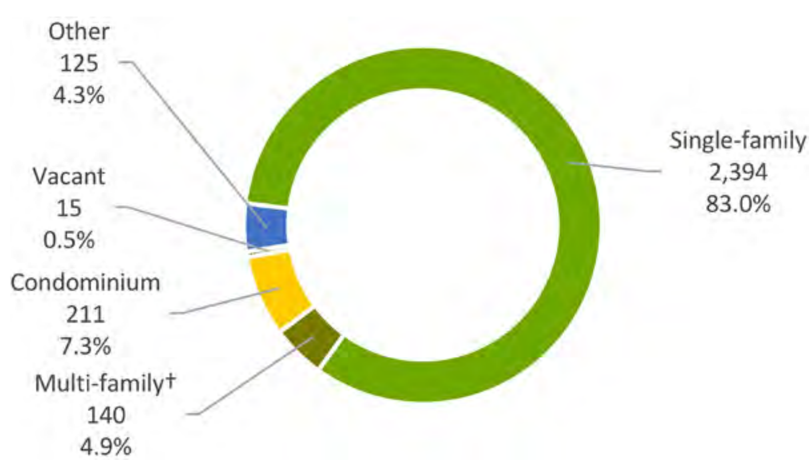
†Includes agriculture, public utilities, dedicated parcels, parking and other parcels.

Residential Properties

As of 2016, there were 2,885 residential parcels (occupied and vacant) in the SIA (Figure 5-64), with the vast majority being single-family detached homes (83.0%), followed by condominium units (7.3%) and multi-family units (4.9%).

Figure 5-64

Residential Parcels – Salt Lake City S-Line – 2016



The shares reported in Figure 5-64 fluctuated through the years, as indicated by the number of parcel counts reported in Table 5-31 and the changes in total acreage of Table 5-32. The fluctuations during the 2007–2016 timeframe reflect the generalized impact of the real estate crisis in the study area and the entire county. The number of occupied single-family parcels declined throughout the entire period, while the number of condominium parcels and acreage increased by 21.3 percent.

Table 5-31 *Residential Parcel Counts – Salt Lake City S-Line*

Property Type	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Single-family	2,464	2,462	2,450	2,456	2,449	2,451	2,427	2,391	2,387	2,394
Multi-family†	136	136	127	136	136	134	135	138	140	140
Condominium	174	174	174	186	215	203	203	203	203	211
Vacant	20	18	19	19	16	12	14	15	13	15
Other	111	108	113	114	118	116	116	127	128	125
Total	*2,905*	*2,898*	*2,883*	*2,911*	*2,934*	*2,916*	*2,895*	*2,874*	*2,871*	*2,885*

† Includes apartment complexes ranging from 3 to 10 and more units.

Table 5-32 *Residential Parcel Acreage – Salt Lake City S-Line*

Property Type	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Single-family	345.2	344.4	343.3	343.5	342.8	343.1	341.6	341.5	341.4	341.9
Multi-family†	46.1	47.8	44.7	47.2	47.1	46.3	47.2	48.1	49.7	49.8
Condominium	1.7	1.7	1.7	1.9	2.2	2.0	2.0	2.0	2.0	2.1
Vacant	1.8	1.8	1.8	1.8	1.2	0.6	0.7	0.8	0.8	1.2
Other	1.8	1.5	1.9	2.2	2.6	2.5	2.5	2.8	2.7	2.0
Total	*396.7*	*397.2*	*393.4*	*396.5*	*395.8*	*394.5*	*394.0*	*395.2*	*396.6*	*396.9*

† Includes apartment complexes ranging from 3 to 10 and more units.

During the streetcar planning phase, when several development plans were announced, the majority of proposed sites were located on the eastern section of the corridor. Figure 5-65 shows major redevelopment, which includes the following:

- Urban on Eleventh – 30 condominium units in mixed-use development with 750 sf of retail space.
- Wilmington Gardens – 80–100 residential units, including 5 townhomes, with 15,000 sf of office and 68,000 sf of retail development.
- The View at Sugar House Crossing – apartment complex offering studio, two-bedroom, and three-bedroom apartments for rent.
- Liberty Village – five-story affordable housing apartment complex 0.1 mile north of Sugarmont streetcar station offering apartments varying in size from 502–1,056 sf and monthly rents from $540–$900.

- Sugarhouse Apartments – 70-unit, high-end complex located 0.3 mile northeast of Fairmont station.
- 21 and View Apartments – complex consisting of 29 one-bedroom and two-bedroom rental units located in close proximity to the eastern boundary of the SIA.

Figure 5-65 *Redevelopments in Proximity of Salt Lake City S-Line Alignment*

Table 5-33 reports average annual property values for the SIA, which reflect the Property Appraiser's market evaluation (i.e., assessed value). The property assessor appraised values are CPI adjusted, reporting all dollar amounts in constant 2016 dollars. Property values increased substantially in the year preceding the real estate crisis, and then adjusted toward 2008 levels.

Table 5-33 *Residential Property Values – Salt Lake City S-Line*

Parcel Type	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Single-family	216,457	212,967	201,484	192,544	185,041	176,203	179,063	183,590	194,747	211,430
Multi-family	849,243	877,183	829,823	738,442	690,365	752,556	842,165	1,061,103	1,421,008	1,594,534
Condominium	150,939	208,926	198,805	188,755	150,158	143,552	150,050	162,842	164,237	270,190
Vacant	22,017	31,537	28,415	27,825	18,677	10,113	10,096	19,966	24,087	23,253
Other	81,517	102,709	96,663	89,786	88,449	77,542	80,008	76,339	83,336	90,576

Figure 5-66 provides a historical perspective comparing trends in the SIA with the rest of the county and the control areas. The graphs indicate that property values decreased during the years following the real estate market crisis and showed signs of recovery starting in 2012. On average, single-family property values located in the SIA were less than the rest of the county and the control areas sharing similar neighborhood characteristics. Multi-family property values were higher, on average, than the county and control areas. Like single-family parcels, condominiums experienced a rapid increase in market value preceding the crisis and declined immediately afterward, but started to recover in 2013 and rapidly increased in 2016. Residential vacant land prices in the SIA peaked in 2012. From these graphs, it is unclear if events related to the streetcar Construction phase affected the increase in vacant land values, although the empirical literature finds ample evidence of anticipated impacts by rail investments on residential property prices.

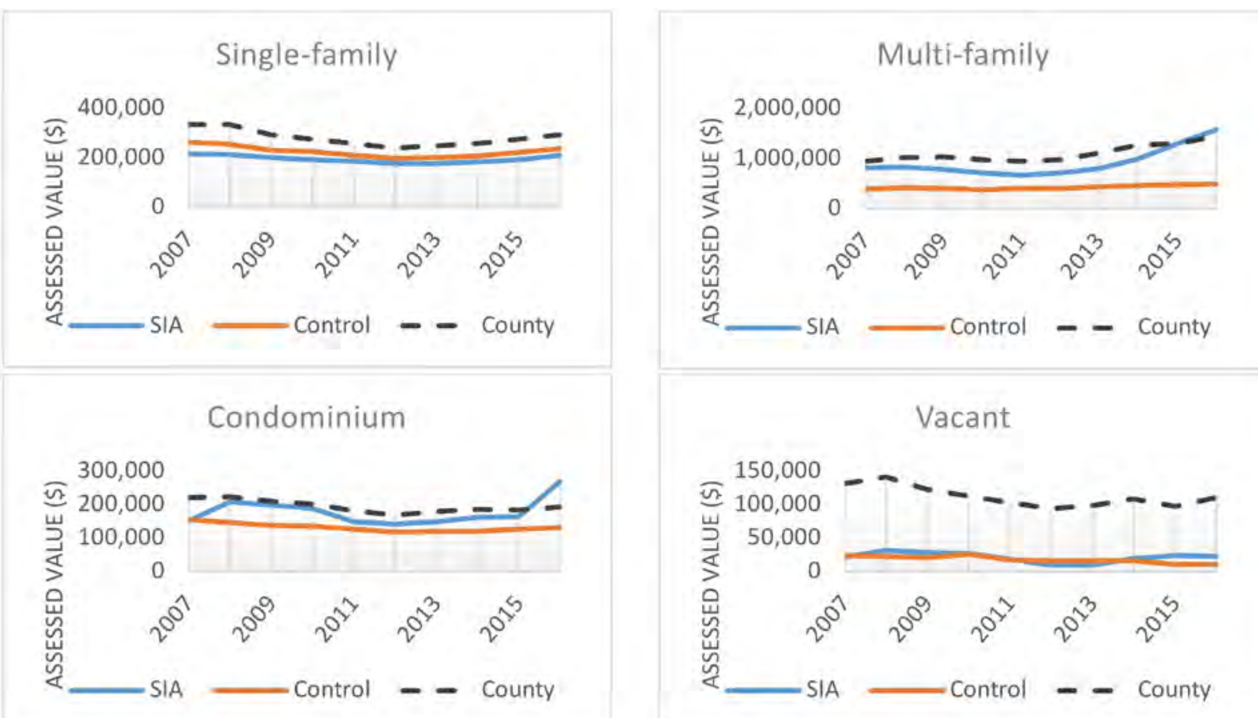


Figure 5-66 *Residential Appraised Values – Salt Lake City S-Line – 2007–2016*

Figure 5-67 and Figure 5-68 display spatial information about market values for residential properties, comparing 2007 (before streetcar announcement) to 2016 (opening phase). The residential parcels included single-family and condominium properties. Most properties with an assessed value greater than $200,000 were located on the eastern portion of the SIA, north of the Sugar House Shopping Center.

The key question to ascertain by examining the maps is to what extent the value of these properties changed through time and whether knowledge of the streetcar project planning and execution affected property prices, either by increasing their value on similar properties located outside the SIA or through market value preservation following the real estate market crisis.

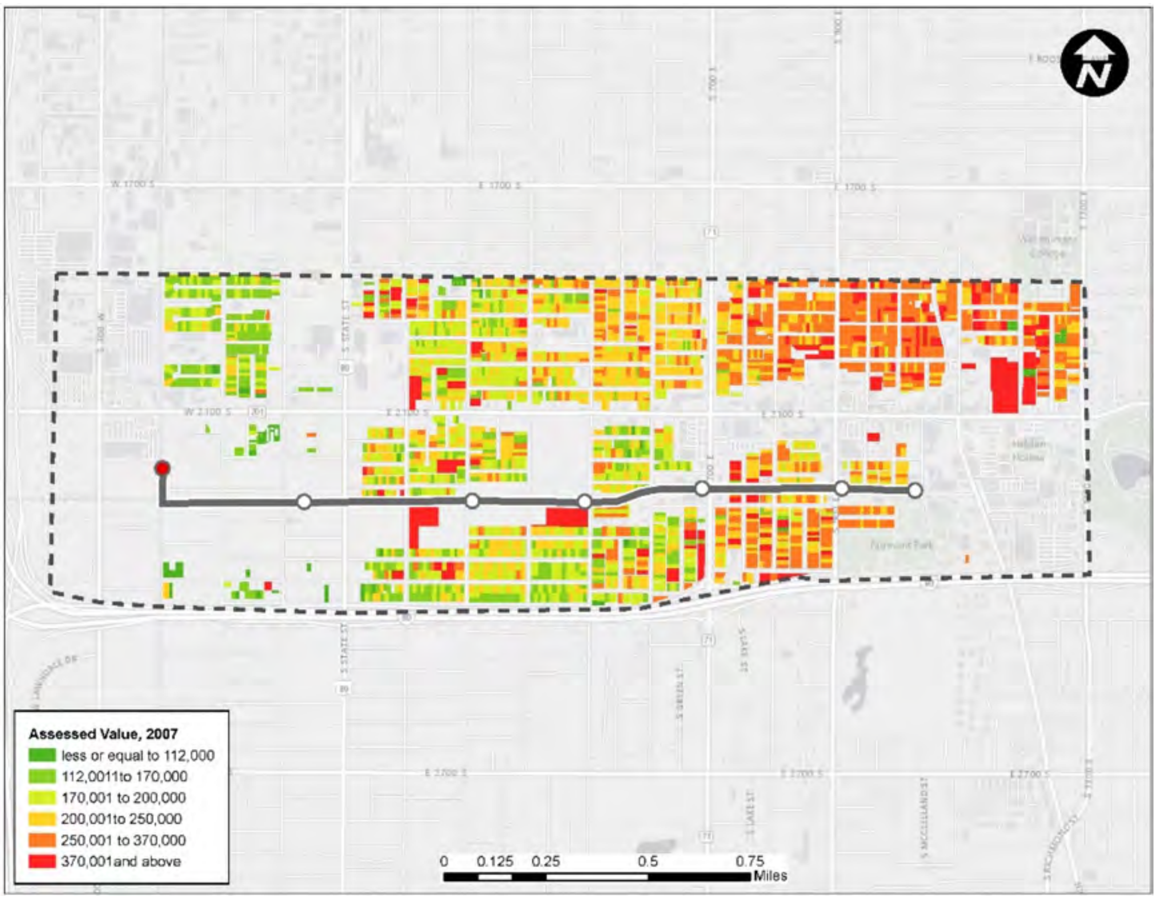


Figure 5-67 *Map of Residential Property Values – Salt Lake City S-Line – 2007*

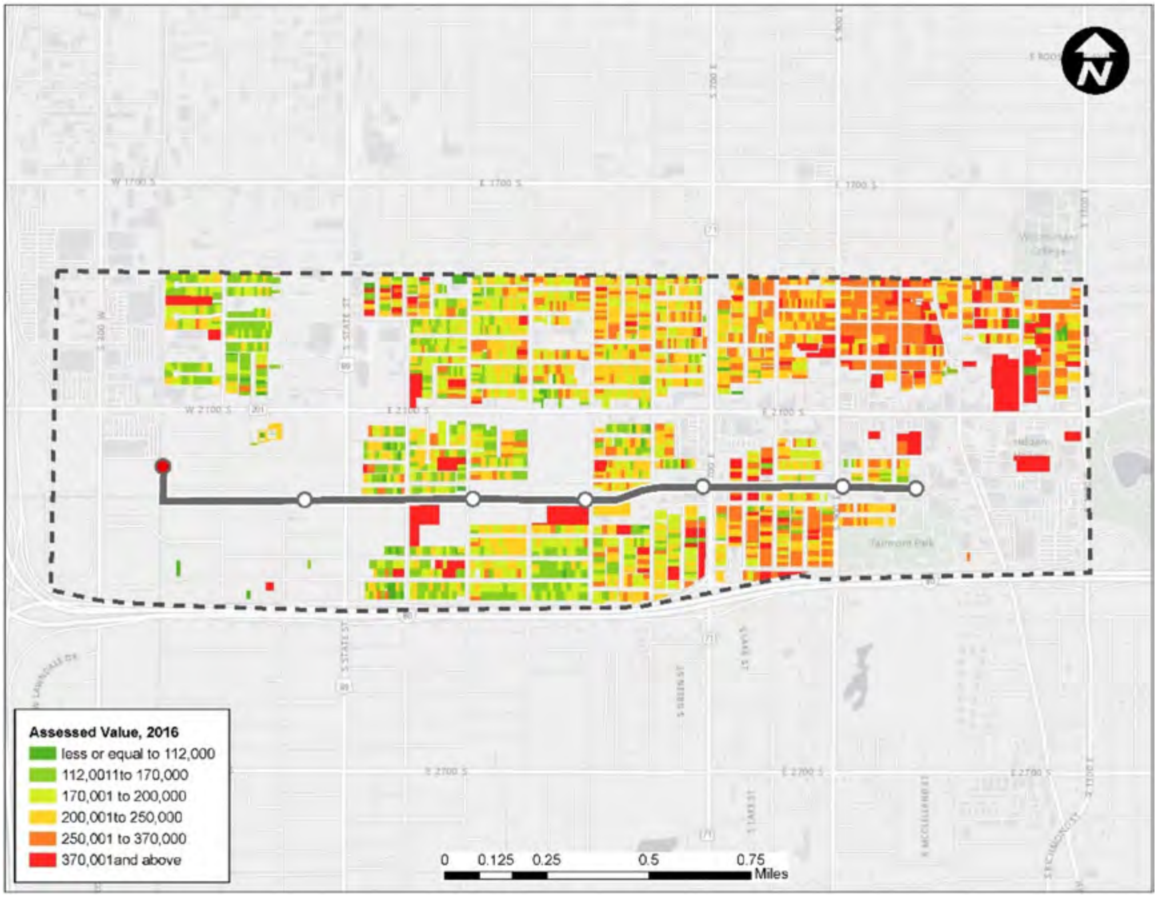


Figure 5-68 *Map of Residential Property Values – Salt Lake City S-Line – 2016*

Commercial Properties

Commercial properties include offices, restaurants, food stores, merchandise shops, department stores, shopping centers, and commercial establishments. As of 2016, there were 550 occupied (271.3 acres) and 41 vacant (9.8 acres) commercial parcels. Figure 5-69 shows that the vast majority of establishments were clustered along East 2100 South, with the largest commercial parcels on the eastern and western portions of the SIA.

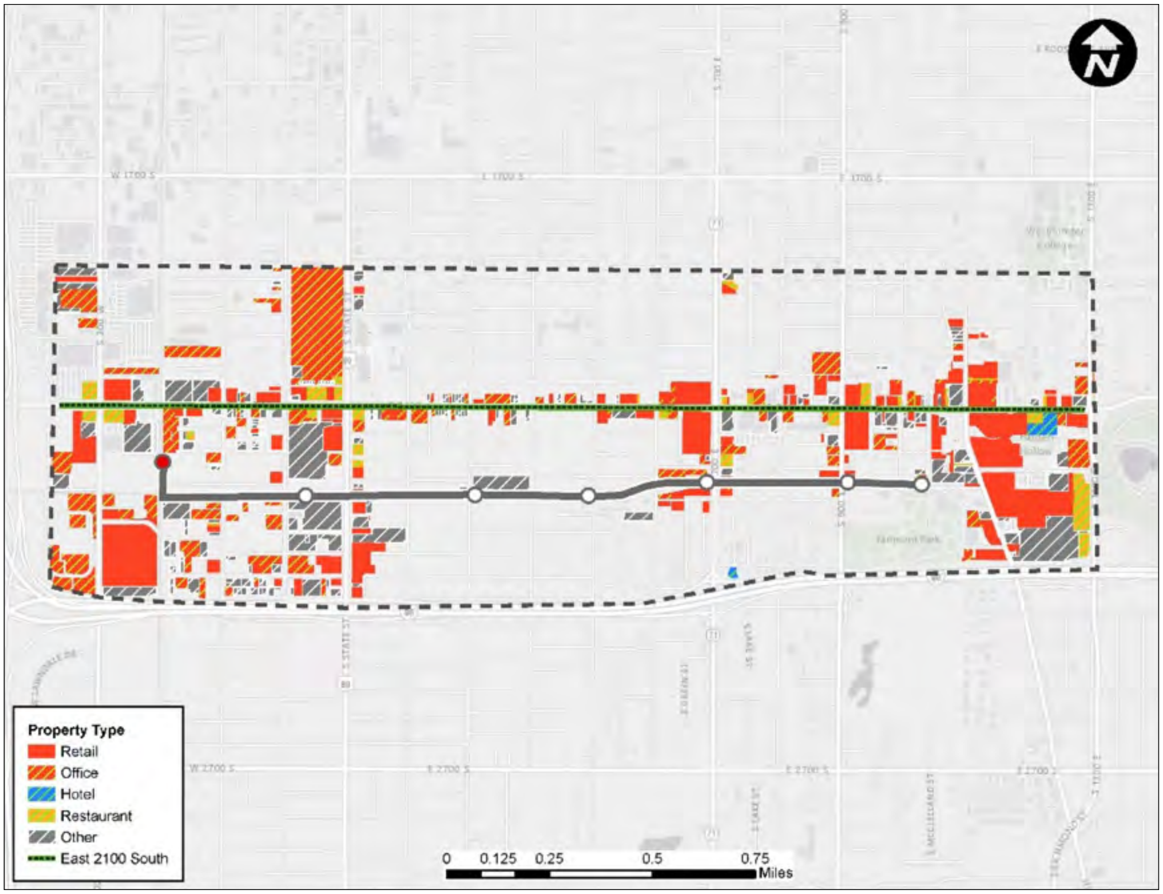
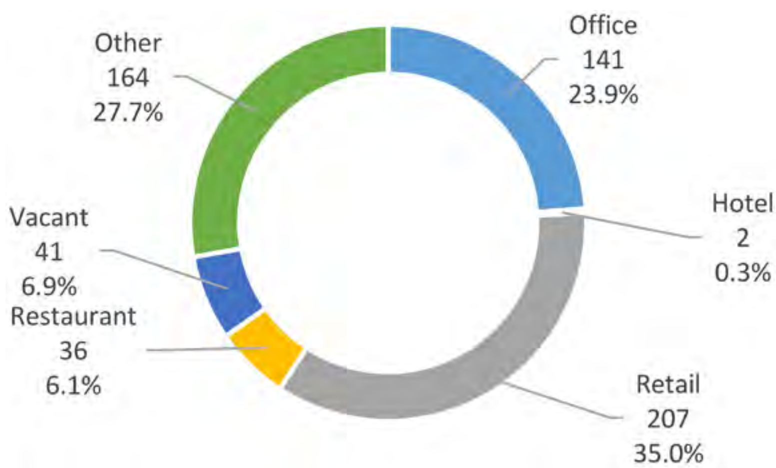


Figure 5-69 *Map of Commercial Parcels – Salt Lake City S-Line*

Figure 5-70 reports the breakdown of occupied and vacant commercial parcels by property type, using 2016 tax roll data. About 200 parcels were retail establishments, representing 35.0 percent of the total 591 parcels, followed by 141 office units (23.9%). Among the parcels categorized as other (27.7%), there were parcels dedicated to storage, warehousing, car wash, and commercial parking.

Figure 5-70

Commercial Parcels Breakdown – Salt Lake City S-Line



Looking at the historical trends of Table 5-34 and Table 5-35, over 2007–2016, the number of parcels dedicated to office space declined by 19 units (-11.9%) with a decrease of 1.9 acres, while retail parcels increased by 12 units (6.2%), adding 1.9 acres. Parcel acreage siting restaurants also increased by 2.7 acres over the same period (20.8%). Vacant parcel acreage declined by about 0.6 acres during 2007-2016, or by about 6.0 percent.

Table 5-34

Commercial Parcel Count – Salt Lake City S-Line

Parcel Type	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Office	160	153	155	160	160	172	169	157	134	141
Hotel	1	1	2	2	2	2	2	2	2	2
Retail	195	199	201	196	206	201	204	209	208	207
Restaurant	31	32	31	33	33	34	34	36	37	36
Vacant	43	45	43	49	46	46	42	44	42	41
Other†	139	138	130	133	134	128	140	169	165	164
Total	*569*	*568*	*562*	*573*	*581*	*583*	*591*	*617*	*588*	*591*

† Includes automotive services, storage, parking and other services.

Table 5-35

Commercial Parcel Acreage – Salt Lake City S-Line

Parcel Type	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Office	70.73	68.3	82.83	82.93	84.65	84.95	82.78	85.34	67.61	68.81
Hotel	0.32	0.32	2.18	2.18	2.18	2.18	2.18	2.18	2.18	2.18
Retail	99.58	99.62	98.82	99.89	103.6	100.3	87.45	100.6	99.9	97.72
Restaurant	13.13	13.45	12.81	14.08	14.08	14.33	13.54	15.02	15.99	15.86
Vacant	10.43	11.09	10.97	12.58	11.74	11.63	11.61	13.14	7.36	9.8
Other†	93.02	90.22	79.71	92.28	89.21	83.83	86.71	86.51	84.22	86.68
Total	*287*	*283*	*287*	*304*	*305*	*297*	*284*	*303*	*277*	*281*

†Includes automotive services, storage, parking and other services.

Figure 5-71 Illustrates historical trends in mean assessed value for occupied and vacant parcels, comparing the study area to similar properties (controls) and the rest of the county. Assessed values of retail properties located in the SIA were higher, on average, and showed increasing trends starting in 2013, reflecting the generalized economic recovery conditions.

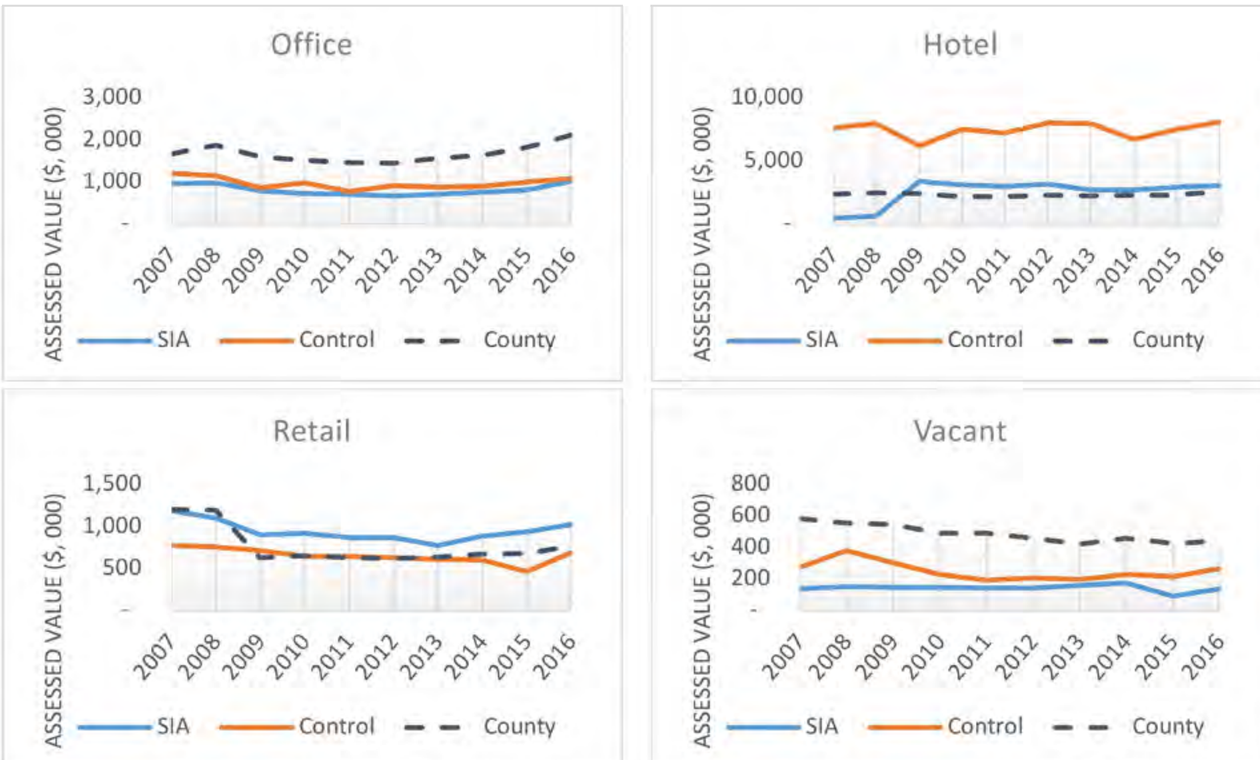


Figure 5-71 *Commercial Property Values – Salt Lake City S-Line*

Figure 5-72 and Figure 5-73 map out commercial property values, comparing the 2007 streetcar pre-planning phase to 2016. Properties with values exceeding $3 million were big-box retailers and shopping centers. The vast majority of properties (90.0%) were valued less than $1.7 million and the properties were clustered around East 2100 South.

Figure 5-72

Map of Commercial Property Values – Salt Lake City S-Line – 2007

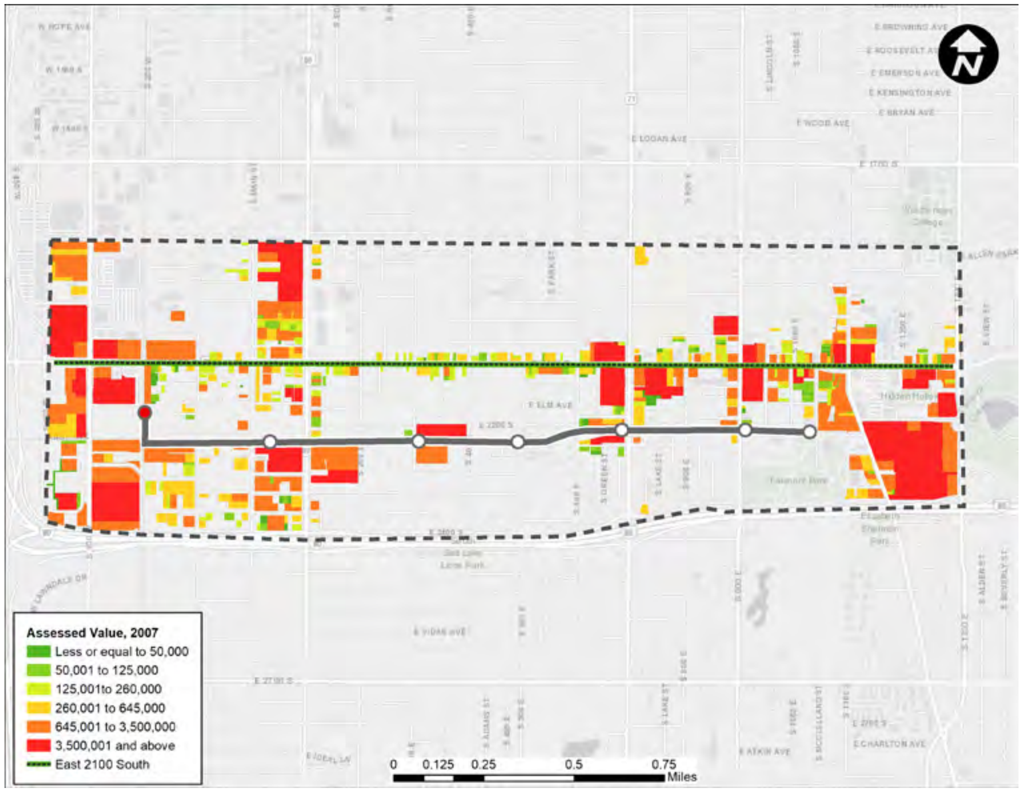
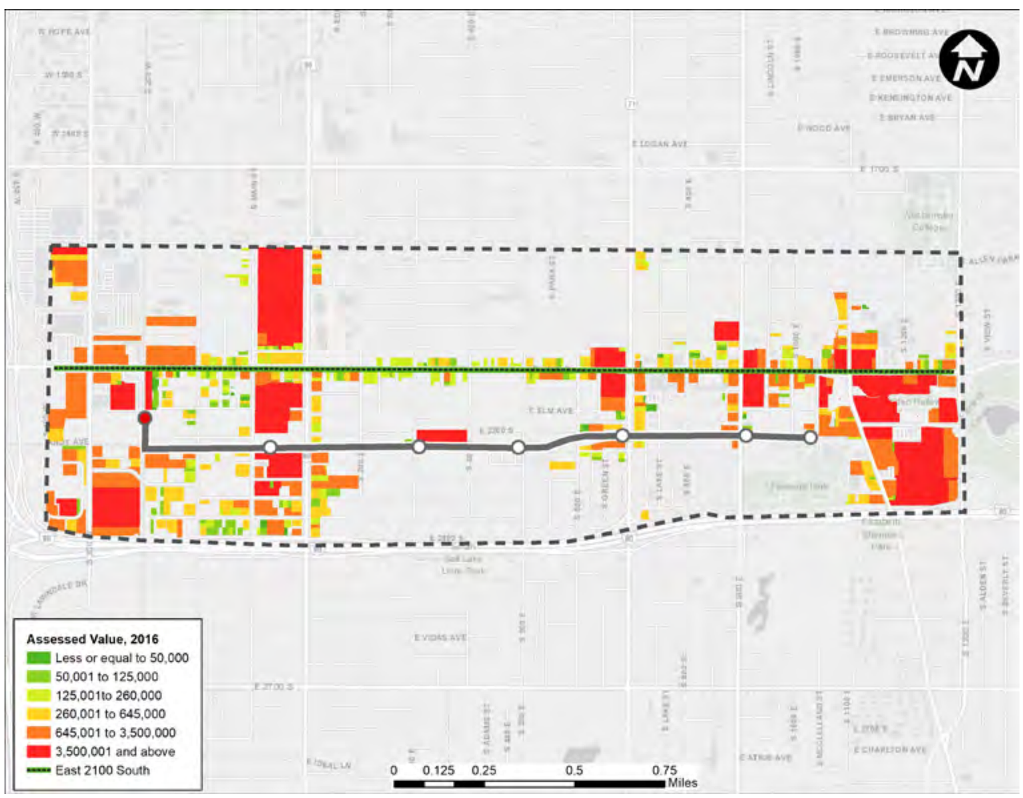


Figure 5-73

Map of Commercial Property Values – Salt Lake City S-Line – 2016



Vacant Properties

In 2016, there were 86 vacant parcels, of which 41 (47.7%) were classified as commercial, 17 were classified as industrial (19.8%), and 15 (17.4%) were classified as residential. Figure 5-74 shows a clustering of small size commercial parcels along East 2100 South, and in proximity of the streetcar alignment.

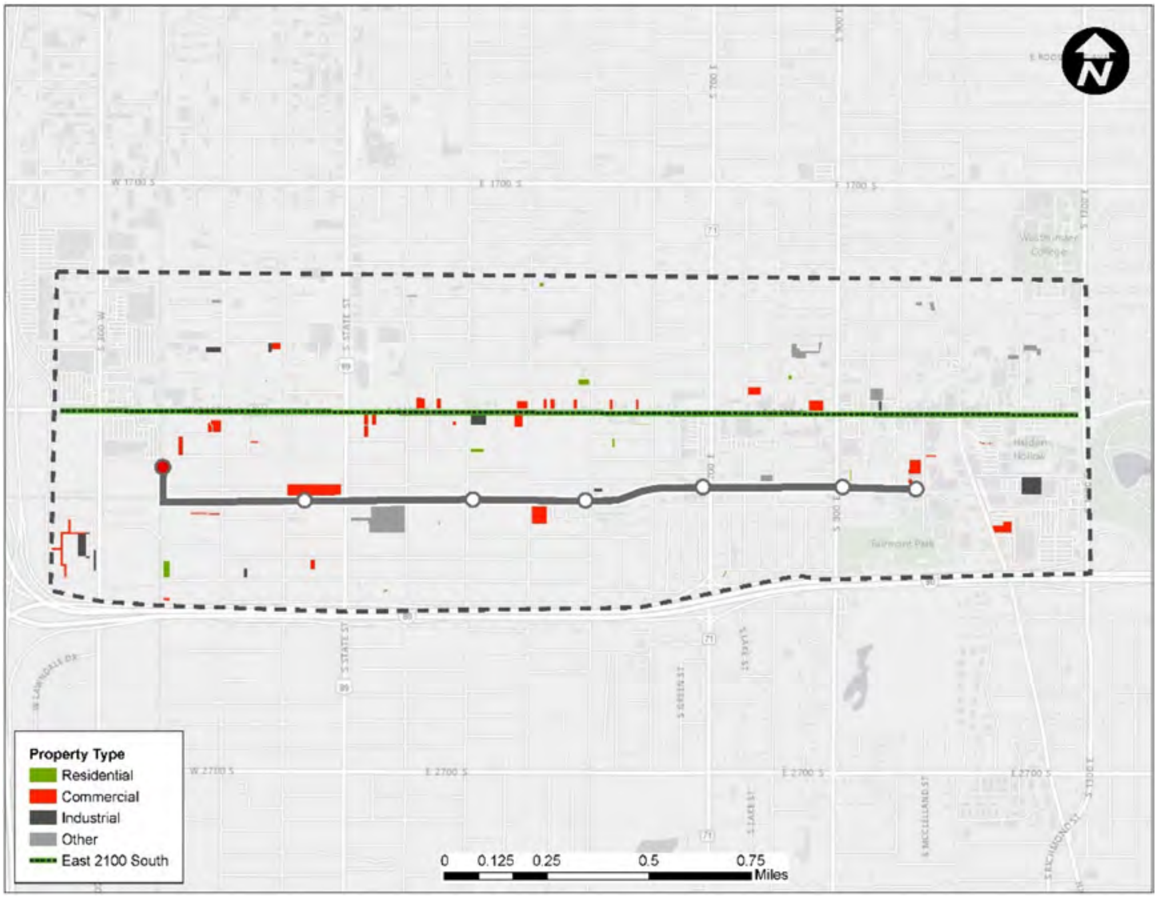
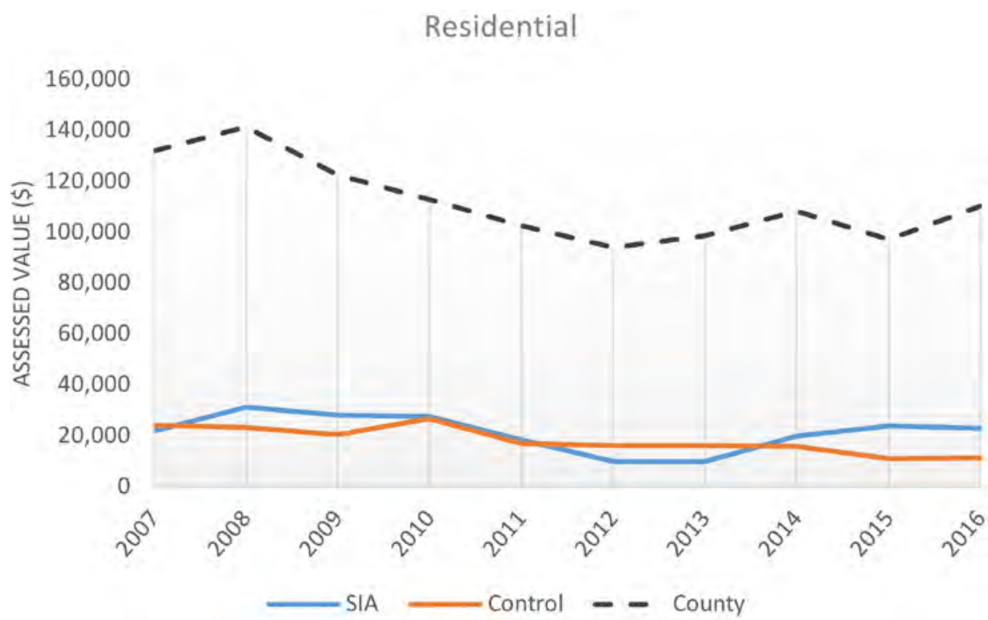


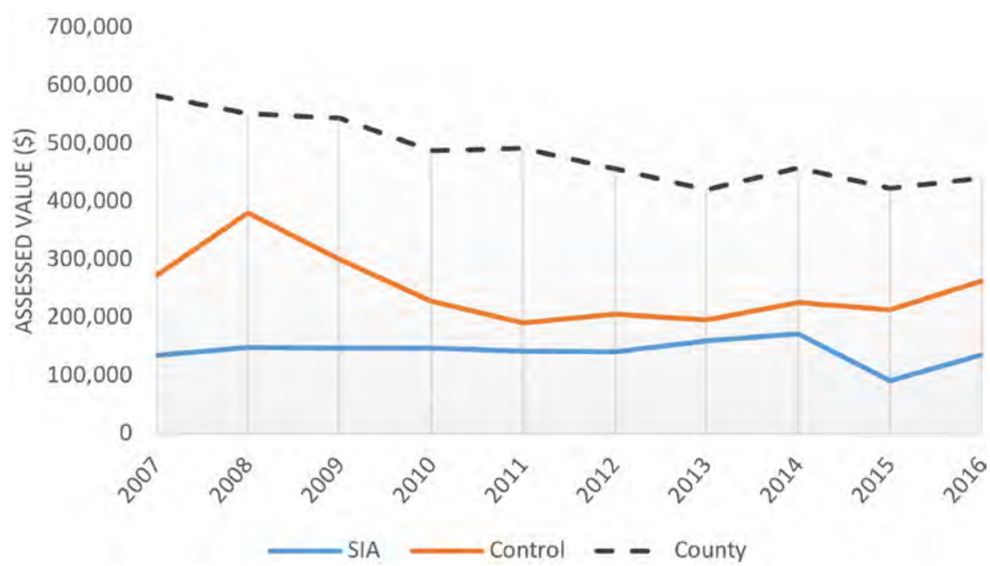
Figure 5-74 *Map of Vacant Parcels – Salt Lake City S-Line*

The assessed value of residential vacant parcels located in the SIA, using the Property Appraiser evaluation of land value, showed a marked increase starting in 2012, in conjunction with the streetcar construction and concurring changes in land-use (Figure 5-75). During 2012–2016, average vacant residential parcels assessed values increased by 41.7 percent.

Figure 5-75

Vacant Parcels Assessed Values – Salt Lake City S-Line





SECTION
6

Econometric Analysis of Property Values

The changes in property values discussed in the previous section provide a historical perspective of how the study area evolved over time. The key question to ascertain is to what extent the value of these properties changed through time and whether knowledge of the streetcar project planning had an impact on property prices, either by increasing value of similar properties located outside the SIA or through market value preservation in response to loss of value caused by the real estate market crisis.

The figures and tables do not discern between growth due to the accessibility improvements provided by the streetcar investment and growth that would have occurred due to other factors or generalized trends. Furthermore, the changes in property values in this area and across the entire county coincide with the most recent economic downturn.

This section presents a statistical analysis that allows distinguishing between changes in property values that would have occurred independent of the streetcar and changes attributable to the project. A series of regression models estimates the differences in property values before and after the project (i.e., Announcement, Planning, Construction, and Opening) and compares the results to the differences for the same before-after periods to a set of comparable parcels. The estimation approach is based on the standard difference-in-differences approach that isolates and quantifies the effects that can be attributed to streetcar planning, construction, and operation. Appendix A details the difference-in-differences estimation.

Cincinnati Bell Connector

CAGIS provides quarterly updates to the GIS parcel shape files, which includes date and amount of the last sale recorded for the quarter. By request, the Hamilton County Auditor's Office, Operations, and Public Records provided a separate sales file that reports all recorded sales for the entire county (including multiple sales for any given parcel) along with detailed building physical characteristics. This database was augmented with GIS layers to identify parcels located in the SIA and control areas to construct the database for empirical modeling.

To investigate the causality between the different project phases and impacts on property values, property sales are aggregated per the most relevant project phases, as reported in Table 6-1. The aggregation of observations by project phase allows setting up a baseline comparison corresponding to the period before any official planning announcement was made (Pre-planning). This phase is characterized by informal news about project planning. Subsequent phases identify when the official decision was made to include the project into the planning process (Announcement and Planning) and include major evaluation studies such as environmental assessments, as well as design and development. The Construction phase coincides with the commencement of construction (2012). The streetcar opened to the public on September 9, 2016.

Table 6-1

Cincinnati Bell Connector Project Phases

Year	Event	Project Phase
2007	HDR Feasibility Study	Pre-planning
2008	City Council approves building plan	Pre-planning
2009	Referendum 1 to stop streetcar	Pre-planning
2010	FTA Approves $25 million grant	Announcement and Planning
2011	Referendum 2 to stop streetcar	Announcement and Planning
2012	Construction starts (Feb)	Design and Construction
2013	Construction on pause	Design and Construction
2016	Streetcar begins operations (Sep)	Opening

Single-family Properties

Table 6-2 reports the sales counts and average sales prices of single-family homes. The sample consists of qualified property sale transactions for the period 2007–2016. The table presents counts after data cleaning to remove outliers (i.e., sales with values above the sample 95th percentile) and single observation outliers. The table includes sales, specifically, determined as qualified by the Property Appraiser's examination of the property deed. The sample contains the last sale registered on a given parcel. It does not include repeat sales of the same property. It represents the last sale registered on the property deed. The vast majority of sales (53.4%) occurred during the Design and Construction phase. Mean sales values reached a peak during the opening phase, although the growth trend started at Design and Construction.

Table 6-2

Single-family Property Sales by Project Phase – Cincinnati Bell Connector

Project Phase	SIA		Control	
	Count	Value ($)	Count	Value ($)
Pre-planning	109	154,589	1,057	128,504
Announcement and Planning	63	145,536	522	116,323
Design and Construction	283	199,493	1,999	153,241
Opening	75	230,190	609	146,926
Total	*530*		*4,187*	

Table 6-3 and Table 6-4 report sample descriptive statistics of single-family property sales for the streetcar influence area and the control areas. The sample includes variables used in the regression models as explanatory variables to account for factors affecting property prices, such as parcel size, size of living space, building age, the presence of amenities, such as parks and distance to major interstates and rail lines. The empirical literature shows that these variables significantly affect property sale prices, and it is common practice to include them in econometric models. The academic literature refers to the approach as "hedonic regression" or modeling that controls for factors having an impact on an individual's willingness to pay for specific building features and attributes.

Table 6-3

Single-family Property Sales Sample Descriptive Statistics – Cincinnati Bell Connector – SIA Parcels

Definition	Mean	Std. Dev.	Min	Max
Sale price ($)	195,629	146,547	10,000	1,175,000
Living space (sf)	1,847	626	588	4,445
Parcel size (acres)	0.05	0.02	0.00	0.21
Building age (years at sale date)	87	58	1	174
Building condition good or excellent	0.32	0.47	0.00	1.00
Distance to nearest streetcar station (ft)	1,796	607	94	2,638
Distance to nearest Interstate (ft)	2,484	1,185	156	5,112
Park within 0.25 mile	0.68	0.47	0.00	1.00

Sample size=530

Table 6-4

Single-family Property Sales Sample Descriptive Statistics – Cincinnati Bell Connector – Control Parcels

Definition	Mean	Std. Dev.	Min	Max
Sale price ($)	151,377	158,502	10,000	1,655,000
Living space (sf)	1,689	746	0	6,017
Parcel size (acres)	0.15	0.11	0.00	0.72
Building age (years at sale date)	86	32	1	169
Building condition good or excellent	0.16	0.37	0.00	1.00
Distance to nearest streetcar station (ft)	26,725	12,568	4,881	75,705
Distance to nearest Interstate (ft)	6,134	5,827	53	31,530
Park within 0.25 mile	0.78	0.42	0.00	1.00

Sample size=4,187

Table 6-3 and Table 6-4 show that SIA and control samples are similar in terms of median housing age, accessibility to nearby amenities, but they differ in terms of mean housing price, building conditions, and transport network. For example, 32 percent of single-family homes located in the SIA have a building condition rated either good or excellent by the County Assessor, compared to 16 percent of similar properties located in the control areas. Single-family homes are on average located at about 2,500 feet to the nearest interstate compared to about 6,000 feet for similar homes located in the control areas.

The econometric model follows the general specification provided in Appendix A. The dependent variable is the natural log of the sale price. The explanatory variables of Table 6-3 and Table 6-4 are included in the final models, with alternative model specifications that include controls for spatial autocorrelation.

Table 6-5 reports the results of the regression using naïve ordinary least square (OLS) estimator and the spatial autoregressive model with spatial autocorrelation (SRAR) estimates. The SRAR model results show that the property prices are spatially correlated with correlation extending to the error term. This is due to factors that are unobserved and that affect property sale values due to spatial proximity of adjacent properties. The SRAR model controls for spatial correlation in the error term, which is statistically significant. For this reason and due to the statistical significant term indicating spatial correlation among properties (the term *lambda*), the preferred model is the SRAR.

Table 6-5

Single-family Property Sales – Cincinnati Bell Connector – Estimation Results

Variable	Definition	Regression Models		
		OLS (1)	OLS (2)	SRAR
treatment	Treatment	0.277***	0.401***	0.290**
		(3.52)	(4.94)	(2.35)
ann_plan	Announcement and Planning	-0.217***	-0.232***	-0.229***
		(-4.96)	(-5.78)	(-6.88)
constr	Construction	0.0425	-0.00694	-0.0216
		(1.45)	(-0.26)	(-0.90)
open	Opening	0.199***	0.142***	0.119***
		(4.27)	(3.43)	(3.39)
tr_ann_plan	Interaction term (treatment*ann_plan)	0.0457	-0.0774	0.0381
		(0.36)	(-0.63)	(0.37)
tr_constr	Interaction term (treatment*constr)	0.0927	0.0918	0.140*
		(1.09)	(1.12)	(1.84)
tr_open	Interaction term (treatment*open)	0.173	0.146	0.239**
		(1.30)	(1.26)	(2.24)
lbsize	Living space size	4.006***	2.665**	0.115
		(3.72)	(2.65)	(0.15)
lbsize2	Squared term of lbsize	-0.228**	-0.126*	0.0428
		(-3.16)	(-1.87)	(0.84)
lpsize	Parcel size	0.293***	0.207***	0.194***
		(4.81)	(3.52)	(9.10)
lpsize2	Squared term of lpsize	0.0426***	0.0307**	
		(3.40)	(2.79)	
lage	Age of structure	0.0837**	0.0711*	0.269***
		(2.07)	(1.68)	(4.85)
lage2	Squared term of lage	-0.0365***	-0.0389***	-0.0812***
		(-4.72)	(-4.86)	(-8.67)
rooms	Number of rooms	0.166***	0.104**	0.000748
		(3.30)	(2.11)	(0.08)
rooms2	Squared term of rooms	-0.0103**	-0.00747**	
		(-3.25)	(-2.35)	
full_bath	Number of full-size bathrooms	0.165***	0.127***	0.122***
		(7.10)	(5.69)	(6.60)
garage	With car garage	0.234***	0.200***	0.157***
		(8.74)	(8.35)	(7.06)
bcond	Building condition good to excellent	0.713***	0.501***	0.506***
		(24.87)	(16.93)	(13.38)
fire	With fireplace	0.174***	0.106**	
		(4.20)	(2.96)	
park	Public park within 0.25 mile	-0.189***	-0.140***	-0.0285
		(-5.52)	(-4.29)	(-0.94)
highway	Highway within 0.5 mile	-0.291***	-0.215***	-0.286***
		(-6.00)	(-4.51)	(-6.11)

Table 6-5 cont'd.

Single-family Property Sales – Cincinnati Bell Connector – Estimation Results

Variable	Definition	Regression Models		
		OLS (1)	OLS (2)	SRAR
rail	Rail line within 0.5 mile	0.200***	-0.0158	0.0710**
		(6.73)	(-0.58)	(2.13)
_cons	Intercept	-6.010	-0.898	8.249**
		(-1.54)	(-0.25)	(2.99)
lambda	Autoregressive term			0.0000590***
_cons				(14.70)
rho	Autoregressive error			0.00110***
_cons				(45.73)
sigma2	Sigma squared			0.358***
				(45.25)
N	Sample size	4,101	4,101	4,101
adj. R-sq	Adjusted R-square	0.46	0.56	

*Standard errors in parenthesis: * $p<0.05$; ** $p<0.01$, *** $p<0.001$.*
Pre-planning phase (pre-plan) is baseline treatment phase.

Statistical inference on the SRAR parameters supports evidence of price premia on single-family property sales during the construction and opening phases. Using the Pre-planning phase at the base for comparison, single-family homes located within the SIA show a sale premium with respect to similar homes located in the control areas ranging from 15.0 percent during Construction to 27.0 percent at the Opening phase.[35]

Condominium Properties

CAGIS provided detailed data on sales of condominium properties via ArcGIS shapefiles.[36] Table 6-6 reports the 2007–2016 sale counts and average sale prices of condominium units, after the removal of outliers. The count of sales in the SIA is higher than the control areas. Sales decreased during the Announcement and Planning phase, which corresponds to the period when the real estate crisis was reaching its peak at the national level, but increased during Design and Construction and Opening. Average sale prices are higher than the control areas showing an increasing trend throughout starting at Announcement and Planning.

[35] For OLS estimate, proportional change estimated by applying following formula [(exp (β)-1)*100], where β is estimated parameter expressing interaction term between treatment project phase. For SRAR estimate, above formula applied only after estimating model total effects as detailed in Appendix A. This is because model includes a spatial lag of dependent variable as an explanatory variable, making relationship simultaneous in nature.

[36] CAGIS provided two sets of files reflecting 2016 conditions: 1) condominium polygon files identifying location of condominium parcels, and 2) condominium attribute files containing information on unit sales and building characteristics.

Table 6-6

Condominium Property Sales by Project Phase – Cincinnati Bell Connector

Project Phase	SIA		Control	
	Count	Value ($)	Count	Value ($)
Pre-planning	273	154,589	371	128,504
Announcement and Planning	102	145,536	59	116,323
Design and Construction	536	199,493	298	153,241
Opening	151	230,190	67	146,926
Total	*1,062*		*795*	

Table 6-7 and Table 6-8 report the sample descriptive statistics for the variables included in the regression analysis. On average, properties located in the SIA sold at a higher price and are, on average, larger in terms of living space. Most notably, condominium properties located in the SIA have a substantially lower average age, indicating that properties sold are of recent construction.

Table 6-7

Condominium Property Sales Sample Descriptive Statistics – Cincinnati Bell Connector – SIA

Definition	Mean	Std. Dev.	Min	Max
Sale price ($)	419,211	403,881	13,000	2,300,000
Living space (sf)	1,558	812	368	6,102
Building age (years at sale date)	46	46	1	136
Story height of main building	1.20	0.43	1.00	3.00
Distance to nearest streetcar station (ft)	11,881	8,628	3,561	58,454
Distance to nearest Interstate (ft)	3,078	2,095	150	8,081
Park within 0.25 mile	0.83	0.38	0.00	1.00

Sample size=1,062

Table 6-8

Condominium Property Sales Sample Descriptive Statistics – Cincinnati Bell Connector – Control Parcels

Definition	Mean	Std. Dev.	Min	Max
Sale price ($)	249,157	108,535	37,000	620,000
Living space (sf)	1,266	500	409	3,934
Building age (years at sale date)	105	46	1	194
Story height of main building	1.27	0.50	1.00	4.00
Distance to nearest streetcar station (ft)	1,021	719	41	2,637
Distance to nearest Interstate (ft)	2,111	1,284	87	4,768
Park within 0.25 mile	0.86	0.34	0.00	1.00

Sample size=795

The results of regressions are reported in Table 6-9. The model labeled OLS (1) is the naïve OLS model, and model OLS (2) is an extension of the OLS (1) and accounts for streetcar station proximity. The last model is the spatial autoregressive model with spatial autocorrelation (SRAR) estimates.[37] The SRAR is preferred to the naïve estimators because it controls for spatial correlation in the error term and spatial autocorrelation, which are statistically significant.

[37] SRAR regression made possible thanks to separate file made available by CAGIS, which provided detailed geolocation of each condominium unit within a condominium complex.

Table 6-9

Condominium Property Sales – Cincinnati Bell Connector – Estimation Results

Variable	Definition	Regression Models		
		OLS (1)	OLS (2)	SRAR
treatment	Treatment	0.488***	0.225***	0.303***
		(7.97)	(3.56)	(4.50)
ann_plan	Announcement and Planning	-0.156*	-0.0980	-0.111*
		(-1.70)	(-1.46)	(-1.69)
constr	Construction	0.0504	-0.0580	-0.0585
		(0.82)	(-1.21)	(-1.16)
open	Opening	0.215**	0.0193	0.0900
		(2.65)	(0.30)	(1.36)
tr_ann_plan	Interaction term (treatment*ann_plan)	-0.132	-0.210**	-0.140*
		(-1.20)	(-2.36)	(-1.72)
tr_constr	Interaction term (treatment*constr)	0.0675	0.143**	0.127**
		(0.94)	(2.33)	(2.15)
tr_open	Interaction term (treatment*open)	0.0208	0.182**	0.163**
		(0.22)	(2.31)	(2.09)
lbsize	Living space size	0.886***	0.830***	0.890***
		(23.79)	(22.17)	(23.41)
lage	Age of structure	-0.0329	-0.0435	-0.0571
		(-0.79)	(-1.26)	(-1.35)
lage2	Squared term of lage	-0.00415	-0.00559	0.00361
		(-0.54)	(-0.86)	(0.47)
floor2	Story height of main building	-0.235***	-0.0804**	-0.123***
		(-6.40)	(-2.58)	(-3.86)
park	Public park within 0.25 mile	0.231***	0.246***	0.202***
		(6.52)	(7.38)	(4.51)
highway	Highway within 0.5 mile	0.176***	-0.0591	0.218***
		(4.85)	(-0.76)	(3.84)
rail	Rail line within 0.5 mile	0.235***	0.0185	0.301***
		(4.46)	(0.45)	(5.18)
_cons	Intercept	5.704***	6.425***	5.610***
		(21.51)	(25.25)	(20.18)
lambda	Autoregressive term			0.000000302
				(0.37)
rho	Autoregressive error			0.000277***
				(80.32)
sigma2	Sigma squared			0.0972***
				(20.64)
N	Sample size	954	954	854
adj. R-sq	Adjusted R-square	0.56	0.69	

*Standard errors in parenthesis: * p<0.05; **p<0.01, ***p<0.001.*

Using the Pre-planning phase at the base for comparison, findings provide evidence of the streetcar project effect on condominium property sales throughout the project phases. During the Announcement and Planning phases, properties located within the SIA show a negative premium (-13.5%). This finding, though contrary to what was hypothesized, might be explained by uncertainty surrounding the fate of the streetcar project. In particular, during this period, a referendum was proposed to stop the project (2011), which was then rejected. During Construction, the model also shows a positive premium (13.5%), which increases at Opening (17.7%).[38]

Commercial Properties

Table 6-10 reports sales data for commercial properties. After removal of outliers, sales in the SIA totaled 658, with 40 valid sales recorded during the Opening and first year of operation (2016).

Table 6-10

Commercial Property Sales – Cincinnati Bell Connector

Project Phase	SIA		Control	
	Count	Value ($)	Count	Value ($)
Pre-planning	186	473,387	261	321,464
Announcement and Planning	55	568,548	100	255,099
Design and Construction	377	590,187	387	332,518
Opening	40	513,339	63	309,230
Total	*658*		*811*	

Table 6-11 and Table 6-12 report the sample descriptive statistics for the variables included in the regression analysis. Due to the CBD higher density, commercial properties are smaller in parcel and front footage. On average, commercial properties located in the SIA sold at a higher price.

Table 6-11

Commercial Property Sales Sample Descriptive Statistics – Cincinnati Bell Connector – SIA

Definition	Mean	Std. Dev.	Min	Max
Sale price ($)	351,822	479,781	10	2,850,000
Parcel size (acre)	0.1	0.1	0.0	2.0
Front footage (sf)	96	100	0	828
Distance to nearest streetcar station (ft)	895	654	0	2,635
Distance to nearest Interstate (ft)	2,644	1,088	113	4,877

Sample size=658

Table 6-12

Commercial Property Sales Sample Descriptive Statistics – Cincinnati Bell Connector – Control Parcels

Definition	Mean	Std. Dev.	Min	Max
Sale price ($)	280,352	451,257	500	2,950,000
Parcel size (acre)	0.2	0.5	0.0	6.9
Front footage (sf)	93	128	0	1,488
Distance to nearest streetcar station (ft)	19,483	11,618	3,832	61,354
Distance to nearest Interstate (ft)	4,101	4,830	36	31,469

Sample size=811

[38] See footnote 14 for explanation of how model parameters are interpreted and premia estimated.

Table 6-13 reports the results of the econometric model. The table presents results from three different model specifications: the naïve model (OLS 1); an extension augmenting it by including streetcar station-specific effects (OLS 2); and the SRAR model to control for spatial spillover effects. The results provide inconclusive evidence of streetcar impacts on commercial property values, with all models performing poorly.

Table 6-13

Commercial Property Sales – Cincinnati Bell Connector – Estimation Results

Variable	Definition	Regression Models		
		OLS (1)	*OLS (2)*	*SRAR*
treatment	Treatment	0.683***	0.148	0.382*
		(5.39)	(1.12)	(1.72)
ann_plan	Announcement and Planning	-0.268**	-0.233*	-0.227*
		(-2.06)	(-1.92)	(-1.76)
constr	Construction	-0.134	-0.120	-0.0789
		(-1.49)	(-1.35)	(-0.89)
open	Opening	-0.0153	-0.0559	-0.0936
		(-0.10)	(-0.39)	(-0.60)
tr_ann_plan	Interaction term (treatment*ann_plan)	-0.249	-0.481**	-0.445**
		(-0.93)	(-2.23)	(-2.11)
tr_constr	Interaction term (treatment*constr)	0.121	0.186	0.0611
		(0.85)	(1.39)	(0.45)
tr_open	Interaction term (treatment*open)	0.0552	0.187	0.214
		(0.21)	(0.83)	(0.85)
lpsize	Size of parcel	0.408***	0.373***	0.373***
		(7.56)	(7.80)	(9.34)
lpsize2	Square of size of parcel	0.0104	0.0131	0.0141
		(0.57)	(0.88)	(0.95)
rail	Rail line within 0.5 mile	-0.220**	-0.299***	-0.219**
		(-2.69)	(-3.76)	(-2.22)
highway	Highway within 0.5 mile	0.0864	-0.0778	0.0625
		(0.83)	(-0.75)	(0.59)
_cons	Intercept	12.91***	12.48***	12.79***
		(105.23)	(81.67)	(112.77)
lambda	Autoregressive term			0.0000187
				(1.47)
rho	Autoregressive error			0.00143***
				(20.72)
sigma2	Sigma squared			1.135***
				(26.89)
N	Sample size	1,468	1,468	1,468
adj. R-sq	Adjusted R-square	0.11	0.27	

*Standard errors in parenthesis: * p<0.05; **p<0.01, ***p<0.001.*
Pre-planning phase (pre-plan) is baseline treatment phase.

As an alternative approach to estimate changes in commercial property values, Table 6-14 reports the results of an FE model using historical assessed values of all commercial parcels for the period 2007–2016. The dependent variable is the natural log of the Property Appraiser total assessed value.

Table 6-14

Commercial Property Assessed Values Fixed Effect Estimation Results – Cincinnati Bell Connector

Variable	Definition	Regression Models	
		OLS	*FE*
treatment	Treatment	0.712***	
		(27.37)	
ann_plan	Announcement and Planning	-0.0596**	
		(-2.49)	
constr	Construction	0.166***	
		(7.69)	
open	Opening	0.962***	
		(26.97)	
tr_ann_plan	Interaction term (treatment*ann_plan)	-0.0222	-0.0221**
		(-0.56)	(-2.30)
tr_constr	Interaction term (treatment*constr)	0.00351	0.0140*
		(0.10)	(1.71)
tr_open	Interaction term (treatment*open)	0.0527	0.0548***
		(1.30)	(5.53)
lpsize	Size of parcel	0.724***	
		(70.83)	
lbsize	Front footage	0.232***	0.338***
		(42.27)	(11.21)
highway	Highway within 0.5 mile	0.577***	
		(28.15)	
rail	Rail line within 0.5 mile	-0.207***	
		(-11.92)	
_cons	Intercept	10.95***	10.04***
		(175.24)	(75.83)
N	Sample size	40,032	40,033
adj. R-sq	Adjusted R-square	0.297	0.2998

*Standard errors in parenthesis: * p<0.05; **p<0.01, ***p<0.001.*
Pre-planning phase (pre-plan) is baseline treatment phase.

The Property Appraiser assessed values define a panel database with yearly observations of the same parcel, which consists of repeated observations over time. The statistical analysis of panel data by multivariate regression (i.e., ordinary least square regression) produces biased results because of the omission of time-constant parcel-specific unobserved factors affecting the assessed values. To overcome this problem, FE can be used to eliminate the time-constant unobserved effects and, under certain assumptions, give unbiased estimates. In addition, FE regression allows estimating the change in assessed value within parcels as opposed to OLS, which estimates changes in assessed valued across all observations (i.e., pooling of data).

Table 6-14 shows the results of two models: the naïve regressor (OLS), and the FE. The FE provides evidence of positive premia realized throughout the phases of the project. As in the case of condominium properties, commercial properties show a negative sale price premium during the Announcement and Planning phase (-2.2%), and positive premia during Construction (1.4%), and at Opening (5.6%).[39]

Vacant Parcels

Table 6-15 and Table 6-16 report sale data for vacant parcels. Over the project phases, mean sale prices of residential parcels in the SIA are lower than sales in comparable control areas. Sales of commercial parcels in the SIA exhibit larger growth when comparing the Opening to the Pre-planning phase.

Table 6-15

Vacant Residential Property Sales by Project Phase – Cincinnati Bell Connector

Project Phase	SIA		Control	
	Count	*Value ($)*	*Count*	*Value ($)*
Pre-planning	42	80,680	247	81,931
Announcement and Planning	24	64,666	93	96,420
Design and Construction	148	115,718	455	169,416
Opening	50	165,752	96	173,631
Total	*264*		*891*	

Table 6-16

Vacant Commercial Property Sales by Project Phase – Cincinnati Bell Connector

Project Phase	SIA		Control	
	Count	*Value ($)*	*Count*	*Value ($)*
Pre-planning	32	261,681	58	223,641
Announcement and Planning	19	314,326	19	534,787
Design and Construction	93	300,894	92	389,428
Opening	36	783,190	36	413,788
Total	*180*		*205*	

The regression of property sale prices performed poorly, most likely due to the relatively small number of valid recorded sales in the SIA through the project phases and did not provide any conclusive evidence about streetcar effects on vacant property sales.

An alternative approach is to use the County Auditor's historical data and estimate a fixed-effect model as was done for the commercial parcels in the previous section. Table 6-17 reports the results of the panel-based approach, using the natural log of total full cash value as the dependent variable. The table reports results for all parcels with separate runs for residential and commercial properties.

[39] See footnote 35 for explanation of how model parameters interpreted and premia estimated.

Table 6-17 *Vacant Parcels Assessed Values Fixed Effect Model Estimation Results – Cincinnati Bell Connector*

Variable	Definition	Regression Models			
		OLS All Parcels	FE All Parcels	FE Residential	FE Commercial
treatment	Treatment	0.892***			
		(36.76)			
ann_plan	Announcement and Planning	-0.133***			
		(-7.06)			
constr	Construction	-0.196***			
		(-11.71)			
open	Opening	0.00938			
		(0.33)			
tr_ann_plan	Interaction term (treatment*ann_plan)	0.0418	0.0668***	0.0948***	0.0489*
		(1.11)	(4.35)	(5.35)	(1.75)
tr_constr	Interaction term (treatment*constr)	0.163***	0.153***	0.215***	0.0549**
		(5.04)	(5.42)	(14.35)	(2.25)
tr_open	Interaction term (treatment*open)	0.230***	0.209***	0.281***	0.0990***
		(5.77)	(6.99)	(15.79)	(3.56)
lpsize	Size of parcel	0.720***			
		(76.06)			
lbsize	Front footage	0.0597***	0.461**	1.288***	0.201
		(13.24)	(2.67)	(6.98)	(1.45)
highway	Highway within 0.5 mile	0.749***			
		(43.72)			
rail	Rail line within 0.5 mile	0.334***			
		(24.90)			
_cons	Intercept	9.478***	6.424***	3.054***	9.646***
		(180.71)	(9.94)	(4.48)	(16.68)
N	Sample size	53711	53744	39308	4708
adj. R-sq	Adjusted R-square	0.213	0.084	0.045	0.135

*Standard errors in parenthesis: * p<0.05; **p<0.01, ***p<0.001.*
Pre-planning phase (pre-plan) is baseline treatment phase.

The analysis finds evidence of positive premia realized through all phases of the project and across all parcel types. Overall, the R-squared values indicate that the models do not perform well. When considering all vacant parcels, premia range from 6.9 percent during Announcement and Planning to 17.7 percent during Construction and 25.9 percent during the Opening phase. When modeling vacant residential parcels, the premia range from 9.9 percent during Announcement and Planning, 24.0 percent during Construction, and 23.2 percent at Opening.

Factors Affecting Inference

Several factors unique to the study area are likely to exert influence on the results of the econometric analysis of property values. The streetcar is located in an area that underwent radical changes over the course of several decades, with alternating cycles of economic growth and recession that have shaped and reshaped the urban landscape. The vast majority of these events predates the streetcar project phases, whereas some others, such as the City of Cincinnati redevelopment efforts, began in conjunction with the streetcar planning efforts. The OTR historic district is perhaps the area that has experienced the most drastic impact of redevelopment efforts.

The bulk of redevelopment in the SIA, and especially within Over-the-Rhine, is a result of the Cincinnati Center City Development Corporation, better known as 3CDC, a tax-exempt, private, non-profit corporation.[40] Its establishment dates back to 2003 as the City's last attempt to lift OTR and surrounding areas from years of economic distress by engaging the private sector in a comprehensive, long-run, economic development effort. The organization operates with private funds obtained through a combination of corporate contributions, management fees, and below-market developer fees. In 2005, 3CDC formed OTR Holdings Inc. to purchase vacant, abandoned and dilapidated properties in OTR and move forward with the redevelopment plans. Over the course of 2005–2016, 3CDC activities resulted in the restoration of historic buildings and new mixed-used redevelopment valued at about $1.1 billion. In addition, 3CDC rehabilitated public greenspaces and community service facilities, such as Washington Park, Fountain Square and Music Hall. Figure 6-1 shows the location and Table 6-18 reports details on completed and ongoing commercial, residential, and mixed-use projects.

[40] https://www.3cdc.org/about-3cdc/.

Figure 6-1

Redevelopment Projects – Cincinnati Bell Connector

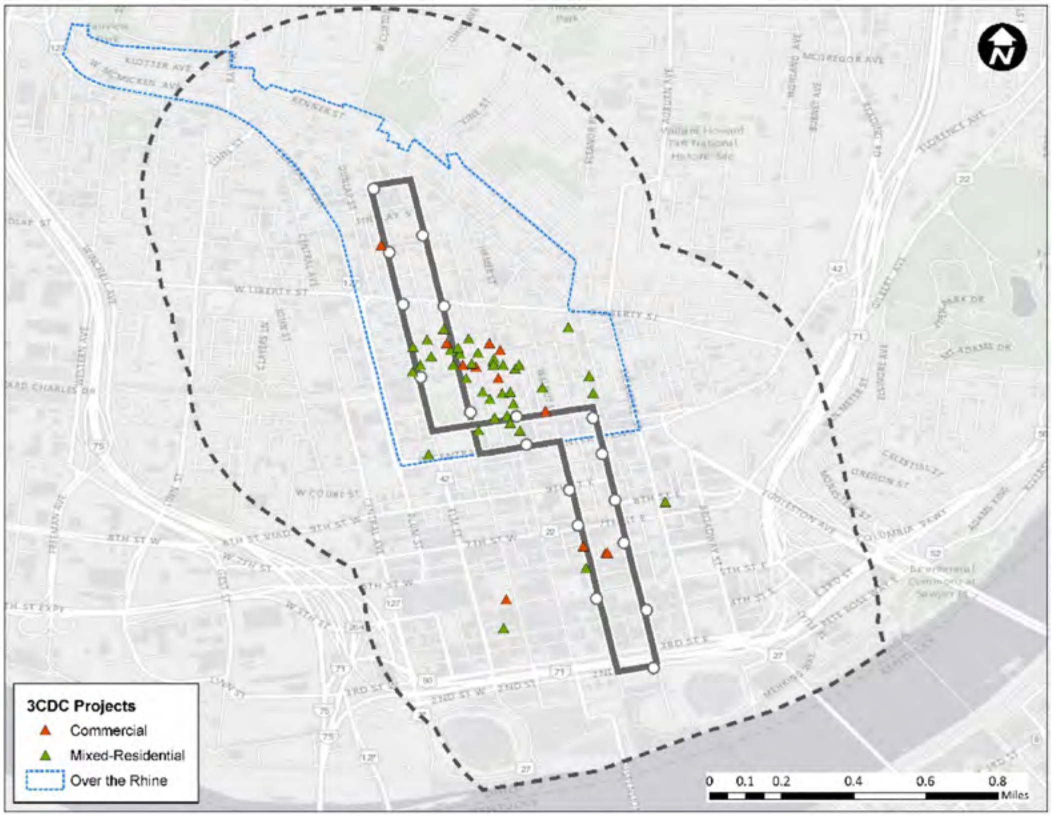


Table 6-18 *3CDC Redevelopment Projects – City of Cincinnati*

Project Name	Completion Date	Property Type	Total Cost ($, million)	Development Size (sf)	No. of Condo Units	Average Condo Price ($, current)	Average Condo Size (sf)
1201 Walnut	2015	commercial	7.1	28,000			
1403 Vine	2014	mixed	1.6		2	293,000	2,872
15W & 14th	2015	commercial	1.1	3,225			
15 & vine	Underway	commercial	19.5	55,000			
21C Museum Hotel	2012	commercial	57.8	8,000			
4th and Race	2018	mixed	41.0	22,000	225		
641 Walnut	2009	mixed	2.3	2,025	3		1,000
84.51	2015	commercial	139.7	310,000			
8th & Sycamore	2016	mixed	52.0	7,000	131		
B-Side Apartments	2013	residential	2.8		14		850
Bakery Lofts	2013	residential	2.4		9	223,000	1,080
Belmain	2009	mixed	2.3	2,811	16		680
Boca/Sotto	2013	commercial	12.6	22,900			
Bremen Lofts	Underway	mixed	3.6	930	17	120,000	865
Centennial Row	2015	residential	1.8		8	175,000	950
City Home 1401 Race	2011	mixed	1.6	3,083	4		1,430
City Home Pleasant St	2015	residential	6.2		18	270,000	1,600
Duncanson Lofts	2009	mixed	7.4	9,000	25	128,255	802
Duveneck Flats	2011	mixed	5.0	7,500	15	210,000	1,360
Falling Wall	2009	mixed	1.8	7,410	6	253,000	1,481
Gateway Arts	2009	mixed	3.0	3,178	12		
Gateway Condos	2007	mixed	7.3	7,712	26	160,000	986
Glassmeyer	2017	mixed	3.6	950	8	375,000	950
Globe Building	2015	commercial	4.0	14,881			
Good Fellows Hall	2011	mixed	2.1	1,095	5	282,000	1,766
Hummel Building	2013	mixed	1.6	2,440	4	385,000	
IGBY'S	2013	commercial	3.9	7,500			
Lackman Lofts	2013	mixed	2.2	923	7	152,000	796
Mercer Commons	2014	mixed	49.0	14,500	95		1,100
Mercer III Townhomes	2016	residential	5.5		12		1,800
Mottanai	2011	residential	2.9	175,000	8		1,198
Nicolay	2013	mixed	2.3	1,200	10		1,200
Paint Building	2013	commercial	5.7	12,273			
Parksite	2015	residential	3.6		8		1,192
Parvis Lofts	2017	mixed	11.9	15,421	32		870
The Allison	2017	mixed	5.0	4,500	17		1,200
Republic Street Lofts	2013	residential	2.4		9		1,000
Saengerhalle	2011	commercial	8.3	32,750			
Taft's Ale House	2015	commercial	9.6	12,345			
Tea Company Townhomes	2015	mixed	3.1	1,100	9		1,242

Table 6-18 cont'd. *3CDC Redevelopment Projects – City of Cincinnati*

Project Name	Completion Date	Property Type	Total Cost ($, million)	Development Size (sf)	No. of Condo Units	Average Condo Price ($, current)	Average Condo Size (sf)
The Olson	2015	mixed	1.8	830	5		
The Osborne	2015	mixed	3.6	917	11		
The Stafford	2017	mixed	4.3	2,800	11	220,900	660
Trideca Lofts	2015	mixed	3.3	3,275	9	204,500	1,023
Trinity at 14 & Vine	2009	mixed	3.5	1,165	9	202,112	1,252
Trinity Flats	2011	mixed	6.0	7,500	25	175,000	1,050
Union Hall	2015	commercial	16.7	7,000			
Westfalen Lofts	2011	residential	3.4		9	220,000	1,300
Westfalen Lofts II	2014	mixed	8.6	4,000	33	202,000	803
YMCA	2016	mixed	29.0	25,000	65		

Charlotte CityLYNX Gold Line

Through its GeoPortal website, Mecklenburg County Assessor's Office provides public access to sales and assessed value data for the period 2007–2016. The datasets contain information on all sales of properties for the entire Mecklenburg County, with information on date, amounts and transaction types.[41] The sales data were matched to parcels located in the SIA and control areas to provide detailed information on land-use classification for commercial parcels, building characteristics for residential parcels, and other data to construct the database for empirical modeling.

To investigate the causality between the different project phases and impacts on property values, property sales are aggregated per the most relevant project phases, as reported in Table 6-19. The aggregation of observations by project phase allows setting up a baseline comparison corresponding to the period before any official planning announcement was made (Pre-planning). This phase is characterized by informal news about project planning. Subsequent phases identify when the official decision was made to include the project into the planning process (Announcement and Planning), and include major evaluation studies such as environmental assessments, as well as design and development. The Construction phase coincides with beginning of construction (2012). The streetcar opened to the public on July 14, 2015.

Table 6-19

Charlotte CityLYNX Gold Line Project Phases

Year	Event	Project Phase
2006	City approves construction priority	Pre-planning
2008	City approves feasibility study	Pre-planning
2009	Tracks on Elizabeth Avenue	Pre-planning
2010	FTA Approves $25 million grant	Announcement and Planning
2012	Construction starts (Dec)	Design and Construction
2015	Streetcar begins operations (Jul)	Opening

[41] http://maps.co.mecklenburg.nc.us/openmapping/data.html.

Single-family Properties

Table 6-20 reports the sales counts and average sales prices of single-family homes. The sample consists of qualified property sale transactions for the period 2007–2016. The table presents counts after data cleaning to remove outliers (i.e., sales with values above the sample 95th percentile) and single observation outliers. The table includes sales determined specifically as qualified by the Property Appraiser's examination of the property deed. The sample contains the last sale registered on a given parcel. It does not include repeat sales of the same property; it represents the last sale registered on the property deed. Following the real estate crisis, there were relatively few single-family home sales during the project phases following the FTA grant announcement in 2010. Mean sales values reached a peak during the Design and Construction phases.

Table 6-20

Single-family Property Sales by Project Phase – Charlotte CityLYNX Gold Line

Project Phase	SIA		Control	
	Count	*Value ($)*	*Count*	*Value ($)*
Pre-planning	50	413,388	817	278,707
Announcement and Planning	30	413,983	521	317,627
Design and Construction	66	471,297	942	351,534
Opening	28	461,232	390	333,045

Table 6-21 and Table 6-22 report sample descriptive statistics of single-family property sales for the streetcar influence area and the control areas. The sample includes variables used in the regression models as explanatory variables to account for factors affecting property prices, such as parcel size, size of living space, building age, the presence of amenities such as parks and schools, waterfront location, and distance to major interstates and rail lines. The empirical literature shows that these variables significantly affect property sale prices, and it is common practice to include them in econometric models. The academic literature refers to the approach as hedonic regression, or modeling that controls for factors having an impact on an individual's willingness to pay for specific building features and attributes.

Table 6-21

Single-family Property Sales Sample Descriptive Statistics – Charlotte CityLYNX Gold Line – SIA Parcels

Definition	Mean	Std. Dev.	Min	Max
Sale price ($)	443,000	176,427	81,500	937,500
Sale price ($/sf)	211.7	54.7	59.5	383.3
Living space (sf)	2,134	842	924	5,372
Parcel size (acres)	0.06	0.11	0.00	0.99
Building age (yrs at sale date)	58	37	1	115
Building condition good or excellent	0.39	0.49	0.00	1.00
Distance to nearest streetcar station (ft)	1,929	397	985	2,538
Distance to nearest Interstate (ft)	1,951	1,123	258	4,427
Blue Line stop within 0.5 mile	0.27	0.44	0.00	1.00
Park within 0.25 mile	0.65	0.48	0.00	1.00

Sample size=171

Table 6-22

Single-family Property Sales Sample Descriptive Statistics – Charlotte CityLYNX Gold Line – Control Parcels

Definition	Mean	Std. Dev.	Min	Max
Sale price ($)	319,656	215,194	49,000	965,000
Sale price ($/sf)	159.4	80.0	17.5	953.9
Living space (sf)	1,977	727	0	6,161
Parcel size (acres)	0.05	0.10	0.00	2.01
Building age (yrs at sale date)	41	36	1	116
Building condition good or excellent	0.24	0.43	0.00	1.00
Distance to nearest streetcar station (ft)	27,866	24,560	3,864	83,582
Distance to nearest Interstate (ft)	5,278	3,293	99	22,910
Blue Line stop within 0.5 mile	0.15	0.35	0.00	1.00
Park within 0.25 mile	0.26	0.44	0.00	1.00

Sample size=2,341

Table 6-21 and Table 6-22 show that SIA and control samples are similar in terms of housing stock (age, building, and parcel size), but they differ in terms of accessibility to nearby amenities and transport network. For example, 65 percent of single-family homes located in the SIA have a park within 0.25 mile compared to 26 percent of homes located in the control areas. About 39 percent of homes in the SIA are characterized to be in good or excellent conditions compared to 24 percent of similar homes located in the control areas.

The econometric model follows the general specification provided in Appendix A. The dependent variable is the natural log of the sale price. The explanatory variables Table 6-21 are included in the final models with alternative model specifications that include controls for spatial autocorrelation.

Table 6-23 reports the results of the regression using naïve OLS estimator and the spatial autoregressive model with spatial autocorrelation (SRAR) estimates. The SRAR model results show that the property prices are spatially-correlated and correlation extends to the error term. This is due to factors that are unobserved and that affect property sale values due to spatial proximity of adjacent properties. The SRAR model controls for spatial correlation in the error term, which is statistically significant. For this reason and due to the statistically significant term indicating spatial correlation among properties (the term *lambda*), the preferred model is the SRAR. Although both models show positive signs associated with price appreciation during the Construction and Opening phases, statistical inference does not support evidence of price premia. On the other hand, results indicate that properties located in proximity of the Lynx Blue Line station are characterized by higher and statistically significant premia compared to similar properties within the SIA. These results are indicative that single-family property sales are affected by accessibility to a more extensive rail system than the current streetcar system (Phase 1).

Table 6-23

Single-family Property Sales Estimation Results – Charlotte CityLYNX Gold Line

Variable	Definition	Regression Models	
		OLS	*SRAR*
treatment	Treatment	0.314***	0.380***
		(4.74)	(5.63)
ann_plan	Announcement and Planning	-0.171***	-0.203***
		(-6.18)	(-9.30)
constr	Construction	-0.0118	-0.0572**
		(-0.49)	(-2.95)
open	Opening	0.0271	0.0223
		(0.89)	(0.93)
tr_ann_plan	Interaction term (treatment*ann_plan)	-0.0342	-0.112
		(-0.27)	(-1.23)
tr_constr	Interaction term (treatment*constr)	0.127	0.0238
		(1.62)	(0.40)
tr_open	Interaction term (treatment*open)	0.0736	0.0503
		(0.73)	(0.68)
lbsize	Size of living space	0.662***	0.844***
		(17.35)	(24.88)
lpsize	Parcel size	0.0642***	-0.0102
		(4.65)	(-0.57)
lage	Age of structure	0.0419***	0.0144*
		(3.77)	(1.65)
fullbaths	Number of full-size bathrooms	0.0858***	0.0368**
		(4.07)	(2.15)
bcond	Building condition good to excellent	0.154***	0.0482*
		(6.75)	(1.94)
lint_dist	Distance to nearest Interstate	0.190***	0.135***
		(13.09)	(9.79)
blue_s	Blue Line stop within 0.25 mile	0.597***	0.589***
		(20.19)	(33.89)
_cons	Intercept	5.598***	4.894***
		(17.90)	(18.28)
lambda	Autoregressive term		-0.0000178***
			(-9.35)
rho	Autoregressive error		0.00203***
			(132.93)
sigma2	Sigma squared		0.0426***
			(22.14)
N	Sample size	981	981
adj. R-sq	Adjusted R-square	0.689	

*Standard errors in parenthesis: * p<0.05; **p<0.01, ***p<0.001.*
Pre-planning phase (pre-plan) is baseline treatment phase.

Multi-family and Condominium Properties

Table 6-24 reports the 2007–2016 sale counts and average sale prices of condominium and multi-family units after the removal of outliers. The count of sales in the SIA is higher than the control areas. Sales decreased during the Announcement and Planning phase, which corresponds to the period when to the real estate crisis was reaching its peak, but increased during Design and Construction and Opening. Average sale prices during the first year of opening are higher than the pre-planning phase.

Table 6-24

Condominium Property Sales by Project Phase – Charlotte CityLYNX Gold Line

Project Phase	SIA		Control	
	Count	Value ($)	Count	Value ($)
Pre-planning	410	329,208	236	230,429
Announcement and Planning	249	284,308	146	159,701
Design and Construction	508	313,421	270	197,968
Opening	260	351,769	118	242,813

Table 6-25 and Table 6-26 report the sample descriptive statistics for the variables included in the regression analysis. On average, properties located in the SIA sold at a higher price. This is due to properties being, on average, larger in terms of living space and number of bathrooms and due to a larger share of high-rise condominiums.

Table 6-25

Condominium Property Sales Sample Descriptive Statistics, Charlotte CityLYNX Gold Line – SIA

Definition	Mean	Std. Dev.	Min	Max
Sale price ($)	299,049	140,977	41,000	999,000
Sale price ($/sf)	276.3	70.5	38.5	783.9
Living space (sf)	1,087	432	470	4,017
Building age (years at sale date)	13	18	1	108
Building condition good or excellent	0.36	0.48	0.00	1.00
High-rise condominium unit	0.66	0.47	0.00	1.00
Number of full size bathrooms	2	1	0	4
Distance to nearest streetcar station (ft)	1,765	483	674	2,492
Distance to nearest Interstate (ft)	1,889	741	92	3,769
Blue Line stop within 0.5 mile	0.80	0.40	0.00	1.00
Park within 0.25 mile	0.98	0.15	0.00	1.00

Sample size=1,698

Table 6-26

Condominium Property Sales Sample Descriptive Statistics – Charlotte CityLYNX Gold Line – Control Parcels

Definition	Mean	Std. Dev.	Min	Max
Sale price ($)	203,673	92,544	36,000	615,500
Sale price ($/sf)	198.8	61.3	28.3	580.6
Living space (sf)	1,042	368	384	2,625
Building age (years at sale date)	14	21	1	94
Building condition good or excellent	0.66	0.47	0.00	1.00
High-rise condominium unit	0.16	0.37	0.00	1.00
Number of full size bathrooms	1	1	0	3
Distance to nearest streetcar station (ft)	9,491	7,923	3,902	41,520
Distance to nearest Interstate (ft)	4,632	2,131	378	11,447
Blue Line stop within 0.5 mile	0.39	0.49	0.00	1.00
Park within 0.25 mile	0.15	0.36	0.00	1.00

Sample size=857

The results of regressions are reported in Table 6-27. The table reports results for two models, with OLS (1) showing the results of a model that includes all of the property sales of Table 6-26, while OLS (2) reports results from a sub-sample of properties that were built after 2006.

The results show evidence of the Charlotte CityLYNX Gold Line project having an effect on condominium sales prices only for newer properties that were built after 2006. Using the Pre-planning phase at the base for comparison, findings provide evidence of the streetcar project effect on condominium property sales throughout the project phases. Properties located within the SIA show a premium increasing from 34.7 percent at Announcement and Planning to 15.3 percent during the Construction phase and 16.3 percent at Opening.[42]

[42] See footnote 35 for an explanation of how the model parameters are interpreted and premia estimated.

Table 6-27

Condominium Property Sales Estimation Results – Charlotte CityLYNX Gold Line

Variable	Definition	Regression Models		
		OLS (1)	*OLS (2)*	*OLS (3)*
treatment	Treatment	0.277***	0.0693*	0.133***
		(9.35)	(1.66)	(6.08)
ann_plan	Announcement and Planning	-0.247***	-0.330***	-0.353***
		(-6.91)	(-7.75)	(-11.69)
constr	Construction	-0.0325	-0.0213	-0.0742**
		(-1.03)	(-0.49)	(-2.76)
open	Opening	0.175***	0.0791	0.0410
		(4.44)	(1.45)	(0.89)
tr_ann_plan	Interaction term (treatment*ann_plan)	-0.00673	0.298***	0.107**
		(-0.15)	(7.15)	(2.90)
tr_constr	Interaction term (treatment*constr)	0.00379	0.142***	0.0569**
		(0.10)	(3.73)	(1.98)
tr_open	Interaction term (treatment*open)	-0.0890*	0.151**	0.0916*
		(-1.92)	(3.07)	(1.91)
lbsize	Size of living space	-3.119***	0.535	-0.893*
		(-6.84)	(1.04)	(-1.90)
lbsize2	Parcel size	0.279***	0.0180	0.123***
		(8.71)	(0.49)	(3.63)
lage	Age of structure	-0.123***	-0.238***	-0.00740
		(-5.71)	(-4.74)	(-0.26)
lage2	Number of full-size bathrooms	0.00118	0.0581**	-0.0378**
		(0.25)	(2.51)	(-2.64)
fullbaths	Building condition good to excellent	0.209***	0.126***	0.0904***
		(10.61)	(6.29)	(4.99)
blue_s	Distance to nearest Interstate	0.0488**	0.0725***	0.109***
		(2.90)	(4.29)	(6.93)
hrise	Blue Line stop within 0.25 mile	0.257***	0.169***	0.179***
		(14.04)	(6.05)	(13.67)
_cons	Intercept	20.17***	7.666***	12.47***
		(12.46)	(4.20)	(7.63)
N	Sample size	2197	748	1254
adj. R-sq	Adjusted R-square	0.701	0.855	0.813

*Standard errors in parenthesis: * p<0.05; **p<0.01, ***p<0.001.*
Pre-planning phase (pre-plan) is baseline treatment phase.

Commercial Properties

Table 6-28 reports sales data for commercial properties. After removal of outliers, sales in the SIA totaled 111, with 18 valid sales recorded during the opening and first year of operation (2015–2016).

Table 6-28

Commercial Property Sales by Project Phase – Charlotte CityLYNX Gold Line

Phase	SIA		Control	
	Count	Value ($)	Count	Value ($)
Pre-planning	41	769,085	60	912,067
Announcement and Planning	20	2,107,350	28	938,893
Design and Construction	32	1,731,344	65	1,258,046
Opening	18	2,474,750	28	843,375

Table 6-29 and Table 6-30 report the sample descriptive statistics for the variables included in the regression analysis. Due to the CBD's higher density, commercial properties are smaller in parcel size, but larger in terms of building capacity. On average, commercial properties located in the SIA sold at a higher price.

Table 6-29

Commercial Property Sales Sample Descriptive Statistics – Charlotte CityLYNX Gold Line – SIA

Definition	Mean	Std. Dev.	Min	Max
Sale price ($)	1,564,216	2,770,798	45,000	15,500,000
Sale price ($/sf)	213.0	86.7	52.8	500.0
Building size (sf)	10,920	30,085	90	193,821
Parcel size (acres)	0.13	0.39	0.00	2.70
Building age (years at sale date)	61	32	1	115
Building condition good or excellent	0.42	0.50	0.00	1.00
Distance to nearest streetcar station (ft)	1,303	558	39	2,546
Distance to nearest Interstate (ft)	1,875	1,087	59	4,431
Blue Line stop within 0.5 mile	0.62	0.49	0.00	1.00
Park within 0.25 mile	0.86	0.34	0.00	1.00

Sample size=111

Table 6-30

Commercial Property Sales Sample Descriptive Statistics – Charlotte CityLYNX Gold Line – Control Parcels

Definition	Mean	Std. Dev.	Min	Max
Sale price ($)	1,029,837	1,862,115	50,000	14,000,000
Sale price ($/sf)	198.9	92.1	38.2	532.3
Building size (sf)	7,226	18,699	436	144,668
Parcel size (acres)	0.65	2.53	0.00	23.96
Building age (years at sale date)	41	39	1	115
Building condition good or excellent	0.53	0.50	0.00	1.00
Distance to nearest streetcar station (ft)	24,325	22,314	3,897	82,888
Distance to nearest Interstate (ft)	4,544	2,545	30	11,253
Blue Line stop within 0.5 mile	0.27	0.45	0.00	1.00
Park within 0.25 mile	0.25	0.43	0.00	1.00

Sample size=181

Table 6-31 reports the results of the econometric model. The table presents results from two different model specifications, with the second model (OLS 2) augmenting the first one (OLS 2) by including streetcar station-specific effects.

These are modeled by including a set of dummy variables identifying the streetcar stop closest to each parcel regressed. As in the case of condominium properties, spatial autoregressive models could not be run due to the clustering of one or more businesses at the same geographical location (i.e., same parcel, multiple units).

Table 6-31

Commercial Property Sales Estimation Results – Charlotte CityLYNX Gold Line

Variable	Definition	Regression Models	
		OLS (1)	OLS (2)
treatment	Treatment	-0.0666	0.0213
		(-0.79)	(0.22)
ann_plan	Announcement and Planning	-0.298**	-0.268**
		(-2.84)	(-2.40)
constr	Construction	-0.194**	-0.188**
		(-2.72)	(-2.58)
open	Opening	-0.239**	-0.230**
		(-2.63)	(-2.54)
tr_ann_plan	Interaction term (treatment*ann_plan)	0.0824	0.0206
		(0.59)	(0.14)
tr_constr	Interaction term (treatment*constr)	0.0616	0.0149
		(0.57)	(0.14)
tr_open	Interaction term (treatment*open)	0.350**	0.291*
		(2.21)	(1.84)
lbsize	Building size	0.955***	0.950***
		(49.31)	(49.50)
lage	Age of structure	0.0338*	-0.0156
		(1.66)	(-0.60)
bcond	Building condition good to excellent	0.111**	0.103**
		(2.25)	(2.07)
int_dist	Distance to nearest Interstate	-0.0000332**	-0.0000219
		(-2.82)	(-1.43)
_cons	Intercept	5.688***	5.659***
		(32.71)	(16.50)
N	Sample size	306	306
adj. R-sq	Adjusted R-square	0.930	0.934

*Standard errors in parenthesis: * p<0.05; **p<0.01, ***p<0.001.*
Pre-planning phase (pre-plan) is baseline treatment phase.

The results support evidence of streetcar impacts on commercial property values only after the streetcar opens, but the estimated premia appear relatively large, ranging from 41.9 percent (OLS 1) to 33.8 percent (OLS 2). Although the relatively high R-squared values are indicative of a good model fit, the results could be affected by the relatively small number of valid recorded sales in the SIA.

As an alternative approach to estimate changes in commercial property values, Table 6-32 reports the results of a fixed-effect model using as a sample all assessed values of all commercial parcels for the period 2007–2016. The dependent variable is the natural log of the Property Appraiser total assessed value.

Table 6-32

Commercial Property Assessed Values Fixed Effect Estimation Results – Charlotte CityLYNX Gold Line

Variable	Definition	Regression Models	
		OLS	FE
treatment	Treatment	0.0726***	
		(0.0181)	
ann_plan	Announcement and Planning	-0.182	
		(0.252)	
constr	Construction	-0.0247	
		(0.0256)	
open	Opening	-0.126	
		(0.251)	
tr_ann_plan	Interaction term (treatment*ann_plan)	0.0453*	0.0138*
		(0.0257)	(0.00795)
tr_constr	Interaction term (treatment*constr)	0.0286	0.0179**
		(0.0283)	(0.00873)
tr_open	Interaction term (treatment*open)	0.0438	0.0210**
		(0.0285)	(0.00893)
lbsize	Building size	0.936***	0.120***
		(0.00387)	(0.0108)
lage	Age of structure	-0.0933***	-0.112***
		(0.00518)	(0.00753)
bcond	Building condition good to excellent	0.176***	0.0805***
		(0.0108)	
_cons	Intercept	5.700***	12.45***
		(0.0382)	(0.0927)
	Time trend variables	yes	yes
N	Sample size	11,170	11,170
R-sq	Adjusted R-squared	0.85	0.39

*Standard errors in parenthesis: * p<0.05; **p<0.01, ***p<0.001.*
Pre-planning phase (pre-plan) is baseline treatment phase.

The Property Appraiser assessed values define a panel database with yearly observations, which consists of repeated observations over time of the same parcel. The statistical analysis of panel data by multivariate regression (i.e., OLS) produces biased results because of the omission of time-constant parcel-specific unobserved factors affecting the assessed values. To overcome this problem, FE can be used to eliminate the time-constant unobserved effects and, under certain assumptions, given unbiased estimates. In addition, FE regression allows estimating the change in assessed value within parcels as opposed to OLS, which estimates changes in assessed value across all observations (i.e., pooling of data).

Table 6-32 shows the results of two models, the naïve regressor (OLS) and the FE. Both models provide evidence of positive premia being realized throughout the phases of the project. Referring to FE as the preferred model and applying the proportional formula, the estimated premia range from 1.4 percent during Announcement and Planning to 1.8 percent during Construction and 2.1 percent during the Opening phase.

Sun Link Tucson Streetcar

The Pima County Assessor's website provides public access to sales data for the period 2007–2016. The files (defined as Affidavit of Sales) contain information on all sales of properties for the entire Pima County, with information on date, amounts and transaction types.[43] The sales data were matched to parcels located in the SIA and control areas and other County Assessor files to provide detailed information on land-use classification for commercial parcels, building characteristics for residential parcels, and other data to construct the database for empirical modeling.

To investigate the causality between the different project phases and impacts on property values, property sales are aggregated according to the most relevant project phases, as reported in Table 6-33. The aggregation of observations by project phase allows setting up a baseline comparison corresponding to the period before any official planning announcement was made (Pre-planning). This phase is characterized by informal news about project planning. Subsequent phases identify when the official decision was made to include the project into the planning process (Announcement and Planning) and include major evaluation studies such as environmental assessments as well as design and development. The Construction phase coincides with beginning of construction (2012). The project opened to the public on July 25, 2014, and has been in operation since that time.

Table 6-33

Tucson Streetcar Project Phases

Year	Event	Project Phase
2006	Streetcar in regional transportation plan	Pre-planning
2010	TIGER grant awarded (Feb)	Announcement and Planning
2011	FTA Findings of no significant impact (Jan)	Announcement and Planning
2012	Construction begins (Apr)	Design and Construction
2013	Construction ends (Oct)	Design and Construction
2014	Streetcar begins operation (Jul)	Opening and Operation
2015	Streetcar in regular operation	Opening and Operation

Single-family Properties

Table 6-34 reports the sales counts and average sale prices of single-family homes. The sample consists of qualified property sale transactions for the period 2007-2016. The table presents counts after data cleaning to remove outliers (i.e., sales

[43] http://www.asr.pima.gov/links/data.aspx.

with values above the sample 95th percentile) and single observation outliers. The table includes only sales determined as qualified by the Property Appraiser's examination of the property deed. The sample contains multiple sales of the same property, but this inclusion does not affect the random sample assumption. Following the real estate crisis, there were relatively few single-family home sales during the project phases following the formal announcement in 2010. In the SIA, mean sales values reached a peak during the Design and Construction phase.

Table 6-34

Single-family Properties Sales by Project Phase – Sun Link Tucson Streetcar

Project Phase	SIA		Control	
	Count	Value ($)	Count	Value ($)
Pre-planning	97	252,780	558	195,817
Announcement and Planning	22	271,356	107	178,018
Design and Construction	50	256,536	257	149,154
Opening	80	237,365	524	166,786

Table 6-35 and Table 6-36 report sample descriptive statistics of single-family property sales for the streetcar influence area and the control areas. The sample includes variables used in the regression models as explanatory variables to account for factors affecting property prices, such as parcel size; size of living space; building age; the presence of amenities, such as parks and schools, waterfront location; and distance to major interstates and rail lines. The empirical literature shows that these variables significantly affect property sale prices, and it is common practice to include them in econometric models. The academic literature refers to the approach as "hedonic regression," or modeling that controls for factors having an impact on an individual's willingness to pay for specific building features and attributes.

Table 6-35

Single-family Properties Sample Descriptive Statistics – Sun Link Tucson Streetcar – SIA

Variable	Mean	Std. Dev.	Min	Max
Sale price ($)	236,605	128,860	22,500	930,000
Living space (sf)	1,372	559	441	4,240
Parcel size (acres)	0.15	0.07	0.04	0.62
Building age (years at sale date)	70	29	2	116
Carport only	0.19	0.39	0.00	1.00
Building condition good or excellent	0.17	0.38	0.00	1.00
Distance to nearest streetcar station (ft)	1,573	667	152	2,551
Within neighborhood stabilization program	0.12	0.33	0.00	1.00
Distance to nearest Interstate (ft)	5,876	3,766	151	13,891
Amtrak rail line within 0.5 mile	0.27	0.44	0.00	1.00
Park within 0.25 mile	0.60	0.49	0.00	1.00
Liquor store or bar within 0.25 mile	0.40	0.49	0.00	1.00
Adjacent to UAZ campus	0.32	0.47	0.00	1.00
Hotel within 0.25 mile	0.28	0.45	0.00	1.00
Distance to nearest popular landmark (ft)	2,620	844	461	4,231

Sample size=249
Property Appraiser variable to stratify structure by quality (1=minimum; 2= fair; 3=good; 3=excellent)

Table 6-36

Single-family Properties Sample Descriptive Statistics – Sun Link Tucson Streetcar – Control Parcels

Variable	Mean	Std. Dev.	Min	Max
Sale price ($)	165,893	120,017	25,000	999,000
Living space (sq ft)	1,396	566	345	4,784
Parcel size (acres)	0.24	0.32	0.04	4.04
Building age (years at sale date)	47	22	2	112
Carport only	0.40	0.49	0.00	1.00
Building condition good or excellent	0.26	0.44	0.00	1.00
Distance to nearest streetcar station (ft)	20,742	22,752	2,692	138,724
Within neighborhood stabilization program	0.38	0.49	0.00	1.00
Distance to nearest Interstate (ft)	12,038	8,365	59	38,524
Amtrak rail line within 0.5 mile	0.19	0.39	0.00	1.00
Park within 0.25 mile	0.46	0.50	0.00	1.00
Liquor store or bar within 0.25 mile	0.33	0.47	0.00	1.00
Adjacent to UAZ campus	0.00	0.06	0.00	1.00
Hotel within 0.25 mile	0.01	0.10	0.00	1.00
Distance to nearest popular landmark (ft)	6,919	3,009	1,414	14,984

Sample size=1,446
Property Appraiser variable to stratify structure by quality (1=minimum; 2= fair; 3=good;3=excellent)

The variable *nsp* determines if the parcel is located within an economically-depressed area or the Neighborhood Stabilization Program (NSP). The NSP was established by the 2009 American Recovery and Reinvestment Act (ARRA) to use federal funds to stabilize communities suffering from foreclosures and abandonment. These areas contain the greatest percentage of home foreclosures and homes financed with the highest subprime mortgage-related loans.

Table 6-35 and Table 6-36 show that SIA and control samples are similar in terms of housing stock (building and parcel size), but they differ in terms of accessibility to nearby amenities and transport network. The econometric model follows the general specification provided in Appendix A. The dependent variable is the natural log of the sale price. The explanatory variables of Table 6-35 are included in the final models, with alternative model specifications that include streetcar station dummies and controls for spatial autocorrelation.

Table 6-37 reports the results of the regression using naïve OLS estimator and the spatial autoregressive model with spatial autocorrelation (SRAR) estimates. The naïve OLS has two specifications, one (OLS 1) without streetcar station dummy variables and one (OLS 2) with station identifiers. The SRAR model results show that the property prices are spatially-correlated, and correlation extends to the error term. This is due to factors that are unobserved and that affect property sale values due to spatial proximity of adjacent properties. The SRAR model controls for spatial correlation in the error term, which is statistically significant. For this reason and due to the statistical significant term indicating spatial correlation among properties (the term *lambda*), the preferred model is the SRAR. Both the OLS and SRAR models show evidence of positive price premia effects during all project phases. The SRAR model, which controls for spatial spillover effects of adjacent property sales, estimates that the price premia range from 19.2 percent at Announcement, 14.5 percent during Construction, and 13.1 percent at Opening and the year after.[44]

Table 6-37

Single-family Property Sales Estimation Results – Sun Link Tucson Streetcar

Variable	Definition	Regression Models		
		OLS (1)	OLS (2)	SRAR
treatment	Treatment	0.171***	0.287***	0.132**
		(4.23)	(6.71)	(2.65)
ann_plan	Announcement and Planning	-0.317***	-0.316***	-0.334***
		(-10.43)	(-10.85)	(-12.10)
constr	Construction	-0.330***	-0.323***	-0.329***
		(-14.92)	(-15.25)	(-16.47)
open	Opening	-0.201***	-0.186***	-0.180***
		(-10.76)	(-10.37)	(-10.91)
tr_ann_plan	Interaction term (treatment*ann_plan)	0.194**	0.162**	0.179**
		(2.50)	(2.18)	(2.67)
tr_constr	Interaction term (treatment*constr)	0.143**	0.116**	0.141**
		(2.52)	(2.11)	(2.81)
tr_open	Interaction term (treatment*open)	0.132**	0.124**	0.130**
		(2.70)	(2.62)	(3.05)
lbsize	Size of living space	0.752***	0.736***	0.653***
		(27.38)	(27.44)	(25.45)
lpsize	Parcel size	0.369***	0.387***	0.374***
		(11.10)	(11.48)	(10.15)
lpsize2	Squared term of parcel size	0.0797***	0.0808***	0.0623***
		(6.36)	(6.45)	(4.87)
lage	Age of structure	-0.164**	-0.0838	0.0166
		(-2.72)	(-1.41)	(0.29)
lage2	Squared term of age of structure	0.0239**	0.00327	-0.0159*
		(2.35)	(0.32)	(-1.66)
carport	Presence of carport structure	-0.0473**	-0.0492**	-0.0204
		(-2.95)	(-3.15)	(-1.37)
bcond	Building condition good to excellent	0.0810***	0.0824***	0.0659**
		(3.33)	(3.46)	(2.79)
nsp	Within neighborhood stabilization program	-0.367***	-0.391***	-0.253***
		(-19.48)	(-14.35)	(-6.93)

[44] For OLS estimate, proportional change estimated by applying following formula [(exp (β)-1)*100], where β is estimated parameter expressing interaction term between treatment project phase. For SRAR estimate, above formula applied only after estimating model total effects, as detailed in Appendix A. This is because model includes spatial lag of dependent variable as explanatory variable, making relationship simultaneous in nature.

Table 6-37 cont'd.

Single-family Property Sales Estimation Results – Sun Link Tucson Streetcar

Variable	Definition	Regression Models		
		OLS (1)	*OLS (2)*	*SRAR*
lint_dist	Distance to nearest Interstate	0.0623***	-0.000634	0.0831***
		(6.90)	(-0.05)	(5.73)
amtrak_r	Amtrak rail line within 0.5 mile	-0.0432**	-0.0541**	-0.0774**
		(-2.11)	(-2.23)	(-2.71)
park2	Park within 0.25 mile	0.0545***	0.0626***	0.0149
		(3.33)	(3.83)	(0.76)
crime	Liquor store or bar within 0.25 mile	-0.0415**	-0.00441	-0.0419**
		(-2.60)	(-0.26)	(-2.17)
uaz	Adjacent to UAZ campus	0.141**	0.0698	-0.00615
		(3.26)	(1.52)	(-0.13)
hotel	Hotel within 0.25 mile	0.00834	-0.00836	-0.00377
		(0.21)	(-0.20)	(-0.09)
lpop_dist	Distance to nearest popular landmark (ft)	-0.0789***	-0.0492**	-0.102***
		(-4.10)	(-2.49)	(-3.54)
_cons	Intercept	7.543***	7.872***	8.210***
		(25.60)	(21.50)	(23.42)
lambda	Autoregressive term			-0.0000265**
				(-2.80)
rho	Autoregressive error			0.00306***
				(36.06)
sigma2	Sigma squared			0.0692***
				(29.11)
N	Sample size	1,954	1,954	1,695
adj. R-sq	Adjusted R-square	0.681	0.710	

*t-statistics in parenthesis: * p<0.05; **p<0.01, ***p<0.001.*
Pre-planning phase (pre-plan) is baseline treatment phase.

Multi-family and Condominium Properties

Table 6-38 reports the 2002–2016 sale counts and average sale prices of condominium and multi-family units after the removal of outliers. The count of sales is lower for condominium and multi-family units than for single-family units. Sales decreased during the Announcement and Planning phase, which corresponds to the period when the real estate crisis was reaching its peak, but increased during Design and Construction and Opening. Note that average sale prices during Opening are higher than during the Pre-planning phase.

Table 6-38

Condominium and Multi-family Properties Sales by Project Phase – Sun Link Tucson Streetcar

Project Phase	SIA		Control	
	Count	*Value ($)*	*Count*	*Value ($)*
Pre-planning	23	221,789	229	114,160
Announcement and Planning	7	232,286	42	92,335
Design and Construction	23	214,891	87	93,036
Opening	23	234,859	113	89,149

Table 6-39 and Table 6-40 report the sample descriptive statistics for the variables included in the regression analysis. On average, properties located in the SIA share similar characteristics to the control areas, such as the mean size of the living space and building condition. Properties located in the SIA score better in terms of building condition. An equal share of the control properties is located in an NSP neighborhood.

Table 6-39

Multi-family and Condominium Sample Descriptive Statistics – Sun Link Tucson Streetcar – SIA

Variable	Mean	Std. Dev.	Min	Max
Sale price ($)	240,553	108,887	86,382	489,005
Living space (sf)	1,199	451	281	2,278
Parcel size (acres)	0.04	0.04	0.00	0.13
Building age (years at sale date)	32	24	2	96
Building condition good or excellent	0.75	0.43	0.00	1.00
Distance to nearest streetcar station (ft)	1,680	602	713	2,611
Within an NSP	0.04	0.19	0.00	1.00
Distance to nearest Interstate (ft)	5,052	1,999	1,127	11,625
Amtrak rail line within 0.5 mile	0.64	0.48	0.00	1.00
Park within 0.25 mile	0.53	0.50	0.00	1.00
Liquor store or bar within 0.25 mile	0.39	0.49	0.00	1.00
Adjacent to University of Arizona Campus	0.34	0.48	0.00	1.00
Hotel within 0.25 mile	0.74	0.44	0.00	1.00
Distance to nearest popular landmark (ft)	1,703	849	657	3,489

Sample size=77
Property Appraiser variable to stratify structure by quality (1=minimum; 2= fair; 3=good;3=excellent)

Table 6-40

Multi-family and Condominium Sample Descriptive Statistics – Sun Link Tucson Streetcar – Control Parcels

Variable	Mean	Std. Dev.	Min	Max
Sale price ($)	108,055	56,899	28,796	428,894
Living space (ft)	1,040	376	546	2,253
Parcel size (acres)	0.05	0.05	0.00	0.22
Building age (years at sale date)	35	9	11	67
Building condition good or excellent	0.21	0.40	0.00	1.00
Distance to nearest streetcar station (ft)	94,741	51,802	4,160	142,024
Within an NSP	0.04	0.19	0.00	1.00
Distance to nearest Interstate (ft)	10,258	14,171	117	38,967
Amtrak rail line within 0.5 mile	0.01	0.11	0.00	1.00
Park within 0.25 mile	0.13	0.34	0.00	1.00
Liquor store or bar within 0.25 mile	0.22	0.42	0.00	1.00
Adjacent to University of Arizona Campus	0.00	0.00	0.00	0.00
Hotel within 0.25 mile	0.08	0.27	0.00	1.00
Distance to nearest popular landmark (ft)	7,903	5,727	421	15,695

Sample size=471
Property Appraiser variable to stratify structure by quality (1=minimum; 2=fair; 3=good; 3=excellent)

The results of the OLS and SRAR regressions of Table 6-41 show evidence of the Tucson streetcar project is effecting condominium sales prices, starting at the Construction phase. Using the Pre-planning phase at the base for comparison, properties located within the SIA show a premium increasing from 13.4 percent during the Construction phase and 19.2 percent at Opening.[45]

Table 6-41

Condominium Property Sales Estimation Results – Sun Link Tucson Streetcar

Variable	Definition	Regression Models		
		OLS (1)	OLS (2)	SRAR
treatment	Treatment	0.506***	0.552***	0.600***
		(5.64)	(5.95)	(6.48)
ann_plan	Announcement and Planning	-0.309***	-0.309***	-0.352***
		(-7.35)	(-7.36)	(-8.95)
constr	Construction	-0.389***	-0.383***	-0.411***
		(-12.06)	(-11.84)	(-13.05)
open	Opening	-0.369***	-0.362***	-0.381***
		(-14.65)	(-14.25)	(-16.28)
tr_ann_plan	Interaction term (treatment*ann_plan)	0.212*	0.187	0.141
		(1.77)	(1.56)	(1.33)
tr_constr	Interaction term (treatment*constr)	0.192**	0.203**	0.132*
		(2.30)	(2.44)	(1.67)
tr_open	Interaction term (treatment*open)	0.180**	0.199**	0.188**
		(2.28)	(2.50)	(2.53)
lbsize	Natural log of size of living space	0.911***	0.922***	0.834***
		(27.79)	(27.71)	(21.41)
lage	Natural log of age of structure	-0.207***	-0.225***	-0.184***
		(-6.78)	(-7.04)	(-5.59)
bcond	Building condition good to excellent	0.0127	0.00109	-0.0295
		(0.42)	(0.04)	(-0.86)
nsp	Within neighborhood stabilization program	-0.383***	-0.274***	-0.344***
		(-6.89)	(-3.43)	(-5.59)
lint_dist	Natural log of distance to nearest Interstate	0.0124	0.00391	0.0187*
		(1.57)	(0.43)	(1.89)
amtrak_r	Amtrak rail line within 0.5 mile	-0.0659	-0.0535	-0.0311
		(-0.96)	(-0.77)	(-0.46)
park2	Park within 0.25 mile	0.262***	0.266***	0.0465
		(8.51)	(8.65)	(1.20)
crime	Liquor store or bar within 0.25 mile	0.0118	0.0164	-0.0294
		(0.45)	(0.63)	(-0.96)
uaz	Adjacent to University of Arizona Campus	-0.151*	-0.148*	-0.0910
		(-1.78)	(-1.75)	(-1.03)
hotel	Hotel within 0.25 mile	0.0448	0.0401	0.0457
		(1.18)	(1.06)	(1.11)

[45] See footnote 35 for explanation of how model parameters are interpreted and premia estimated.

Table 6-41 cont'd.

Condominium Property Sales Estimation Results – Sun Link Tucson Streetcar

Variable	Definition	Regression Models		
		OLS (1)	OLS (2)	SRAR
lpop_dist	Natural log of distance to nearest popular landmark (ft)	0.0445**	0.0408**	0.0605**
		(2.84)	(2.60)	(3.05)
_cons	Intercept	5.628***	5.769***	6.076***
		(21.13)	(20.89)	(18.35)
lambda	Autoregressive term			-0.0000237***
				(-3.57)
rho	Autoregressive error			0.000699***
				(39.94)
sigma2	Sigma squared			0.0466***
				(17.06)
N	Sample size	651	651	584
adj. R-sq	Adjusted R-square	0.806	0.807	

*t-statistics in parenthesis: * $p<0.05$; ** $p<0.01$, *** $p<0.001$.*
Pre-planning phase (pre-plan) is baseline treatment phase.

Commercial Properties

Table 6-42 reports sales data for commercial properties. After removal of outliers, sales in the SIA totaled 91, with 31 valid sales recorded during the opening and first year of operation (2014–2016).

Table 6-42

Commercial Property Sales by Project Phase – Sun Link Tucson Streetcar

Project Phase	SIA		Control	
	Count	Value ($)	Count	Value ($)
Pre-planning	31	568,278	171	600,811
Announcement and Planning	7	260,000	33	468,731
Design and Construction	22	863,536	60	334,718
Opening	31	740,065	74	313,498

Table 6-43 reports the results of the econometric model. The table presents results from two specifications, one using the sales database (OLS 1), and one using an augmented version, including detail from a separate Property Appraiser file (OLS 2). The second model uses data from the commercial cost details file, which provides information on building characteristics (age, quality indicator, ground floor size, number of stories, etc.). This file is available under the Notice of Value Data database.[46] As in the case of condominium properties, spatial autoregressive models could not be run due to the clustering of one or more businesses at the same geographical location (i.e., same parcel, multiple units).

[46] http://www.asr.pima.gov/downloads/pages/noticeval.aspx?year=2015.

Table 6-43

Commercial Property Sales OLS Estimation Results – Sun Link Tucson Streetcar

Variable	Definition	Regression Models		
		OLS (1)	OLS (2)	SRAR
treatment	Treatment	-0.147	-0.168	-0.301
		(-0.73)	(-0.92)	(-1.21)
ann_plan	Announcement and Planning	0.0680	-0.0603	-0.750***
		(0.16)	(-0.20)	(-4.43)
constr	Construction	-0.200	-0.303	-0.454***
		(-0.68)	(-1.44)	(-3.93)
open	Opening	-0.445	0.125	-0.371***
		(-1.32)	(0.38)	(-3.57)
tr_ann_plan	Interaction term (treatment*ann_plan)	-0.355	-0.0343	0.0932
		(-0.98)	(-0.12)	(0.25)
tr_constr	Interaction term (treatment*constr)	0.529**	0.656**	0.349
		(2.14)	(3.15)	(1.37)
tr_open	Interaction term (treatment*open)	0.777***	0.795***	0.583**
		(3.56)	(4.49)	(2.75)
lint_dist	Distance to nearest Interstate	-0.00730	-0.0533*	-0.0316
		(-0.18)	(-1.82)	(-0.66)
amtrak_r	Amtrak rail line within 0.5 mile	0.192**	0.142**	0.150
		(2.42)	(2.29)	(1.37)
uaz	Adjacent to University of Arizona Camapus	-0.321*	-0.239	-0.252
		(-1.72)	(-1.56)	(-1.24)
lpop_dist	Distance to nearest popular landmark (ft)	-0.326***	-0.258***	-0.269**
		(-4.14)	(-3.65)	(-2.62)
lage	Naural log of age of structure		-0.0887**	-0.187***
			(-2.31)	(-3.79)
lgfloor	Natural log of total ground floor area		0.0102	-0.00109
			(1.41)	(-0.12)
_cons	Intercept	15.61***	15.28***	16.01***
		(18.93)	(20.61)	(16.49)
lambda	Autoregressive term			0.00000734
				(0.10)
rho	Autoregressive error			0.00376***
				(14.46)
sigma2	Sigma squared			0.423***
				(13.61)
Year Dummies		yes	yes	yes
N	Sample size	457	733	379
adj. R-sq	Adjusted R-square	0.167	0.204	

*t-statistics in parenthesis: * p<0.05; **p<0.01, ***p<0.001.*
Pre-planning phase (pre-plan) is baseline treatment phase.

The SRAR model uses the same dataset of OLS (2), and the results show that the property prices are not spatially-correlated, but spatial correlation extends to the error term. This is due to factors that are unobserved and that affect property sale values due to spatial proximity of adjacent properties. Although the OLS models show evidence of positive price premia during Construction and at Opening, the SRAR model provides statistically significant evidence only at Opening. Relying on the SRAR model results indicate that the price premia at Opening are 70.6 percent higher than comparable parcels located elsewhere in the county.[47] The results could be affected by the relatively small number of valid recorded sales in the SIA.

As an alternative approach to estimate changes in commercial property values, Table 6-44 reports the results of a fixed-effect model using as a sample all assessed values of all commercial parcels for the period 2007–2016. The dependent variable is the natural log of the Property Assessor current assessed value.

Table 6-44

Commercial Property Assessed Values Fixed Effect Estimation Results – Sun Link Tucson Streetcar

Variable	Definition	FE (1)	FE (2)
tr_ann_plan	Interaction term (treatment*ann_plan)	0.0338***	0.0635**
		(5.11)	(2.73)
tr_constr	Interaction term (treatment*constr)	0.0959***	0.141***
		(14.29)	(6.01)
tr_open	Interaction term (treatment*open)	0.125***	0.162***
		(20.12)	(7.21)
_cons	Intercept	11.69***	11.34***
		(3093.95)	(720.42)
Year dummies	Variables controlling for secular trends	yes	yes
N	Sample size	19,549	1,638
R-sq	Adjusted R-square	0.415	0.392

*t-statistics in parenthesis: * p<0.05; **p<0.01, ***p<0.001*
Pre-planning phase (pre-plan) is baseline treatment phase.

The Property Assessor appraised values define a panel database with yearly observations on the assessed value (current assessed value), which consists of repeated observations of the same parcel over time. Statistical analysis of panel data by multivariate regression (i.e., ordinary least square regression) produces biased results because of the omission of time-constant parcel-specific unobserved factors affecting the assessed values. To overcome this problem, FE can be used to eliminate the time-constant unobserved effects and, under certain assumptions, can give unbiased estimates. In addition, FE regression allows estimating the change in assessed value within parcels, as opposed to OLS, which estimates changes in assessed valued across all observations (i.e., pooling of data).

[47] For OLS estimate, proportional change estimated by applying following formula [(exp (β)-1)*100], where β is estimated parameter expressing interaction term between treatment project phase. For SRAR estimate, above formula applied only after estimating model total effects, as detailed in Appendix A. This is because model includes spatial lag of dependent variable as explanatory variable, making relationship simultaneous in nature.

Table 6-44 also shows the results of two models—FE (1) with all the appraised commercial properties of SIA and controls and FE (2) with a balanced sample consisting of those properties being assessed consecutively from 2007–2016. Both models provide evidence of positive premia being realized through all phases of the project. Using the balanced sample model, the estimated premia range from 3.3 percent during Announcement and Planning to 10.1 percent during Construction and 13.3 percent at Opening and year thereafter.

Vacant Parcels

Table 6-45 reports sales data for vacant parcels, consisting of residential and commercial units. After removal of outliers, sales in the SIA total 100, with most of the sales occurring during the Opening phase.

Table 6-45

Vacant Parcel Sales by Project Phase – Sun Link Tucson Streetcar

Project Phase	SIA		Control	
	Count	Value (2016 $)	Count	Value (2016 $)
Pre-planning	29	148,176	77	304,489
Announcement and Planning	16	55,489	9	127,695
Design and Construction	27	85,603	29	141,739
Opening	28	237,700	42	189,904

In terms of valid sales, 68 (77.4%) of the 100 transactions recorded in the SIA during 2007–2016 are located in the Mercado San Augustin Area. The vast majority of the sales are residential parcels and occur in conjunction with the streetcar project phases and the planned and realized development plans in the Mercado San Augustin area. Figure 6-2 shows the number of residential sales, and Figure 6-3 maps parcel sales by streetcar project phases in proximity of the Mercado San Augustin area.

Figure 6-2

Total Vacant Residential Sales, Sun Link Tucson Streetcar – SIA and Mercado San Augustin

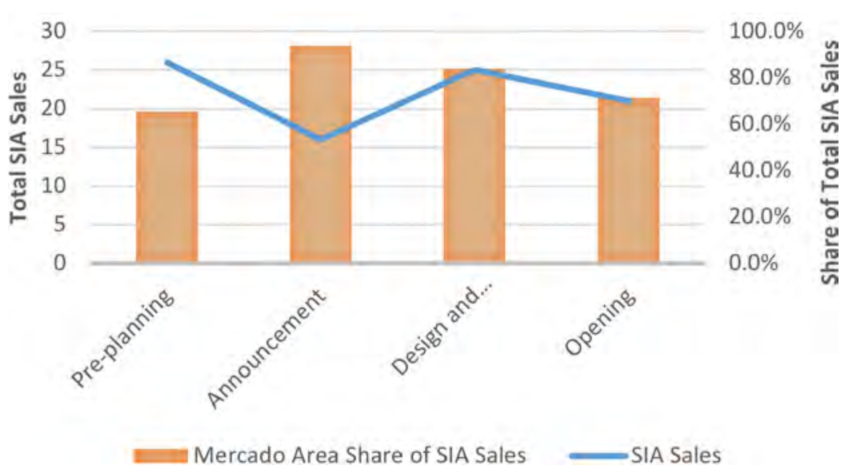


Figure 6-3

Location of Vacant Parcel Sales, Sun Link Tucson Streetcar – SIA, Mercado

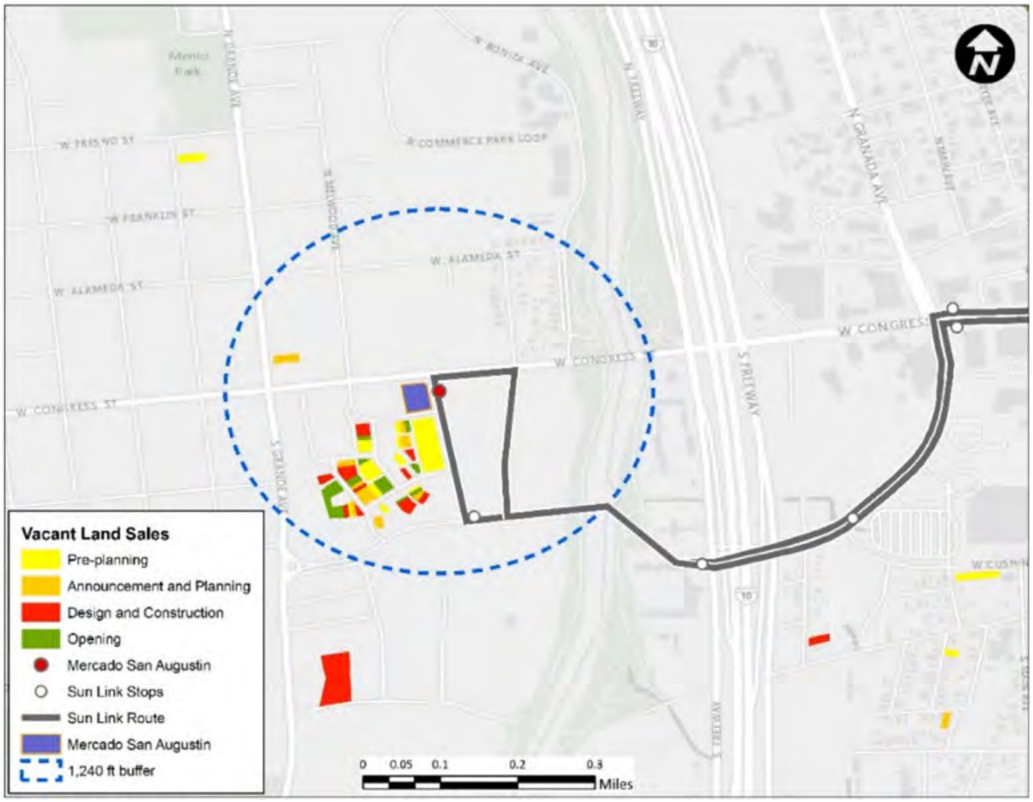


Table 6-46 reports the results of the regression using naïve OLS estimator and the spatial autoregressive model with spatial autocorrelation (SRAR) estimates. The SRAR model results show that the property prices are spatially-correlated, and correlation extends to the error term. This is due to factors that are unobserved and that affect property sale values due to spatial proximity of adjacent properties. The SRAR model controls for spatial correlation in the error term, which is statistically significant. For this reason, and due to the statistically significant term indicating spatial correlation among properties (the term *lambda*), the preferred model is the SRAR. Both the OLS and SRAR models show evidence of positive price premia effects during the Opening phase and the following year, but the estimated premia appear relatively large (ranging from 101.6% of the SRAR to 106.3% of the OLS model). The results are most likely affected by the relatively small number of valid recorded sales in the SIA and the small R-squared value of the OLS model (indicating low explanatory power of the model).

Table 6-46

Vacant Parcel Sales Property Sales Estimation Results – Sun Link Tucson Streetcar

Variable	Definition	Regression Models	
		OLS	SRAR
treatment	Treatment	0.412	0.294
		(1.20)	(0.82)
ann_plan	Announcement and Planning	-0.113	-0.296
		(-0.17)	(-0.68)
constr	Construction	-0.580	-0.812***
		(-1.04)	(-3.35)
open	Opening	0.723	-0.331*
		(1.16)	(-1.65)
tr_ann_plan	Interaction term (treatment*ann_plan)	0.0550	-0.470
		(0.10)	(-0.84)
tr_constr	Interaction term (treatment*constr)	0.437	0.564
		(1.24)	(1.47)
tr_open	Interaction term (treatment*open)	0.724**	0.824**
		(2.18)	(2.37)
lint_dist	Distance to nearest Interstate	0.146**	0.0552
		(2.09)	(0.77)
amtrak_r	Amtrak rail line within 0.5 mile	-0.0951	-0.134
		(-0.48)	(-0.67)
uaz	Adjacent to University of Arizona Campus	0.482	1.419**
		(1.03)	(2.73)
lpop_dist	Distance to nearest popular landmark (feet)	0.961***	0.751***
		(5.19)	(3.90)
mercado	Parcel located in Mercado area	-0.196	0.944
		(-0.76)	(1.55)
_cons	Intercept	2.204	5.220**
		(1.20)	(2.83)
lambda	Autoregressive term		-0.000171**
			(-2.10)
rho	Autoregressive error		0.000834**
			(2.55)
sigma2	Sigma squared		0.947***
			(10.53)
Year dummies		Yes	Yes
N	Sample size	257	224
adj. R-sq	Adjusted R-square	0.275	

*t-statistics in parenthesis: * p<0.05; **p<0.01, ***p<0.001.*
Pre-planning phase (pre-plan) is baseline treatment phase.

An alternative approach is to use the Property Assessor data run a fixed-effect model on the assessed vacant parcels. Table 6-47 reports the results of the panel-based approach using the natural log of total full cash value as dependent variable. According to the Pima County Property Assessor, the full cash value is "determined annually using standard appraisal methods and techniques as determined by market values or by applying a method of valuation as prescribed by statute." [48]

The analysis finds evidence of positive premia being realized through all project phases when considering all vacant parcels. Vacant parcels assessed values are, on average, 2.3–2.5 percent higher than comparable areas during Announcement and Construction, and increased to 12.4 percent after the system starts operations. When modeling commercial parcels, the effect on property values is limited to the Construction and Opening phases. Vacant residential parcels show also show evidence of higher values, ranging from 3.5 percent during Construction to 15.0 percent at Opening.

Table 6-47

Vacant Parcels Assessed Values Fixed Effect Estimation Results – Sun Link Tucson Streetcar

Variable	Definition	Fixed-effect Model		
		All Parcels	*Residential*	*Commercial*
tr_ann_plan	Interaction term (treatment*ann_plan)	0.0226*	0.0270*	0.0124
		(1.73)	(1.84)	(0.46)
tr_constr	Interaction term (treatment*constr)	0.0244*	0.0348**	0.0598**
		(1.84)	(2.34)	(2.21)
tr_open	Interaction term (treatment*open)	0.117***	0.140***	0.101***
		(9.38)	(9.91)	(3.92)
_cons	Constant	10.37***	10.26***	10.66***
		(1416.33)	(1174.00)	(812.05)
Time trend variables		yes	yes	yes
N	Sample size	11,440	8,743	2,697
R-sq	Adjusted R-square	0.256	0.259	0.403

*t-statistics in parenthesis: * p<0.05; **p<0.01, ***p<0.001.*
Pre-planning phase (pre-plan) is baseline treatment phase.

Atlanta Streetcar

A public query of the Property Appraiser website provided Fulton County sales data for the period 2007–2016. The sales data were matched to parcels located in the SIA and control areas.

To investigate the causality between the different project phases and impacts on property values, property sales were aggregated according to the most relevant project phases, as reported in Table 6-48. The aggregation of observations by project phase allowed setting up a baseline comparison corresponding to the period before any official planning announcement was made (Pre-planning). This phase is characterized by informal news about project planning. Subsequent phases identify when the official decision was made to include the project in the planning process (Announcement and Planning) and to include major evaluation

[48] http://www.asr.pima.gov/links/glossary.aspx.

studies such as environmental assessments as well as design and development. The Construction phase coincides with beginning of construction (2013). The project opened to the public on December 30, 2014.

Table 6-48

Atlanta Streetcar Project Phases

Year	Event	Project Phase
2003	Atlanta Streetcar Inc. formed	Pre-planning
2007	Peachtree Corridor Partnership formed	Pre-planning
2009	Media promotion starts	Pre-planning
2009	Atlanta City Council approved feasibility study	Pre-planning
2010	TIGER II grant awarded	Announcement and Planning
2011	Siemens contract to build four streetcars	Announcement and Planning
2012	Utility construction begins	Announcement and Planning
2013	Streetcar system construction begins	Construction
2014	Construction (opening Dec. 2014)	Construction
2015	Operation	Opening

Single-family Properties

Table 6-49 reports the sales counts and average sales prices of single-family homes. The sample consists of qualified property sale transactions for the period 2007–2016. The table presents counts after data cleaning to remove outliers (i.e., sales with values above the sample 95th percentile) and single observation outliers. The table includes sales determined only as qualified by the Property Appraiser's examination of the property deed. The sample contains multiple sales of the same property, but this inclusion does not affect the random sample assumption. In the streetcar influence area, there were relatively few single-family home sales during the Announcement, Planning, Design and Construction, and Opening phases. The mean sales value increased through the phases both in the SIA and control areas.

Table 6-49

Single-family Properties Sales – Atlanta Streetcar

Project Phase	SIA		Control	
	Count	Value ($)	Count	Value ($)
Pre-planning	34	206,392	1,058	263,546
Announcement and Planning	23	190,394	481	273,978
Design and Construction	25	309,207	667	356,612
Opening	36	447,089	572	422,402

Table 6-50 and Table 6-51 report sample descriptive statistics of single-family property sales for the streetcar influence area and the control areas. The sample includes variables used in the regression models as explanatory variables to account for factors affecting property prices, such as parcel size, size of living space, building age, presence of amenities such as parks and schools, waterfront location, and distance to major interstates and rail lines.

Table 6-50

Single-family Properties Sample Descriptive Statistics – Atlanta Streetcar – SIA

Variable	Mean	Std. Dev.	Min	Max
Sale price ($, 2016)	298,490	199,491	31,649	913,600
Parcel size (acre)	0.10	0.04	0.00	0.20
Size of living space (sf)	1,809	790	552	6,060
Years	52	41	1	96
Rooms	7	2	2	14
Full-size bathrooms	2	1	1	4
Half-size bathrooms	0	1	0	2
Liquor stores within 1/2 mile	0.01	0.09	0.00	1.00
MARTA station within 1/2 mile	0.20	0.40	0.00	1.00
School within 1/2 mile	0.99	0.09	0.00	1.00
Distance to nearest highway	1,288	641	87	2,608
Distance to nearest public park	686	330	4	1,376
Future land use: high-density residential	0.08	0.27	0.00	1.00
Future land use: low-density residential	0.63	0.49	0.00	1.00
Future land use: multiple use	0.01	0.09	0.00	1.00
Future land use: single-family	0.00	0.00	0.00	0.00
Within NSP area	0.00	0.00	0.00	0.00

Table 6-51

Single-family Properties Sample Descriptive Statistics – Atlanta Streetcar – Control Parcels

Variable	Mean	Std. Dev.	Min	Max
Sale price ($, 2016)	320,407	273,769	10,426	1,750,000
Parcel size (acre)	0.18	0.10	0.00	1.28
Size of living space (sf)	1,861	813	200	6,282
Years	60	35	1	145
Rooms	7	2	0	20
Full-size bathrooms	2	1	0	6
Half-size bathrooms	0	1	0	3
Liquor stores within 1/2 mile	0.15	0.35	0.00	1.00
MARTA station within 1/2 mile	0.21	0.40	0.00	1.00
School within 1/2 mile	0.76	0.43	0.00	1.00
Distance to nearest highway	3,084	2,338	29	10,646
Distance to nearest public park	3,583	7,877	0	35,286
Future land use: high-density residential	0.01	0.12	0.00	1.00
Future land use: low-density residential	0.35	0.48	0.00	1.00
Future land use: multiple use	0.01	0.08	0.00	1.00
Future land use: single-family	0.38	0.49	0.00	1.00
Within NSP area	0.19	0.39	0.00	1.00

In addition, the tables include a set of dichotomous variables that control for the impact of future land use planning on property values. These variables were created using a GIS layer developed by the City of Atlanta to represent the city's long-term growth and development plan and to serve as guide in zoning and other land-use regulations. The variables indicate whether a residential parcel will be located in a high- or low-density development or will be part of a multiple-use parcel. Finally, the variable nsp determines if the parcel is located within an economically-depressed area or the NSP. The NSP was established to stabilize communities suffering from foreclosures and abandonment. These areas contain the greatest percentage of home foreclosures and homes financed with the highest subprime mortgage-related loans.

Table 6-50 and Table 6-51 show that SIA and control samples are similar in terms of housing stock (age, building and parcel size), but they differ in terms of accessibility to nearby amenities and transport network. For example, due to I-75/85 running through downtown and clustering homes nearby the MLK site, single-family detached units are, on average, about 1,500 feet closer to a highway than the control sample.

The econometric model follows the general specification provided in Appendix A. The dependent variable is the natural log of the sale price. The explanatory variables of Table 6-50 are included in the final models, with alternative model specifications that include streetcar station dummies and controls for spatial autocorrelation.

Table 6-52 reports the results of the regression using naïve OLS estimators (Model 1 and Model 2, which includes streetcar station controls) and the spatial autoregressive model with spatial autocorrelation (SRAR) estimates (Model 3). The SRAR model results show that the property prices are spatially-correlated, and correlation extends to the error term. This is due to factors that are unobserved and that affect property sale values due to spatial proximity of adjacent properties. The SRAR model controls for spatial correlation in the error term, which is statistically significant. For this reason and due to the statistical significant term indicating spatial correlation among properties (the term lambda), the preferred model is the SRAR.

All models reject the hypothesis of a price premia effect during the Announcement and Planning stages, but find evidence of price premia during the Construction and Opening phases. Model 3, which accounts for the effect of spatial proximity between single-family homes (i.e., spatial autocorrelation), shows large effects on property price sale premiums, which range from 73.3 percent during Construction to 48.4 percent at Opening.[49]

[49] See footnote 35.

Table 6-52 *Single-family Property Sales Estimation Results – Atlanta Streetcar*

Variable	Definition	Regression Models		
		OLS (1)	OLS (2)	SRAR (3)
treatment	Treatment	-0.130	-0.485***	-0.268**
		(-1.22)	(-5.21)	(-2.27)
ann_plan	Announcement and Planning	0.0576	0.0418	-0.214***
		(0.63)	(0.52)	(-7.29)
constr	Construction	0.314**	0.290**	0.0292
		(2.90)	(3.08)	(1.03)
open	Opening	0.664***	0.664***	0.369***
		(6.25)	(7.17)	(12.36)
tr_ann_plan	Interaction term (treatment*ann_plan)	-0.111	-0.144	-0.0790
		(-0.51)	(-0.79)	(-0.53)
tr_constr	Interaction term (treatment*constr)	0.414**	0.459***	0.497***
		(2.65)	(3.62)	(3.33)
tr_open	Interaction term (treatment*open)	0.297**	0.368**	0.358**
		(2.05)	(3.10)	(2.59)
psize	Parcel size	0.959**	1.425***	1.678***
		(2.34)	(3.87)	(5.59)
psize2	Squared term of parcel size	-1.393**	-1.602**	-1.345***
		(-2.11)	(-2.59)	(-3.50)
bsize	Size of living space	0.000877***	0.000798***	0.000598***
		(10.93)	(10.64)	(10.67)
bsize2	Squared term of living space	-0.000000116***	-0.000000118***	-6.87e-08***
		(-7.49)	(-7.78)	(-6.60)
age	Age of structure	-0.00768***	-0.00968***	-0.0120***
		(-3.54)	(-5.01)	(-6.98)
age2	Squared term of age	0.0000971***	0.0000903***	0.000114***
		(4.70)	(4.93)	(6.84)
rooms	Number of rooms	-0.0371	-0.000451	-0.0305
		(-1.12)	(-0.02)	(-1.42)
rooms2	Squared term of rooms	0.000995	-0.000872	0.000825
		(0.49)	(-0.51)	(0.67)
bath_f	Number of full baths	0.104***	0.0567**	0.0498**
		(4.79)	(3.11)	(2.73)
bath_h	Number of half baths	0.0816**	0.0653**	0.0657**
		(2.67)	(2.56)	(2.65)
crime	Liquor stores within 1/2 mile	0.288***	0.0715**	-0.0365
		(7.82)	(2.22)	(-0.81)
marta_s	MARTA station within 1/2 mile	-0.515***	-0.475***	-0.262***
		(-13.58)	(-15.84)	(-6.53)
school_d	School within 1/2 mile	-0.191***	-0.238***	-0.0850**
		(-5.51)	(-7.45)	(-2.40)
lint_dist	Natural log of distance to nearest highway	0.0462**	-0.00331	-0.0272

Table 6-52 cont'd.

Single-family Property Sales Estimation Results – Atlanta Streetcar

Variable	Definition	Regression Models		
		OLS (1)	OLS (2)	SRAR (3)
		(3.02)	(-0.22)	(-1.37)
lpark_dist	Distance to nearest public park	-0.180***	-0.0868***	-0.103***
		(-15.16)	(-8.00)	(-9.49)
fluc_hdr	Future land use: high-density residential	0.353***	-0.152	0.333***
		(3.36)	(-1.63)	(3.60)
fluc_ldr	Future land use: low-density residential	0.478***	0.0295	0.189***
		(10.45)	(0.66)	(4.13)
fluc_mu	Future land use: multiple use	-0.210	-0.349**	-0.0350
		(-1.14)	(-2.31)	(-0.27)
fluc_sfr	Future land use: single-family	0.277***	0.0782*	0.0624
		(5.98)	(1.79)	(1.54)
nsp	Within stabilization program area	-0.000197***	-0.000105***	-0.000217***
		(-10.41)	(-5.91)	(-7.81)
_cons	Intercept	11.41***	11.54***	11.37***
		(50.12)	(53.60)	(57.47)
lambda	Autoregressive term			0.000107***
				(10.17)
rho	Autoregressive error			0.000712***
				(40.84)
sigma2	Sigma squared			0.302***
				(38.05)
N	Sample size	2,761	2,761	2,896
adj. R-sq	Adjusted R-square	0.527	0.646	

*t-statistics in parenthesis: * p<0.05; **p<0.01, ***p<0.001.*
Pre-planning phase (pre-plan) is baseline treatment phase.

Condominium Properties

Table 6-53 reports the 2002–2016 sale counts and average sale prices of condominium and multi-family units, after the removal of outliers. The count of sales is greater for condominium and multi-family units than for single-family units. Sales decreased during the Announcement and Planning phase, which corresponds to the period when the real estate crisis was reaching its peak, but increased during Construction and Opening. Note that average sale prices during Design and Construction are higher than the Pre-planning phase.

Table 6-53

Condominium and Multi-family Properties Sales by Project Phase – Atlanta Streetcar

Project Phase	SIA		Control	
	Count	Value ($)	Count	Value ($)
Pre-planning	419	226,801	403	200,338
Announcement and Planning	287	145,268	298	162,795
Design and Construction	211	177,246	302	169,563
Opening	172	200,654	249	207,199

Table 6-54 and Table 6-55 report sample descriptive statistics for the variables included in the regression analysis. On average, properties located in the SIA share characteristics similar to the control areas, such as the mean size of the living space, number of rooms, and bathrooms. Properties located in the control areas are, on average, 12 years older, and about 15 percent are located in the NSP area.

Table 6-54

Multi-family and Condominium Sample Descriptive Statistics – Atlanta Streetcar – SIA

Variable	Mean	Std. Dev.	Min	Max
Sale price ($, 2016)	191,582	108,234	14,516	812,090
Parcel size (acre)	0.11	0.47	0.00	4.11
Size of living space (sf)	985	309	387	1,809
Years	21	27	1	90
Rooms	3	1	1	9
Full-size bathrooms	1	0	1	3
Half-size bathrooms	0	0	0	2
Liquor stores within 1/2 mile	0.59	0.49	0.00	1.00
MARTA station within 1/2 mile	0.72	0.45	0.00	1.00
School within 1/2 mile	0.43	0.50	0.00	1.00
Distance to nearest highway	742	744	20	2,567
Distance to nearest public park	738	538	0	2,667
Future land use: high-density residential	0.07	0.26	0.00	1.00
Future land use: low-density residential	0.03	0.16	0.00	1.00
Future land use: multiple use	0.61	0.49	0.00	1.00
Future land use: single-family	0.00	0.00	0.00	0.00
Within NSP area	0.00	0.00	0.00	0.00

Table 6-55

Multi-family and Condominium Sample Descriptive Statistics – Atlanta Streetcar – Control Parcels

Variable	Mean	Std. Dev.	Min	Max
Sale price ($, 2016)	185,343	115,668	1	872,988
Parcel size (acre)	0.42	1.07	0.00	4.93
Size of living space (sf)	977	308	412	1,814
Years	33	29	1	90
Rooms	4	1	1	10
Full-size bathrooms	1	0	1	4
Half-size bathrooms	0	0	0	2
Liquor stores within 1/2 mile	0.33	0.47	0.00	1.00
MARTA station within 1/2 mile	0.63	0.48	0.00	1.00
School within 1/2 mile	0.78	0.42	0.00	1.00
Distance to nearest highway	2,131	1,101	367	7,440
Distance to nearest public park	961	579	0	2,356
Future land use: high-density residential	0.00	0.07	0.00	1.00
Future land use: low-density residential	0.20	0.40	0.00	1.00
Future land use: multiple use	0.27	0.44	0.00	1.00
Future land use: single-family	0.02	0.15	0.00	1.00
Within NSP area	0.15	0.35	0.00	1.00

The results of the OLS regression presented in Table 6-56 show evidence of the Atlanta streetcar project's effect on condominium sales prices.[50] Due to the clustering of several units in one parcel (i.e., same geographic location), the analysis does not include results from SRAR models. Model 2 specification controls for station-specific effects and explains more of the variance in the sample (R-square is about 0.54). Using the Pre-planning phase at the base for comparison, findings provide evidence of the streetcar project effect on condominium property sales at Construction and Opening. Properties located within the SIA show a premium increasing from 10.3 percent at Construction to 28.0 percent at the Opening phase.

Table 6-56

Condominium Property Sales Estimation Results – Atlanta Streetcar

Variable	Definition	Regression Models	
		OLS (1)	OLS (2)
treatment	Treatment	-0.102**	-0.172***
		(-2.40)	(-3.94)
ann_plan	Announcement and Planning	-0.134	-0.0678
		(-1.62)	(-0.85)
constr	Construction	0.169*	0.191**
		(1.92)	(2.24)
open	Opening	-0.184	-0.211
		(-0.20)	(-0.24)
tr_ann_plan	Interaction term (treatment*ann_plan)	0.0361	-0.0259
		(0.57)	(-0.42)
tr_constr	Interaction term (treatment*constr)	0.0822	0.0980**
		(1.62)	(2.04)
tr_open	Interaction term (treatment*open)	0.210	0.247*
		(1.56)	(1.86)
psize	Parcel size	-0.0449	-0.0307
		(-0.41)	(-0.29)
psize2	Squared term of parcel size	0.00431	-0.0130
		(0.15)	(-0.46)
bsize	Size of living space	0.00165***	0.00174***
		(6.59)	(7.27)
bsize2	Squared term of living space	-0.000000261**	-0.000000268**
		(-2.43)	(-2.54)
age	Age of structure	-0.0205***	-0.0254***
		(-8.40)	(-11.12)
age2	Squared term of age	0.000213***	0.000270***
		(7.94)	(10.66)
rooms	Number of rooms	-0.192***	-0.108**
		(-3.57)	(-2.11)
rooms2	Squared term of rooms	0.0176**	0.0129**
		(2.70)	(2.08)

[50] See footnote 35.

Table 6-56 cont'd.

Condominium Property Sales Estimation Results – Atlanta Streetcar

Variable	Definition	Regression Models	
		OLS (1)	OLS (2)
bath_f	Number of full baths	0.0318	-0.0309
		(0.99)	(-0.97)
bath_h	Number of half baths	0.0318	0.0481
		(0.56)	(0.94)
crime	Liquor stores within 1/2 mile	0.160**	0.0262
		(3.12)	(0.54)
marta_s	MARTA station within 1/2 mile	-0.253***	-0.196***
		(-5.91)	(-3.32)
school_d	School within 1/2 mile	0.0186	-0.153**
		(0.40)	(-3.24)
lint_dist	Natural log of distance to nearest highway	0.0123	0.0190
		(0.65)	(1.08)
lpark_dist	Distance to nearest public park	0.0437***	0.0238**
		(4.13)	(2.16)
fluc_hdr	Future land use: high-density residential	-0.367***	-0.0385
		(-5.96)	(-0.44)
fluc_ldr	Future land use: low-density residential	0.128**	0.0197
		(2.14)	(0.28)
fluc_mu	Future land use: multiple use	0.133***	0.0807**
		(4.27)	(2.80)
fluc_sfr	Future land use: single-family	0.336**	0.206
		(2.38)	(1.50)
nsp_d	Within stabilization program area	-0.370***	-0.210**
		(-4.31)	(-2.51)
_cons	Intercept	10.68***	10.43***
		(52.08)	(53.01)
N	Sample size	1781	1781
adj. R-sq	Adjusted R-square	0.509	0.544

*t-statistics in parenthesis: * $p<0.05$; ** $p<0.01$, *** $p<0.001$.*
Pre-planning phase (pre-plan) is baseline treatment phase.

Commercial Properties

Table 6-57 reports sales data for commercial properties, which show a wide variation in average sales values due to the inclusion of parcels allocated to office, retail, and other commercial purposes.

Table 6-57

Commercial Property Sales by Project Phase – Atlanta Streetcar

Project Phase	SIA		Control	
	Count	Value ($)	Count	Value ($)
Pre-planning	703	1,111,924	1,961	722,771
Announcement and Planning	510	804,788	1307	328,546
Design and Construction	577	5,631,645	1294	406,468
Opening	452	1,792,827	1252	1,015,590

Table 6-58 reports the results of the econometric model, which provides no evidence of streetcar impacts on commercial property values. As was the case with condominium properties, spatial autoregressive models could not be run due to the clustering of one or more businesses at the same geographical location (i.e., same parcel, multiple units). The parameters associated with the streetcar project phases (highlighted in gray) are negative and are not statistically significant. Due to the relatively small number of recorded sales in the SIA, the analysis does not provide any conclusive evidence about streetcar effects on commercial property sales.

Table 6-58

Commercial Property Sales Estimation Results – Atlanta Streetcar

Variable	Definition	Regression Models	
		OLS (1)	*OLS (2)*
treatment	Treatment	0.0979*	-0.139**
		(1.71)	(-2.30)
ann_plan	Announcement and Planning	-0.243***	-0.254***
		(-5.09)	(-5.64)
constr	Construction	0.134***	0.0339
		(3.46)	(0.96)
open	Opening	0.380***	0.308***
		(8.01)	(6.88)
tr_ann_plan	Interaction term (treatment*ann_plan)	0.0154	-0.0364
		(0.21)	(-0.53)
tr_constr	Interaction term (treatment*constr)	0.0263	0.106*
		(0.39)	(1.69)
tr_open	Interaction term (treatment*open)	0.133	0.216**
		(1.59)	(2.57)
psize	Parcel size	-0.109*	0.347***
		(-1.75)	(3.57)
psize2	Squared term of parcel size	0.0413**	-0.112***
		(2.69)	(-3.76)
age	Age of structure	-0.0271***	-0.0261***
		(-13.21)	(-12.81)
age2	Squared term of age	0.000273***	0.000249***
		(13.16)	(12.31)
marta_r	MARTA station within 1/2 mile	-0.117***	-0.183***
		(-3.53)	(-5.45)
five_point	MARTA Five Point station	-0.994***	-0.128
		(-6.33)	(-0.59)
p_tree	Peachtree Station	-0.324***	-0.135**
		(-6.23)	(-2.01)
lint_dist	Natural log of distance to nearest highway	-0.00715	-0.00151
		(-0.39)	(-0.08)
fluc_hdr	Future land use: high-density residential	0.0874	-0.0253

Table 6-58 cont'd.

Commercial Property Sales Estimation Results – Atlanta Streetcar

Variable	Definition	Regression Models	
		OLS (1)	OLS (2)
		(1.17)	(-0.26)
fluc_ldr	Future land use: low-density residential	0.401***	0.0328
		(9.84)	(0.76)
fluc_mu	Future land use: multiple use	0.0460	-0.116**
		(1.23)	(-2.82)
fluc_sfr	Future land use: single-family	0.410***	0.228***
		(8.34)	(4.89)
nsp_d	Within stabilization program area	-0.580***	-0.310***
		(-11.31)	(-4.77)
_cons	Intercept	12.29***	13.74***
		(84.83)	(41.24)
N	Sample size	6967	6967
adj. R-sq	Adjusted R-square	0.139	0.233

*t-statistics in parenthesis: * p<0.05; **p<0.01, ***p<0.001.*
Pre-planning phase (pre-plan) is baseline treatment phase.

Vacant Properties

Table 6-59 reports sales data for residential and commercial vacant parcels. After removal of outliers, sales in the SIA total 50, with most of the sales occurring during the Opening phase.

Table 6-59

Vacant Property Sales by Project Phase – Atlanta Streetcar

Project Phase	SIA		Control	
	Count	Value ($)	Count	Value ($)
Pre-planning	13	4,007,633	223	711,727
Announcement and Planning	7	158,710	161	197,873
Design and Construction	11	3,510,815	46	359,854
Opening	19	1,086,911	128	819,295

The number of sales in the SIA is too small to run a regression model, as was done in the previous section (Section 2, Commercial Properties). An alternative approach was to estimate changes in vacant property values.

Table 6-60 reports the results of an FE model using as a sample all assessed values of all commercial parcels for the period 2007–2016. The dependent variable is the natural log of the Property Assessor's current assessed value. The appraised values define a panel database with yearly observations on the assessed value (current assessed value), which consists of repeated observations of the same parcel over time. The statistical analysis of panel data by multivariate regression (i.e., OLS regression) produces biased results because of the omission of time-constant parcel-specific unobserved factors affecting the assessed values. To overcome this problem, FE can be used to eliminate the time-constant unobserved effects and, under certain assumptions, give unbiased estimates.

In addition, FE regression allows estimating the change in assessed value within parcels as opposed to OLS, which estimates changes in assessed valued across all observations (i.e., pooling of data).

Table 6-60

Vacant Property Assessed Values Fixed Effect Estimation Results – Atlanta Streetcar

Variable	Definition	Fixed-effect Model		
		All Parcels	*Residential*	*Commercial*
lpsize	Natural log of parcel size	0.0145	-0.0284*	0.0305*
		(0.96)	(-1.67)	(1.65)
tr_ann_plan	Interaction term (treatment*ann_plan)	0.0992**	-0.0195	-0.0335
		(3.16)	(-0.73)	(-0.60)
tr_constr	Interaction term (treatment*constr)	0.163***	0.172***	0.0189
		(33.12)	(38.61)	(0.29)
tr_open	Interaction term (treatment*open)	0.196***	0.187***	0.0512
		(32.91)	(37.43)	(0.80)
_cons		9.765***	9.896***	10.97***
		(273.04)	(253.87)	(247.75)
	Variables controlling for secular trends	yes	yes	yes
N	Sample size	13,071	7,878	2,590
R-sq	Adjusted R-square	0.536	0.696	0.267

*t-statistics in parenthesis: * p<0.05; **p<0.01, ***p<0.001*
Pre-planning phase (pre-plan) is baseline treatment phase.

Table 6-60 shows the results of the two models. The analysis finds evidence of positive premia during Construction and Opening, when considering all vacant parcels. A breakdown by parcel type shows that the effects are statistically significant only for residential parcels. Vacant residential parcels assessed values are, on average, 18.8 percent higher than comparable areas during Construction and 20.6 percent higher after the system starts operations.

Salt Lake City S-Line

The econometric models follow the general specification provided in Appendix A with adjustments that compensate for some of the data constraints of the property values provided by the tax assessor. Utah is a nondisclosure state, and information on private sales is not publicly available. These constraints do not allow modeling the sales data.

The only publicly-disclosed information is the annual assessed values from the local Property Appraiser for tax roll purposes. This data collection process defines a panel database with yearly observations on the assessed value (total value) and detailed information on any building present in each parcel. Ultimately, this results in repeated observations over time of the same parcel and its physical attributes. The statistical analysis of panel data by multivariate regression (i.e., OLS regression) produces biased results because of the omission of time-constant parcel-specific unobserved factors affecting the assessed values.

To overcome this problem, FE can be used to eliminate the time-constant unobserved effects and, under certain assumptions, give unbiased estimates. In addition, FE regression allows estimating the change in assessed value within parcels, as opposed to OLS, which estimates changes in assessed valued across all observations (i.e., pooling of data).

To investigate the causality between the project phases and impacts on property values, annual property appraisals are aggregated according to the most relevant project phases, as reported in Table 6-61. The aggregation of observations by project phase allows setting up a baseline comparison corresponding to the period before any official planning announcement was made (Pre-planning). This phase is characterized by informal news about project planning. Subsequent phases identify when the official decision was made to include the project into the county planning process (Announcement and Planning), including major evaluation studies such as environmental assessments and design and development phases. The Construction phase coincides with beginning of construction (2012). The Opening phase begins when the system opens to the public. The streetcar opened on December 8, 2013, and operated throughout 2016.

Table 6-61

Salt Lake City S-Line Project Phases

Year	Event	Project Phase
2006	Planning and study of alternatives	Pre-planning
2008	Locally Preferred Alternative (LPA) adopted by City	Announcement and Planning
2009	Financial feasibility study	Announcement and Planning
2010	TIGER II grant awarded	Announcement and Planning
2011	Sugar House Streetcar website established	Announcement and Planning
2011	Environmental and FONSI	Announcement and Planning
2012	Final design and construction	Construction
2013	Construction and Opening (Dec. 2013)	Construction
2014	Opening and Operation	Opening and Operation

Table 6-62 reports the parcel count and mean assessed value of single-family homes after data cleaning to remove outliers. Assessed values were lower, on average, at the Opening phase when compared to the Pre-planning phase. This trend is similar to what is shown in Table 6-62 but does not take into account all the factors considered in the econometric model, including building, neighborhood characteristics, and historical trends.

Table 6-62

Single-family Properties Assessed Values by Project Phase – Salt Lake City S-Line

Project Phase	SIA		Control	
	Count	Value ($)	Count	Value ($)
Pre-planning	7,119	207,054	39,298	224,338
Announcement and Planning	4,752	186,176	25,512	201,691
Design and Construction	4,730	175,094	27,032	185,290
Opening	6,938	192,857	39,021	200,806

Table 6-63 and Table 6-64 report sample descriptive statistics of the variables used in the regression models as independent variables to control for factors affecting property prices, such as parcel size, size of living space, building age, the presence of amenities such as parks and schools, waterfront location, and distance to major interstates and rail lines. The empirical literature shows that these variables significantly affect property sale prices, and it is common practice to include them in econometric models. The academic literature refers to this approach as *hedonic regression* or modeling that controls for factors having an impact on an individual's willingness to pay for specific building features and attributes.

Table 6-63

Single-family Properties Sample Descriptive Statistics – Salt Lake City S-Line – SIA

Variable	Variable	Mean	Std. Dev.	Min	Max
ass_value	Assessed value ($, 2016)	192,233	48,312	51,000	411,111
psize	Parcel size (acres)	0.14	0.04	0.03	0.45
bsize	Size of living space (sf)	1,042	276	430	2,087
age	Age of structure	25	4	1	49
rooms	Total number of rooms	7	2	2	12
bath_full	Full-size bathrooms	1	0	0	4
bath_half	Half-size bathrooms	1	0	0	2
duplex	Duplex unit	0.04	0.20	0.00	1.00
stat_dist	Distance to nearest streetcar station (ft)	1544.50	731.52	15.58	3234.73
tx_dist	TRAX station within 1/2 mile	5924.83	2508.77	813.97	11768.12
school_d	School within 1/2 mile	1	0	0	1
int_dist	Distance to nearest highway (ft)	1,137	753	17	3,358
park_dist	Distance to nearest public park (ft)	1421.22	689.47	0.00	3097.25
golf_dist	Distance to nearest golf course (ft)	3985.89	1629.80	332.56	8010.77
liquor	Distance to nearest liquor store	1720.35	634.20	47.77	3097.23
env_dist	Distance to nearest LQG site (ft)	4024.58	2080.58	136.66	8842.61
hist_dist	Within historical district	0.39	0.49	0.00	1.00
cbd	Within 1/2 mile of CBD	0.00	0.00	0.00	0.00

Table 6-64

Single-family Properties Sample Descriptive Statistics – Salt Lake City S-Line – Control Parcels

Variable	Variable	Mean	Std. Dev.	Min	Max
ass_value	Assessed value ($, 2016)	204,840	72,178	36,701	434,884
psize	Parcel size (acres)	0.16	0.05	0.01	0.45
bsize	Size of living space (sf)	1,127	307	336	2,100
age	Age of structure	24	5	1	53
rooms	Total number of rooms	8	2	1	12
bath_full	Full-size bathrooms	1	0	0	5
bath_half	Half-size bathrooms	1	0	0	4
duplex	Duplex unit	0.06	0.24	0.00	1.00
stat_dist	Distance to nearest streetcar station (ft)	11516.74	7649.69	3549.51	39603.73
tx_dist	TRAX station within 1/2 mile	7196.89	3835.27	56.85	20044.89
school_d	School within 1/2 mile	1	0	0	1
int_dist	Distance to nearest highway (ft)	2,039	1,239	9	5,007
park_dist	Distance to nearest public park (ft)	1299.44	916.64	0.00	4836.52
golf_dist	Distance to nearest golf course (ft)	5815.46	3212.98	0.00	15993.08
liquor	Distance to nearest liquor store	3473.64	2520.37	51.79	17663.69
env_dist	Distance to nearest LQG site (ft)	5693.73	2682.75	212.21	15104.18
hist_dist	Within historical district	0.25	0.43	0.00	1.00
cbd	Within 1/2 mile of CBD	0.00	0.05	0.00	1.00

Other variables control for external factors that negatively affect property prices, such as a liquor store located near the property (a proxy for crime) or the distance to the nearest site generating large quantities of hazardous waste. The Utah Department of Environmental Quality (DEQ) defines "large quantity generators" (LQG) as those sites that generate 1,000 kilogram per month or more of hazardous waste or more than 1 kilogram per month of acutely hazardous waste. The tables show that SIA and control samples are similar in terms of housing stock (age, building and parcel size), but differ in terms of accessibility to nearby amenities and transport network. On average, parcels located in the SIA are about 1,540 feet from the nearest streetcar station, with the closest parcels located adjacent. Some of the control parcels are located in the immediate outskirts of the SIA at a distance of about 3,550 feet, because the propensity-score matching approach to select control areas identified some of the control block groups in close proximity to the SIA.

The dependent variable is the natural log of the assessed value. The explanatory variables in Table 6-63 are included in the final models, with alternative model specifications that include streetcar station dummies to control for station-specific effects. All models have standard errors corrected for heteroskedasticity (i.e., error variance not constant) and clustered around the parcels. By construct, multiple regression via OLS works by pooling all observations. Because the dataset consists of repeated observations over time (i.e., yearly assessment of parcels), the OLS models produce biased results because they do not account for time-constant parcel-specific unobserved factors affecting the assessed values. To overcome this problem, FE can be used to eliminate the time-constant unobserved effects, and, under certain assumptions, give unbiased estimates. In addition, FE regression allows estimating the change in assessed value within parcels as opposed to OLS regression, which estimates changes in assessed valued across all observations (i.e., pooling of data). By construct, FE cancels time-constant effects such as distance to amenities and other building variables. Therefore, the FE model is the preferred approach to make statistical inference. Using Model 4 as the preferred model, the analysis finds evidence of premia for single-family homes ranging from a 2.2 percent premium during the Announcement and Planning stages to an increase to 3.6 percent during Construction, to a decrease at the Opening to about 1.2 percent.

Table 6-65 reports the results of the regression using naïve OLS models (Model 1 and Model 2), which account for parcel-specific characteristics but do not control for unobserved time-invariant factors or control for within-parcel variation. Model 3 and Model 4 report the results of FE regression, with Model 4 estimated using a balanced version of the panel (i.e., only parcels being assessed yearly between 2007 and 2016).

All models find statistically-significant evidence of price premia effects at different phases of the project. The explanatory variables measuring the impact on percent changes in assessed values from Announcement and Planning through the Opening phase are highlighted in the table. Model 2 and Model 4 estimated parameters are similar in magnitude, but the standard errors of Model 4 are about 60 percent smaller. Model 4 is the preferred model. Using Model 4 as the preferred model, the analysis finds evidence of premia for single-family homes ranging from a 2.2 percent premium during the Announcement and Planning stages to an increase to 3.6 percent during Construction, to a decrease at the Opening to about 1.2 percent.[51]

[51] See footnote 35.

Table 6-65 *Single-family Property Values Estimation Results – Salt Lake City S-Line*

Variable	Definition	Regression Model			
		(1) OLS	*(2) OLS†*	*(3) FE*	*(4) FE††*
treatment	Treatment	0.0837***	0.0263***		
		(0.00229)	(0.00189)		
ann_plan	Announcement and Planning	-0.0812***	-0.0803***		
		(0.00179)	(0.00127)		
constr	Construction	-0.124***	-0.118***		
		(0.00184)	(0.00131)		
open	Opening	-0.0320***	-0.0116***		
		(0.00167)	(0.00122)		
tr_ann_plan	Interaction term (treatment*ann_plan)	0.0169***	0.0217***	0.0221***	0.0216***
		(0.00348)	(0.00273)	(0.00111)	(0.00112)
tr_constr	Interaction term (treatment*constr)	0.0347***	0.0348***	0.0365***	0.0356***
		(0.00352)	(0.00278)	(0.00134)	(0.00134)
tr_open	Interaction term (treatment*open)	0.00878**	0.0117***	0.0147***	0.0122***
		(0.00320)	(0.00258)	(0.00146)	(0.00149)
lpsize	Natural log of parcel size	-0.0739***	-0.000631		
		(0.0121)	(0.00997)		
lpsize2	Squared term of lpsize	-0.0221***	-0.0321***		
		(0.00304)	(0.00254)		
lbsize	Natural log of size of living space	1.090***	1.568***	0.151***	0.174***
		(0.107)	(0.0847)	(0.0139)	(0.0139)
lbsize2	Squared term of lbsize	-0.0565***	-0.0964***		
		(0.00767)	(0.00605)		
lage	Natural log of age of structure	0.526***	0.560***	0.355***	0.425***
		(0.0241)	(0.0214)	(0.0156)	(0.0267)
lage2	Squared term of lage	-0.132***	-0.159***	-0.149***	-0.158***
		(0.00412)	(0.00364)	(0.00285)	(0.00464)
bath_full	Number of full-size bathrooms	0.0635***	0.0563***	0.0388***	0.0405***
		(0.00154)	(0.00116)	(0.00295)	(0.00309)
duplex	Duplex unit	0.00557*	0.0212***		
		(0.00305)	(0.00244)		
ltx_dist	Natural log of distance to nearest Trax station	0.196***	-0.0116***		
		(0.00187)	(0.00161)		
school_d	School within 1/2 mile	0.0650***	0.0247***		
		(0.00210)	(0.00178)		
lint_dist	Natural log of distance to nearest interstate	0.0480***	0.0202***		
		(0.000618)	(0.000657)		
crime	Liquor stores within 1/2 mile	-0.0158***	-0.0309***		
		(0.00147)	(0.00127)		
hist_dist	Within historical district	0.137***	0.0856***		
		(0.00143)	(0.00132)		
lpark_dist	Natural log of distance to nearest park	0.0174***	-0.0150***		

Table 6-65 cont'd *Single-family Property Values Estimation Results – Salt Lake City S-Line*

Variable	Definition	Regression Model			
		(1) OLS	(2) OLS†	(3) FE	(4) FE††
		(0.000700)	(0.000481)		
lgolf_dist	Natural log of distance to nearest golf course	-0.00491***	0.0333***		
		(0.000721)	(0.000892)		
lenv_dist	Natural log of distance nearest large polluting site	0.0557***	-0.0108***		
		(0.00144)	(0.00125)		
cbd	Within 1/2 mile of CBD	.	0.187***		
		.	(0.0121)		
occupied	Occupied property	0.0235***	0.0310***		
		(0.00227)	(0.00170)		
_cons	Intercept	5.463***	8.413***	12.11***	11.92***
		(0.375)	(0.305)	(0.115)	(0.129)
N	Sample size	153454	153788	154398	131134
R-sq	R-squared (OLS adjusted; FE within)	0.620	0.801	0.713	0.722

Note: Models include building condition and year dummy variables (not shown).
*Standard errors in parenthesis: * p<0.05; **p<0.01, ***p<0.001.*
Pre-planning phase (pre-plan) is baseline treatment phase.
† Model with streetcar station dummies (not shown). †† Balanced panel

Impact on Condominium Units

Table 6-66 shows the breakdown of condominium properties and mean assessed values by project phase after the removal of outliers. Although less than the control areas, average assessed values of SIA condominium properties rose faster over the streetcar project phases. The sample difference-in-differences in mean values between treatment and control at Opening is $18,600 greater [($283,144-246,507)-($313,635-295,680) = $18,682]. That is, at Opening, SIA condominium mean values retained a difference of about $18,682 compared to similar properties located elsewhere in the county.

Table 6-66

Condominium Properties Assessed Values by Project Phase – Salt Lake City S-Line

Project Phase	SIA		Control	
	Count	Value ($)	Count	Value ($)
Pre-planning	520	246,507	4,752	295,680
Announcement and Planning	397	234,420	3,512	286,308
Design and Construction	403	289,196	3,833	303,053
Opening	609	283,144	6,090	313,635

Table 6-67 and Table 6-68 report the sample descriptive statistics of the variables included in the regression analysis for the SIA and control parcels. Although similar in terms of living space, number of rooms, and full-size bathrooms, condominiums in the SIA are newer, with an average age of just 9 years, compared to 18 years for the controls. The difference in age is evident when comparing the proportion of units having a kitchen and bathroom defined by the County Assessor as having a modern design. About 70 percent of SIA condominiums have newer features, compared to about 40 percent of the control parcels.

Table 6-67

Condominium Properties Sample Descriptive Statistics – Salt Lake City S-Line – SIA

Variable	Definition	Mean	Std. Dev.	Min	Max
ass_value	Assessed value ($, 2016)	171,921	70,090	60,093	529,419
bsize	Size of living space (sf)	832	167	493	1,171
age	Age of structure	9	9	1	34
brooms	Total number of rooms	2	1	0	3
bath_full	Full-size bathrooms	1	0	1	2
kitchen_sm	Kitchen with modern look	0.70	0.46	0.00	1.00
bath_sm	Bathroom with modern look	0.70	0.46	0.00	1.00
cond_e	Overall condition from good to excellent	0.69	0.46	0.00	1.00
stat_dist	Distance to nearest streetcar station (ft)	1,381	832	132	2,835
tx_dist	Distance to nearest TRAX station	5,928	4,088	1,390	11,573
int_dist	Distance to nearest highway (ft)	1,310	981	254	2,897
park_dist	Distance to nearest public park (ft)	1,688	1,057	165	2,930
golf_dist	Distance to nearest golf course (ft)	4,384	1,556	1,035	6,385
liquor	Distance to nearest liquor store	1,633	723	810	2,732
env_dist	Distance to nearest LQG site (ft)	4,613	2,932	1,392	8,849
school_d	School within 1/2 mile	0.63	0.48	0.00	1.00
hist_dist	Within historical district	0.08	0.28	0.00	1.00
cbd	Within 1/2 mile of CBD	0.00	0.00	0.00	0.00

Table 6-68

Condominium Properties Sample Descriptive Statistics – Salt Lake City S-Line – Controls

Variable	Definition	Mean	Std. Dev.	Min	Max
ass_value	Assessed value ($, 2016)	162,456	66,347	60,000	319,902
bsize	Size of living space (ft)	879	306	390	1,510
age	Age of structure	18	9	1	34
brooms	Total number of rooms	2	1	0	4
bath_full	Full-size bathrooms	1	0	1	2
kitchen_sm	Kitchen with modern look	0.40	0.49	0.00	1.00
bath_sm	Bathroom with modern look	0.43	0.50	0.00	1.00
cond_e	Overall condition from good to excellent	0.21	0.41	0.00	1.00
stat_dist	Distance to nearest streetcar station (ft)	16,058	5,985	3,744	38,866
tx_dist	Distance to nearest TRAX station	3,912	3,103	183	19,062
int_dist	Distance to nearest highway (ft)	1,658	1,081	44	4,195
park_dist	Distance to nearest public park (ft)	1,376	808	73	3,204
golf_dist	Distance to nearest golf course (ft)	8,875	5,468	11	15,633
liquor	Distance to nearest liquor store	2,851	1,418	458	7,950
env_dist	Distance to nearest LQG site (ft)	6,429	2,054	1,935	12,255
school_d	School within 1/2 mile	0.82	0.39	0.00	1.00
hist_dist	Within historical district	0.34	0.47	0.00	1.00
cbd	Within 1/2 mile of CBD	0.25	0.43	0.00	1.00

Table 6-69 reports the regression results. As in the case of single-family properties, the regression analysis employed naïve OLS and FE estimators. The OLS and FE provide evidence of the streetcar project effect on condominium values throughout the project phases. In particular, using the FE balanced sample model (Model 4) as the preferred specification, properties located within the SIA show a premium increasing from 5.3 percent at Announcement and Planning to 9.9 percent at during the Construction phase, and 15.4 at Opening and the following two years of operation.

Table 6-69

Condominium Property Sales Estimation Results – Salt Lake City S-Line

Variable	Definition	Regression Model			
		(1) OLS	(2) OLS†	(3) FE	(4) FE††
treatment	Treatment	-0.168***	-0.142***		
		(0.0121)	(0.0113)		
ann_plan	Announcement and Planning	-0.104***	-0.110***		
		(0.00681)	(0.00631)		
constr	Construction	-0.174***	-0.180***		
		(0.00674)	(0.00625)		
open	Opening	-0.0276***	-0.0310***		
		(0.00680)	(0.00630)		
tr_ann_plan	Interaction term (treatment*ann_plan)	0.0120	-0.00304	0.0562***	0.0520***
		(0.0164)	(0.0152)	(0.0101)	(0.0100)
tr_constr	Interaction term (treatment*constr)	0.116***	0.0954***	0.0942***	0.0942***
		(0.0148)	(0.0137)	(0.00921)	(0.00917)
tr_open	Interaction term (treatment*open)	0.199***	0.158***	0.155***	0.143***
		(0.0145)	(0.0134)	(0.00910)	(0.00918)
lbsize	Natural log of size of living space	0.168***	0.170***		
		(0.00590)	(0.00604)		
lage	Natural log of age of structure	0.115***	0.192***	0.107***	0.134***
		(0.0107)	(0.0102)	(0.00928)	(0.0101)
lage2	Squared term of lage	-0.0444***	-0.0603***	-0.0186***	-0.0217***
		(0.00239)	(0.00237)	(0.00261)	(0.00286)
brooms	Number of bedrooms	0.170***	0.176***		
		(0.00327)	(0.00318)		
kitchen_sm	Semi- to modern kitchen	-0.0847***	-0.0408***	-0.0284**	-0.0290**
		(0.00524)	(0.00502)	(0.0143)	(0.0143)
bath_sm	Semi- to modern bathroom	0.153***	0.140***	0.110***	0.113***
		(0.00470)	(0.00449)	(0.00883)	(0.00905)
bath_full	Number of full-size bathrooms	0.0699***	0.0103**		
		(0.00470)	(0.00457)		
cond_e	Overall building rating very good to excellent	0.0851***	0.0906***	0.0899***	0.126***
		(0.00845)	(0.00825)	(0.00858)	(0.0117)
parking_g	Parking garage	0.192***	0.127***		
		(0.00363)	(0.00385)		

Table 6-69 cont'd

Condominium Property Sales Estimation Results – Salt Lake City S-Line

Variable	Definition	Regression Model			
		(1) OLS	(2) OLS†	(3) FE	(4) FE††
elev	Elevator	-0.0810***	-0.143***		
		(0.00455)	(0.00480)		
ltx_dist	Natural log of distance to nearest Trax station	-1.071***	0.924***		
		(0.108)	(0.140)		
ltx_dist2	Squared term of ltx_dist	0.0829***	-0.0429***		
		(0.00638)	(0.00830)		
cbd	Within 1/2 mile of CBD	2.040***	4.389***		
		(0.218)	(0.266)		
ltx_dist_cbd	Interaction term of cbd and ltx_dist	-0.211***	-0.516***		
		(0.0298)	(0.0359)		
school_d	School within 1/2 mile	-0.0652***	0.00609		
		(0.00697)	(0.00715)		
hist_dist	Within historical district	0.367***	0.194***		
		(0.00385)	(0.00626)		
_cons	Intercept	14.06***	7.794***	11.98***	11.66***
		(0.402)	(0.503)	(0.0195)	(0.0362)
N	Sample size	13745	13745	13749	11463
R-sq	R-squared (OLS adjusted; FE within)	0.777	0.809	0.277	0.316

Note: Models include building condition and year dummy variables (not shown).
*Standard errors in parenthesis: * p<0.05; **p<0.01, ***p<0.001.*
Pre-planning phase (pre-plan) is baseline treatment phase.
† Model with streetcar station dummies (not shown). †† Balanced panel

Commercial Properties

Table 6-70 reports sales data for commercial properties. After removal of outliers, sample mean assessed values in the SIA are higher in the Opening phase compared to the controls, but lower than Pre-planning phase mean values. As discussed in Section 2.1, SIA commercial parcels consist mostly of offices, retail, restaurant, and other parcels. These characteristics are reflected in the mean assessed values.

Table 6-70

Commercial Properties Assessed Values by Project Phase – Salt Lake City S-Line

Project Phase	SIA		Control	
	Count	Value ($)	Count	Value ($)
Pre-planning	927	652,732	3,580	599,253
Announcement and Planning	611	704,854	2,315	635,560
Design and Construction	602	632,393	2,363	607,804
Opening	300	593,284	1,177	574,558

Table 6-71 and Table 6 -72 report sample descriptive statistics of the variables included in the regression analysis. In particular, the SIA sample outlier removal excludes the top 95th percentile assessed value to remove the impact of those properties siting big-box or retail mall outlets. The tables show that the SIA and control parcels are similar in terms of parcel characteristics and size of commercial space. About 9 percent of the structures located in the SIA rate good to excellent in terms of overall condition, compared to about 13 percent in the control parcels. The shares of parcels siting offices, restaurants, fast-food establishments, and retail stores are similar. Reflecting the mix of commercial and light industrial parcels located near the Central Pointe Station, the SIA is characterized by a higher share of warehouse parcels (12%) compared to the control parcels (7%).

Table 6-71

Commercial Properties Sample Descriptive Statistics, Salt Lake City S-Line – SIA

Variable	Definition	Mean	Std. Dev.	Min	Max
ass_value	Assessed value ($, 2016)	653,457	733,163	29,626	5,403,256
psize	Parcel size (acres)	0.40	0.33	0.04	1.70
bsize	Size of commercial space (sf)	4,543	5,516	0	79,474
age	Age of structure	26	9	1	58
cond_e	Overall condition from good to excellent	0.09	0.29	0.00	1.00
office	Office	0.19	0.40	0.00	1.00
restaurant	Restaurant	0.04	0.19	0.00	1.00
fast_food	Fast food restaurant	0.06	0.23	0.00	1.00
retail_store	Retail store	0.16	0.37	0.00	1.00
warehouse	Warehouse	0.12	0.32	0.00	1.00
stat_dist	Distance to nearest streetcar station (ft)	1,101	542	15	2,825
tx_dist	Distance to nearest TRAX station	5,290	3,755	32	11,758
int_dist	Distance to nearest highway (ft)	878	785	37	2,979
env_dist	Distance to nearest LQG site (ft)	4,264	2,549	32	9,006
cbd	Within 1/2 mile of CBD	0.00	0.00	0.00	0.00

Table 6-72

Commercial Properties Sample Descriptive Statistics – Salt Lake City S-Line – Control Parcels

Variable	Definition	Mean	Std. Dev.	Min	Max
ass_value	Assessed value ($, 2016)	607,154	751,960	13,738	5,492,336
psize	Parcel size (acres)	0.34	0.33	0.01	1.76
bsize	Size of commercial space (sf)	4,728	9,881	0	267,072
age	Age of structure	27	11	1	62
cond_e	Overall condition from good to excellent	0.13	0.34	0.00	1.00
office	Office	0.20	0.40	0.00	1.00
restaurant	Restaurant	0.05	0.21	0.00	1.00
fast_food	Fast food restaurant	0.03	0.18	0.00	1.00
retail_store	Retail store	0.16	0.37	0.00	1.00
warehouse	Warehouse	0.07	0.26	0.00	1.00
stat_dist	Distance to nearest streetcar station (ft)	12,735	6,848	3,548	37,278
tx_dist	Distance to nearest TRAX station	3,583	3,272	65	17,329
int_dist	Distance to nearest highway (ft)	853	965	26	5,002
env_dist	Distance to nearest LQG site (ft)	5,068	2,713	269	14,069
cbd	Within 1/2 mile of CBD	0.23	0.42	0.00	1.00

Table 6-73 reports the results of the econometric analysis, showing evidence of streetcar impacts on commercial property values. The naïve estimators, represented by Model 1 and Model 2, consist of pooled multivariate models (OLS) controlling for the most relevant factors affecting commercial assessed values. Model 3 and Model 4 report the results of FE regression, which shows that all streetcar phases have a positive and statistically significant impact on assessed values. The standard errors of these models are about 40 smaller than the OLS estimators of Model 1 and Model 2. As in the previous regressions, Model 4 is the preferred model. The streetcar has an estimated impact on commercial property values ranging from 3.5 percent at Announcement to 5.6 percent at Construction to 5.1 percent at Opening phase.

Table 6-73

Commercial Property Sales Estimation Results – Salt Lake City S-Line

Variable	Definition	Regression Model			
		(1) OLS	*(2) OLS†*	*(3) FE*	*(4) FE††*
treatment	Treatment	0.355**	0.369**		
		(0.138)	(0.154)		
ann_plan	Announcement and Planning	-0.0779**	-0.0787**		
		(0.0281)	(0.0282)		
constr	Construction	-0.0885**	-0.0843**		
		(0.0309)	(0.0310)		
open	Opening	-0.0500	-0.0472		
		(0.0353)	(0.0355)		
tr_ann_plan	Interaction term (treatment*ann_plan)	0.00727	0.00767	0.0349***	0.0369***
		(0.0155)	(0.0155)	(0.00952)	(0.00965)
tr_constr	Interaction term (treatment*constr)	0.0374**	0.0353**	0.0574***	0.0591***
		(0.0174)	(0.0175)	(0.00956)	(0.00965)
tr_open	Interaction term (treatment*open)	0.0387*	0.0379*	0.0485***	0.0513***
		(0.0200)	(0.0201)	(0.0121)	(0.0122)
lpsize	Natural log of parcel size	0.779***	0.785***		
		(0.0362)	(0.0364)		
lpsize2	Squared term of lpsize	0.0915***	0.0906***		
		(0.0102)	(0.0106)		
lbsize	Natural log of size of commercial space	-0.508***	-0.500***		
		(0.109)	(0.107)		
lbsize2	Squared term of lbsize	0.0486***	0.0480***		
		(0.00692)	(0.00679)		
lage	Natural log of age of structure	-0.239***	-0.243***	-0.0345**	-0.0328**
		(0.0343)	(0.0337)	(0.0124)	(0.0127)
lint_dist	Natural log of distance to nearest interstate	-0.0229**	-0.0440***		
		(0.0101)	(0.0114)		
hist_dist	Within 1/2 mile of CBD	0.0207	0.0192		
		(0.0426)	(0.0466)		
lenv_dist	Natural log of distance nearest large polluting site	0.153***	0.0640*		

Table 6-73 cont'd

Commercial Property Sales Estimation Results – Salt Lake City S-Line

Variable	Definition	Regression Model			
		(1) OLS	(2) OLS†	(3) FE	(4) FE††
		(0.0269)	(0.0341)		
cbd	Within 1/2 mile of CBD	0.114	0.142		
		(0.0905)	(0.0907)		
_cons	Intercept	15.37***	16.48***	12.84***	12.83***
		(0.522)	(0.568)	(0.0438)	(0.0448)
N	Sample size	9,426	9,426	9,435	8,608
R-sq	R-squared (OLS adjusted; FE within)	0.769	0.774	0.130	0.138

Note: Models include building condition and year dummy variables (not shown).
*Standard errors in parenthesis: * $p<0.05$; ** $p<0.01$, *** $p<0.001$.*
Pre-planning phase (pre-plan) is baseline treatment phase.
† Model with streetcar station dummies (not shown). †† Balanced panel

Vacant Properties

Table 6-74 reports sales data for vacant parcels, including residential and commercial units.

Table 6-74

Vacant Properties Assessed Values by Project Phase – Salt Lake City S-Line

Project Phase	SIA		Control	
	Count	Value ($)	Count	Value ($)
Pre-planning	13	4,007,633	223	711,727
Announcement and Planning	7	158,710	161	197,873
Design and Construction	11	3,510,815	46	359,854
Opening	19	1,086,911	128	819,295

Table 6-75 reports the results of a fixed effect model using as a sample all assessed values of all commercial parcels for the period 2007-2016. The dependent variable is the natural log of the Property Assessor current assessed value. The analysis finds evidence of positive premia being realized during Construction (8.4%) and Opening (10.5%), when considering all vacant parcels. A breakdown by parcel type shows that the effects are statistically significant only for residential parcels. Residential vacant parcels assessed values are on average 20.2 higher than comparable areas during construction and 60.8 percent higher after the system started operation. The estimates are not precise because the models have low explanatory power, as indicated by their respective R-squared value.

Table 6-75

Vacant Property Assessed Values Fixed Effect Estimation Results – Salt Lake City S-Line

Variable	Definition	Fixed-effect Model		
		All Parcels	Residential	Commercial
lpsize	Natural log of parcel size	-7.093**	.	-6.685**
		(-2.03)	.	(-2.81)
tr_ann_plan	Interaction term (treatment*ann_plan)	-0.00170	-0.0400	0.00540
		(-0.05)	(-0.44)	(0.21)
tr_constr	Interaction term (treatment*constr)	0.0815**	0.184*	0.0510*
		(2.42)	(1.88)	(1.92)
tr_open	Interaction term (treatment*open)	0.101**	0.519***	0.00630
		(3.11)	(4.72)	(0.25)
_cons	Intercept	-6.778	8.246***	-3.175
		(-0.80)	(193.44)	(-0.62)
	Variables controlling for secular trends	yes	yes	yes
N	Sample size	3050	891	2159
R-sq	Adjusted R-square	0.079	0.103	0.132

*Standard errors in parenthesis: * p<0.05; **p<0.01, ***p<0.001*
Pre-planning phase (pre-plan) is baseline treatment phase.

Summary of Findings

Cincinnati Bell Connector

A historical trend analysis of property counts and values shows the SIA experienced a rapid growth in property values leading to the onset of the widespread national real estate crisis of 2007–2009. During the period 2002–2016, property values in the study area show a marked upward trend compared to similar properties located elsewhere. Sample descriptive statistics indicate some premia differential between SIA properties and properties in neighborhoods sharing similar socio-demographic characteristics. These areas are defined as controls, using an objective selection process defined as *propensity-score matching* (explained in Appendix A). The controls served to compile a sample suitable for econometric modeling and geared at uncovering any causality between the streetcar project phases and property value premia.

Table 6-76 summarizes the results of the econometric models of Section 6. With the exception of single-family properties at the Announcement and Planning phases, the analysis provides statistically significant evidence of impact during all of the streetcar project phases. In particular, vacant parcels exhibit the largest impact, an indication of several interplaying factors affecting the value of properties in the study area, as discussed in the next section.

Table 6-76 *Property Value Analysis Summary of Results – Cincinnati Bell Connector*

Project Phase	Single-family	Condominium	Commercial	Vacant – All Parcels
Announcement and Planning	no evidence	-13.1%	-2.2%	6.9%
Design and Construction	15.0%	13.5%	1.4%	17.7%
Opening	27.0%	17.7%	5.6%	25.9%

Note: Comparison is with respect to Pre-planning phase.

As detailed in Section 6, the redevelopment effort undertaken by the City of Cincinnati most likely had and is having impacts that cannot be disentangled from the estimates of this analysis. Although it is difficult to untangle and quantify the contribution of each of these actions, the results of the analysis quantify the overall contribution of the initiatives that are linked more closely to the Cincinnati Bell Connector.

Charlotte CityLYNX Gold Line

A historical trend analysis of property counts and values shows that the SIA experienced a rapid growth in property values leading to the onset of the widespread national real estate crisis of 2007–2009. During the period 2009–2016, property values in Mecklenburg County show downward trends, whereas properties located in the SIA show an upward trend. Sample descriptive statistics indicate some premia differential between SIA properties and properties in neighborhoods sharing similar socio-demographic characteristics (i.e., controls). With the exception of single-family properties, the econometric models of Section 6 find statistically significant evidence of impact during all of the streetcar project phases, as reported in Table 6-77.

Table 6-77 *Property Value Analysis Summary of Results – Charlotte CityLYNX Gold Line*

Project Phase	Single-family	Condominium	Commercial
Announcement and Planning	no evidence	29.8%	1.4%
Construction	no evidence	14.2%	1.8%
Opening	no evidence	15.1%	2.1%

Note: Comparison is with respect to Pre-planning phase.

Sun Link Tucson Streetcar

The historical trend analysis of property counts and values shows that the SIA experienced a rapid growth in property values leading to the onset of the widespread national real estate crisis of 2007–2008. During the period 2009–2016, property values in Pima County show downward trends, whereas properties located in the SIA show an upward trend. Sample descriptive statistics indicate some premia differential between SIA properties and properties in neighborhoods sharing similar socio-demographic characteristics. These areas are defined as controls, using an objective selection process defined as *propensity-score matching*, which is explained in Appendix A. The controls served to compile a sample suitable for econometric modeling and geared at uncovering any causality between the streetcar project phases and property value premia.

With the exception of single-family properties, the econometric models of Section 6 find statistically significant evidence of impact during all of the streetcar project phases, as reported in Table 6-78. The econometric models do not provide statistically significant evidence of streetcar effects on single-family during construction and opening.

Table 6-78

Property Value Analysis Summary of Results – Sun Link Tucson Streetcar

Project Phase	Single-family	Condominium	Commercial	Vacant
Announcement and Planning	19.2%	no evidence	3.3%	2.3%
Construction	14.5%	13.4%	10.1%	2.5%
Opening	13.1%	19.2%	13.3%	12.4%

Note: Comparison is with respect to Pre-planning phase.

Atlanta Streetcar

A preliminary historical trend analysis of property counts and values shows that the SIA experienced a rapid growth in property values leading to the onset of the widespread national real estate crisis of 2008. During the period of 2009–2016, property values show downward trends. Sample descriptive statistics indicate some premia differential between SIA properties and properties in neighborhoods sharing similar socio-demographic characteristics. These areas are defined as controls, using an objective selection process defined as propensity-score matching (explained in Appendix A). The controls served to compile a sample suitable for econometric modeling and were geared at uncovering any causality between the streetcar project phases and property value premia. The econometric models find statistically significant evidence of impact from the streetcar project phases—Construction and Opening—on all property types as reported in Table 6-79.

Table 6-79

Property Value Analysis Summary of Results – Atlanta Streetcar

Project Phase	Single-Family	Condominium	Commercial	Vacant
Announcement and Planning	no evidence	no evidence	no evidence	no evidence
Construction	73.3%	10.3%	11.2%	18.8%
Opening	48.4%	28.0%	24.1%	20.6%

Note: Comparison is with respect to Pre-planning phase.

The Property Assessor's tax roll data provides estimates of the total appraised and total assessed values for each property. By using the applicable millage rates and exemptions provided by the Fulton County Property Tax Calculator, it is possible to estimate the total tax revenue for the properties located in the SIA.[52] Table 6-80 reports the change in estimated tax revenues associated with the increase in properties prices identified in Table 6-79. By applying the property value premium of the construction phase, the total tax revenue increases to $17.8 million annually.

Table 6-80

Estimated Impact on Tax Revenue – Atlanta Streetcar

Property Type	Baseline	New	Difference
Single-Family	1.2	1.8	0.7
Condominium	13.1	17.1	4.0
Commercial	54.0	67.1	13.1
Vacant	0.1	0.2	0.0
Total	*68.4*	*86.2*	*17.8*

Salt Lake City S-Line

The 2016 county property assessor data defined a total of 3,843 parcels located in the SIA, with a mix of residential parcels similar to the rest of Salt Lake County, but with a higher percentage of commercial parcels, indicating the study area serves as a destination for commercial and recreational activities.

A preliminary historical trend analysis of property counts and values shows that the SIA experienced a rapid growth in property values during the period 2007–2010, in line with the rest of the county and with the general trends characterizing the onset of the widespread national real estate crisis. The data indicate some premia differential between SIA properties and properties in neighborhoods sharing similar socio-demographic characteristics. These areas are defined as controls, using an objective selection process defined as *propensity-score matching* and explained in Appendix A. The controls served to compile a sample suitable for econometric modeling and geared at uncovering any causality between the streetcar project phases and property value premia.

The econometric models of Section 2 find statistically significant evidence of impact from the streetcar project phases—Planning, Construction, and Operation—on single-family, condominium, and commercial properties. Table 6-81 summarizes these results. Overall, condominium and commercial properties experienced the largest premia across all project phases, with gains reaching a peak during the construction phase.

Table 6-81

Property Value Analysis Summary of Results – Salt Lake City S-Line

Project Phase	Single-family	Condominium	Commercial	Vacant
Announcement and Planning	2.2%	5.3%	3.5%	n.a.
Construction	3.6%	9.9%	5.6%	8.4%
Opening	1.2%	15.4%	5.1%	10.5%

Note: Comparison is with respect to Pre-planning phase.
Unreported values (n.a.) due to parameters not statistically significant.

The Property Assessor tax roll data details information on the taxable value for each property along with the applicable current tax rate. This allows estimating the total taxable value and tax revenue for the properties located in the SIA. By applying the property value premia estimate of Table 6-81, it is possible to estimate the impact on future tax revenues. The calculation is summarized in

Table 6-82. If the property premia estimates remain constant in future years, the impact on tax revenues will be about $0.36 million per year.

Table 6-82

Impact on Taxable Revenue – Salt Lake City S-Line

Property Type	Tax Revenue		
	Current	New	Change
Single-family	4,267,583	4,318,794	51,211
Condominium	288,136	332,509	44,373
Commercial	5,295,355	5,565,418	270,063
Total	*9,851,074*	*10,216,720*	*365,647*

SECTION
7

Trend Analysis of Business Activities

This section presents a historical perspective of the economic environment of each case study, a precursory step to the econometric modeling of Section 8To measure changes in employment levels, the analysis employs time-series data from Infogroup, a provider of business and residential data. The national business database contains more than 24 million businesses, and the national consumer database has more than 265 million consumer records. All records are telephone verified and updated daily. Each record in the business database is geocoded and includes business name, address, employee size, and North America Industry Classification System (NAICS) codes at the six-digit level. Firms have unique identifiers, allowing year-over-year comparisons to analyze industry changes and general economic trends over a certain period of time. This allows constructing a panel data to conduct longitudinal inference on location patterns and employment changes.

The analysis compares changes in employment levels and business location patterns within the SIA to changes in comparable areas during 2007–2016. Comparable areas are selected using the methodology described in Appendix A.

Cincinnati Bell Connector

The Cincinnati Bell Connector is located in the core of the Cincinnati CBD. The SIA is characterized by a diversified economic base that includes manufacturing, wholesale and retail trade, insurance and finance, and educational and government services. The study area sites several Fortune 500 companies operating in various industry sectors, such as Procter & Gamble, the Kroger Company, Omnicare, and American Financial.

As of 2016, there were about 2,900 businesses operating in the study area. Figure 7-1 displays a breakdown by industry type following the NAICS two-digit level of aggregation. The area is heterogeneous in terms of businesses, with a larger presence of professional and technical services (15.8%), finance and insurance (15.3%), and public administration (9.8%). The study area location within the Cincinnati CBD and the location of Fortune 500 companies explains the presence of retailers, entertainment, and food and recreation services.

Figure 7-1

Business Composition – Cincinnati Bell Connector SIA

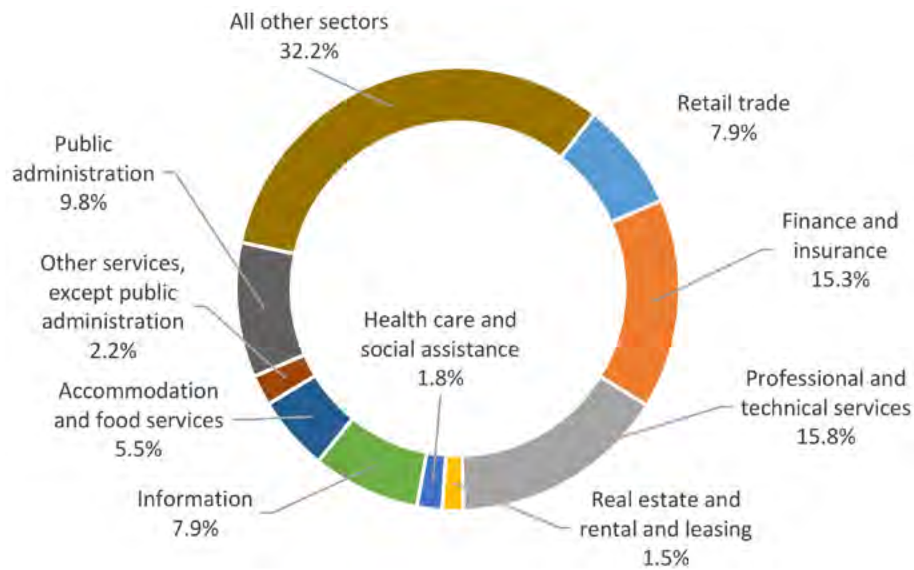
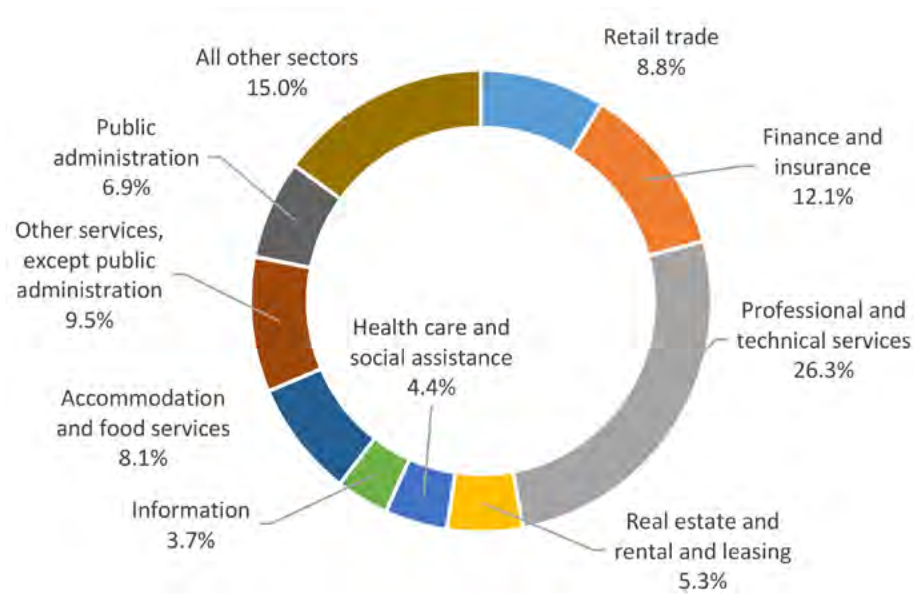


Figure 7-2 shows the industry breakdown by employment levels. In 2016, businesses in the SIA employed about 81,000 workers. About 89 percent of the businesses employed 30 or fewer workers, with an average size of about 6 employees. Professional and technical is the largest sector, employing more than 12,900 workers (26.3%). Finance and insurance employed 12.1 percent, and other services employed 9.5 percent.

Figure 7-2

Employment by Industry Sector – Cincinnati Bell Connector SIA



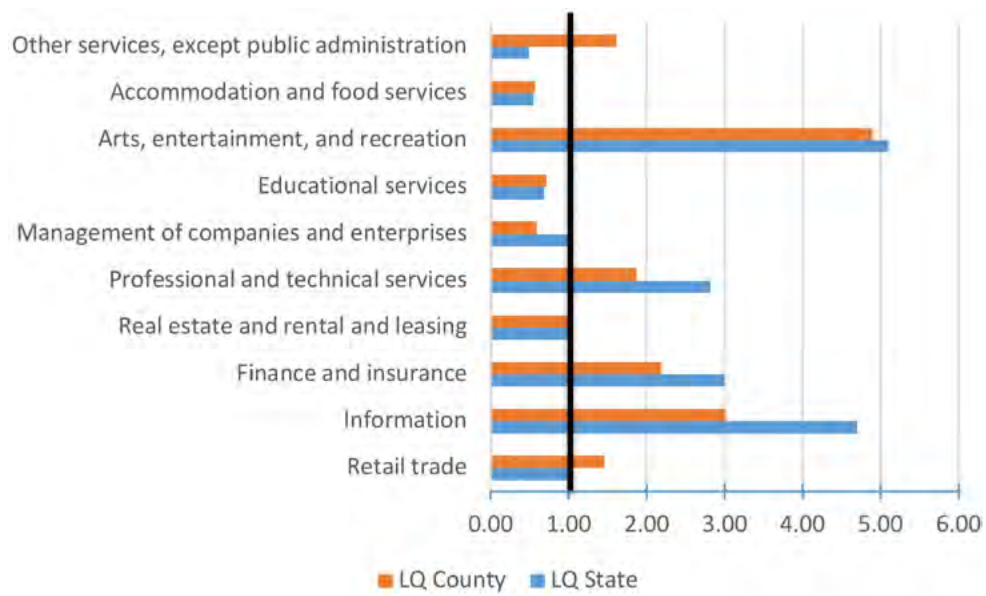
To better understand how SIA businesses relate to the rest of the county in terms of concentration, Figure 7-3 reports the location quotient (LQ), comparing employment levels of businesses in the SIA to the rest of the county. The LQ measures the concentration of a particular industry sector in the study area as compared to the rest of the county and the state. The quotient is calculated by comparing a given industry share of employment within the SIA to its share of county employment. The LQ measures the relative presence of an industry sector in the SIA and control areas with respect to a reference area, and is expressed as:

$$LQ_{i,j} = \frac{emp_{i,j}/emp_j}{emp_{i,c}/emp_c}$$

Where $emp_{i,j}$ is the employment in sector i in area j (i.e., control and treatment areas), emp_j is total employment in area j, $emp_{i,c}$ is county employment in sector i, and emp_c is total employment in Hamilton County, the reference area.

Figure 7-3

Location Quotient – Cincinnati Bell Connector SIA



For example, in 2016, professional and technical services accounted for 15.8 percent of total employment within the SIA, but jobs in the same sector accounted for 8.6 percent of total county employment. The SIA LQ for professional and technical services is equal to (15.8/8.6) = 1.8, meaning that businesses in this sector employ 1.8 times more employees in the SIA than the rest of the county. Other sectors, such as educational services, accommodation and food services, and arts and entertainment, are highly concentrated, indicating the study area's relevance to the economic vitality of Hamilton County and the entire state. The vertical dashed line of Figure 7-15 indicates an LQ equal to 1.0, meaning a given industry has the same share of employment in the SIA as it does in the reference areas, Hamilton County, and the state of Ohio. Figure 7-4 maps the study area businesses, showing those with the five highest LQ.

Figure 7-4

Map of Businesses with Highest LQ – Cincinnati Bell Connector SIA

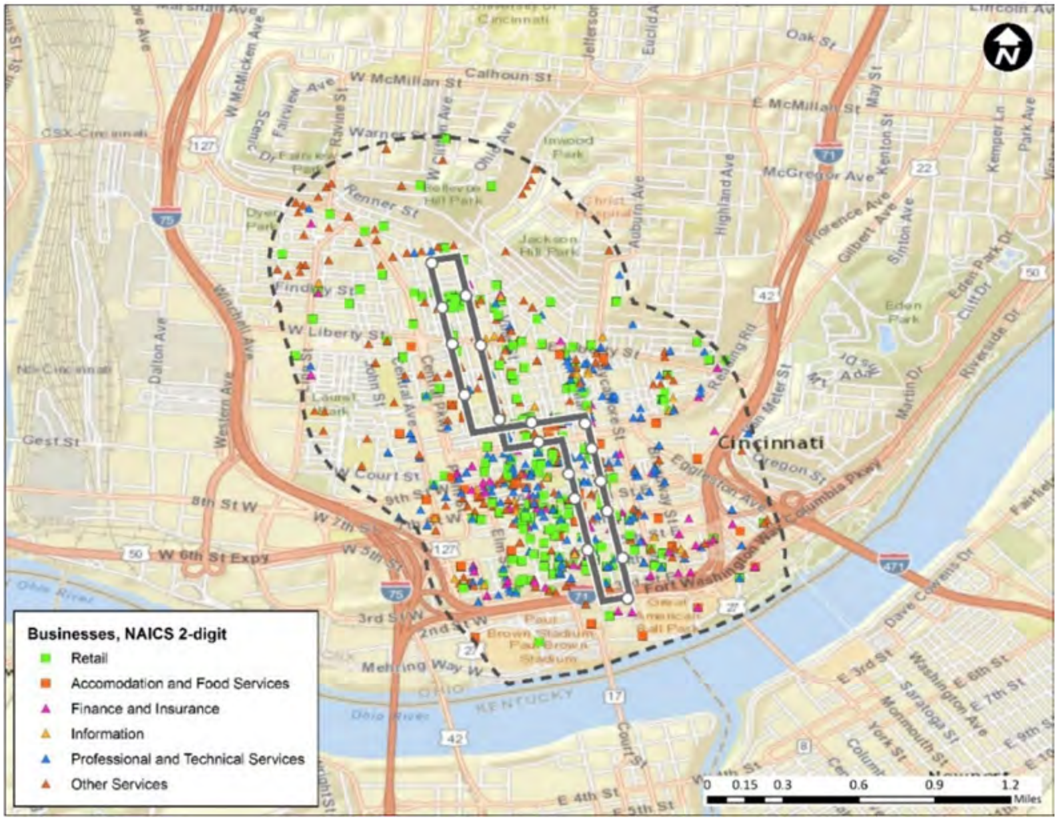


Table 7-1 reports LQs for a subset of industry sectors disaggregated at the NAICS 3-digit level. The disaggregation allows focusing on key businesses operating within the broader NAICS 2-digit sectors. The SIA shows a high concentration of businesses operating in the publishing (NAICS 511), and securities investments (NAICS 523), insurance (NAICS 524), and professional and technical services (NAICS 541) industry sectors. The professional and technical services sector comprises establishments specialized in providing professional, scientific, and technical activities for a variety of businesses and households. These sectors require a high degree of expertise and training and are characterized by higher than average hourly wages. These businesses are highly specialized and have a high LQ compared to the rest of the county and the state.

Table 7-1 *Highly Concentrated Businesses – Cincinnati Bell Connector– NAICS 3-digit Level*

NAICS	Industry Sector	Establishments	Total Employment	Average Employment	LQ County	LQ State
424	Merchant wholesalers, nondurable goods	21	4,200	200.0	2.9	2.5
511	Publishing industries, except internet	18	1,597	88.7	4.4	4.9
517	Telecommunications	31	1,442	46.5	2.8	2.0
523	Securities, commodity contracts, investments	93	3,951	42.5	2.2	5.1
524	Insurance carriers and related activities	122	7,159	58.7	3.5	3.5
541	Professional and technical services	777	12,953	16.7	5.8	1.9
711	Performing arts and spectator sports	27	1,727	64.0	5.9	3.4
712	Museums, historical sites, zoos, and parks	18	516	28.7	5.1	2.5
722	Food services and drinking places	229	3,361	14.7	0.5	0.5
812	Personal and laundry services	98	633	6.5	0.6	0.7

Figure 7-5 displays historical employment and establishment data for 2007–2016 for the top six NAICS 3-digit sectors in terms of location quotient. In general, the graphs indicate that economic activity started to recover from the Great Recession of 2008–2009, as marked by the upward trends in establishments and employment. Some sectors, such as personal services and performing arts and spectator sports, experienced marked growth even during the recession, showing increased specialization compared to the rest of the county and the state. This is probably due to concurring events, such as the City's revitalization efforts discussed in Section 6. These businesses have experienced the fastest growth over the 2012–2016 period. Since 2007, the professional and technical services added about 1,200 jobs (25.7% increase). Growth in this sector probably stimulated the demand for recreational activities and personal services, as shown by the rapid growth experienced by industries engaged in the provision of food (NAICS 722), recreation (NAICS 712), and personal services (NAICS 812).

Figure 7-5 *Industry Establishments and Employment – Cincinnati Bell Connector – Selected Industries*

Figure 7-6 shows historical sales and LQ data for the same businesses. Increased sales and LQ indicate increased specialization of a given business and its relevance to the overall economic growth of the entire county. While remaining a concentrated industry sector, the personal and laundry services (NAICS 812) sector experienced declining sales from 2007 to 2012 and increasing growth thereafter through 2016. This subsector groups establishments that provide personal care services: death care services, laundry and dry cleaning services, and a wide range of other personal services, such as pet care (except veterinary) services, photofinishing services, and temporary parking services.

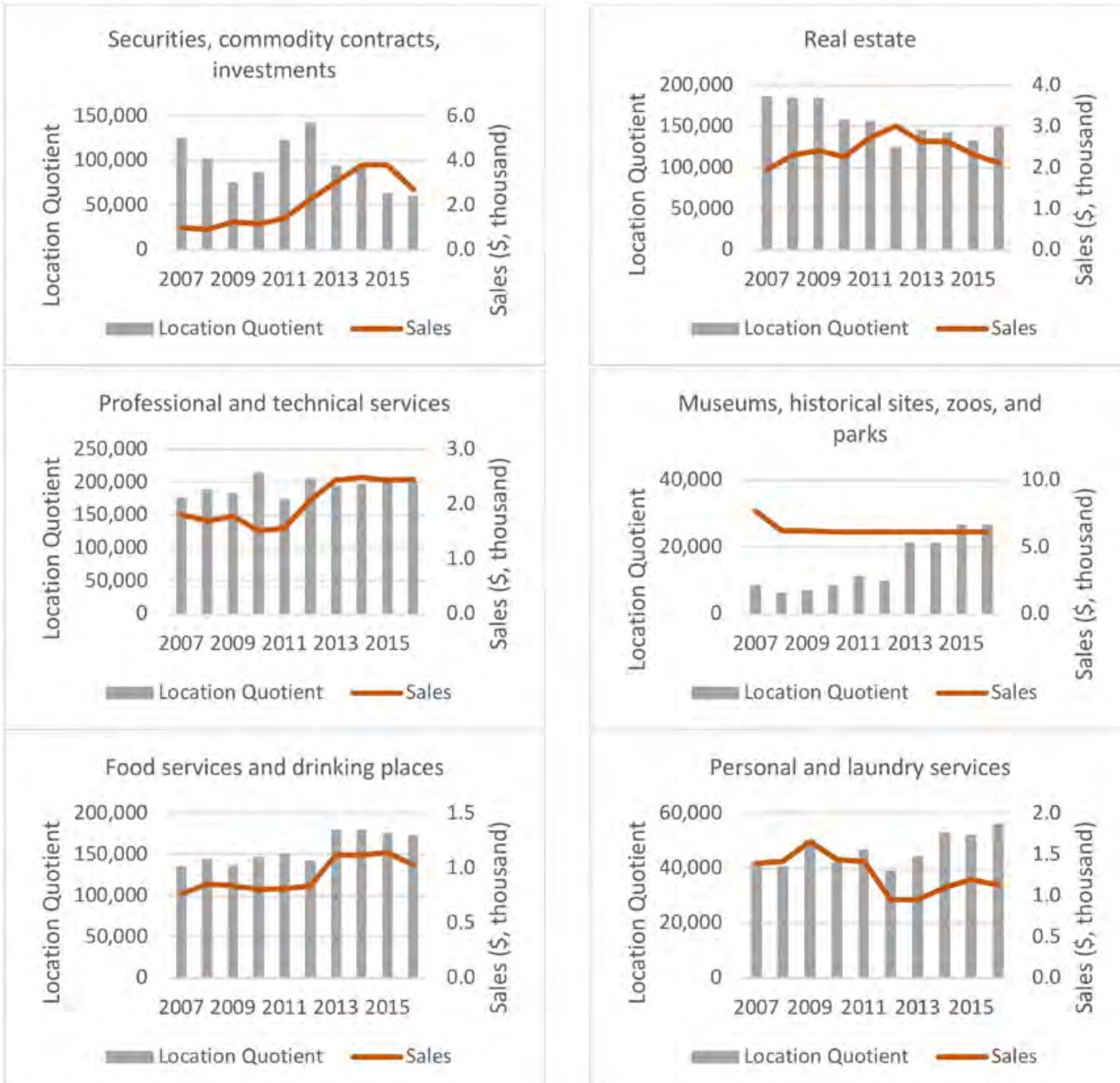


Figure 7-6 *Gross Sales and Location Quotient – Cincinnati Bell Connector – Selected Industries*

Businesses operating in the professional and technical services (NAICS 812) are characterized by a similar trend with sales growing 15.0 percent annually leading to greater specialization with respect to the county as shown by an increased LQ from 2.2 to 2.4 over 2007–2016.

The above historical data are subjected to causality inference by modeling the longitudinal patterns of business employment levels to test the hypothesis that increased accessibility from the streetcar resulted in increased business activity in the study area.

Charlotte CityLYNX Gold Line

As of 2016, there are about 1,900 businesses operating in the study area. Figure 7-7 displays a breakdown by industry type following the NAICS two-digit level of aggregation. The area is heterogeneous in terms of businesses, with a larger presence of professional and technical services (23.6%), healthcare and social assistance services (18.4%), and accommodation and food services (10.2%). The study area location within the Charlotte CBD and the proximity of the University of North Carolina explain the presence of retailers, entertainment, and food and recreation services.

Figure 7-7

Business Composition – Charlotte CityLYNX Gold Line SIA

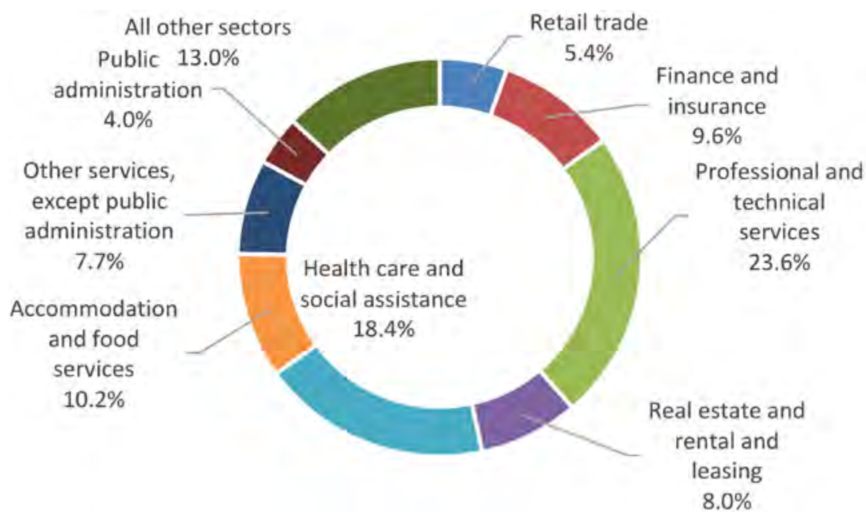


Figure 7-8 shows the industry breakdown by employment levels. In 2016, businesses in the SIA employed about 13,000 workers. About 90 percent of the businesses employed 30 or fewer workers, with an average size of about 7 employees. Accommodation and food services is the largest sector, employing more than 2,500 workers (19.3%), followed by professional and technical services (17.5%), and health care and social assistance (14.9%).

Figure 7-8

Employment by Industry Sector – Charlotte CityLYNX Gold Line SIA

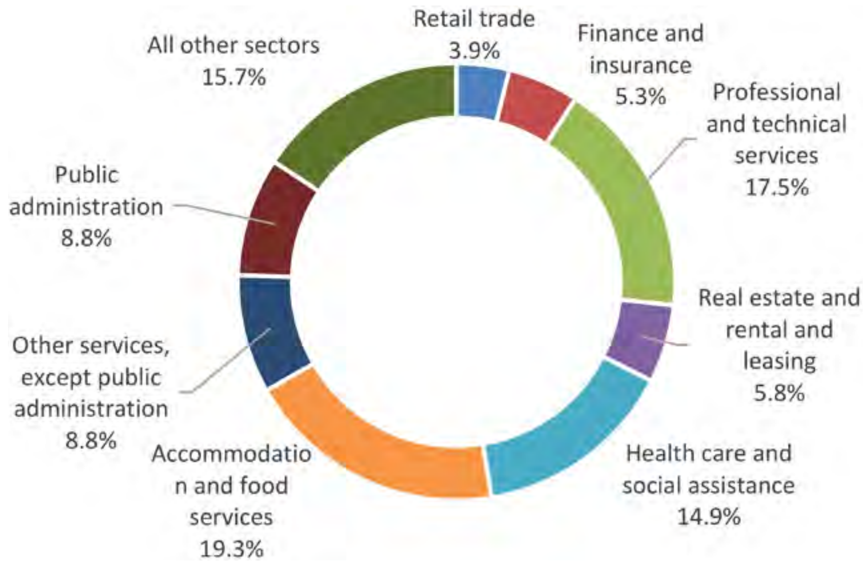


Figure 7-9 reports the LQ, comparing employment levels of businesses in the SIA to the rest of the county. The vertical green line indicates an LQ equal to 1.0, meaning a given industry has the same share of employment in the SIA as it does in the reference areas, Mecklenburg County, and the state of North Carolina. Figure 7-10 maps the study area businesses, showing those with the highest LQ.

Figure 7-9

Location Quotient – Charlotte CityLYNX Gold Line SIA

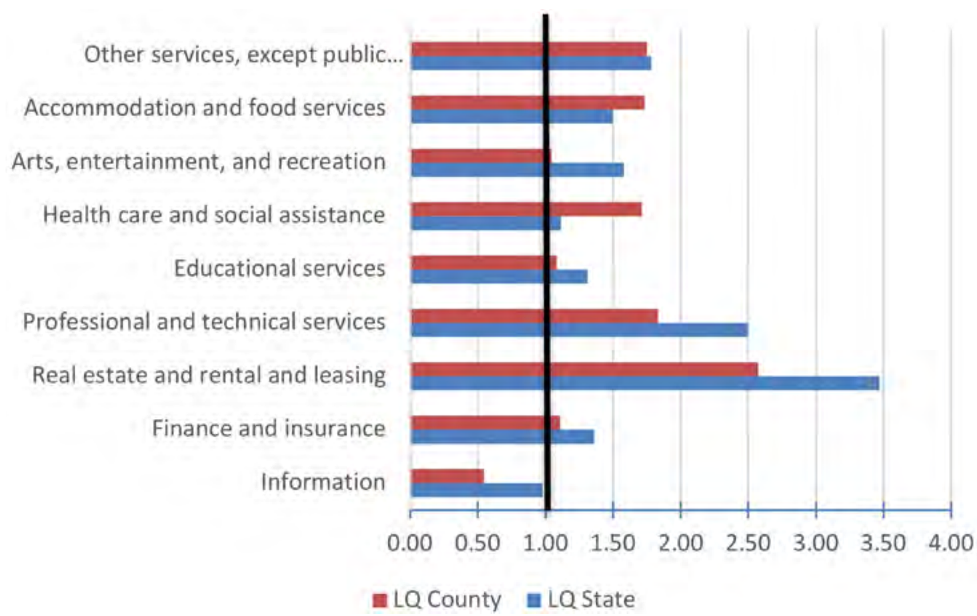


Figure 7-10

Map of Businesses with Highest LQ – Charlotte CityLYNX Gold Line SIA

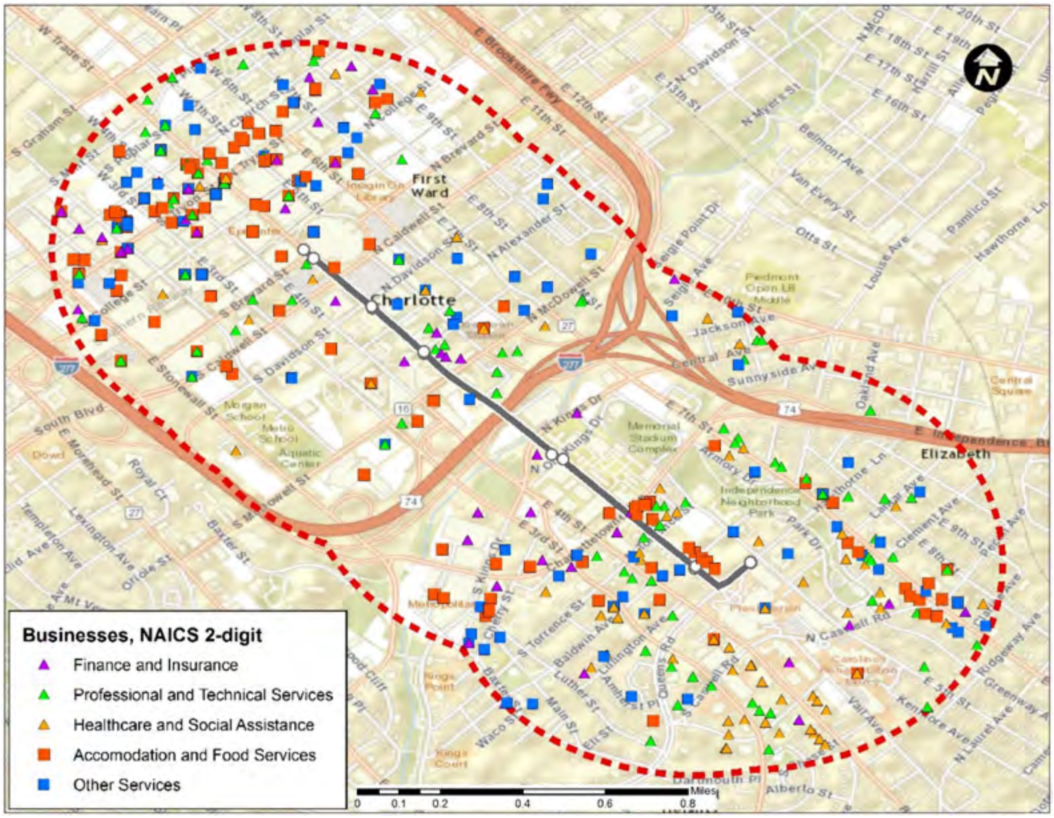


Table 7-2 reports LQs for a subset of industry sectors disaggregated at the NAICS 3-digit level. The disaggregation allows focusing on key businesses operating within the broader NAICS 2-digit sectors. The SIA shows a high concentration of businesses operating in real estate (NAICS 531), and professional and technical services. The professional and technical services sector (NAICS 541) comprises establishments specialized in providing professional, scientific, and technical activities for a variety of businesses and households. These sectors require a high degree of expertise and training and are characterized by higher than average hourly wages.

Table 7-2 *Highly Concentrated Businesses – Charlotte CityLYNX Gold Line SIA*

Industry Sector	Establishments	Total Employment	Average Employment	LQ County	LQ State
Electronics and appliance stores	9	54	6.0	1.3	1.7
Miscellaneous store retailers	28	116	4.1	1.4	1.3
Data processing, hosting and related services	8	82	10.3	1.3	1.7
Securities, commodity contracts, investments	37	191	5.2	0.9	2.6
Real estate	154	746	4.8	3.5	4.4
Professional and technical services	469	2,291	4.9	1.8	2.5
Ambulatory health care services	322	1,553	4.8	2.5	1.8
Performing arts and spectator sports	17	127	7.5	1.2	2.6
Food services and drinking places	195	2,360	12.1	1.8	1.5
Personal and laundry services	80	468	5.9	2.9	3.3

Charlotte is home to the Charlotte-Mecklenburg Government Center, the Charlotte Transportation Center, Time Warner Cable Arena (home of NBA Charlotte Bobcats), EpiCentre, Central Piedmont Community College–Central Campus, and the Presbyterian Hospital. These facilities cluster businesses in the ambulatory healthcare services (NAICS 621), and professional and technical services (NAICS 541). NAICS sector 621 includes establishments operating in a subsector to provide health care services directly or indirectly to ambulatory patients and usually do not provide inpatient services. These businesses are highly specialized and have a high LQ compared to the rest of the county and the state.

Figure 7-11 displays historical employment and establishment data for 2007-2016 for the top six sectors in terms of location quotient. In general, the graphs indicate that economic activity levels started to recover from the Great Recession of 2008–2009, as marked by the upward trends in establishments and employment. Some sectors, such as personal services and performing arts and spectator sports experienced marked growth even during the recession, showing increased specialization compared to the rest of the county and the state.

Figure 7-11 *Industry Establishments and Employment – Charlotte CityLYNX Gold Line– Selected Industries*

The fastest-growing industry sector in the SIA is ambulatory healthcare services (NAICS 621). Since 2007, the number of businesses increased by more than 100 units (54.1% increase), with employment growing from about 500 jobs in 2007 to 1,500 in 2016, or 5.7 percent annually.

Figure 7-12 shows historical sales and LQ data for the same businesses. Increased sales and LQ indicate increased specialization of a given business and its relevance to the overall economic growth of the entire county. Personal and laundry services (NAICS 812) shows increased growth through 2012, followed by a decline through 2016. This subsector groups establishments that provide personal care services: death care services, laundry and dry cleaning services, and a wide range of other personal services, such as pet care (except veterinary) services, photofinishing services, and temporary parking services.

Figure 7-12 *Gross Sales and LQ – Charlotte CityLYNX Gold Line – Selected Industries*

As previously outlined, businesses in ambulatory healthcare services show increased relevance in terms of sales and presence in the SIA. The employment and sales growth (3.4% annually) in this sector led to high specialization with respect to the county by increasing its LQ from 2.2 to 2.5 over 2007–2016. The above historical data are subjected to causality inference by modeling the longitudinal patterns of business employment levels to test the hypothesis that increased accessibility from the streetcar resulted in increased business activity in the study area.

Sun Link Tucson Streetcar

As of 2016, there were about 1,900 businesses operating in the study area. Figure 7-13 displays a breakdown by industry type following the NAICS two-digit level of aggregation. The area is heterogeneous in terms of businesses, with a large presence of professional and technical services (21.9%), public administration (14.7%), and healthcare and social assistance services (9.7%). The study area location within the Tucson CBD and the proximity of UAZ explain the presence of retailers, entertainment, and food and recreation services.

Figure 7-13

Business Composition – Sun Link Tucson Streetcar SIA

Figure 7-14 shows the industry breakdown by employment levels. In 2016, businesses in the SIA employed about 30,000 workers (including UAZ). About 92 percent of the businesses employed 30 or fewer workers, with an average size of about 6 employees. Public administration is the largest sector, employing more than 7,700 workers, followed by health care (21.2%), professional and technical services (10.2%), and accommodation and food services (9.5%).

Figure 7-14

Employment by Industry Sector – Sun Link Tucson Streetcar SIA

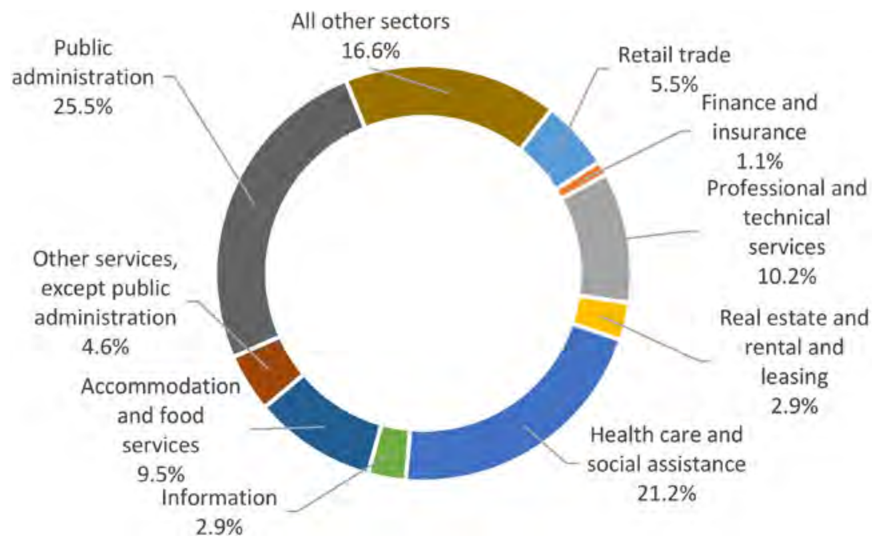


Figure 7-15 reports the LQ comparing employment levels of businesses in the SIA to the rest of the county. For example, in 2016, professional and technical services accounted for 10.2 percent of total employment within the SIA, but jobs in the same sector accounted for 5.4 percent of total county employment. The SIA LQ for professional and technical services is equal to (10.2/5.4)=1.9, meaning that businesses in this sector employed 1.9 times more employees in the SIA than the rest of the county. Other sectors, such as educational services, accommodation and food services, and arts and entertainment, are highly concentrated in the area. The vertical green line of Figure 7-15 indicates an LQ equal to 1.0, meaning a given industry has the same share of employment in the SIA as it does in the reference areas, Pima County, and the state of Georgia. Figure 7-15 also shows that educational services and professional and technical services are highly concentrated sectors compared to the rest of the state, indicating the study area's relevance to the economic vitality of Pima County and the entire state.

Figure 7-15

Location Quotient – Sun Link Tucson Streetcar SIA

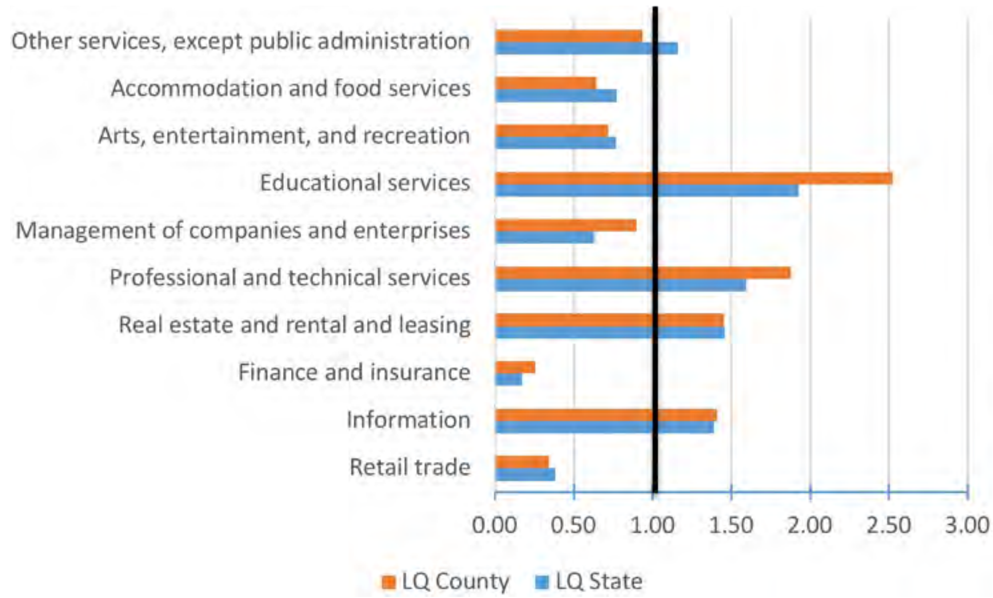


Figure 7-16 maps the study area businesses, showing those with the highest LQ. Food services and drinking places are clustered in the core of the CBD, along the 4th Avenue Business District and in proximity of UAZ.

Figure 7-16

Businesses with Highest Location Quotient – Sun Link Tucson Streetcar SIA

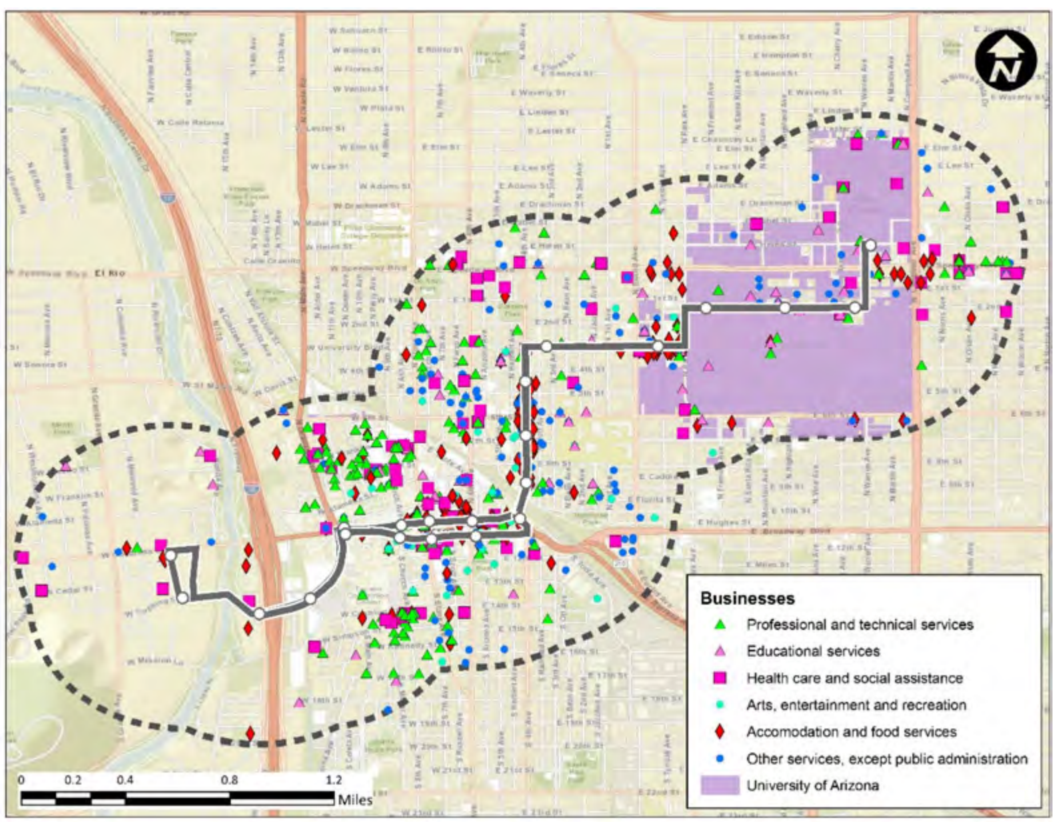


Table 7-3 reports LQs for a subset of industry sectors disaggregated at the NAICS 3-digit level. The disaggregation allows focusing on key businesses operating in the most specialized NAICS 2-digit sectors. The SIA shows a concentration of businesses operating in the educational services (NAICS 612) and museums, historical sites, and similar institutions sector (NAICS 712). Clothing and (NAICS 448) and miscellaneous store retailers (NAICS 453) are also concentrated. The UAZ campus likely contributes to a large presence of establishments specialized in providing professional, scientific, and technical activities (NAICS 541) and businesses engaged in publishing services (NAICS 511). These activities require a high degree of expertise and training and are characterized by a high LQ compared to the rest of Pima County and the state of Arizona.

Table 7-3 *Highly Concentrated Businesses – Sun Link Tucson Streetcar SIA*

NAICS	Industry Sector	Establishments	Total Employment	Average Employment	LQ County	LQ State
448	Clothing and clothing accessories stores	23	834	36.3	1.9	1.6
453	Miscellaneous store retailers	54	301	5.6	1.3	1.1
511	Publishing industries, except internet	10	351	35.1	2.6	1.2
541	Professional and technical services	421	3,080	7.3	1.6	1.9
611	Educational services	73	1,465	20.1	1.9	2.5
712	Museums, historical sites, zoos, and parks	19	133	7.0	4.4	3.7
721	Accommodation	21	485	23.1	0.7	0.5
722	Food services and drinking places	139	2,401	17.3	0.8	0.7

The City of Tucson convention center is the site of the Tucson Music Hall, the Tucson Arena (home to the University of Arizona club hockey team), and the Leo Rich Theatre. These facilities cluster businesses in the accommodation (NAICS 721) and food and services (NAICS 722) sectors. These businesses employ on average about 17 to 23 workers.

Figure 7-17 displays historical employment and establishment data for 2007–2016 for the top six sectors in terms of location quotient. In general, the graphs indicate that economic activity levels started to recover from the Great Recession of 2008–2009, as marked by the upward trends in establishments and employment. Some sectors, such as professional and technical services, and publishing experienced marked growth even during the recession, showing increased specialization compared to the rest of the county and the state.

Figure 7-17 *Industry Establishments and Employment – Sun Link Tucson Streetcar – Selected Industries*

Figure 7-18 shows historical sales and LQ data for the same businesses. Specialization businesses providing publishing services (NAICS 511) increased sales and relevance to the overall economic growth of the entire county. This subsector groups establishments that engage in the publishing of magazines, other periodicals, and books, as well as directory and mailing lists and software publishing. Food services and drinking establishments show growth in gross sales and market concentration, an indication of more businesses locating in the SIA.

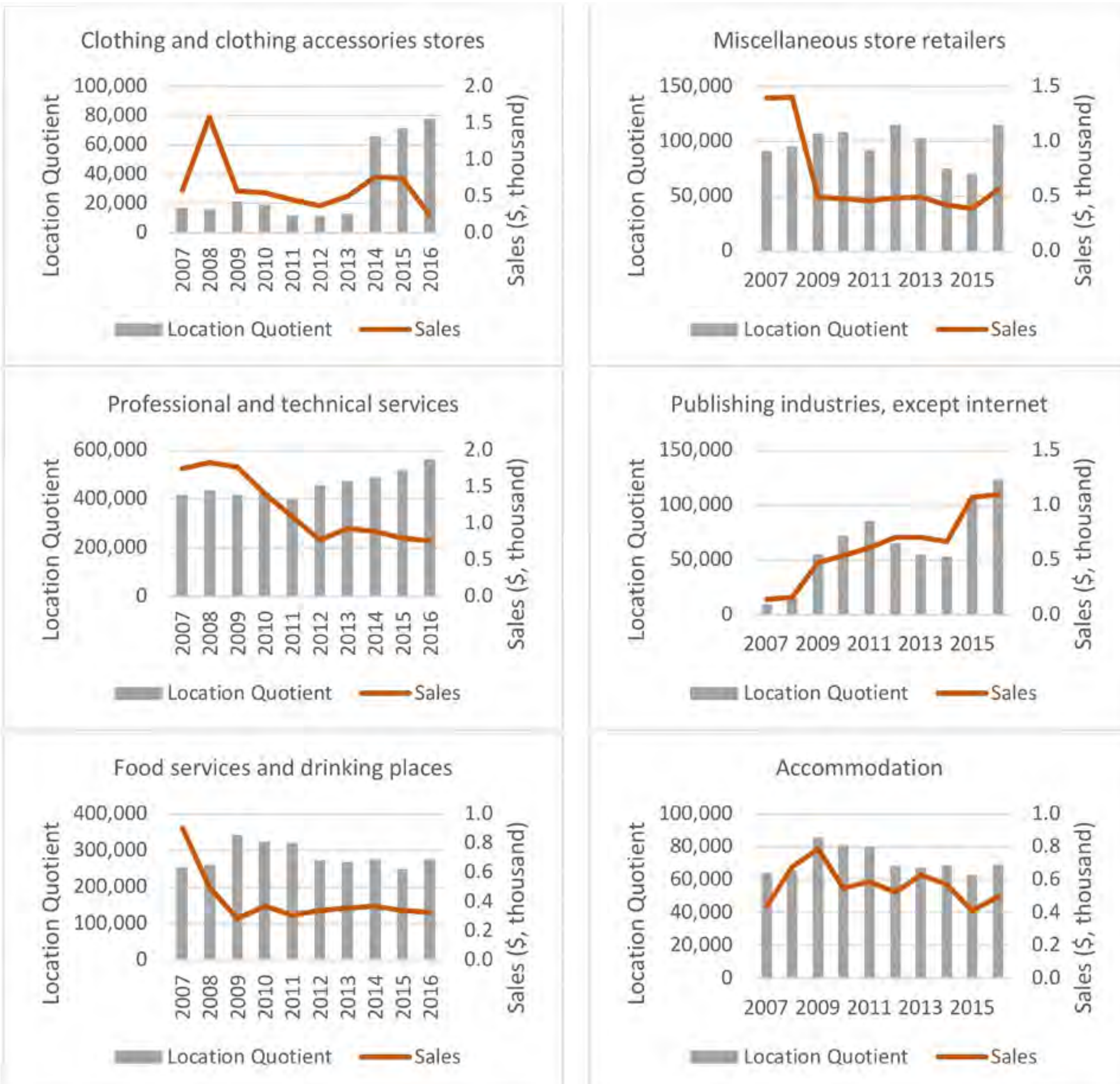


Figure 7-18 *Gross Sales and Location Quotient – Sun Link Tucson Streetcar – Selected Industries*

The above historical data are subjected to causality inference by modeling the longitudinal patterns of business employment levels to test the hypothesis that increased accessibility from the streetcar resulted in increased business activity in the study area.

Atlanta Streetcar

As of 2016, there are about 3,500 businesses operating in the study area. Figure 7-19 displays a breakdown by industry type following the NAICS two-digit level of aggregation. The area is heterogeneous in terms of businesses, with a larger presence of professional and technical services (17.9%), retail trade (10.3%), and public administration (15.9%). The study area location within the Atlanta CBD and the proximity of large commercial complexes explain the presence of retailers, entertainment, and food and recreation services.

Figure 7-19

Business Composition – Atlanta Streetcar SIA

Figure 7-20 shows the industry breakdown by employment levels. In 2016, businesses in the SIA employed about 87,000 workers. About 90 percent of the businesses employed 30 or fewer workers, with an average size of about 6 employees. Public administration is the largest sector, employing more than 27,000 workers, followed by accommodation and food services (13.0%) and professional and technical services (12.3%).

Figure 7-20

Employment by Industry Sector – Atlanta Streetcar SIA

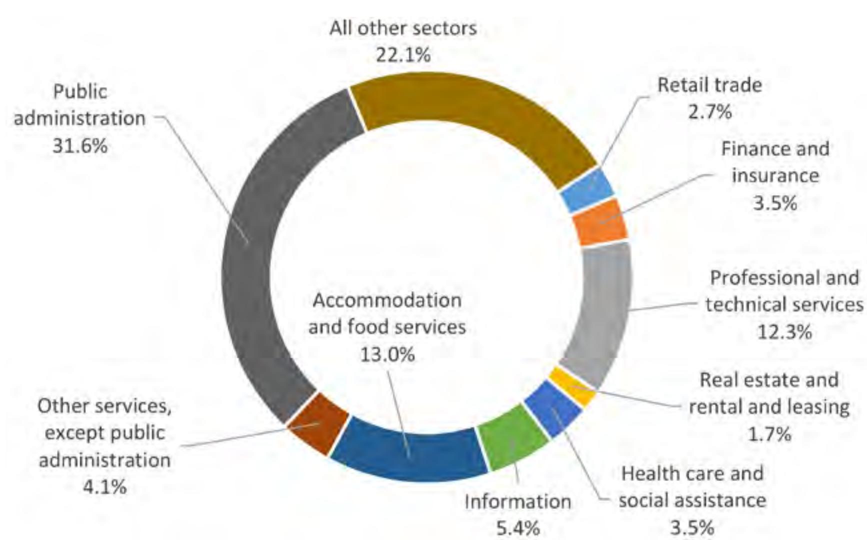


Figure 7-21 reports the LQ, comparing employment levels of businesses in the SIA to the rest of the county. For example, in 2016, accommodation and food services account for 13.0 percent of total employment within the SIA, but jobs in the same sector account for 10.9 percent of total county employment. The SIA LQ for professional and technical services is equal to (13.0/10.9)=1.19, meaning that businesses in this sector employ 1.19 times more employees in the SIA than the rest of the county. Other sectors, such as accommodation and food services, arts and entertainment, and educational services, are highly concentrated in the area. The vertical green line indicates an LQ equal to 1.0, meaning a given industry has the same share of employment in the SIA as it does in the reference areas, Fulton County, and the state of Georgia.

Figure 7-21

Location Quotient – Atlanta Streetcar SIA

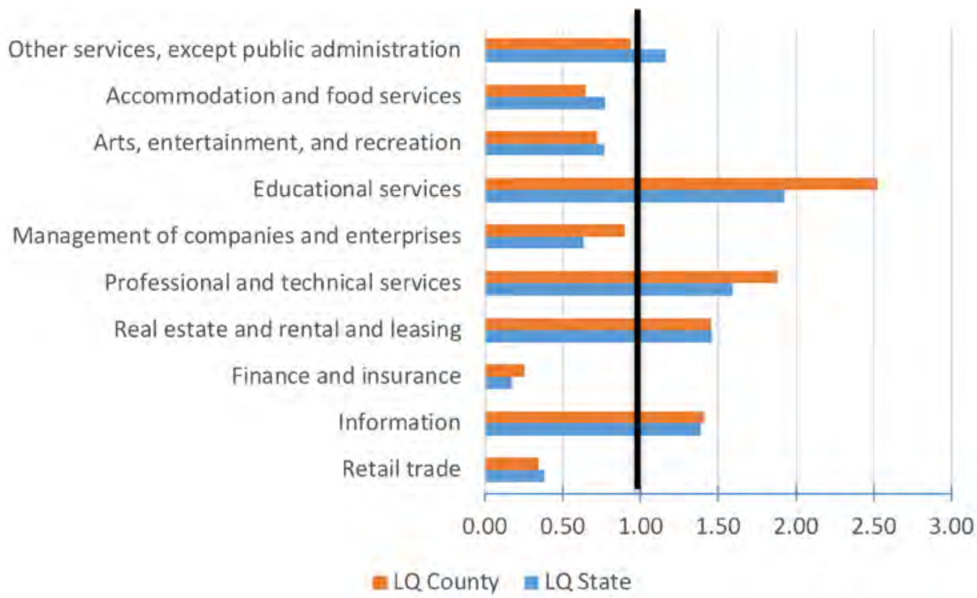


Figure 7-21 also shows that professional and technical services, arts and recreation, and real estate and leasing services are highly concentrated sectors compared to the rest of the state, indicating the study area's relevance to the economic vitality of Fulton County and the entire state.

Figure 7-22 identifies the study area businesses, showing those with the highest LQ. Food services and drinking places are clustered in the core of the CBD, and historical and sightseeing businesses are in proximity to the MLK Historic Site on the streetcar's eastern loop.

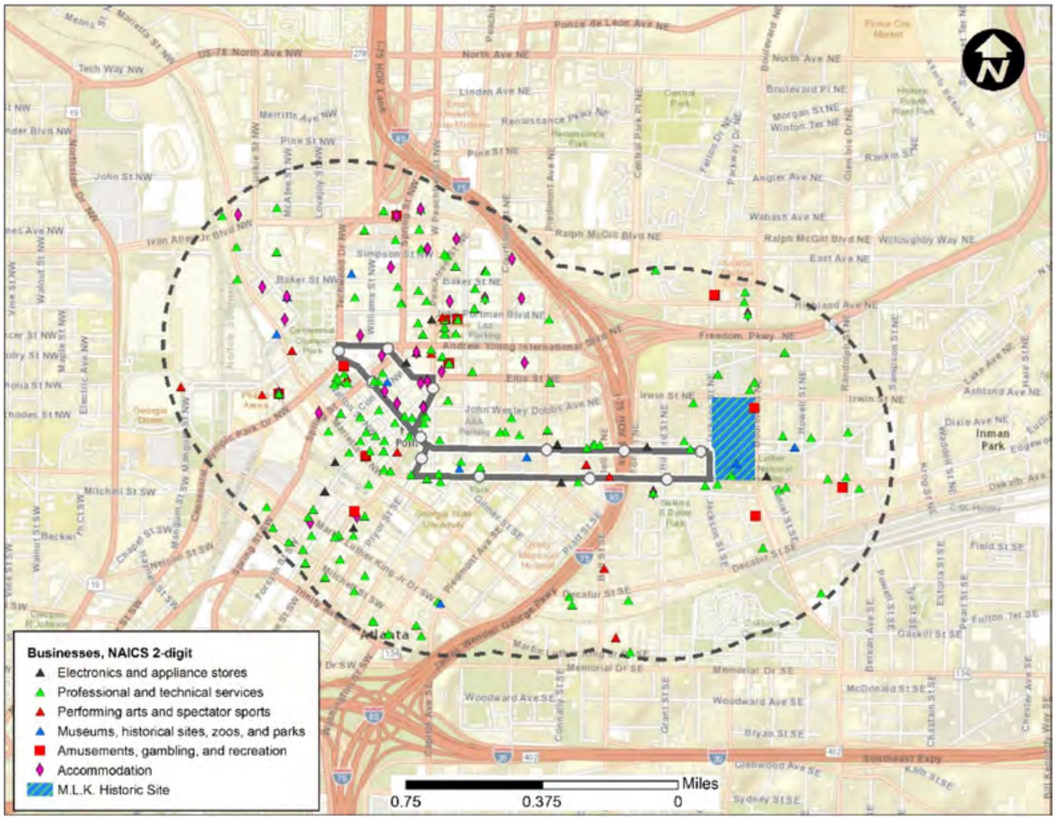


Figure 7-22

Map of Businesses with Highest Location Quotient – Atlanta Streetcar

Table 7-4 reports data for a subset of industry sectors disaggregated at the NAICS 3-digit level with the highest state or county LQ. The disaggregation allows focusing on key businesses that operate in the most specialized NAICS 2-digit sectors.[53] For example, NAICS sector 443 includes establishments that retail new electronics and appliances from point-of-sale locations within the SIA. The real estate subsector (NAICS 531) includes businesses primarily engaged in renting, leasing, and managing real estate; establishments engaged in selling, buying, or renting real estate for others; and businesses providing other real estate related services.

Table 7-4 *Highly Concentrated Businesses – Atlanta Streetcar SIA*

NAICS	Industry Sector	Establishments	Total Employment	Average Employment	LQ County	LQ State
443	Electronics and appliance stores	16	725	45.3	2.6	3.7
531	Real estate	136	1,379	10.1	1.3	0.9
541	Professional and technical services	624	10,743	17.2	1.7	1.0
711	Performing arts and spectator sports	24	978	40.8	5.9	2.2
712	Museums, historical sites, zoos, and parks	15	387	25.8	5.4	1.7
713	Amusements, gambling, and recreation	13	4,082	314.0	4.5	4.5
721	Accommodation	29	6,675	230.2	6.3	4.8
812	Personal and laundry services	139	1,058	7.6	1.0	0.8

[53] https://www.bls.gov/iag/tgs/iag_index_naics.htm.

The City of Atlanta is host to permanent, professional, resident companies in all performing arts disciplines: Atlanta Opera, Atlanta Ballet, Atlanta Symphony Orchestra, and the Alliance Theater. Atlanta is also home to professional franchises in major team sports. In addition, the CNN Center, the Centennial Olympic Park, and the Phillips Arena provide an incentive to the clustering of businesses in the performing arts and spectator sports services (NAICS 711). These businesses employed, on average, about 41 workers per unit, were highly specialized and had a high LQ compared to the rest of Fulton County and the state.

Figure 7-23 displays historical employment and establishment data for 2007–2016 for the top six sectors in terms of location quotient. In general, the graphs indicate that economic activity levels started to recover from the Great Recession in 2010, as reflected by the upward trends in establishments and employment. Some sectors experienced marked growth in conjunction with increased specialization compared to the rest of the county and the state.

Since 2010, the number of businesses engaged in performing arts and spectator sports experienced recovery from the economic downturn. The recovery positively affected employment, which increased from 113 workers in 2011 to 978 workers in 2016 and led to high specialization with respect to the county by increasing its LQ to 2.2. Businesses providing accommodation services were not affected by the recession, with employment increasing by 17.2 percent between 2007 and 2016.

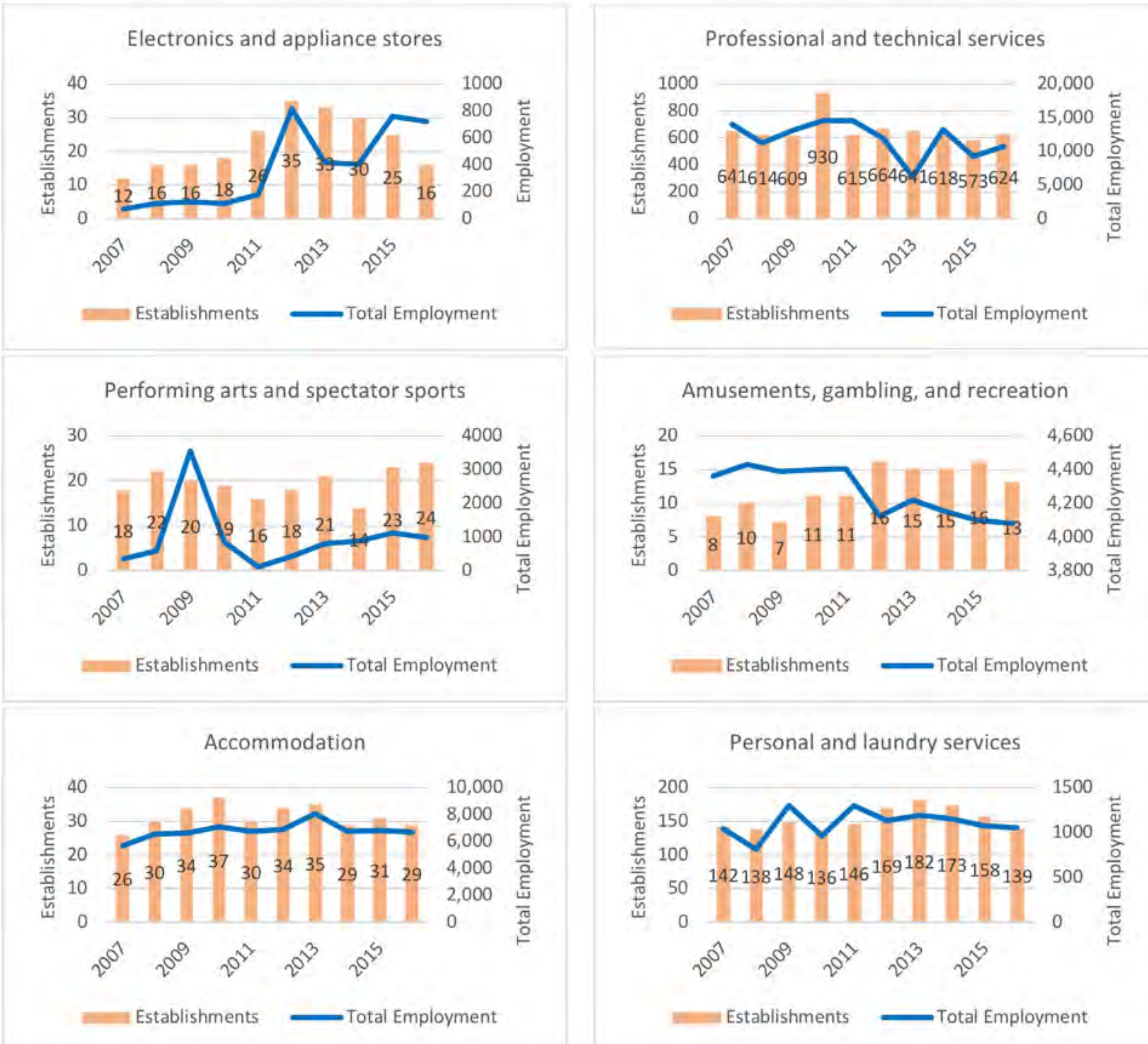


Figure 7-23 *Industry Establishments and Employment – Atlanta Streetcar – Selected Industries*

Figure 7-24 shows historical sales and LQ data for the same businesses. Increased sales and LQ indicate increased specialization of a given business operating in the study area and its relevance to the overall economic growth of the entire county. Total gross sales increased substantially for the businesses engaged in real estate services, with the LQ marking an increased industry concentration. Performing arts and spectator sports establishments seem to have been affected by the economic downturn more than all other sectors, with sales rapidly decreasing in 2011 but quickly recovering in the aftermath. This sector is increasingly more concentrated in the SIA, with an LQ less than 1.7 in 2010 that grew to 2.2 in 2016. Accommodation services show growth in gross sales and market concentration relatively higher than the remainder of the county. On the other end, professional and technical services experienced a downward trend in terms of sales and market concentration.

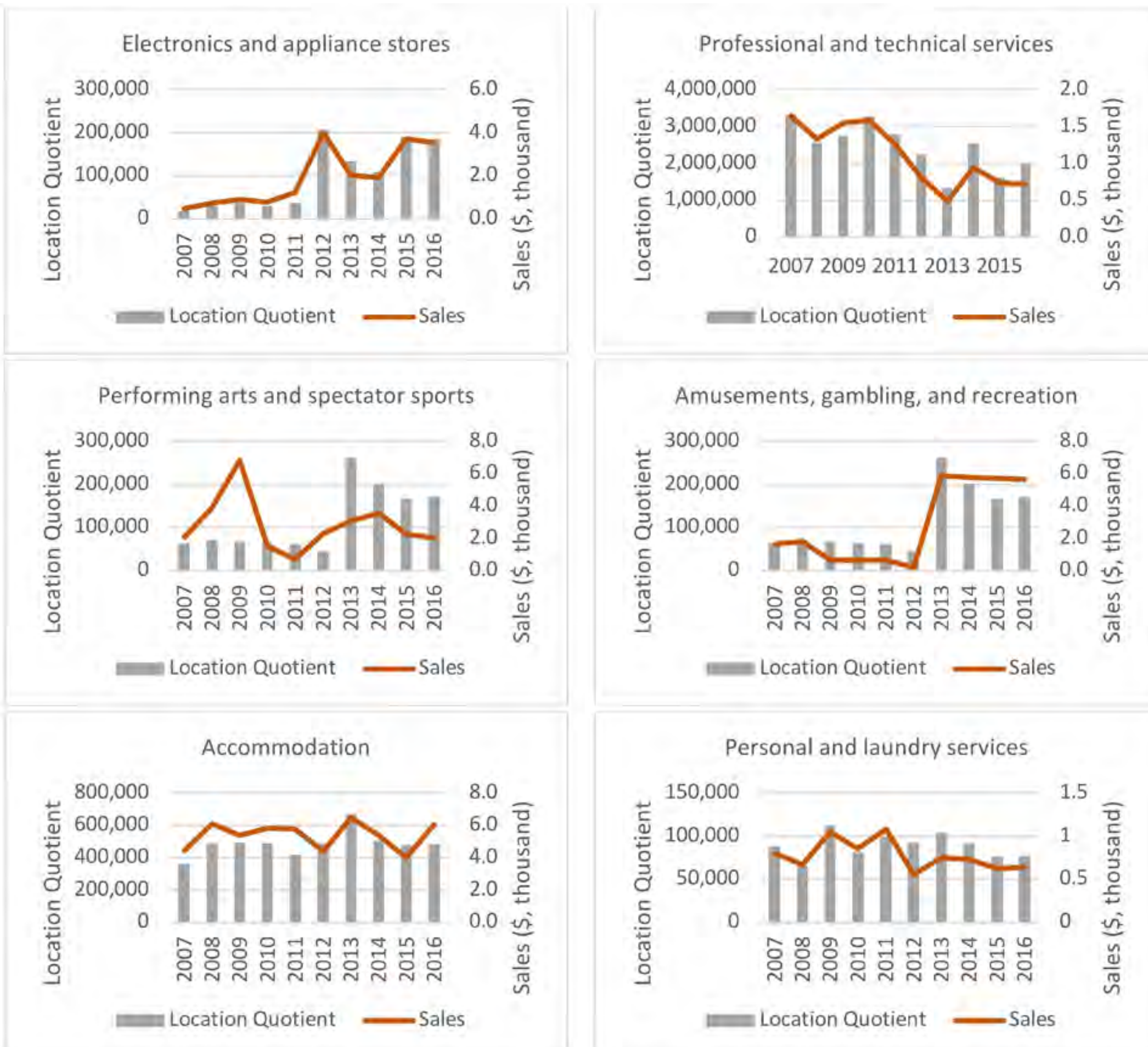


Figure 7-24 *Gross Sales and Location Quotient – Atlanta Streetcar – Selected Industries*

The above historical data are subjected to causality inference by modeling the longitudinal patterns of business employment levels to test the hypothesis that increased accessibility from the streetcar resulted in increased business activity in the study area.

Salt Lake City S-Line

As of 2016, there were about 1,100 businesses operating in the study area. Figure 7-25 displays a breakdown by industry type following the NAICS two-digit level of aggregation. The area is heterogeneous in terms of businesses, with a larger presence of retailers (17.3%), professional and technical services (11.3%), and healthcare and social assistance services (8.9%). The study area comprises the Sugar House Business District, which explains the larger presence of retailers, entertainment, and food and recreation services. The western portion of the study area is characterized by a mix of big-box commercial retailers and light industrial and manufacturing businesses.

Figure 7-25

Business Composition – Salt Lake City S-Line SIA

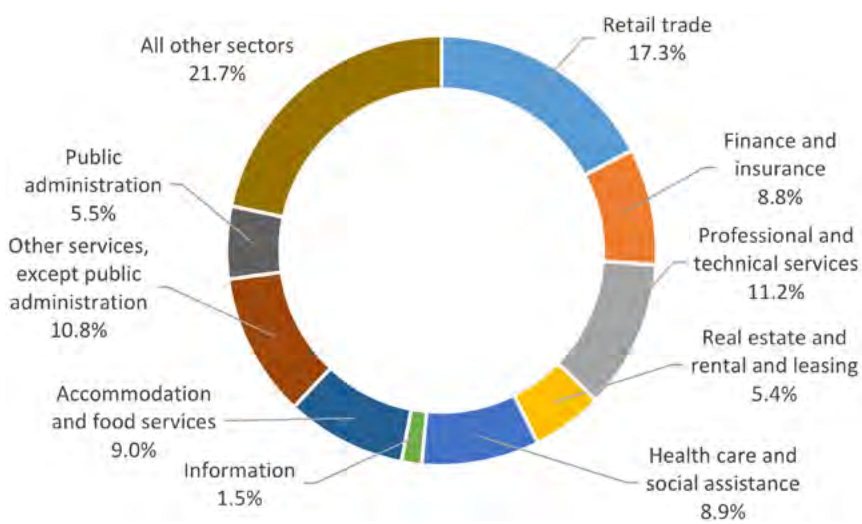


Figure 7-26 shows the industry breakdown by employment levels. Businesses operating in the SIA employed about 17,800 workers. About 92 percent of businesses employed 30 or less workers, with an average size of about 7 employees. The majority were employed in the public administration (24.7%), the retail trade (17.3%) and the accommodation and food services sectors (9.8%).

Figure 7-26

Employment by Industry Sector – Salt Lake City S-Line SIA

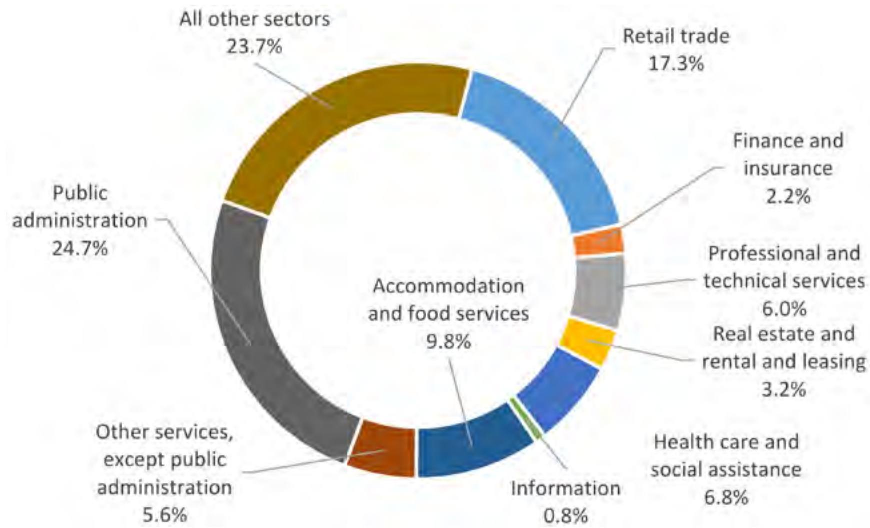


Figure 7-27 reports the LQ, comparing employment levels of businesses in the SIA to the rest of the county. The LQ measures the concentration of a particular industry sector in the study area as compared to the rest of the county and the state. For example, in 2016 retail trade accounted for 17.3 percent of employment within the SIA, but all retail jobs accounted for 11.9 percent of county employment. The SIA LQ for retail trade is equal to (17.3/11.9)=1.45, meaning that retail trade businesses employed 1.4 times more employees in the SIA than the rest of the county. Entertainment and recreation services were highly concentrated in the area, followed by real estate and rental and leasing. The vertical green line indicates an LQ equal to 1.0, meaning a given industry has the same share of employment in the SIA as it does in the reference areas, Salt Lake County and the state of Utah.

Figure 7-27

Location Quotient – Salt Lake City S-Line

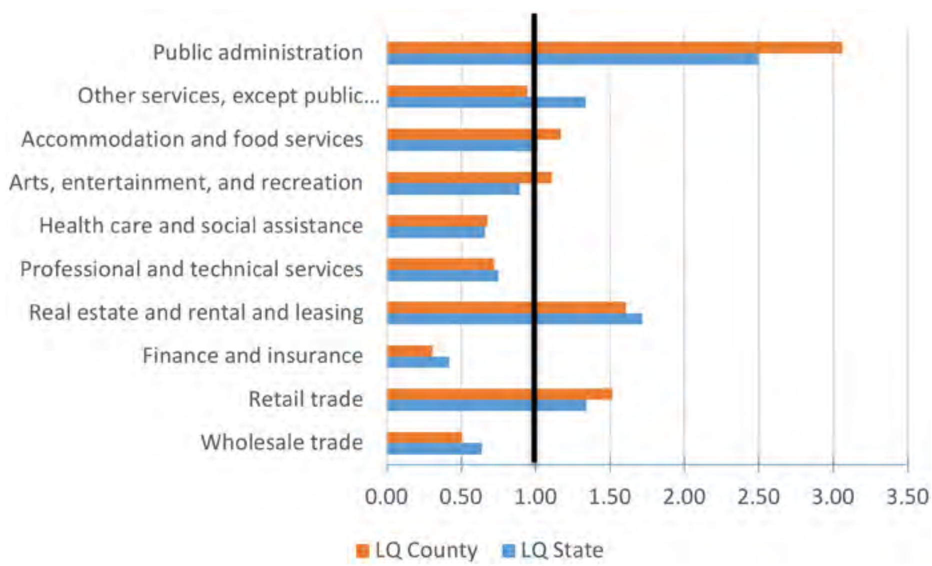


Figure 7-27 also shows that industry concentration in the SIA is comparable to county and state levels, an indication of the study area's relevance to the economic vitality of Salt Lake County and the entire state.

Figure 7-28 maps the study area businesses, displaying those with the highest LQ. Businesses are dispersed along East 2100 South, north of the streetcar rail line, with clustering occurring on both the east and west ends. The majority of wholesale trade businesses were located on the western side of the study area, in proximity to the "big-box" retailers. Retail, food, and accommodation services were clustered at the Sugar House Shopping Center and in its proximity.

Figure 7-28

Businesses with Highest Location Quotient – Salt Lake City S-Line

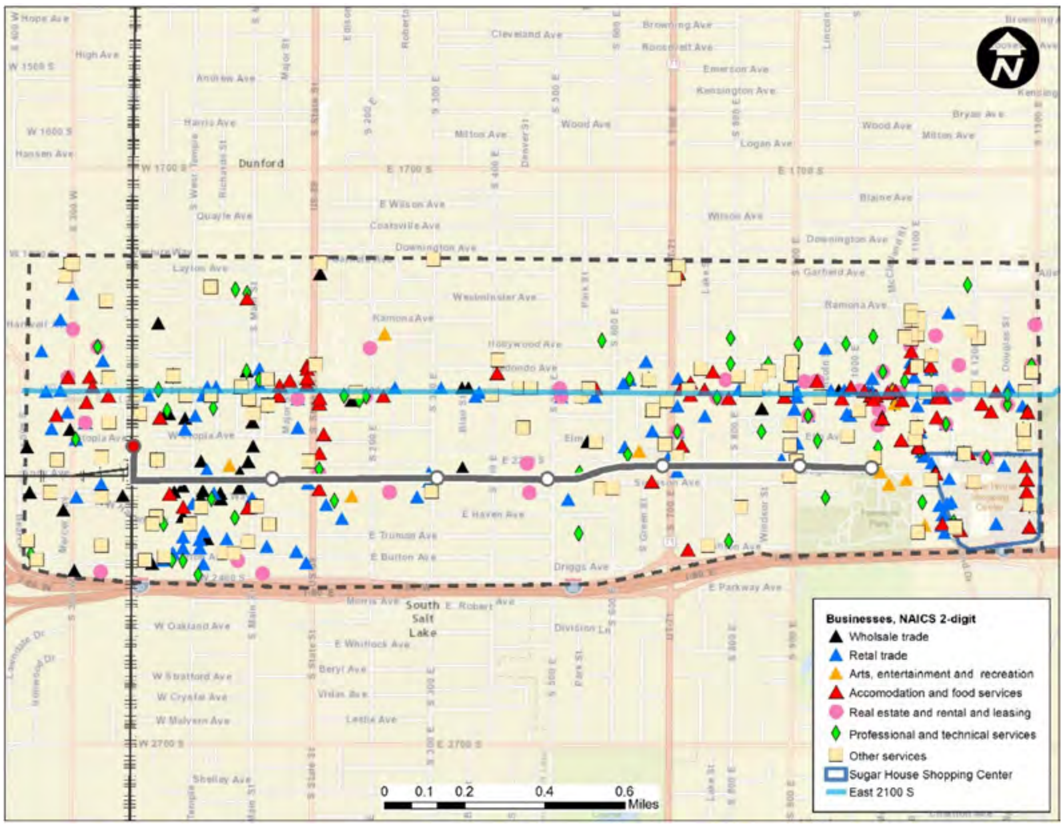


Table 7-5 reports LQ for a subset of industry sectors disaggregated at the NAICS 3-digit level. The disaggregation allows focusing on key businesses operating in the most specialized NAICS 2-digit sectors. Miscellaneous store retailers, electronics and appliance stores, sporting goods, hobby, book, and music stores have the highest LQ, showing a high level of job concentration.

Table 7-5 *Highly Concentrated Businesses – Salt Lake City S-Line SIA*

NAICS	Industry Sector	Establishments	Total Employment	Average Employment	LQ County	LQ State
443	Electronics and appliance stores	12	276	23.0	4.1	4.0
444	Building material and garden supply stores	21	341	16.2	1.7	2.3
451	Sporting goods, hobby, book and music stores	24	320	13.3	2.5	2.7
453	Miscellaneous store retailers	31	397	12.8	4.0	4.2
531	Real estate	46	486	10.6	1.9	1.8
712	Museums, historical sites, zoos, and parks	4	30	7.5	3.0	1.7
713	Amusements, gambling, and recreation	14	237	16.9	1.0	1.5
722	Food services and drinking places	99	1,714	17.3	1.2	1.4
811	Repair and maintenance	39	358	9.2	1.9	2.0
812	Personal and laundry services	48	261	5.4	1.6	1.6

Figure 7-29 displays historical employment and establishment data for 2007–2016 for the top six sectors in terms of location quotients. Real estate is a growing industry in the SIA. Since 2007, the number of businesses engaged in selling, renting, or leasing real estate or providing real estate related services increased from 32 to 46 establishments. This positively affected employment, which grew by 71.7 percent, increasing the concentration of businesses with respect to the county by 86.9 percent. Sporting goods businesses and miscellaneous retailers experienced similar, although less rapid, growth. Miscellaneous retailers consist of florists and used merchandise, pet and pet supply, and other stores. Finally, food services and drinking places experienced a growth of 26.9 percent in establishments and 26.2 percent in employment during 2007-2016. Establishments in this sector include providers of food and drink only, seating and no-seating restaurants (e.g., fast food), and limited entertainment amenities.

Figure 7-29 *Establishments and Employment – Salt Lake City S-Line – Selected Industries*

Figure 7-30 shows historical sales and LQ data for the same businesses. Increased sales and LQ indicate increased specialization of a given business operating in the study area and its relevance to the overall economic growth of the entire county. Total gross sales increased substantially for the businesses engaged in real estate services, with the LQ marking an increased market concentration. Sporting goods and miscellaneous retailers are highly concentrated in the SIA. These sectors, on average, employed five more employees than similar stores located elsewhere in Salt Lake County. Food services and drinking establishments show growth in gross sales and market concentration, an indication of more businesses locating in the SIA.

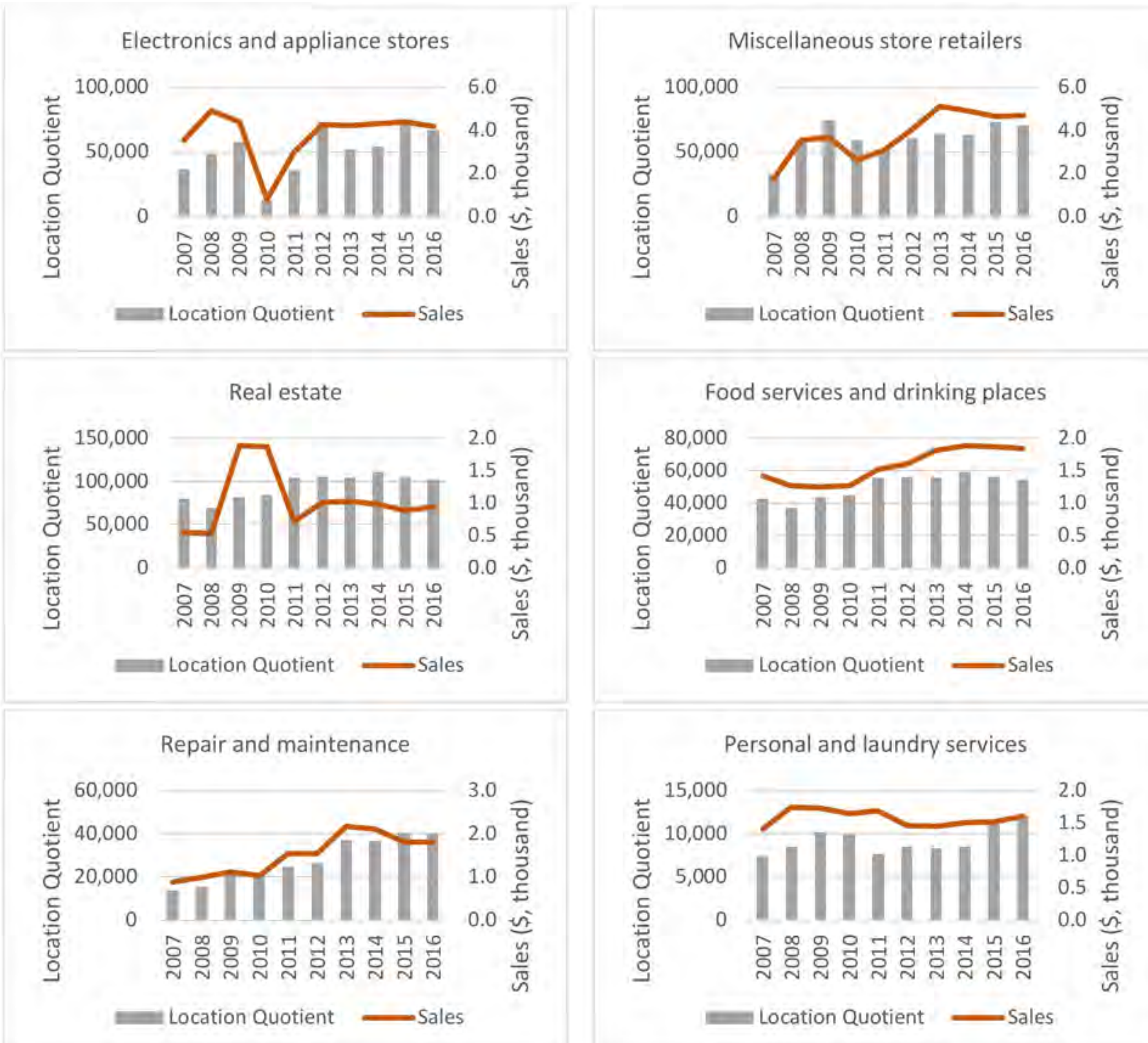


Figure 7-30 *Gross Sales and Location Quotient – Salt Lake City S-Line – Selected Industries*

The historical evidence is subjected to causality tests by modeling the longitudinal patterns of businesses employment levels to test the hypothesis that increased accessibility from the streetcar resulted in increased business activity in the study area.

SECTION

8

Econometric Analysis of Business Activities

The trend analysis of Section 7 served as a background to formulate a set of empirical model to test two main hypotheses relating streetcar investment to local economic growth. Although historical trend analysis is helpful in understanding how a particular area grows over time, it does not uncover any causality between the streetcar investments and changes in business growth.

Firm location theory shows how employment is the result of a firm's decisions about location, current and past levels of product demand, firm-specific market conditions, and generalized economic trends. Firm agglomeration is the result of business profitability decisions and accessibility preferences. A firm's location decision is driven by spillover effects from the clustering of other firms that increase the customer base as well as proximity to a transport network that offers increased accessibility to customers and employees.

The analysis in this section hypothesizes that expected accessibility gains from the streetcar improvement affect business location decisions and employment levels. This is equivalent to assume that firm clustering is either predetermined or endogenous to the process. In essence, we are trying to answer the question, can streetcars serve as a catalyst of economic growth?

The econometric models use panel datasets of businesses located in the SIA and control areas during the period 2007–2016 using the Infogroup historical database. The econometric specification is based on the difference-in-differences approach detailed in Appendix A, which includes a literature review on the use of dynamic panel data models.

Changes in the Number of Establishments

The hypothesis was tested that streetcar project phases positively affected business growth in the SIA and that this growth is higher than comparable areas. The test was carried out by regressing the number of establishments at the NAICS 3-digit level using difference-in-differences estimation and comparing growth in the SIA to growth in the control areas. The econometric models uses FE to control for industry sector time-invariant unobserved characteristics. This is because industry sectors vary by productivity levels, a characteristic that affects location decisions. The model also controls for productivity levels by using a sales-per-employee ratio. This variable is obtained by dividing total gross sales by total number of employees for each industry sector. The ratio is useful when comparing productivity within the same industry. Companies with a higher sales-per-employee ratio tend to be more efficient and more profitable, which affects the number of firms operating within the same sector. The model also uses the location quotient as an explanatory variable to measure the relative concentration within an industry sector.[54]

Cincinnati Bell Connector

Table 8-1 reports sample descriptive statistics. As shown in the previous figures, the number of establishments in the SIA increased during the period 2007–2016.

Table 8-1 *Establishment Characteristics – Cincinnati Bell Connector*

	SIA					Control				
Year	Establishments	Total Employment	Average Employment	Sales/ Employee ($,000)	LQ	Establishments	Total Employment	Average Employment	Sales/ Employee ($,000)	LQ
2007	2,845	50,075	17.6	149.9	1.3	2,533	28,211	11.1	168.0	1.4
2008	2,908	55,090	19.0	145.9	1.4	2,524	28,137	11.1	164.2	1.4
2009	2,972	56,810	19.1	147.6	1.4	2,648	30,036	11.3	164.4	1.3
2010	3,202	58,423	18.3	146.2	1.5	2,607	29,757	11.4	155.9	1.3
2011	2,724	56,553	20.9	140.8	1.3	2,417	30,501	12.6	153.0	1.3
2012	2,802	60,947	21.8	136.1	1.4	2,587	31,381	12.1	147.8	1.4
2013	3,206	62,608	19.6	133.7	1.3	2,777	35,705	12.9	151.1	1.4
2014	3,141	64,105	20.5	133.6	1.3	2,663	38,773	14.6	150.8	1.3
2015	3,118	68,250	21.9	133.9	1.3	2,679	34,155	12.7	146.6	1.3
2016	2,960	63,773	21.6	136.7	1.4	2,510	32,060	12.8	150.2	1.3

Table 8-2 displays the results of the regression on the number of establishments. The initial sample consists of 820 observations (41 NAICS 3-digit sectors each for SIA and control and T=10 years). Model 1 reports the pooled OLS regression, and Model 2 shows the FE results controlling for unobserved time-invariant local and industry-specific effects. Model 3 is the same as Model 2, but uses a balanced sample (only industry sectors appearing consecutively over 2007-2016). The final sample size is smaller due to the removal of outliers. To remove outliers represented by very large employers, the sample includes businesses with 60 or fewer employees. All models control for common exogenous shock from business cycle effects and secular trends by including "year dummy variable."

[54] Regression models also include another index of industry spatial concentration, the Hirschmann-Herfindahl index.

Table 8-2

Changes in Number of Establishments, Regression Results – Cincinnati Bell Connector

Variable	Definition	Regression Model		
		(1)	(2)	(3)
		OLS	FE	FE†
treatment	Treatment	-0.00792		
		(0.132)		
ann_plan	Announcement and Planning	0.283***		
		(0.0860)		
constr	Construction	0.451***		
		(0.102)		
open	Opening	0.310***		
		(0.104)		
tr_ann_plan	Interaction term (treatment*ann_plan)	-0.0466	0.0639*	0.0618*
		(0.104)	(0.0336)	(0.0337)
tr_constr	Interaction term (treatment*constr)	-0.0140	0.201***	0.207***
		(0.0968)	(0.0285)	(0.0285)
tr_open	Interaction term (treatment*open)	-0.0707	0.107**	0.120***
		(0.140)	(0.0419)	(0.0422)
lsale_emp_3	Natural log of revenue per employee	-0.164	0.0861***	0.0948***
		(0.146)	(0.0183)	(0.0186)
lnlq	Natural log of location quotient	0.495***	0.239***	0.242***
		(0.104)	(0.0194)	(0.0202)
lblack	Natural log of spatial concentration index	-0.220***	0.0228***	0.0231***
		(0.0594)	(0.00713)	(0.00710)
_cons	Constant term	3.269***	3.018***	3.022***
		(0.768)	(0.0931)	(0.0949)
N	Sample size	601	601	591
R-sq	Adjusted R-square	0.35	0.29	0.30

*Robust standard errors in parenthesis: * p<0.05; **p<0.01, ***p<0.001.*
Pre-planning phase (pre-plan) is baseline treatment phase.
†Balanced sample.

The parameters of interest are highlighted and represent the difference-in-differences estimators of streetcar project phase effects on the total number of establishments. The OLS is the naïve estimator, which does not account for industry-specific, time-invariant, unobserved factors. Model 2 and Model 3, after accounting for industry-specific characteristics, provide strong evidence (1% significance level) of positive effects on establishment growth during all phases. What appears to be the driving factor affecting the number of establishments is industry clustering, as indicated by the relatively large magnitude and high statistical significance (1% level) of the location quotient parameter. Referring to Model 3 as the preferred estimator and using the proportional change formula, the streetcar Announcement and Planning phases are associated with a 6.4 percent increase in the number of establishments compared to the Pre-Planning phase. The Construction phase is associated with higher growth (23.0%). At the Opening phase, growth in the number of establishments is 12.7 percent higher than comparable areas in the rest of the county.

Charlotte CityLYNX Gold Line

The SIA experienced growth in the number of establishments during the period 2007–2016. Table 8-3 reports sample descriptive statistics.

Table 8-3 *Establishment Characteristics – Charlotte CityLYNX Gold Line*

	SIA					Control				
Year	Establishments	Total Employment	Average Employment	Sales/ Employee ($,000)	LQ	Establishments	Total Employment	Average Employment	Sales/ Employment	LQ
2007	1,875	9,186	5.7	159.7	1.9	1,616	8,758	4.7	166.0	2.2
2008	1,918	9,402	5.7	153.4	1.9	1,652	8,872	4.6	159.3	2.1
2009	1,922	9,323	5.7	154.5	1.9	1,638	8,874	4.6	159.0	2.0
2010	2,272	10,076	4.8	156.7	1.9	2,103	11,322	5.0	161.1	2.0
2011	2,174	10,988	6.1	153.2	1.7	1,811	11,697	5.4	178.0	1.8
2012	2,228	13,014	6.7	163.7	1.7	1,943	12,192	5.5	203.9	1.8
2013	2,346	14,524	6.5	151.4	1.8	2,219	12,504	5.3	169.3	1.9
2014	2,326	14,436	6.7	146.3	1.8	2,168	12,655	5.4	162.6	1.9
2015	2,368	13,923	6.6	143.4	1.8	2,104	12,566	5.3	160.0	1.9
2016	2,124	13,065	6.6	144.7	1.8	1,986	12,261	5.8	156.0	1.9

Table 8-4 displays the results of the regression on the number of establishments. The initial sample consists of 1,088 observations (68 NAICS 3-digit sectors each for SIA and control and T=9 years). Model 1 reports the pooled OLS regression, and Model 2 shows the FE results controlling for unobserved time-invariant local and industry-specific effects.[55] Model 3 is the same as Model 2, but uses a balanced sample (only industry sectors appearing consecutively over 2007–2016). The final sample size is smaller due to the removal of outliers. To remove outliers represented by very large employers, the sample includes businesses with fewer than 40 employees. All models include "year dummy variables" to control for common exogenous shock from business cycle effects and secular trends.

[55] Note that by construct, the FE model removes time-invariant dummy variables, such treatment and construction phases.

Table 8-4

Changes in Number of Establishments, Regression Results – Charlotte CityLYNX Gold Line

Variable	Definition	Regression Model		
		(1)	(2)	(3)
		OLS	FE	FE†
treatment	Treatment	-0.136		
		(0.146)		
ann_plan	Announcement and Planning	0.173*		
		(0.0950)		
constr	Construction	0.130		
		(0.0939)		
open	Opening	0.110		
		(0.113)		
tr_ann_plan	Interaction term (treatment*ann_plan)	0.0705	0.131***	0.150***
		(0.114)	(0.0313)	(0.0308)
tr_constr	Interaction term (treatment*constr)	0.0885	0.207***	0.225***
		(0.142)	(0.0350)	(0.0343)
tr_open	Interaction term (treatment*open)	-0.0224	0.133***	0.124***
		(0.117)	(0.0356)	(0.0351)
lsale_emp_3	Natural log of revenue per employee	0.0198	0.150***	0.126***
		(0.109)	(0.0239)	(0.0238)
lnlq	Natural log of location quotient	0.818***	0.568***	0.547***
		(0.116)	(0.0217)	(0.0226)
_cons	Constant term	3.061***	2.611***	2.534***
		(0.563)	(0.144)	(0.118)
Time trend variables		yes	yes	yes
N	Sample size	685	715	657
R-sq	Adjusted R-square	0.46	0.54	0.53

*Robust standard errors in parenthesis: * $p<0.05$; ** $p<0.01$, *** $p<0.001$.*
Pre-planning phase (pre-plan) is baseline treatment phase.
†Balanced sample.

The parameters of interest are highlighted and represent the difference-in-differences estimators of streetcar project phase effects on the total number of establishments. The OLS is the naïve estimator, which does not account for industry-specific, time-invariant, unobserved factors. Model 2 and Model 3, after accounting for industry-specific characteristics, provides strong evidence (1% significance level) of positive effects on establishment growth during all phases. What appears to be the driving factor affecting the number of establishments is industry clustering, as indicated by the relatively large magnitude and high statistical significance (1% level) of the location quotient parameter. Referring to Model 3 as the preferred estimator and using the proportional change formula, the streetcar Announcement and Planning phases are associated with a 16.2 percent increase in the number of establishments compared to the Pre-Planning phase. The Construction phase is associated with higher growth (25.2%). At the

Opening phase, growth in the number of establishments is 13.2 percent higher than in comparable areas in the rest of the county.

Sun Link Tucson Streetcar

As shown in Table 8-5, the number of establishments in the SIA increased during the period 2007–2016. The number of total establishments in the control areas is greater than in the SIA because of the two-to-one matching selection of control block groups for each treatment group, resulting in a bigger sample. Average employment in the SIA is higher, confirming higher localized specialization with respect to the control and the rest of the county, as previously shown by the higher location quotient.

Table 8-5 *Establishment Characteristics – Sun Link Tucson Streetcar*

	SIA					Control				
Year	Establishments	Total Employment	Average Employment	Sales/ Employee ($,000)	LQ	Establishments	Total Employment	Average Employment	Sales/ Employee ($,000)	LQ
2007	1,909	31,656	16.6	108.2	1.0	3,303	36,996	11.2	190.2	1.3
2008	1,794	31,904	17.8	105.8	1.0	3,081	38,529	12.5	186.3	1.3
2009	1,850	26,659	14.4	108.8	1.0	3,166	37,241	11.8	186.7	1.3
2010	2,217	27,217	12.3	116.6	1.0	3,107	39,162	12.6	176.3	1.3
2011	1,967	31,011	15.8	109.4	1.0	3,288	40,371	12.3	175.7	1.3
2012	1,955	31,756	16.2	101.9	1.0	3,264	39,986	12.3	163.0	1.4
2013	2,258	33,818	15.0	101.6	1.1	3,546	42,815	12.1	166.9	1.2
2014	2,160	33,107	15.3	104.8	1.1	3,427	43,452	12.7	169.7	1.2
2015	2,053	30,536	14.9	102.8	1.1	3,242	41,528	12.8	168.4	1.2
2016	1,922	26,280	13.7	108.8	1.2	3,006	40,369	13.4	170.3	1.3

Table 8-6 displays the results of the regression on the number of establishments. The initial sample consists of 1,088 observations (68 NAICS 3-digit sectors each for SIA and control and T=8 years). Model 1 reports the pooled OLS regression, and Model 2 shows the fixed-effect results controlling for unobserved time-invariant local and industry-specific effects. The final sample size is smaller due to the removal of outliers. To remove outliers represented by big-box employers, the sample includes businesses with less than 40 employees. Both models include year dummy variables to control for common exogenous shock from business cycle effects and secular trends.

Table 8-6

Changes in Number of Establishments, Regression Result s– Sun Link Tucson Streetcar

Variable	Definition	(1) OLS	(2) FE	(3) FE†
treatment	Treatment	-0.440***		
		(0.123)		
ann_plan	Announcement and Planning	0.224***		
		(0.0480)		
constr	Construction	0.421***		
		(0.0829)		
open	Opening	0.288**		
		(0.112)		
tr_ann_plan	Interaction term (treatment*ann_plan)	-0.0520	0.129***	0.0868**
		(0.106)	(0.0400)	(0.0398)
tr_constr	Interaction term (treatment*constr)	-0.0935	0.234***	0.181***
		(0.119)	(0.0347)	(0.0343)
tr_open	Interaction term (treatment*open)	-0.167	0.119**	0.0734
		(0.145)	(0.0530)	(0.0520)
lsale_emp_3	Natural log of revenue per employee	-0.186*	0.0362	0.0234
		(0.0982)	(0.0239)	(0.0233)
lnlq	Natural log of location quotient	0.423***	0.269***	0.289***
		(0.0775)	(0.0175)	(0.0192)
lblack	Natural log of spatial concentration index	-0.477***	-0.0198	-0.0338**
		(0.0825)	(0.0156)	(0.0162)
_cons	Constant term	2.297***	2.983***	3.100***
		(0.640)	(0.141)	(0.139)
N	Sample size	594	594	572
R-sq	Adjusted R-square	0.494	0.368	0.354

*Robust standard errors in parenthesis: * p<0.05; **p<0.01, ***p<0.001.*
Pre-planning phase (pre-plan) is baseline treatment phase.

†Balanced sample.

The parameters of interest are highlighted and represent the difference-in-differences estimators of streetcar project phase effects on the total number of establishments. The OLS is the naïve estimator, which does not account for industry-specific, time-invariant, unobserved factors. Model 2, after accounting for industry-specific characteristics, provides strong evidence of positive effects on establishment growth during the Construction and Opening phases, at the one-percent significance level. What appears to be the driving factor affecting the number of establishments is industry clustering, as indicated by the relatively large magnitude (0.269) and high statistical significance (1% level) of the location quotient parameter. Referring to Model (3) as the preferred estimator and using the proportional change formula, the streetcar Announcement and Planning phase is associated with a 9.1 percent higher growth in the number of establishments. The Construction phase is associated with a 19.8 percent increase in the number of establishments. The Opening phase, while having the expected positive sigh, does not have a statistically significant impact.

Atlanta Streetcar

As shown in the historical trend analysis, the number of establishments in the SIA increased during the period 2007–2016. Table 8-7 reports sample descriptive statistics after removal of outliers. Average firm employment in the SIA is higher, confirming higher localized specialization with respect to the control and the remainder of the county, as previously shown by the higher location quotient.

Table 8-7 *Establishment Characteristics – Atlanta Streetcar*

	SIA					Control				
Year	Establishments	Total Employment	Average Employment	Sales/ Employee ($,000)	LQ	Establishments	Total Employment	Average Employment	Sales/ Employee ($,000)	LQ
2007	3,335	76,146	22.9	236.4	0.9	1,245	22,510	18.1	240.7	0.6
2008	3,208	72,401	22.6	221.3	0.9	1,255	25,068	20.0	237.0	0.6
2009	3,087	73,308	23.8	199.6	1.1	1,227	23,333	19.0	232.1	0.5
2010	3,550	73,192	20.7	212.7	1.1	1,718	25,308	14.7	261.7	0.7
2011	3,159	74,669	22.3	233.1	1.3	1,723	26,308	14.7	273.7	0.7
2012	3,505	75,410	20.5	288.5	1.2	2,153	26,688	11.9	347.3	0.7
2013	3,759	65,799	16.9	311.6	1.0	2,512	29,039	11.3	456.3	0.8
2014	3,513	75,926	21.1	328.3	1.0	2,390	28,999	11.9	448.3	0.8
2015	3,556	80,714	22.4	321.7	1.1	2,387	29,501	12.2	444.3	0.7
2016	3,402	83,029	24.2	305.0	1.0	2,218	28,840	13.0	459.3	0.8

Table 8-8 displays the results of the regression on the number of establishments. The initial sample consisted of 750 observations (75 NAICS 3-digit sectors each for SIA and control and T=10 years). Model 1 reports the pooled OLS regression, and Model 2 shows the fixed-effect results controlling for unobserved time-invariant local and industry-specific effects. The final sample size is smaller due to the removal of outliers. Both models include year dummy variables to control for common exogenous shock from business cycle effects and secular trends.

Table 8-8

Changes in Number of Establishments, Regression Results – Atlanta Streetcar

Variable	Definition	(1) OLS	(2) FE	(3) FE†
treatment	Treatment	0.787***		
		(0.156)		
ann_plan	Announcement and Planning	0.409***		
		(0.104)		
constr	Construction	0.921***		
		(0.174)		
open	Opening	0.741***		
		(0.158)		
tr_ann_plan	Interaction term (treatment*ann_plan)	-0.270**	0.0303	0.0371
		(0.104)	(0.0433)	(0.0437)
tr_constr	Interaction term (treatment*constr)	-0.332	0.153***	0.176***
		(0.196)	(0.0506)	(0.0515)
tr_open	Interaction term (treatment*open)	-0.342*	0.102**	0.119**
		(0.188)	(0.0500)	(0.0507)
lsale_emp_3	Natural log of revenue per employee	-0.406	0.188***	0.165***
		(0.241)	(0.0408)	(0.0431)
lnlq	Natural log of location quotient	0.493***	0.437***	0.419***
		(0.0930)	(0.0279)	(0.0308)
lblack	Natural log of spatial concentration index	-0.145	0.0516***	0.0534***
		(0.103)	(0.0138)	(0.0138)
_cons	Constant term	3.885***	2.460***	2.667***
		(1.372)	(0.226)	(0.236)
N	Sample size	550	550	518
R-sq	Adjusted R-square	0.40	0.41	0.37

*Robust Standard errors in parenthesis: * p<0.05; **p<0.01, ***p<0.001.*
Pre-planning phase (pre-plan) is baseline treatment phase.
†Balanced sample.

The parameters of interest are highlighted and represent the difference-in-differences estimators of streetcar project phase effects on the total number of establishments. The OLS regression (Model 1) does not provide any evidence of streetcar effect on establishment growth. Model 2, after accounting for industry-specific characteristics, provides strong evidence of positive effects on establishment growth during the Construction (0.153) and Opening (0.102) phases, at the one-percent significance level. What also appears to be a driving factor affecting the number of establishments is industry specialization, as indicated by the relatively large magnitude and high statistical significance (1% level) of the location quotient parameter. Referring to the FE model as the preferred estimator and using the proportional change formula, the streetcar Construction phase is associated with a 16.5 percent higher growth in the number of establishments with respect to the control areas. The effect decreases to 10.7 percent at Opening and afterwards.

Salt Lake City S-Line

Table 8-9 reports sample descriptive statistics. The number of total establishments in the control areas is greater than the SIA because of the two-to-one matching selection of control block groups for each treatment group, resulting in a bigger sample. Average employment in the SIA is higher, confirming higher localized specialization with respect to the control and the rest of the county, as previously shown by the higher location quotient.

Table 8-9 *Establishment Characteristics – Salt Lake City S-Line*

	SIA					Control				
Year	Establishments	Total Employment	Average Employment	Sales/ Employee ($,000)	LQ	Establishments	Total Employment	Average Employment	Sales/ Employee ($,000)	LQ
2007	629	7,554	20.1	184.0	2.1	2,246	29,586	16.2	203.3	1.8
2008	599	7,078	21.6	178.0	1.8	2,278	33,860	17.7	199.4	1.7
2009	611	6,718	17.3	177.6	2.0	2,290	33,976	17.1	197.6	1.8
2010	566	6,156	17.4	175.8	2.1	3,061	33,905	13.3	189.3	1.8
2011	725	10,574	18.3	173.6	1.7	2,841	36,462	17.1	202.7	1.9
2012	749	11,532	18.3	241.6	1.7	2,910	39,897	17.5	269.8	2.0
2013	806	12,074	17.8	249.6	1.8	2,992	49,625	19.9	248.1	1.8
2014	830	12,080	17.5	246.7	1.8	2,886	46,059	21.2	242.6	1.9
2015	818	8,779	14.7	235.9	2.0	2,958	44,683	16.4	248.0	2.0
2016	734	8,836	16.4	235.1	2.0	2,681	45,950	17.9	255.1	2.0

Table 8-9 displays the results of the regression on the number of establishments. The final sample consists of an unbalanced panel of 480 observations (24 NAICS 3-digit sectors each for SIA and control and T=10 years).

Model 1 reports the pooled naïve OLS regression, and Model 2 and Model 3 show the fixed-effect results controlling for unobserved time-invariant local and industry-specific effects. Both models include year dummy variables to control for common exogenous shock from business cycle effects and secular trends. Model 3 consists of a balanced sample using industry sectors appearing continuously over 2007-2016.

The parameters of interest are highlighted and represent the difference-in-differences estimators of streetcar project phase effects on the total number of establishments. Model 3 is the preferred model (balanced sample) and provides statistically significant evidence of positive impact on business growth is during construction and at opening and operation. The parameter (0.106) is statistical at the 10-percent significance level. Model 2, after accounting for industry-specific characteristics, provides evidence of positive effects on establishment growth during the Construction (0.0729) and Opening phases (0.103), again at the 10-percent significance level. What appears to be the driving factor affecting the number of establishments is industry clustering, as indicated by the relatively large magnitude (0.378) and high statistical significance (1% level) of the location quotient parameter. Referring to the fixed-effect Model 3 (FE) as the preferred estimator and using the proportional change formula, the streetcar Construction phase is associated with a 24.4 percent increase in the number of establishments. The Opening phase is associated with a 20.3 percent growth in the number of establishments.

Table 8-10

Changes in the Number of Establishments, Regression Results – Salt Lake City S-Line

Variable	Definition	Regression Model		
		(1)	(2)	(3)
		OLS	FE	FE†
treatment	Treatment	-1.098***		
		(0.120)		
ann_plan	Announcement and Planning	0.392***		
		(0.0693)		
constr	Construction	0.373***		
		(0.0931)		
open	Opening	0.357***		
		(0.111)		
tr_ann_plan	Interaction term (treatment*ann_plan)	-0.158***	0.0314	0.0312
		(0.0513)	(0.0396)	(0.0398)
tr_constr	Interaction term (treatment*constr)	0.0350	0.218***	0.218***
		(0.105)	(0.0420)	(0.0423)
tr_open	Interaction term (treatment*open)	-0.106	0.186***	0.185***
		(0.151)	(0.0372)	(0.0375)
lsale_emp_3	Natural log of revenue per employee	-0.166	0.0125	0.0125
		(0.234)	(0.0282)	(0.0282)
lnlq	Natural log of location quotient	0.563***	0.189***	0.189***
		(0.121)	(0.0337)	(0.0339)
lblack	Natural log of spatial concentration index	-0.0687	0.0219**	0.0224**
		(0.0946)	(0.00988)	(0.00998)
_cons	Constant term	3.899**	3.277***	3.311***
		(1.464)	(0.156)	(0.156)
N	Sample size	463	463	459
R-sq	Adjusted R-square	0.403	0.193	0.194

*Robust Standard errors in parenthesis: * p<0.05; **p<0.01, ***p<0.001.*
Pre-planning phase (pre-plan) is baseline treatment phase.
†Balanced sample.

Results from Pooled Data Regression

Table 8-11 displays the results of the regression on the number of establishments by combining all case studies. As previously noted, the models control for common exogenous shock from business cycle effects and secular trends by including dichotomous year-trend variables. The parameters of interest are highlighted and represent the difference-in-differences estimators of streetcar project phase effects on the total number of establishments. The results show statistically significant evidence of streetcar having an impact on establishment growth at all phases of project implementation.

Table 8-11

Changes in the Number of Establishments, Regression Results – Pooled Dataset

Variable	Definition	Pooled Data FE†
tr_ann_plan	Interaction term (treatment*ann_plan)	0.0660***
		(0.0152)
tr_constr	Interaction term (treatment*constr)	0.211***
		(0.0155)
tr_open	Interaction term (treatment*open)	0.168***
		(0.0160)
lsale_emp_3	Natural log of revenue per employee	0.0535***
		(0.00690)
lnlq	Natural log of location quotient	0.229***
		(0.00794)
lblack	Natural log of spatial concentration index	0.00918**
		(0.00405)
_cons	Constant term	3.006***
		(0.0397)
N	Sample size	3573
R-sq	Adjusted R-square	0.26

Note: Models include year dummy variables (not shown).Robust Standard errors in parenthesis:
** p<0.05; **p<0.01, ***p<0.001.*
Pre-planning phase (pre-plan) is baseline treatment phase.
†Balanced sample.

Changes in Employment Levels

The hypothesis that streetcar project phases positively affected employment growth at the establishment level was tested. The test was carried out by regressing total employment at the establishment level using difference-in-differences estimation and comparing employment growth in the SIA to growth in the control areas. The econometric models employ dynamic panel regression methods recognizing that employment levels in one year are determined by employment levels in the previous year. Also, because hiring and firing of workers entails costs, employment is expected to adjust to delays in response to changes in firm output. The inclusion of lagged employment makes the fixed-effect model inconsistent, leading to biased coefficient estimates. This is because the dynamic aspect following the inclusion of the lagged dependent variable leads to contemporaneous correlation with the transformed disturbances and possibly to serial correlation of the disturbances. Therefore, the analysis employs generalized method of moments (GMM) estimators for dynamic panel models to account for these factors. To our knowledge, the use of dynamic panel regression is novel to the evaluation of transportation infrastructure investments and employment growth. Furthermore, the inclusion of the lagged dependent variable allows estimating the long-term impact on employment growth.

Finally, by relaxing the assumption of exogenous firm clustering, the hypothesis that businesses tend to cluster as the streetcar project is implemented was tested. This is equivalent to test the assumption that streetcar investments serve as catalyst for economic growth.

The regression results of GMM models were compared with baseline estimates of the naïve OLS limited-dependent variable estimator (OLS-LDV), the FE estimator, dynamic panel instrumental regression of Anderson-Hsiao IV (HSIAO) [29], the Arellano-Bond (Difference GMM) [30], and the Blundell-Bond (System GMM) estimators [31]. The tables also detail the number of instruments used and the associated instrument validity tests. Appendix A discusses the advantages and disadvantages of using the above estimators.

Cincinnati Bell Connector

Table 8-12 compares the regression results of GMM models with baseline estimates of the naïve estimators. The GMM estimator allows checking instrument validity by testing for the presence of second-order autocorrelation in the differenced residuals. Arellano and Bond derive the test for autocorrelation of order m of the first differenced errors. Under the null hypothesis, it is assumed that there is no second-order autocorrelation and, therefore, using lagged values of the dependent variable as instruments leads to misspecification. As an alternative, the Hansen J test for over-identification restriction provides a way to assess the overall validity of the instruments. The last row of Table 8-12 reports the results of the two tests performed on the first differencing GMM. Failure to reject the null of second-order autocorrelation, as indicated by the p-values, provides support to instrument validity.

Table 8-12 *Changes in Firm Employment Levels, Estimation Results – Cincinnati Bell Connector*

Variable	Definition	Regression Models				
		(1)	(2)	(3)	(4)	(5)
		OLS-LDV	*FE-LDV*	*Anderson-Hsiao IV*	*Difference GMM†*	*System GMM†*
L.lemp	Natural log of employment, t-1	0.938***	0.408***	1.075***	0.695***	0.887***
		(0.00395)	(0.0224)	(0.134)	(0.0625)	(0.0207)
lsales	Natural log of sales, t	0.206***	0.149***	-0.115***	0.00143	0.0381
		(0.0169)	(0.0152)	(0.0162)	(0.0319)	(0.0291)
L.lsales	Natural log of sales, t-1	-0.168***	-0.0621***	-0.0134*	-0.00782	0.00875
		(0.0162)	(0.00887)	(0.00548)	(0.0210)	(0.0227)
lnlq	Natural log of location quotient	-0.00284	0.0177	0.0269***	0.0541**	0.0291*
		(0.00199)	(0.0107)	(0.00775)	(0.0209)	(0.0120)
treatment	Treatment	-0.00184				
		(0.00574)				
ann_plan	Announcement and Planning	0.0159**				
		(0.00560)				
constr	Construction	0.00508				
		(0.0118)				
open	Opening	0.0293**				
		(0.00976)				
tr_ann_plan	Interaction term (treatment*ann_plan)	0.0243***	0.0198*	0.0181	-0.00183	0.00427
		(0.00716)	(0.00810)	(0.0170)	(0.00854)	(0.00592)
tr_constr	Interaction term (treatment*constr)	0.0212*	0.0598***	0.0343	0.0240*	0.0284***
		(0.00841)	(0.0105)	(0.0243)	(0.0105)	(0.00691)
tr_open	Interaction term (treatment*open)	-0.0256*	0.0187	-0.00638	-0.0245	-0.0245
		(0.0122)	(0.0148)	(0.0295)	(0.0160)	(0.0129)
_cons	Intercept	-0.160***	0.398***			-0.0972*
		(0.0140)	(0.0752)			(0.0422)
N	Sample size	20,770	20,770	11,666	1,583	20,770
R-sq	R-squared (OLS adjusted; FE within)	0.95	0.32			
AR(2) test (p-value)				0.41	0.37	
Number of instruments				53	60	
Hansen J test (p-value)				0.27	0.5	
Time trend variables		yes	yes	yes	yes	yes

Note: Models include year dummy variables (not shown).
*Robust standard errors in parenthesis: * p<0.05; **p<0.01, ***p<0.001.*
Pre-planning phase (pre-plan) is baseline treatment phase.
†Sales fully endogenous and location quotient predetermined but not strictly exogenous.

The results show that the naïve OLS-LDV estimator, with the lagged dependent variable positively correlated with the error term, produces biased estimates, as shown in the large coefficient equal to 0.94. The within transformation of Model 2 results in a downward bias, reducing the coefficient to 0.41. A more efficient model that accounts for the dynamic panel bias would then have a parameter estimate within the 0.41–0.94 range (see Blundell and Bond [31, 32]).

The Anderson-Hsiao instrumental variable approach uses the second and higher order lags of the dependent variable as instruments for first lag of employment, allowing control for dynamic panel bias. The estimate of the lagged dependent variable is out of range (1.07). Model 4 is the Arellano-Bond "difference GMM," which employs lagged levels of the dependent variable in the regression in first differences. This approach produces the equivalent of the fixed-effect model in terms of removing time-invariant unobserved factors, but controlling for the endogeneity bias from the presence of the lagged dependent variable. Blundell and Bond [31, 32] show that this approach may suffer from a weak instrument problem in the presence of persistent time series. Past levels of employment drive firm employment decisions, with slow adjustments from hiring, firing, and training costs. In this case, the "system GMM" method of Arellano and Bover [33] is preferable to difference GMM. Model 5 is based on the Blundell-Bond estimator, which exploits additional moment conditions resulting in reduced bias.

Model 4 and Model 5 relax the assumption of strict exogeneity of firm sales and firm concentration (as measured by the natural log of location quotient, LQ) and report the results of treating sales and LQ as predetermined and endogenous to the system. Relaxing this assumption is a way of testing the hypothesis that firm sales and location decisions are also affected by accessibility improvements as firm demand is driven by increasing customer demand, which is itself affected by accessibility. Previous regression runs treating sales and LQ as exogenous failed the difference-in-Hansen J-test of validity as an exogenous subset of instruments. Assuming stationarity of employment, Model 5 makes more efficient use of instrumental variables, as shown by the parameters' smaller standard errors. Model 5 is the preferred model.

The parameters of interest are highlighted and are based on the difference-in-differences approach to uncover causality between the streetcar project phases and changes in firm employment levels. Model 5 fails to reject the null hypothesis of no streetcar influence on firm employment (p-value<0.001) during Announcement and Planning and at Opening. The project phases have a positive influence on firm employment levels during the construction phase. Applying the proportional change formula, the streetcar investment impact on firm employment ranges during construction phase resulted in firms employing, on average, 2.7 percent more workers than businesses located in comparable locations elsewhere in the county.

Charlotte CityLYNX Gold Line

Table 8-13 reports the regression results, compares the regression results of GMM estimator with baseline estimates of the naïve estimators. The last row of Table 8-13 reports the results of the two tests performed on the first differencing GMM. Failure to reject the null of second-order autocorrelation, as indicated by the p-values, provides support to instrument validity.

Table 8-13

Changes in Firm Employment Levels, Estimation Results – Charlotte CityLynx Gold Line

Variable	Definition	Regression Models				
		(1)	(2)	(3)	(4)	(5)
		OLS-LDV	FE-LDV	Anderson-Hsiao IV	Difference GMM†	System GMM†
L.lemp	Natural log of employment, t-1	0.938***	0.608***	0.351***	0.649***	0.711***
		(0.00427)	(0.0898)	(0.0196)	(0.0449)	(0.0304)
lsales	Natural log of sales, t	0.451***	-0.201***	0.451***	0.294**	0.234***
		(0.0182)	(0.0348)	(0.0192)	(0.111)	(0.0614)
L.lsales	Natural log of sales, t-1	-0.407***	-0.0396***	-0.110***	-0.116	-0.0524
		(0.0187)	(0.00999)	(0.0168)	(0.0778)	(0.0539)
lnlq		0.0153***	0.0210*	0.0832***	0.101***	0.0912***
		(0.00215)	(0.0110)	(0.0131)	(0.0283)	(0.0203)
treatment	Treatment	-0.00747*				
		(0.00418)				
ann_plan	Announcement and Planning	-0.0164**				
		(0.00565)				
constr	Construction	-0.00968				
		(0.00651)				
open	Opening	-0.0135***				
		(0.00408)				
tr_ann_plan	Interaction term (treatment*ann_plan)	0.0139**	0.0297**	0.0229**	0.0279**	0.0243**
		(0.00652)	(0.0130)	(0.00778)	(0.00856)	(0.00784)
tr_constr	Interaction term (treatment*constr)	0.0158	0.0432**	0.0209**	0.0225*	0.0248**
		(0.00966)	(0.0138)	(0.00836)	(0.0119)	(0.00962)
tr_open	Interaction term (treatment*open)	0.0208***	0.0673***	0.0309***	0.0373**	0.0369***
		(0.00525)	(0.0115)	(0.00715)	(0.0120)	(0.00737)
_cons	Intercept	-0.180***	-1.243***	0.0649***		-0.773***
		(0.0166)	(0.0934)	(0.00912)		(0.105)
N	Sample size	16427	16427	8429	12039	16427
R-sq	R-squared (OLS adjusted; FE within)	0.943	0.510	-0.411		
AR(2) test (p-value)			0.065	0.129		
Number of instruments			53	60		
Hansen J test (p-value)			0.298	0.292		
Time trend variables		yes	yes	yes	yes	yes

Note: Models include year dummy variables (not shown).
*Robust standard errors in parenthesis: * p<0.05; **p<0.01, ***p<0.001.*
Pre-planning phase (pre-plan) is baseline treatment phase.
†Sales fully endogenous and location quotient predetermined but not strictly exogenous.

The results show that the naïve OLS estimator, with the lagged dependent variable positively correlated with the error term, produces biased estimates, as shown in the large coefficient equal to 0.94. The within transformation of Model 2 results in a downward bias, reducing the coefficient to 0.61. A more efficient model that accounts for the dynamic panel bias would then have a parameter estimate within the 0.61–0.94 range.

Model 5 makes more efficient use of instrumental variables, as shown by the parameters' smaller standard errors. Model 5 is the preferred model. The parameters of interest are highlighted and are based on the difference-in-differences approach to uncover causality between the streetcar project phases and changes in firm employment levels. Model 5 rejects the null hypothesis of no streetcar influence on firm employment (p-value<0.001). The project phases seem to exert a positive influence on firm employment levels on each stage of implementation. Applying the proportional change formula, the streetcar investment impact on firm employment ranges from a 2.5 percent during Announcement and Planning and during Construction to 3.8 percent at Opening.

Sun Link Tucson Streetcar

Table 8-14 reports the regression results of GMM models with baseline estimates of the naïve fixed-effect estimators. The last row of Table 8-14 reports the results of the two tests performed on the first differencing GMM. Failure to reject the null of second-order autocorrelation, as indicated by the p-values, provides support to instrument validity.

Table 8-14

Changes in Firm Employment Levels, Estimation Results – Sun Link Tucson Streetcar

Variable	Definition	Regression Models				
		(1)	(2)	(3)	(4)	(5)
		OLS-LDV	*FE-LDV*	*Anderson-Hsiao IV*	*Difference GMM†*	*System GMM†*
L.lemp	Natural log of employment, t-1	0.948***	0.429***	0.808***	0.746***	0.798***
		(0.00433)	(0.0219)	(0.113)	(0.0462)	(0.0292)
lsales	Natural log of sales, t	0.379***	0.348***	-0.202***	0.337***	0.307***
		(0.0196)	(0.0204)	(0.0310)	(0.0924)	(0.0640)
L.lsales	Natural log of sales, t-1	-0.350***	-0.131***	-0.0257**	-0.202*	-0.180**
		(0.0196)	(0.0154)	(0.00871)	(0.0785)	(0.0562)
lnlq	Natural log of location quotient	0.00671				
		(0.00482)				
treatment	Treatment	0.000641				
		(0.00512)				
ann_plan	Announcement and Planning	-0.0172*				
		(0.00779)				
constr	Construction	0.00494				
		(0.00421)				
open	Opening	-0.00579	-0.0105	-0.00364	-0.0113	0.00950
		(0.00638)	(0.00606)	(0.0138)	(0.00686)	(0.00690)
tr_ann_plan	Interaction term (treatment*ann_plan)	0.0653***	0.0352***	0.0120	0.0382***	0.0659***
		(0.0110)	(0.00965)	(0.0191)	(0.0113)	(0.0101)
tr_constr	Interaction term (treatment*constr)	-0.00561	0.0176	-0.0392	-0.00526	0.0177*
		(0.00616)	(0.0101)	(0.0236)	(0.0108)	(0.00749)
tr_open	Interaction term (treatment*open)	-0.00646**	0.00993	0.0351***	0.00215	-0.00192
		(0.00220)	(0.00841)	(0.00769)	(0.0188)	(0.0122)
_cons	Intercept	-0.113***	-0.544***	-0.0149*		-0.514***
		(0.0154)	(0.104)	(0.00673)		(0.0996)
N	Sample size	14,840	14,840	8365	11,321	14,840
R-sq	R-squared (OLS adjusted; FE within)	0.953	0.454	0.63		
AR(2) test (p-value)				0.64	0.37	
Number of instruments				53	60	
Hansen J test (p-value)				0.02	0.57	
Time trend variables		yes	yes	yes	yes	yes

Note: Models include year dummy variables (not shown).
*Robust standard errors in parenthesis: * p<0.05; **p<0.01, ***p<0.001.*
Pre-planning phase (pre-plan) is baseline treatment phase.
†Sales fully endogenous and location quotient predetermined but not strictly exogenous.

The results show that the naïve OLS estimator, with the lagged dependent variable positively correlated with the error term, produces biased estimates, as shown in the large coefficient equal to 0.93. The within transformation of Model 2 results in a downward bias, reducing the coefficient to 0.43. A more efficient model that accounts for the dynamic panel bias would then have a parameter estimate within the 0.43–0.93 range. Model 5 is the preferred model.

The parameters of interest are highlighted and are based on the difference-in-differences approach to uncover causality between the streetcar project phases and changes in firm employment levels. Model 5 rejects the null hypothesis of no streetcar influence on firm employment (p-value<0.001). The project phases seem to excerpt a positive influence on firm employment levels during the early stages of streetcar implementation with no lingering effects at opening. Applying the proportional change formula, the streetcar investment impact on firm employment ranges from 6.8 percent during Announcement and Planning to 1.8 percent during Construction.

Atlanta Streetcar

Table 8-15 compares the regression results of GMM models with baseline estimates of the naïve FE estimator, dynamic panel instrumental regression of Anderson-Hsiao IV (HSIAO), the Arellano-Bond (Difference GMM), and the Blundell-Bond (System GMM) estimators. The table also details the number of instruments used and the associated instrument validity tests.

Table 8-15

Changes in Firm Employment Levels, Estimation Results – Atlanta Streetcar

Variable	Definition	Regression Models				
		(1)	(2)	(3)	(4)	(5)
		OLS-LDV	FE-LDV	Anderson-Hsiao IV	Difference GMM†	System GMM†
L.lemp	Natural log of employment, t-1	0.932***	0.771***	0.288***	0.469***	0.828***
		(0.00467)	(0.0872)	(0.0177)	(0.0519)	(0.0297)
lsales	Natural log of sales, t	0.431***	-0.220***	0.399***	0.179**	-0.0263
		(0.0161)	(0.0292)	(0.0177)	(0.0641)	(0.0610)
L.lsales	Natural log of sales, t-1	-0.391***	-0.0756***	-0.0793***	0.0993	0.0972*
		(0.0165)	(0.0103)	(0.0142)	(0.0635)	(0.0489)
lnlq	Natural log of location quotient	0.0195***	0.0130*	0.0387***	-0.00866	0.0543***
		(0.00194)	(0.00641)	(0.00598)	(0.0159)	(0.0105)
treatment	Treatment	-0.0111*				
		(0.00457)				
ann_plan	Announcement and Planning	-0.0211***				
		(0.00545)				
constr	Construction	-0.0129				
		(0.00750)				
open	Opening	0.0123*				
		(0.00579)				
tr_ann_plan	Interaction term (treatment*ann_plan)	0.0364***	0.0110	0.0278***	0.0229**	0.0371***
		(0.00649)	(0.0148)	(0.00760)	(0.00820)	(0.00775)
tr_constr	Interaction term (treatment*constr)	0.0325**	-0.0833***	0.0288**	0.0172	0.0293**
		(0.0114)	(0.0203)	(0.0109)	(0.0106)	(0.0111)
tr_open	Interaction term (treatment*open)	0.000187	-0.102***	0.0168	-0.0117	-0.00366
		(0.00585)	(0.0238)	(0.0109)	(0.0115)	(0.00917)
_cons	Intercept	-0.137***		-0.976***		-0.211
		(0.0145)		(0.0992)		(0.109)
N	Sample size	22,635	11,959	22,635	16,644	22,635
R-sq	R-squared (OLS adjusted; FE within)	0.93	0.56	0.46		
AR(2) test (p-value)				0.38	0.28	
Number of instruments				53	60	
Hansen J test (p-value)				0.08	0.12	
Time trend variables		yes	yes	yes	yes	yes

Note: Models include year dummy variables (not shown).
*Robust standard errors in parenthesis: * p<0.05; **p<0.01, ***p<0.001.*
Pre-planning phase (pre-plan) is baseline treatment phase.
†Sales fully endogenous and location quotient predetermined but not strictly exogenous.

The results show that the naïve OLS estimator, with the lagged dependent variable positively correlated with the error term, produces biased estimates, as shown in the large coefficient equal to 0.93. The within transformation of Model 2 results in a downward bias, reducing the coefficient to 0.77. A more efficient model that accounts for the dynamic panel bias would then have a parameter estimate within the 0.77–0.93 range.

Model 5 is the preferred model. The parameters of interest are highlighted and are based on the difference-in-differences approach to uncover causality between the streetcar project phases and changes in firm employment levels. Model 5 rejects the null hypothesis of no streetcar influence on firm employment (p-value<0.001). The project phases seem to exert a positive influence on firm employment levels during the early stages of streetcar Announcement and Planning and Construction. Applying the proportional change formula, the streetcar investment impact on firm employment ranges from 3.8 percent during Announcement and Planning to 3.0 percent at Construction.

Salt Lake Sugar House Streetcar

Table 8-16 compares the regression results of GMM models with baseline estimates of the naïve FE estimator, dynamic panel instrumental regression of Anderson-Hsiao IV (HSIAO), the Arellano-Bond (Difference GMM), and the Blundell-Bond (System GMM) estimators. The last row of reports the results of the two tests performed on the first differencing GMM. Failure to reject the null of second-order autocorrelation, as indicated by the p-values, provides support to instrument validity. The results show that the naïve OLS estimator, with the lagged dependent variable positively correlated with the error term, results in biased estimates, as shown in the large coefficient equal to 0.93. The within transformation of Model 2 results in a downward bias, reducing the coefficient to 0.36. A more efficient model that accounts for the dynamic panel bias would then have a parameter estimate within the 0.36–0.93 range.

Table 8-16

Changes in Firm Employment Levels, Estimation Results – Salt Lake City S-Line

Variable	Definition	Regression Models				
		(1)	(2)	(3)	(4)	(5)
		OLS-LDV	FE-LDV	Anderson-Hsiao IV	Difference GMM†	System GMM†
L.lemp	Natural log of employment, t-1	0.929***	0.362***	0.676***	0.606***	0.824***
		(0.00528)	(0.0169)	(0.0724)	(0.0363)	(0.0209)
lsales	Natural log of sales, t	0.323***	0.258***	-0.121***	0.160**	0.143***
		(0.0178)	(0.0173)	(0.0151)	(0.0487)	(0.0384)
L.lsales	Natural log of sales, t-1	-0.283***	-0.0762***	-0.0203**	0.0268	-0.0722*
		(0.0179)	(0.0112)	(0.00649)	(0.0490)	(0.0332)
lnlq	Natural log of location quotient	0.0138***	0.0254***	0.0259***	-0.00900	0.0267**
		(0.00285)	(0.00715)	(0.00697)	(0.0195)	(0.00827)
treatment	Treatment	-0.00316				
		(0.00594)				
ann_plan	Announcement and Planning	-0.00840				
		(0.00574)				
constr	Construction	-0.0100				
		(0.00672)				
open	Opening	0.0310***				
		(0.00721)				
tr_ann_plan	Interaction term (treatment*ann_plan)	0.0213**	0.0185**	0.0309	0.0236**	0.0291***
		(0.00742)	(0.00707)	(0.0160)	(0.00816)	(0.00769)
tr_constr	Interaction term (treatment*constr)	0.00771	0.00959	0.0562*	0.0130	0.0114
		(0.0105)	(0.0111)	(0.0218)	(0.0108)	(0.00978)
tr_open	Interaction term (treatment*open)	0.0195**	0.0310**	0.0277	0.0309**	0.0226***
		(0.00738)	(0.0111)	(0.0260)	(0.0103)	(0.00640)
_cons	Intercept	-0.140***	-0.124	0.0506***		-0.173***
		(0.0159)	(0.0935)	(0.00590)		(0.0432)
N	Sample size	24581	24581	13521	18520	24456
R-sq	R-squared (OLS adjusted;					
FE within)	0.943	0.328	0.62			
AR(2) test (p-value)				0.70	0.72	
Number of instruments				53	60	
Hansen J test (p-value)				0.02	0.07	
Time trend variables		yes	yes	yes	yes	yes

Note: Models include year dummy variables (not shown).
*Robust standard errors in parenthesis: * p<0.05; **p<0.01, ***p<0.001.*
Pre-planning phase (pre-plan) is baseline treatment phase.
†Sales fully endogenous and location quotient predetermined but not strictly exogenous.

Model 5 is the preferred model. The parameters of interest are highlighted and are based on the difference-in-differences approach to uncover causality between the streetcar project phases and changes in firm employment levels. Model 5 rejects the null hypothesis of no streetcar influence on firm employment (p-value<0.001). Announcement and Planning and Opening exert positive influence on firm employment levels. Applying the proportional change formula, the streetcar investment impact on firm employment ranges from 2.0 percent during Announcement and Planning to 3.0 percent at Opening and the following two years of operation. During the first two years of Opening, the short run impact on employment levels is about 2.1 percent. A long run impact can be estimated, considering the lagged adjustment in employment levels, and is equivalent to 17.6 percent.

Results from Pooled Data Regression

Table 8-17 reports the regression results of System GMM model by the pooling all case studies. The parameters of interest are highlighted and are based on the difference-in-differences approach discussed earlier. Similar to the analysis of establishments, the pooled data regression estimates show that streetcar investments exert a positive effect on employment levels at all project stages. Notably, the parameter associated with the location quotient, treated as endogenous, is statistically significant in all case studies and in the pooled data results.

Table 8-17

Changes in Firm Employment Levels, Estimation Results – Pooled Data

Variable	Definition	Pooled Data
L.lemp	Natural log of employment, t-1	0.827***
		(0.0110)
lsales	Natural log of sales, t	0.0809***
		(0.0201)
L.lsales	Natural log of sales, t-1	0.00225
		(0.0170)
lnlq	Natural log of location quotient	0.0452***
		(0.00492)
tr_ann_plan	Interaction term (treatment*ann_plan)	0.0238***
		(0.00311)
tr_constr	Interaction term (treatment*constr)	0.0281***
		(0.00359)
tr_open	Interaction term (treatment*open)	0.00704*
		(0.00321)
_cons	Intercept	0.213***
		(0.0432)
N	Sample size	124,274
AR(2) test (p-value)		0.25
Number of instruments		60
Hansen J test (p-value)		0.02
Time trend variables		yes
Sales fully endogenous and location quotient predetermined but not strictly exogenous.		

Note: Models include year dummy variables (not shown).
*Robust standard errors in parenthesis: * p<0.05; **p<0.01, ***p<0.001.*
Pre-planning phase (pre-plan) is baseline treatment phase.

Summary of Findings

Cincinnati Bell Connector

The study area is home to businesses operating in industry sectors including: manufacturing, wholesale and retail trade, insurance and finance, and educational and government services. The study area identifies several large corporations. Over time, the area experienced substantial changes in business composition and economic growth. The SIA is characterized by higher clustering of establishments than counterparts located in other areas of the county. These businesses employ, on average, more workers than similar businesses elsewhere.

Analyzing changes in the number of establishments provides robust evidence of agglomerative effects on business location patterns and employment levels that can be attributed to the streetcar system (Table 8-18). On the other hand, while the streetcar planning spurred business growth, it did not affect employment until the system entered the construction phase. This could be due to uncertainty surrounding the investment as demonstrated by the repeal initiatives that were undertaken during 2011. At Opening, business growth continued to increase with added businesses to the SIA, but without an impact on job growth. The lack of evidence of impact on employment changes at the firm level could be due to the relative small timeframe between the Opening phase and when this analysis was performed (i.e., only one year of employment data available at the time of this analysis).

Table 8-18

Impact on Business Activity, Summary of Results – Cincinnati Bell Connector

Project Phase	Number of Establishments	Employment
Announcement and Planning	6.4%	—
Design and Construction	23.0%	2.9%
Opening	12.7%	—

Note: Comparison is to Pre-planning phase.
— denotes lack of statistically significant evidence.

Charlotte CityLYNX Gold Line

The study area comprises businesses operating in industry sectors that are more clustered and specialized than counterparts located in other areas of the county. These businesses employ, on average, more workers than similar businesses elsewhere. For example, businesses offering ambulatory health services and establishments engaged in providing personal services have location quotients ranging from 2.5–2.9.

Analyzing changes in the number of establishments provides robust evidence of agglomerative effects on business location patterns and employment levels that can be attributed to the streetcar system (Table 8-19).

Table 8-19

Impact on Business Activity, Summary of Results – Charlotte CityLYNX Gold Line

Project Phase	Number of Establishments	Employment
Announcement and Planning	16.2%	2.5%
Design and Construction	25.2%	2.5%
Opening	13.2%	3.8%

Note: Comparison is to Pre-planning phase.

Sun Link Tucson Streetcar

The study area is home to businesses operating in industry sectors that are more clustered and specialized than counterparts located in other areas of the county. These businesses employ on average more workers than similar businesses elsewhere.

Analyzing changes in the number of establishments provides robust evidence of agglomerative effects on business location patterns that can be attributed to the streetcar system lasting through the construction phase (Table 8-20). The analysis of employment levels provides indication of job growth, which corresponds to a lagged response to the establishments' growth patterns. The opening phase coincides with a leveling of employment growth by about the same percentage, though the findings are not statistically significant when comparing growth in the SIA with growth in comparable areas.

Table 8-20

Impact on Business Activity, Summary of Results – Sun Link Tucson Streetcar

Project Phase	Number of Establishments	Employment
Announcement and Planning	9.1%	—
Design and Construction	19.8%	6.8%
Opening	—	1.8%

Note: Comparison is to Pre-planning phase.
— denotes lack of statistically significant evidence.

Atlanta Streetcar

The study area is home to businesses operating in industry sectors that are more clustered and specialized than counterparts located in other areas of the county. These businesses employed, on average, more workers than similar businesses elsewhere. For example, performing arts and spectator sports, as well as accommodations had location quotients ranging from 2.2–4.8.

When trying to establish causality between the streetcar investment and growth in the number of businesses, the analysis finds evidence of agglomerative effects starting at the Construction phase Table 8-21. Establishments located in the study area experienced a higher growth than comparable areas in Fulton County, ranging from 16.5 percent during Construction to 10.7 percent during Opening. Dynamic panel models accounting for streetcar effects on employment find that the streetcar investment determined changes in job growth at the firm level.

Since the project Announcement and through the Opening phase, the streetcar project is associated with an increase of about 3.0 percent in employment levels.

Table 8-21

Impact on Business Activity, Summary of Results – Atlanta Streetcar

Project Phase	Number of Establishments	Employment
Announcement and Planning	—	3.8%
Design and Construction	19.2%	3.0%
Opening	12.6%	—

Note: Comparison is to Pre-planning phase.
— denotes lack of statistically significant evidence.

Salt Lake Sugar House Streetcar

The study area is home to businesses operating in industry sectors that are more clustered and specialized than counterparts located in other areas of the county. These businesses employed, on average, more workers than similar businesses elsewhere. For example, miscellaneous retail shops have location quotients of 4.2.

The analysis finds evidence of agglomerative effects on business location patterns and employment levels that can be attributed to the streetcar system (Table 8-22). The number of establishments at Opening is estimated to be 20.3 percent higher than comparable areas located elsewhere in the county. In addition, at Opening, the SIA employment level grew at a higher rate (2.3%).

Table 8-22

Impact on Business Activity, Summary of Results – Salt Lake City S-Line

Project Phase	Number of Establishments	Employment
Announcement and Planning	—	3.0%
Design and Construction	24.4%	—
Opening	20.3%	2.3%

Note: Comparison is to Pre-planning phase.
— denotes lack of statistically significant evidence.

Pooled Data

When pooling all the case studies, the analysis shows that streetcar investments tend to experiences higher establishment growth than comparable areas, which increase as the projects mature from announcement and planning (6.8%) to construction (23.5%), with decreasing but lingering impacts at opening and during operation (18.3%). Pooled data dynamic panel models of firm-level employment provide similar evidence, showing positive impacts ranging from 2.4 percent at announcement and planning to less than one percent at opening and operation. The presence of the lagged adjustment in employment (0.83) allows estimating the long run impact on employment growth. Using the pooled estimates at opening (0.7%). In the long-run, the estimated impact on firm-level employment growth is about 4.2 percent.

Table 8-23

Impact on Business Activity, Summary of Results –Pooled Data

Project Phase	Number of Establishments	Employment
Announcement and Planning	6.8%	2.4%
Design and Construction	23.5%	2.8%
Opening	18.3%	0.7%

Note: Comparison is to Pre-planning phase.
— denotes lack of statistically significant evidence.

SECTION

9

Impacts on Workers and Households Accessibility

The construction of the streetcar system can provide additional accessibility gains to households and workers residing in the area as well as workers coming to the area from the rest of the county. To measure changes in job accessibility and household travel times, this study developed a series of multimodal network models that generate zone-to-zone travel time matrices. Using the network models, the analysis estimated two travel time sheds: one with all available transit modes and one excluding the streetcar. The transit time sheds reflect average weekday peak and off-peak travel conditions specific to the SIAs.

The accessibility analysis relies on transit travel time data obtained from (1) Google automated protocol interface (Google Directions API) and (2) a zone-to-zone transit-travel time matrix via a simulation network model running within ArcGIS ArcMap using General Transit Feed Specification (GTFS) data feeds. The origin/destination (O/D) matrix estimates travel patterns with households as origins and businesses as destinations, using a shortest travel-time path. Walking speed is assumed at 3 miles per hour, and the streetcar travels at design speed. Travelers walking can use the street network in both directions or use the streetcar following the system route direction. The O/D matrix allows computing changes in travel times and defines two travel time sheds: one where locations are accessed by walk, bus, light rail (if available) and streetcar, and one excluding the streetcar. The transit time sheds reflect average weekday peak and off-peak travel conditions specific to the SIAs.

Household data come from the Infogroup residential database, which provide information on households, such as address-level location, socio-demographic and life-cycle information over the 2007–2016.

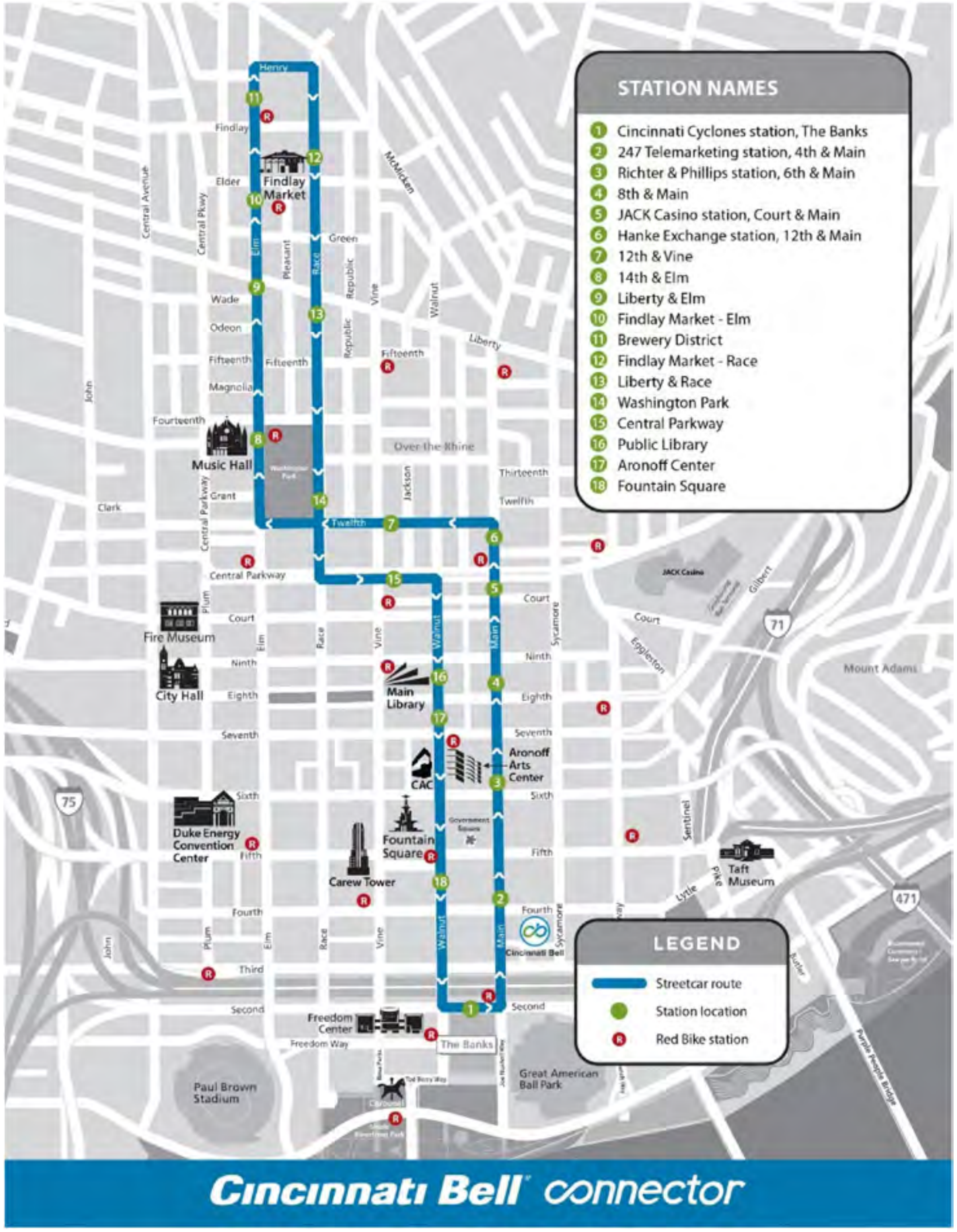
Cincinnati Bell Connector

The streetcar system (Figure 9-1) was conceived to provide additional accessibility to households and workers residing in the area as well as workers coming to the area from the rest of the county. The SIA is well served by METRO's extensive network of bus fixed routes, consisting of 26 local-service and 19 express routes fixed-route bus lines.[56] Several bus routes serve the SIA with service running every 15–30 minutes during weekdays and every 30–60 minutes during weekends.

[56] http://www.go-metro.com/about-metro/about2/copy-of-southwest-ohio-regional-transit-authority.

Figure 9-1

Streetcar Route – City Cincinnati Bell Connector



Source: http://www.cincinnati-oh.gov/streetcar/

The accessibility analysis relies on transit travel time data obtained from a zone-to-zone transit-travel time matrix via a simulation network model running within ArcGIS ArcMap using GTFS data feeds.[57] The O/D matrix estimates travel patterns with households as origins and businesses as destinations, using a shortest travel-time path. Walking speed is assumed at 3 miles per hour and

[57] The procedure is explained in Appendix B.

the streetcar at 20 miles per hour (as per design). Travelers walking can use the street network in both directions, but they use the streetcar following the system route direction. The O/D matrix allows computing changes in travel times and defines two travel time sheds: one where locations are accessed by walk, bus, and streetcar, and one excluding the streetcar.

Household Location Patterns

Information on households comes from the Infogroup dataset and covers the period 2007–2016. Table 9-1 summarizes the sample descriptive statistics for 2016. The table shows that about 90 percent of the 7,900 sampled households consist of single-head families, with about 18 percent having one or more child. About 13.0 percent of households have at least one member that is age 65 or older. The majority resides in rental units (72.5%) with a mean length of residence of about 7.6 years. About 8.9 percent of the household receive an annual income at or above the metropolitan statistical area median income.[58] Fewer than 1 percent of the households belong to the top 5 percent distribution of income.[59] A relevant proportion of SIA households live at or below the U.S. Census poverty threshold (about 38.4%).[60]

Table 9-1

Household Sample Descriptive Statistics – Cincinnati Bell Connector SIA

Definition	Mean	Std. Dev.	Min	Max
Household income ($000)	22,674	24,948	5,000	500,000
Households at or above top 5% income distribution	0.003	0.053	0.000	1.000
Households at or above median income	0.089	0.284	0.000	1.000
Households at or below poverty threshold	0.384	0.486	0.000	1.000
Length of residence (yrs)	7.655	7.878	1.000	55.000
Household size	1.365	0.902	1.000	7.000
Household head married	0.098	0.297	0.000	1.000
Household head single	0.902	0.297	0.000	1.000
Household head age 65 and older	0.125	0.331	0.000	1.000
With children	0.183	0.387	0.000	1.000
Number of children	2.092	1.147	1.000	6.000
Property owner	0.176	0.381	0.000	1.000
Property renter	0.725	0.447	0.000	1.000

[58] According to ACS 2011–2015 5-Year Estimates (Series 1901), median household income for Cincinnati (OH-KY-IN) Metropolitan Statistical Area was $55,501.

[59] For the entire sample (treatment and control), the top 5 percent of household in 2016 received $141,000 per year.

[60] The U.S. Census Bureau publishes annual average weighted poverty threshold estimates, available at https://www.census.gov/data/tables/time-series/demo/income-poverty/historical-poverty-thresholds.html.

During 2007–2016, the percent of households by income group fluctuated in response to changes in generalized economic and local conditions (Figure 9-2). In 2016, the percent of households living at or below the U.S. Census poverty threshold is higher than in 2007, and the percent of households at or above the MSA median income and households on the top 5 percent of the income distribution declined. Overall, the figures indicate the SIA is still coming to grips with the aftermath of the Great Recession of 2008–2009 and underlying structural changes endemic to the area.

Figure 9-2

Percent of Households by Income Group, 2007 and 2016 – Cincinnati Bell Connector SIA

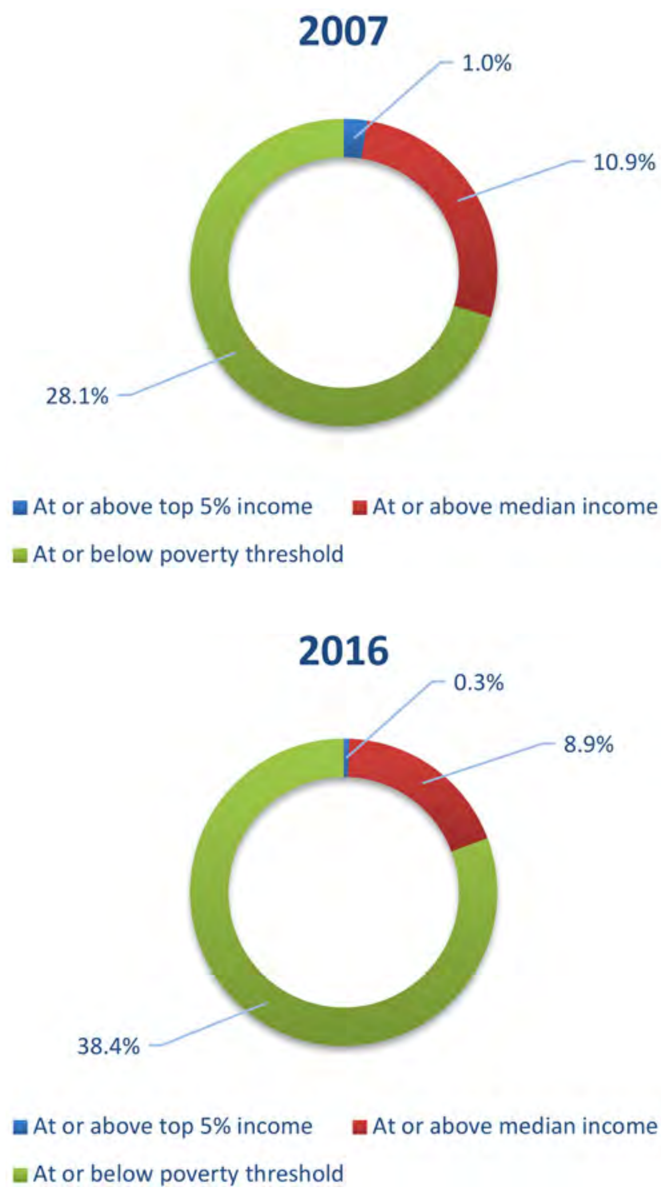


Figure 9-3 does not include any information about the spatial distribution of households by income group within the study area. Spatial kernel surfaces provide a useful method for evaluating changes in the distribution of households in space and time. Kernel methods generate density surfaces that show where point features are concentrated. In this analysis, the surfaces evaluate the density of households measured in the number of households per acre, comparing the streetcar announcement year (2010) to the year after opening (2016).

Figure 9-3

Spatial Density of Households at or Below Poverty Threshold – Cincinnati Bell Connector – 2010

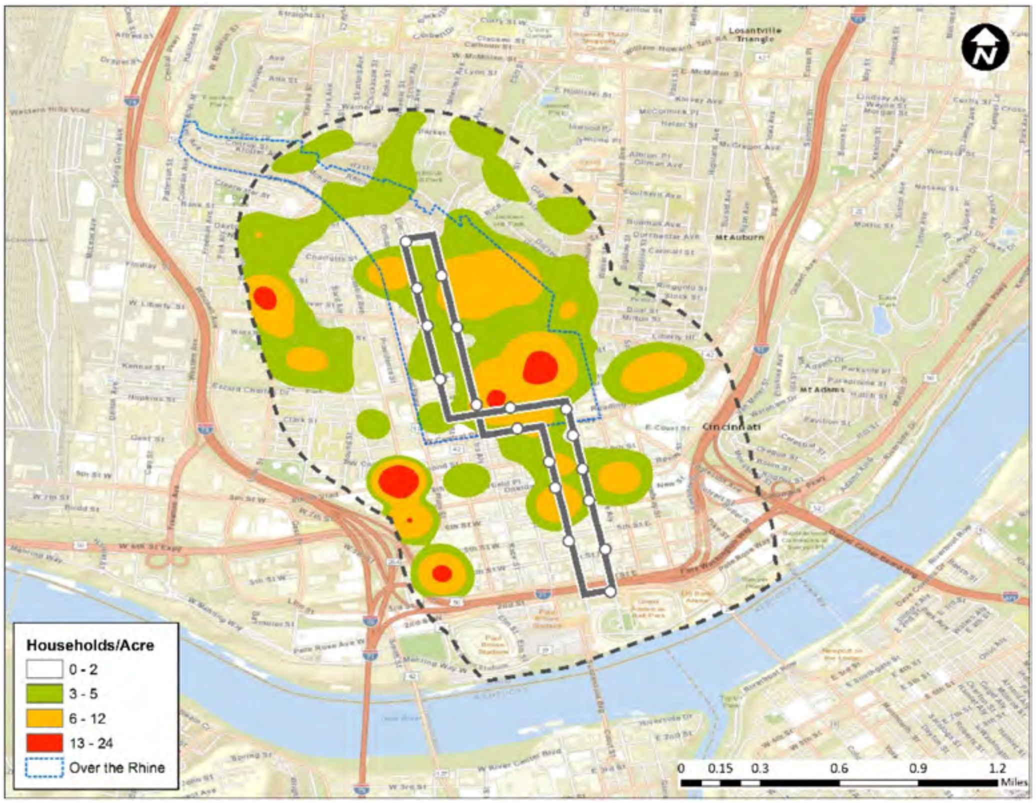
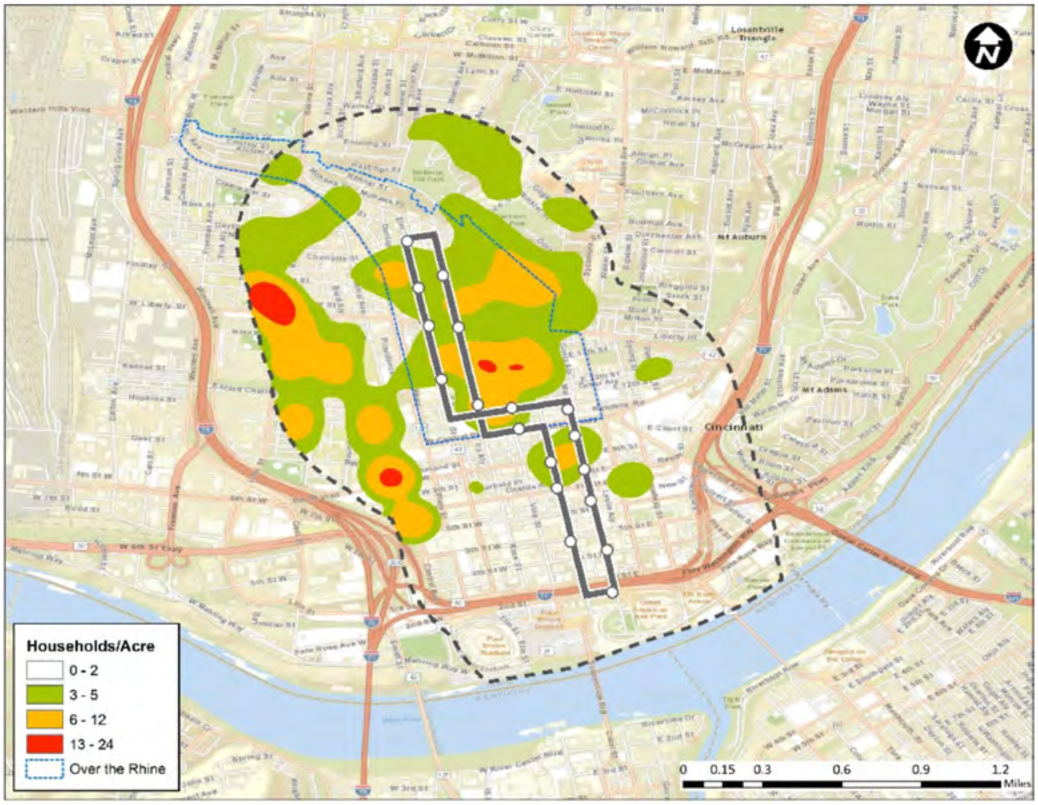


Figure 9-3 and Figure 9-4 display the spatial density estimates of households at or below the threshold of poverty. In 2010, these households appear to appear be more widespread in the study area and more clustered in the OTR historic district. By 2016, the clustering at OTR decreased substantially, and it increased on its fringes on the eastern portion of the SIA. These seems to indicate a spatial reallocation farther away from the streetcar alignment because, historically, the percent of household at or below the threshold of poverty has not declined.

Figure 9-4

Spatial Density of Households at or Below Poverty Threshold – Cincinnati Bell Connector – 2016



In 2010, households at or above median MSA income were clustered in housing located further from the streetcar, and in 2016 the cluster formations appear all over the SIA, with the highest density recorded in proximity of the streetcar. These changes in location patterns are most likely the result of changes in housing stock as discussed in Section 5.

In 2010, these households were mostly concentrated in condominium units on the eastern portion of the SIA (Figure 9-5). In 2016, they appear clustered in the CBD area and closer to the streetcar alignment (Figure 9-6).

Figure 9-5

Spatial Density of Households at or above Median MSA Income – Cincinnati Bell Connector SIA – 2010

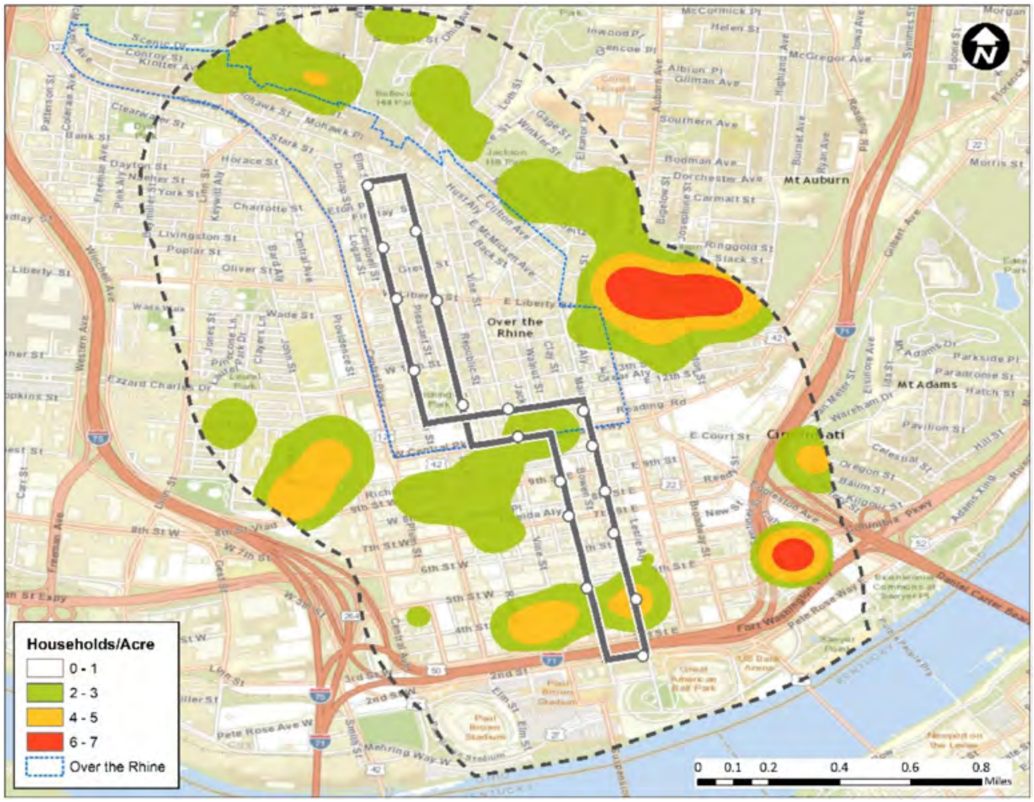


Figure 9-6

Spatial Density of Households at or above Median MSA Income – Cincinnati Bell Connector SIA – 2016

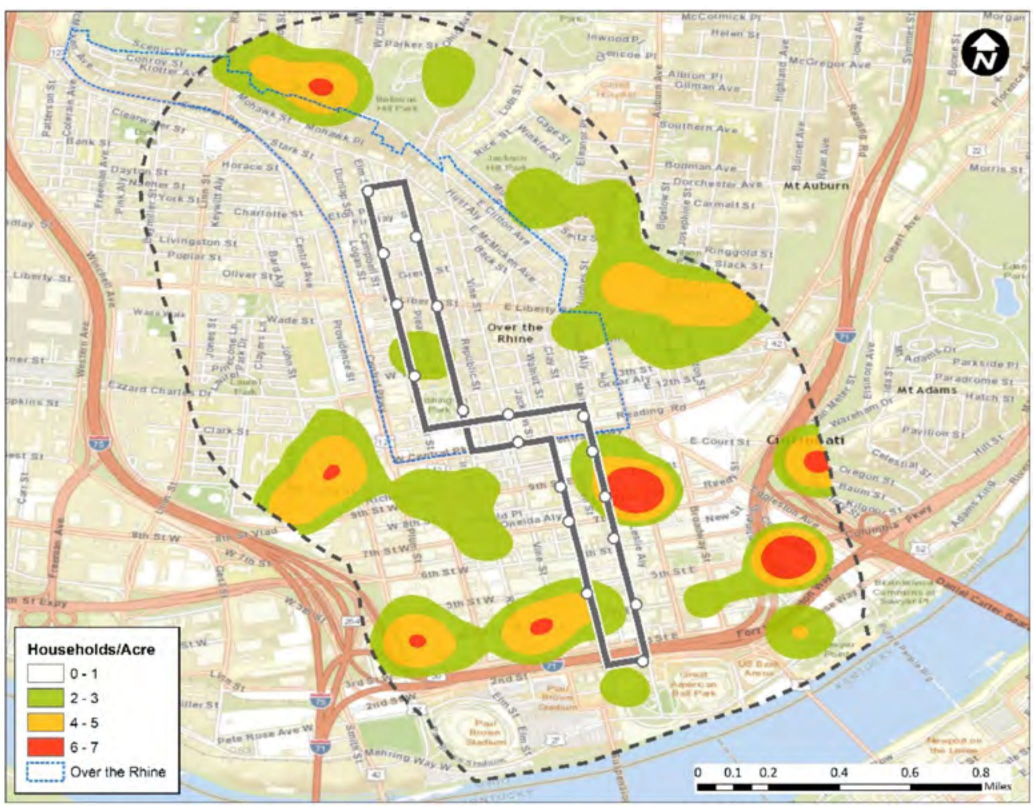


Figure 9-7 and Figure 9-8 show the density maps of households at the top 5 percent income distribution and illustrate a marked change in spatial dispersion or density. The percentage of households in the upper income quartile decreased from 1 to 0.3 percent during 2010–2016.

Figure 9-7

Spatial Density of Households at or above Top 5% Income Distribution – Cincinnati Bell Connector SIA – 2010

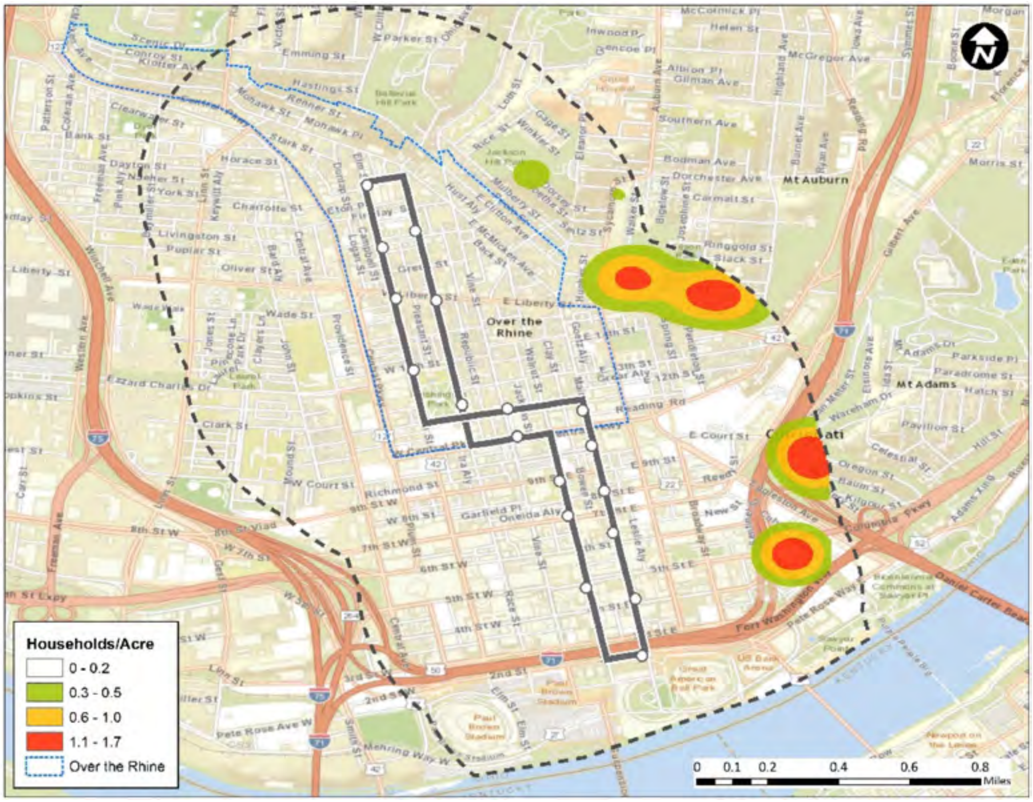
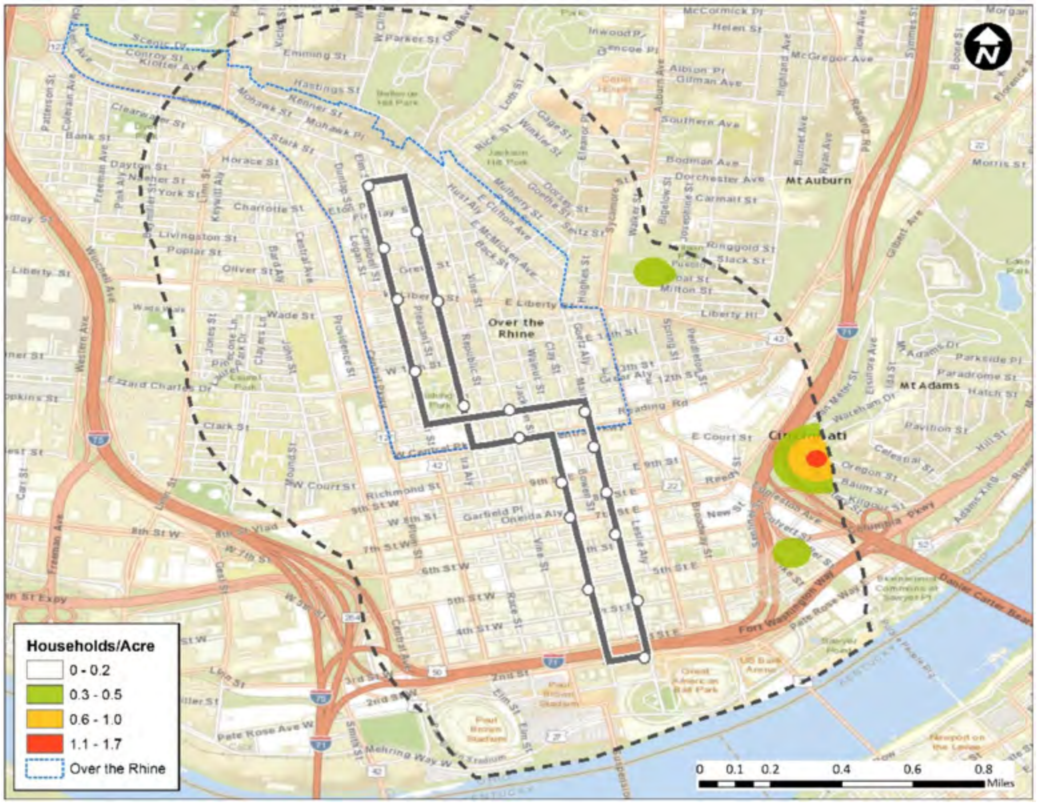


Figure 9-8

Spatial Density of Households at or above Top 5% Income Distribution – Cincinnati Bell Connector SIA – 2016



Changes in Job Accessibility

To understand how the streetcar system might influence household accessibility to job location and non-work activities, it is relevant to obtain information on commute travel patterns. The U.S. Census Bureau Longitudinal Employer-Household Dynamics (LEHD) program allows conducting spatial analysis of workers' commuting patterns by combining federal, state, and Census Bureau data on employers and employees. Through the *OnTheMap* program, a user can import GIS-produced shapefiles identifying specific study areas (i.e., streetcar influence area) and analyze worker/job commuting patterns. The most recent data are for 2014, released in March 2016. The analysis used LEHD to obtain a baseline picture of workers' travel patterns to and from the SIA.

Using the GIS polygon defining the SIA, Table 9-2 summarizes the results of the LEHD analysis. The table provides a baseline picture of workers' travel patterns. According to LEHD, there are 67,479 workers in the SIA, with 7,161 workers living within the SIA and 65,806 working in the SIA, but living elsewhere. Of those living in the SIA, about 23 percent (1,673) work and reside within its boundaries. About 52 percent of those workers living in the SIA but working elsewhere travel less than 10 miles, and 85 percent travel up to 24 miles. About 27 percent of all workers commute within the boundaries of the city of Cincinnati.

Table 9-2

LEHD Commuting Patterns Analysis – Cincinnati Bell Connector SIA

Workers	2014
Living in SIA	7,161
Working and living in SIA	23.36%
Living in SIA and working elsewhere	76.64%
Earning $1,250 per month or less	29.40%
Traveling less than 10 miles	67.87%
Traveling 1–24 miles	18.98%
Working in Cincinnati	46.92%
Working in SIA, living elsewhere	65,806
Earning $1,250 per month or less	16.28%
Traveling less than 10 miles	52.07%
Traveling 10–24 miles	33.23%
Working in Cincinnati	22.71%

The household information of Table 9-1 and the travel pattern numbers of Table 9-2 form the form the basis for evaluating the impact of the streetcar system on job accessibility. In particular, the analysis focuses on households at or below the U.S. Census poverty threshold. These families are more likely to use the public transportation system either to commute to and from work or to reach non-work locations within and outside the study area.

The estimation of travel time sheds, with and without the streetcar, is based on a transportation network simulated in ArcMap, which employs METRO's general transit feed specification (GTFS) data. GTFS data include information on all bus stops, routes, trips, and schedule data.[61] Using a multiple-origin, multiple-destination algorithm, the network model computes shortest paths based on specified cutoff times or uses a fixed number of closest destinations to produce an origin-destination (O/D) matrix. To estimate accessibility changes from the streetcar operation, the following sections use household residential location units as origin points and business locations as destinations.

Household Job Accessibility

Using the network model, the analysis estimated two travel time sheds: one with walking, bus, and streetcar and one excluding the streetcar. Trip origins are based on the clustering patterns of households at or below the U.S. Census poverty threshold, as shown in Figure 9-4. The time sheds are based on the morning peak hour departing time and 10-minute intervals. The size and shape of the time sheds are a function of the multimodal network, which considers streetcar bus routes, stops, scheduling options, and feasible walking routes. The estimation of the travel time sheds is limited only by the extent of the GTFS data coverage.

[61] http://www.go-metro.com/about-metro/developer-data.

Figure 9-9 shows the travel time shed without the streetcar, and Figure 9-10 shows the travel time shed with the streetcar serving as an accelerator to walking and bus, with the small dots representing businesses. The travel time sheds are almost identical, meaning that the streetcar does not provide added accessibility in the SIA beyond what already provided by the current transit network.

Figure 9-9

Travel Time Shed and Job Accessibility – Cincinnati Bell Connector – No Streetcar

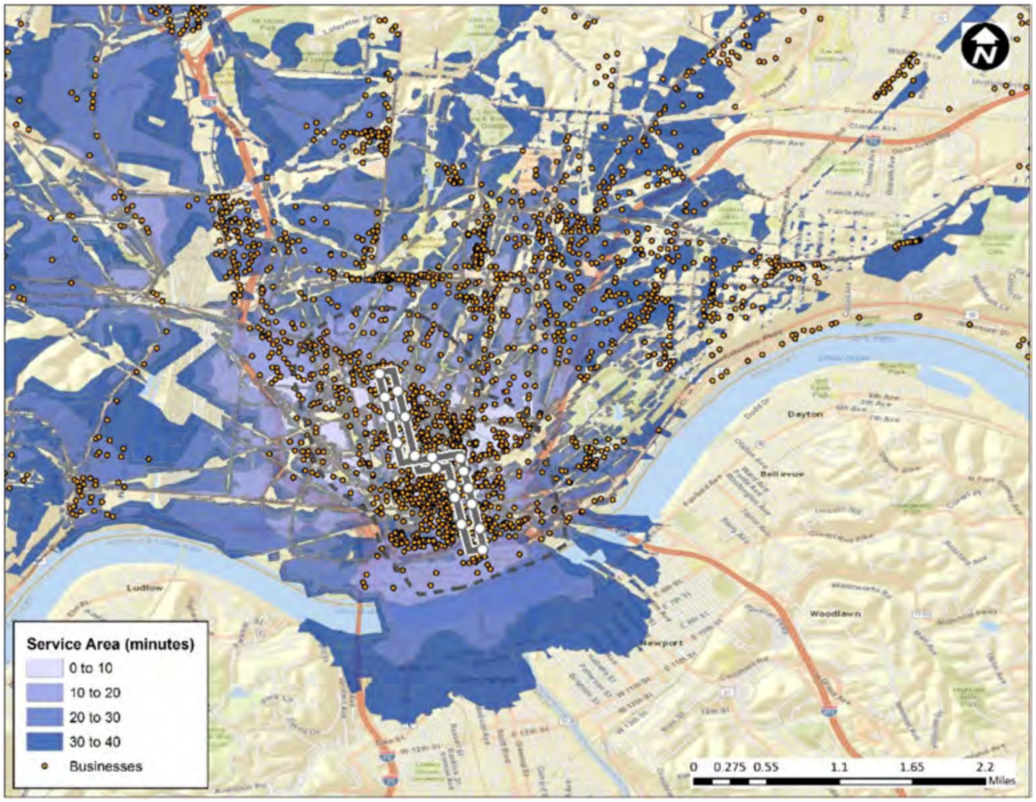


Table 9-3 shows that the streetcar does not provide discernible gains in accessibility to businesses and jobs located within five minutes of the household residential units. The gains in job accessibility and accessibility to non-work activities (e.g., shopping and recreational activities) seem to increase once travel time extends beyond a 10-minute trip, though the differences are not statistically significant.

Figure 9-10

Travel Time Shed and Job Accessibility – Cincinnati Bell Connector – Streetcar

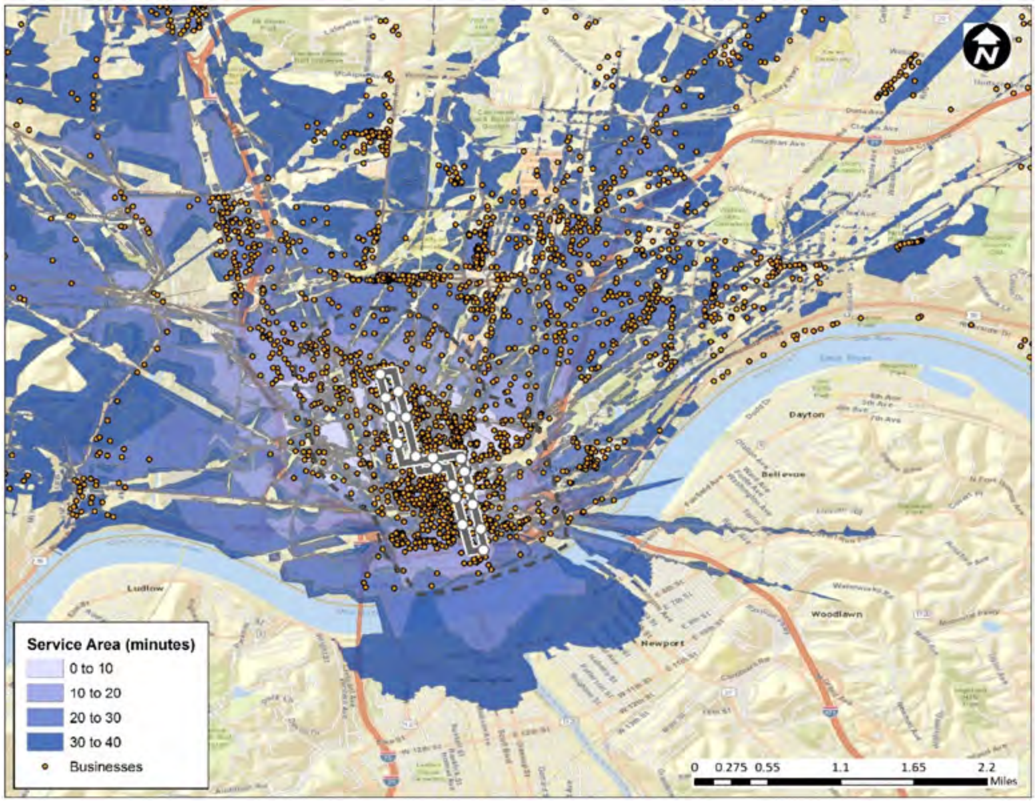


Table 9-3 *Streetcar Impact on Travel Time Shed and Job Accessibility – Cincinnati Bell Connector*

Travel Time (min)	No Streetcar			Streetcar			Difference		
	Service Area (sq.mi.)	*Business (#)*	*Jobs (#)*	*Service Area (sq.mi.)*	*Business (#)*	*Jobs (number)*	*Service Area (sq.mi.)*	*Business (#)*	*Jobs (#)*
0 to 10	0.44	360	3,124	0.45	384	3,265	0.01	24	141
10 to 20	3.85	1,491	29,352	3.91	1,554	29,867	0.06	63	515
20 to 30	14.95	2,711	59,414	15.03	2,701	57,980	0.08	-10	-1,434
30 to 40	43.28	4,357	98,480	43.35	4,481	99,064	0.07	124	584

Changes in Household Travel Times

Table 9-4 reports the network simulation of household travel times from the household residential units to each establishment in the Infogroup database used in the analysis in Section 7It assumes two starting times: one in the AM peak period (8:30 AM) and one in the off-peak period (2:00 PM). The results show that the streetcar does not provide added travel time benefits to households living in the SIA in terms of mean travel times. There is some variation in the sample, showing that some households do experience savings as shown by the maximum amount of travel time saved equivalent to about 23 minutes. It appears that because of their location, the top 5 percent earners experience fewer gains than the rest of the sample.

Table 9-4

Household Travel Time Savings – Cincinnati Bell Connector

Departure Time	Peak (8:30 AM)			Off-peak (2:00 PM)		
	Mean	*Min*	*Max*	*Mean*	*Min*	*Max*
All households	0.86	0.00	7.04	1.00	0.00	23.43
At or above top 5% income	0.28	0.01	0.59	0.71	0.00	1.46
At or above median income	0.56	0.00	5.49	1.39	0.00	23.43
At or below poverty threshold	0.71	0.00	7.04	1.48	0.00	23.43

As an alternative to the network simulation, the following analysis employs Google's Direction automated program interface (API). Google Directions API relies on GTFS transit feeds and allows batch processing of origin/destination travel distances and travel times.[62] The API service computes directions between locations by specifying origin and destination by either address or latitude and longitude coordinates. Detailed trip information can be obtained in batch-mode processing for multiple observations with output provided in JavaScript Object Notation (JSON). The use of ad-hoc text parsing macro modules working in SAS allows batch-mode extracting relevant trip information from the JSON file.

The trip origin is the household residential unit, and the destination is Findlay Market located in the OTR district. Findlay Market is one of Ohio's oldest public markets, representing a focal point of attraction and gathering place for locals and tourists.[63] The analysis compares two modal alternatives: (1) bus and (2) bus and streetcar. Route choice is based on minimizing the total travel time (option "best route"), without imposing a walking time-distance threshold between modes (Google's API allows selecting an option that accounts for the preference "less walking"). The SAS script batch processes travel times for all households in the 2016 Infogroup sample (7,920 households) at the scheduled time of 8:30 AM on a weekday.

[62] https://developers.google.com/maps/documentation/directions/intro.

[63] http://www.findlaymarket.org/about.

Table 9-5 reports the mean and maximum household travel time savings by income cohort, and Figure 9-11 shows where they occur most often in the SIA. About 18.6 of the households enjoy some travel time savings, ranging from 1 to 5 minutes.

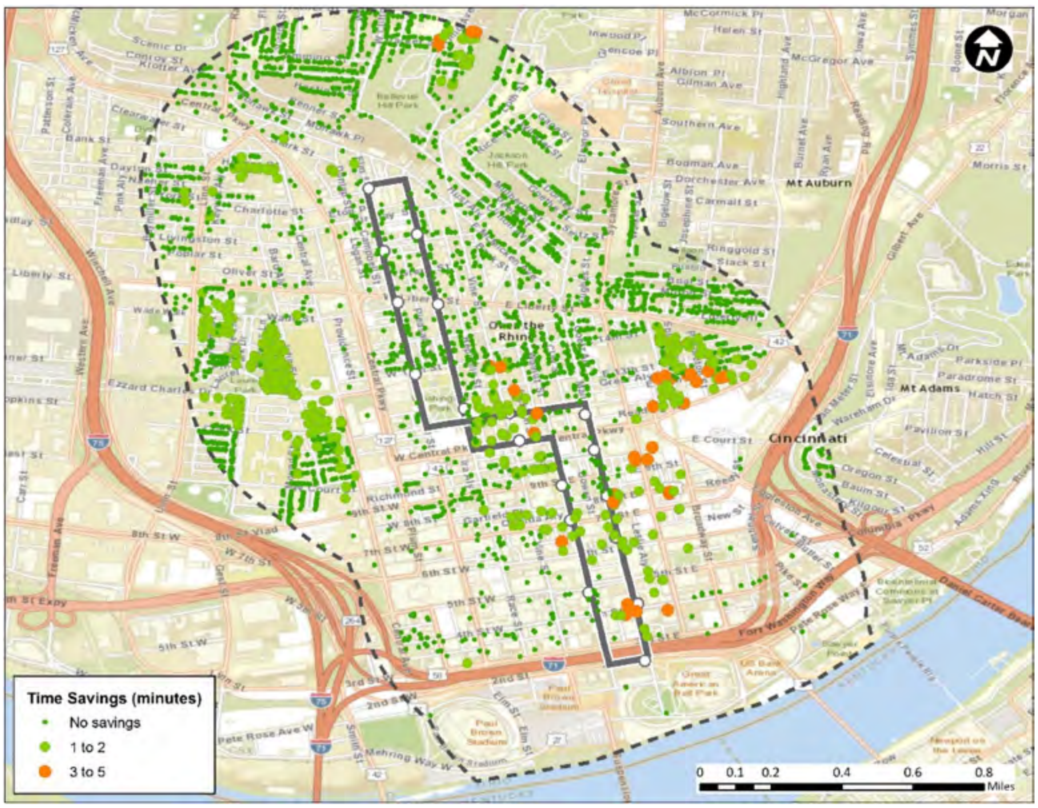
Table 9-5

Household Travel Time Savings: Travel to Findlay Market – Cincinnati Bell Connector

Departure Time	Percent with Time Savings	Mean	Min	Max
All households	18.6%	1.57	1.00	5.00
At or above top 5% income	9.1%	2.50	2.00	3.00
At or above median income	15.4%	1.71	1.00	3.00
At or below poverty threshold	18.5%	1.38	1.00	4.00

Figure 9-11

Household Travel Time Savings to Findlay Market – Cincinnati Bell Connector



Charlotte CityLYNX Gold Line

The streetcar system was conceived to provide additional accessibility to households and workers residing in the area as well as workers coming to the area from the rest of the county. The SIA is well-served by the Charlotte Area Transit System (CATS) extensive network of fixed-route bus and light rail. The CATS system consists of 73 fixed-route bus lines and one light rail line, the LYNX Blue Line. The LYNX Blue Line is 9.6 miles long and operates from I-485 at South

Boulevard to Seventh Street in Center City Charlotte. Several bus routes serve the SIA, with service running every 15–30 minutes during weekdays and every 30–60 minutes during weekends. In addition, CATS provides free rides through the LYNX Gold Line (Figure 9-12), connecting the LYNX Blue Line and the Charlotte CBD. The LYNX Red Line operates every 15 minutes during weekdays.

Figure 9-12 *Streetcar Route – CityLYNX Gold Line*

The accessibility analysis relies on transit travel time data obtained from (1) Google automated protocol interface (Google Directions API) and (2) a zone-to-zone transit-travel time matrix via a simulation network model running within ArcGIS ArcMap using GTFS data feeds. The O/D matrix estimates travel patterns with households as origins and businesses as destinations, using a shortest travel-time path. Walking speed is assumed at 3 miles per hour, and the streetcar travels at 20 miles per hour (as per design). Travelers walking can use the street network in both directions or use the streetcar following the system route direction. The O/D matrix allows computing changes in travel times and defines two travel time sheds: one where locations are accessed by walk, bus, and streetcar and one excluding the streetcar.

Household Location Patterns

Information on households comes from the Infogroup dataset and covers the period 2007–2016. Table 9-6 summarizes the sample descriptive statistics for 2016. The table shows that about 84 percent of the 5,200 sampled households consists of single-head families, with about 11 percent having one or more child. About 9 percent of households have at least one member that is age 65 or older. The majority resides in rental units (45.6%), with a mean length of residence of about 6.6 years. About 61 percent of the households receive an annual income at or above the metropolitan statistical area median income.[64] About 2

[64] According to ACS 2011–2015 5-Year Estimates (Series 1901), median household income for Charlotte-Gastonia-Concord Metropolitan Statistical Area was $53,168.

percent of the households live at or below the U.S. Census poverty threshold (about 38.4%).[65] About 8 percent of the households belong to the top 5 percent distribution of income.[66]

During 2007–2016, the percent of households by income group fluctuated in response to changes in generalized economic and local conditions (Figure 9-13).

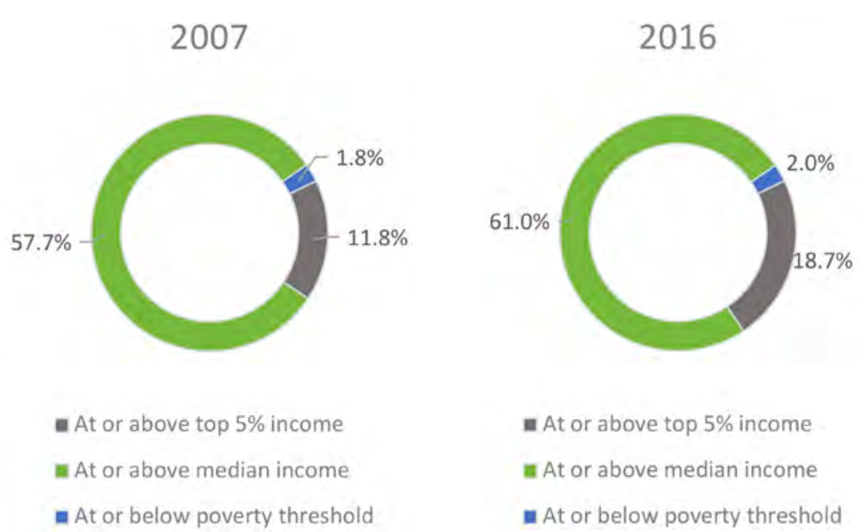
Table 9-6

Household Sample Descriptive Statistics – Charlotte CityLYNX SIA

Definition	Mean	Std. Dev.	Min	Max
Household income ($,000)	89.43	75.22	5.00	500.00
Households at or above top 5% income	0.08	0.27	0.00	1.00
Households at or above median income	0.61	0.49	0.00	1.00
Households at or below poverty threshold	0.02	0.14	0.00	1.00
Length of residence (yrs)	6.60	8.51	1.00	56.00
Household size	1.29	0.71	1.00	8.00
Household head married	0.16	0.36	0.00	1.00
Household head single	0.84	0.36	0.00	1.00
Household head age 65 and older	0.09	0.29	0.00	1.00
With children	0.11	0.31	0.00	1.00
Number of children	1.80	0.93	1.00	6.00
Property owner	0.35	0.48	0.00	1.00
Property renter	0.45	0.50	0.00	1.00

Figure 9-13

Percent of Households by Income Group, 2007 and 2016 – Charlotte CityLYNX SIA



[65] The U.S. Census Bureau publishes annual average weighted poverty threshold estimates, available at https://www.census.gov/data/tables/time-series/demo/income-poverty/historical-poverty-thresholds.html.

[66] For the entire sample (treatment and control), the top 5 percent of household in 2016 received $242,000 per year.

The percent of households living at or below the U.S. Census poverty threshold remained almost unchanged, and the percent of households at or above the MSA median income and households on the top 5 percent of the income distribution increased.

Figure 9-13 does not provide any information about the spatial distribution of households by income group within the study area. Spatial kernel surfaces provide a useful method for evaluating changes in the distribution of households in space and time. Kernel methods generate density surfaces that show where point features are concentrated. In this analysis, the surfaces evaluate the density of households measured in the number of households per acre, comparing the streetcar announcement year (2010) to the year after opening (2016).

Figure 9-14 and Figure 9-15 display the spatial density estimates of households at or below the threshold of poverty. These figures seem to indicate a spatial reallocation within the SIA, because, historically, the percent of households at or below the threshold of poverty has not declined, as indicated in Figure 9-13.

Figure 9-14

Spatial Density of Households at or below Poverty Threshold – Charlotte CityLYNX SIA – 2010

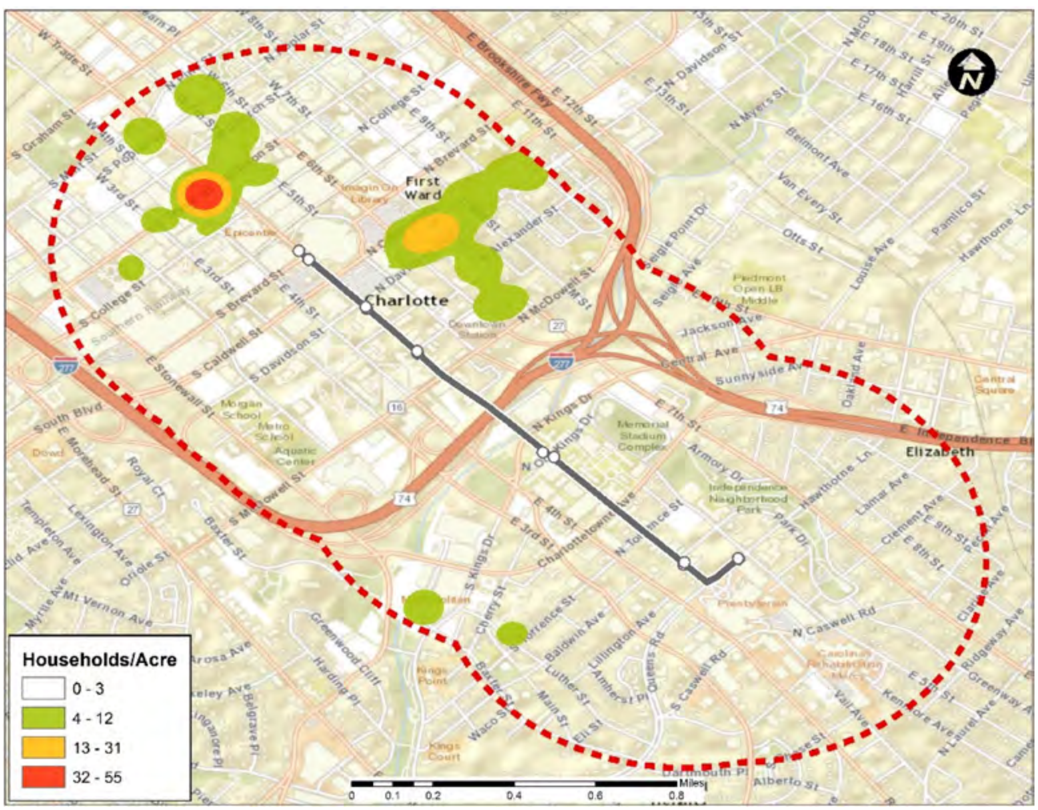


Figure 9-15

Spatial Density of Households at or below Poverty Threshold – Charlotte CityLYNX SIA – 2016

Figure 9-16 and Figure 9-17 represent density maps of households at or above median MSA income. In 2010, most households were concentrated in Charlotte CBD and in the northern part of the SIA in proximity to the University of North Carolina. In 2016, the density in this area increased substantially within the same area and in closer proximity to the streetcar alignment.

Figure 9-18 and Figure 9-19 represent the density maps of households at the top 5 percent income distribution and reflect a marked change in density. These households are concentrated in the northern section of the SIA, east of the University of North Carolina. The percentage of households in the upper income quartile increased from 11.8 to 18.7 percent during 2010–2016.

Figure 9-16

Spatial Density of Households at or above Median MSA Income – Charlotte CityLYNX SIA – 2010

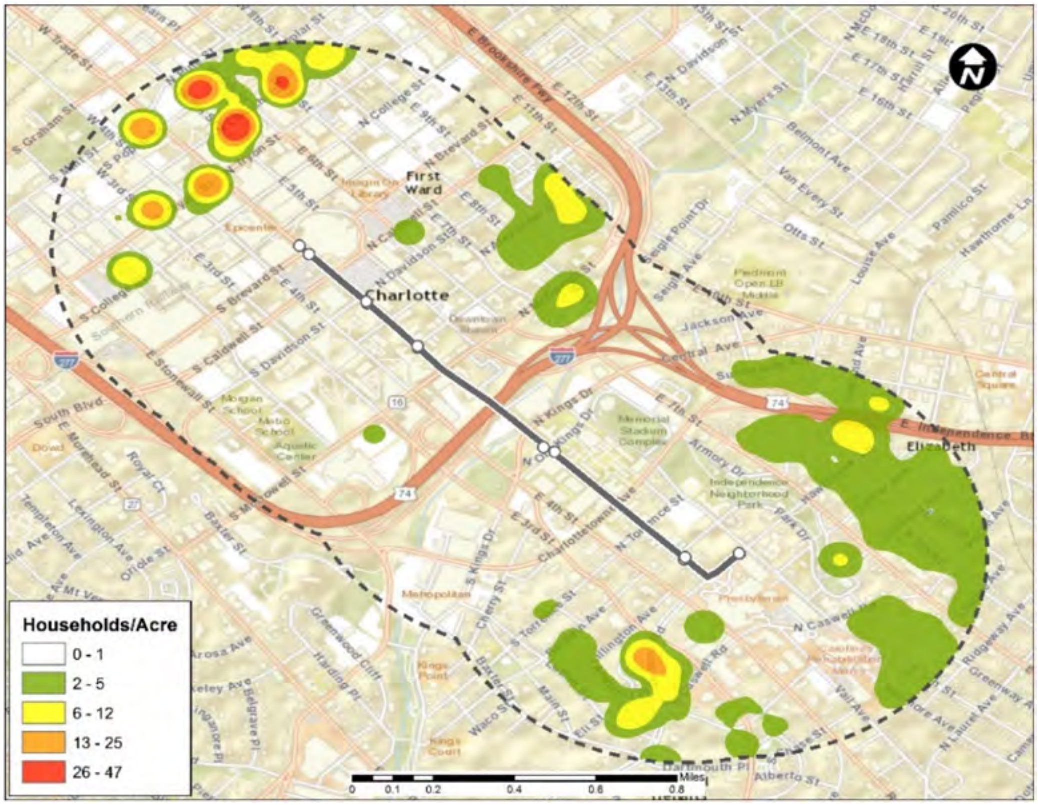


Figure 9-17

Spatial Density of houSeholds at or above Median MSA Income – Charlotte CityLYNX SIA – 2016

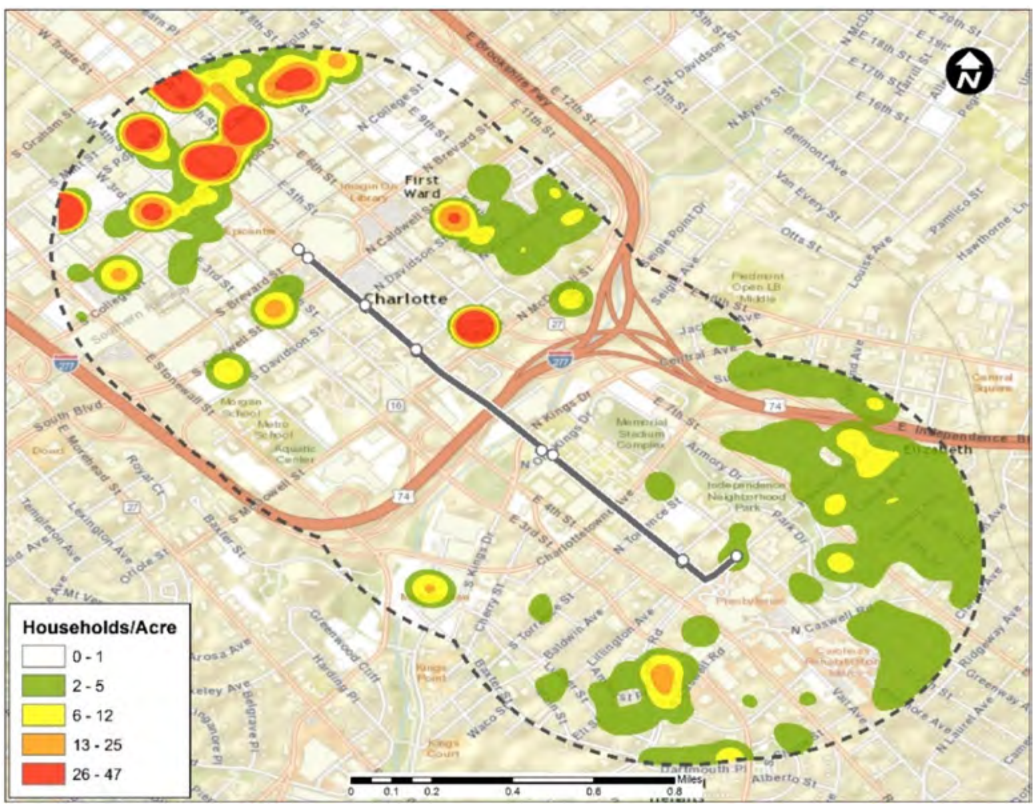


Figure 9-18

Spatial Density of Households at or above Top 5% Income Distribution – Charlotte CityLYNX SIA – 2010

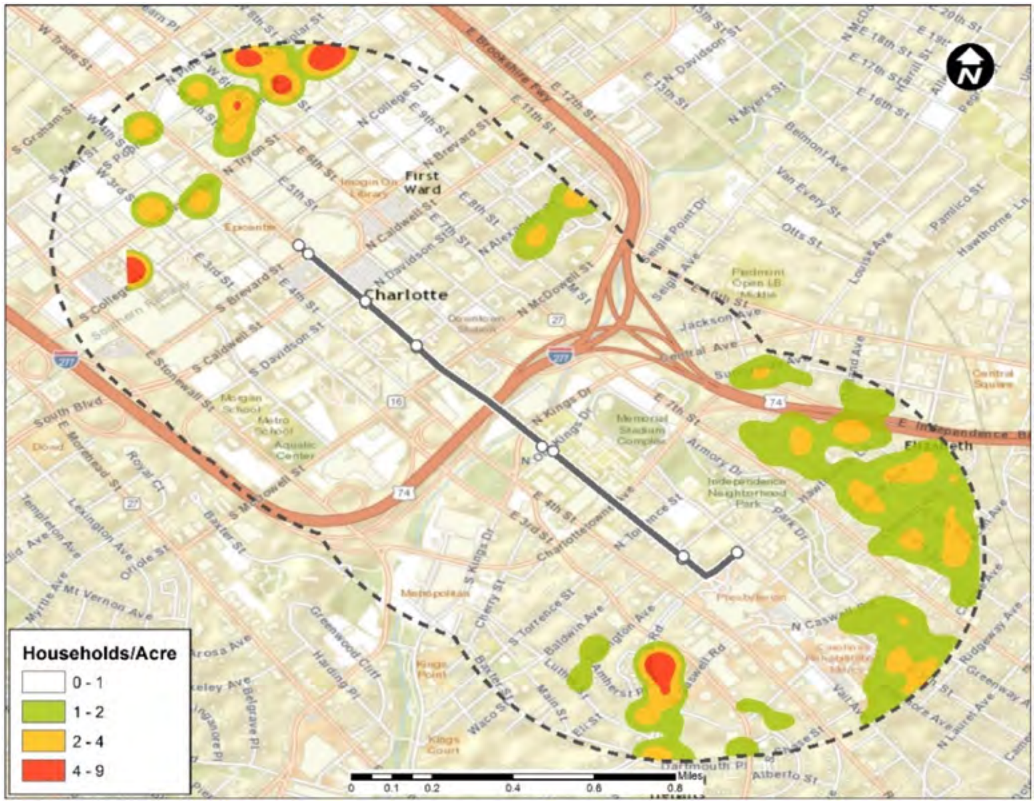
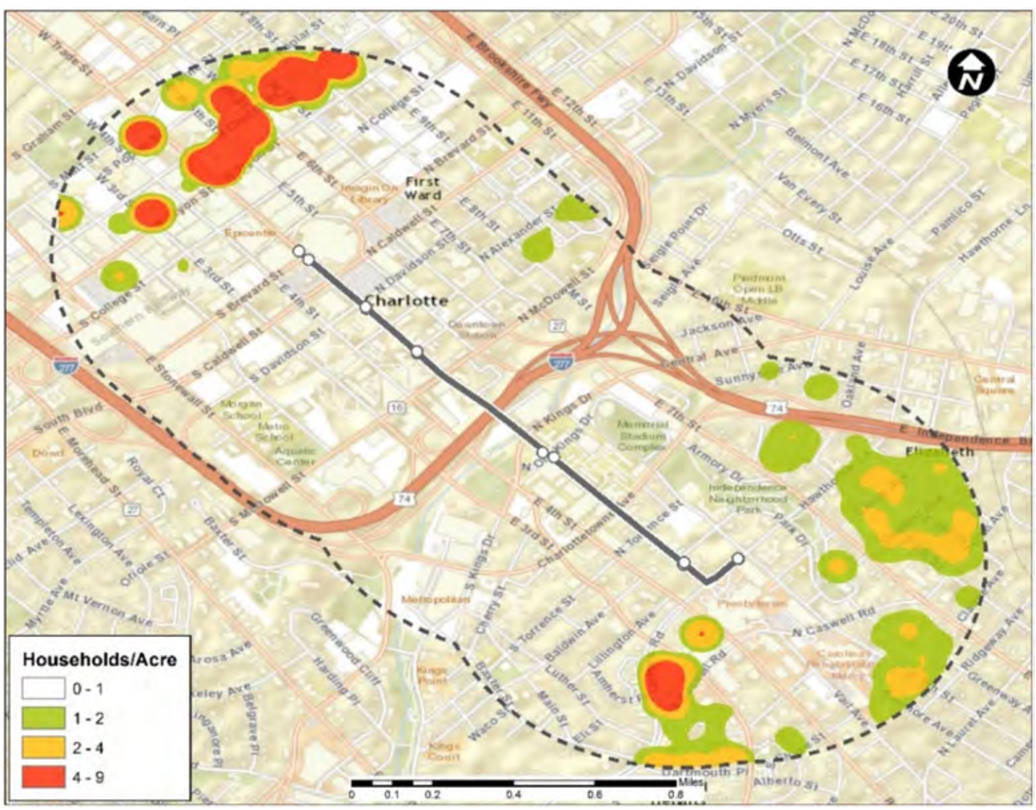


Figure 9-19

Spatial Density of Households at or above Top 5% Income Distribution – Charlotte CityLYNX SIA – 2016



Changes in Job Accessibility

To understand how the streetcar system might influence household accessibility to job location and non-work activities, it is relevant to obtain information on commute travel patterns. The LEHD program allows the conduct of a spatial analysis of workers' commuting patterns by combining federal, state, and Census Bureau data on employers and employees. Through the *OnTheMap* program, a user can import GIS-produced shapefiles identifying specific study areas (i.e., streetcar influence area) and analyze worker/job commuting patterns. The most recent data are for 2014 and were released in March 2016. The analysis used LEHD to obtain a baseline picture of workers' travel patterns to and from the SIA.

Using the GIS polygon defining the SIA, Table 9-7 summarizes the results of the LEHD analysis. The table provides a baseline picture of workers' travel patterns. According to the LEHD, there are 55,000 workers in the SIA, with 4,251 workers living within the SIA and 87,965 working in the SIA but living elsewhere. Out of those living in the SIA, about 24 percent (1,025) work and reside within its boundaries. About 65 percent of those workers living in the SIA, but working elsewhere, travel less than 10 miles, and 68 percent travel up to 24 miles. About 67 percent commute within the boundaries of the city of Charlotte.

Table 9-7

LEHD Commuting Patterns Analysis – Charlotte CityLYNX SIA

Workers	2014
Living in SIA	4,251
Working and living in SIA	24.1%
Living in SIA and working elsewhere	75.9%
Earning $1,250 per month or less	15.0%
Traveling less than 10 miles	65.0%
Traveling 10–24 miles	3.0%
Working in Charlotte	67.1%
Working in SIA, living elsewhere	87,965
Earning $1,250 per month or less	9.3%
Traveling less than 10 miles	41.1%
Traveling 10–24 miles	38.4%
Working in Charlotte	47.4%

The household information of Table 9-6, and the travel pattern numbers of Table 9-7 form the basis for evaluating the impact of the streetcar system on job accessibility. In particular, the analysis focuses on low-income households. These families are more likely to use the public transportation system either to commute to and from work or to reach non-work locations within and outside of the study area.

The estimation of travel time sheds, with and without the streetcar, is based on a transportation network simulated in ArcMap, which employs CATS' GTFS data. GTFS data feed includes information on all bus stops, routes, trips, and schedule data. The streetcar is part of CATS' GTFS data feed; however, in the data frame, it is coded as a fixed route bus line. Therefore, the modeling effort required recoding the streetcar route and schedule using GTFS data as a stand-alone mode to generate a multimodal network consisting of fixed route bus, streetcar, and pedestrian modes. Using a multiple-origin and multiple-destination algorithm, the network model computed shortest paths based on specified cutoff times or used a fixed number of closest destinations to produce an O/D matrix. To estimate accessibility changes from the streetcar operation, the following sections use household residential location units as origin points and business locations as destinations.

Household Job Accessibility

Using the network model, the analysis estimated two travel time sheds: one with walking, bus, and streetcar and one excluding the streetcar. The trip origins are based on the clustering of residential parcels. The time sheds are based on the morning peak hour departing time and 5 minute intervals. The size and shape of the time shed is a function of the multimodal network, which consider streetcar bus routes, stops, and scheduling options, and feasible walking routes. The estimation of the travel time shed was limited to the SIA, because the GTFS data coverage beyond the SIA was not complete. For example, the transit network was available, but GTFS data was missing.

Figure 9-20 shows the travel time shed without the streetcar, and Figure 9-21 shows the travel time shed with the streetcar serving as an accelerator to walking and bus, with the small dots representing businesses. The travel time sheds are almost identical, meaning that the streetcar does not provide added accessibility in the SIA beyond what the current transit network already provides.

Table 9-8 shows that the streetcar does not provide incremental gains in accessibility to businesses and jobs located within five minutes of the household residential units. The gains in job accessibility and accessibility to non-work activities (e.g., shopping and recreational activities) seem to increase once travel time extends beyond a 5-minute trip, although the differences are not statistically significant.

Figure 9-20

Travel Time Shed and Job Accessibility – Charlotte CityLYNX – No Streetcar

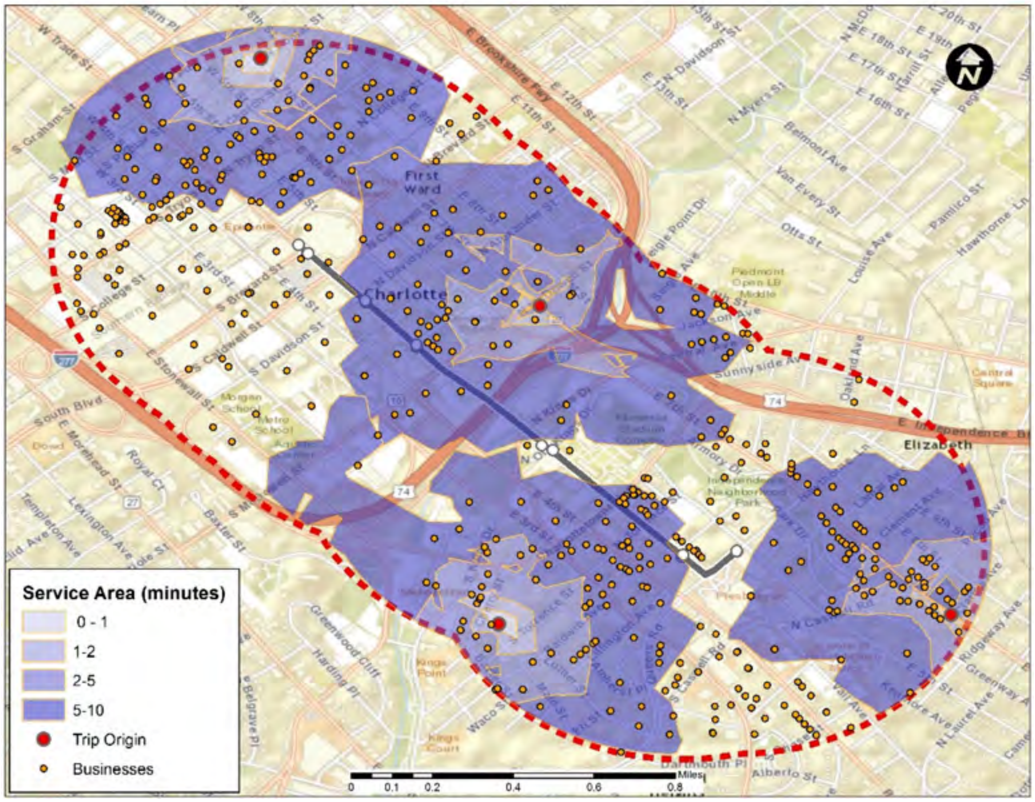


Figure 9-21

Travel Time Shed and Job Accessibility – Charlotte CityLYNX – Streetcar

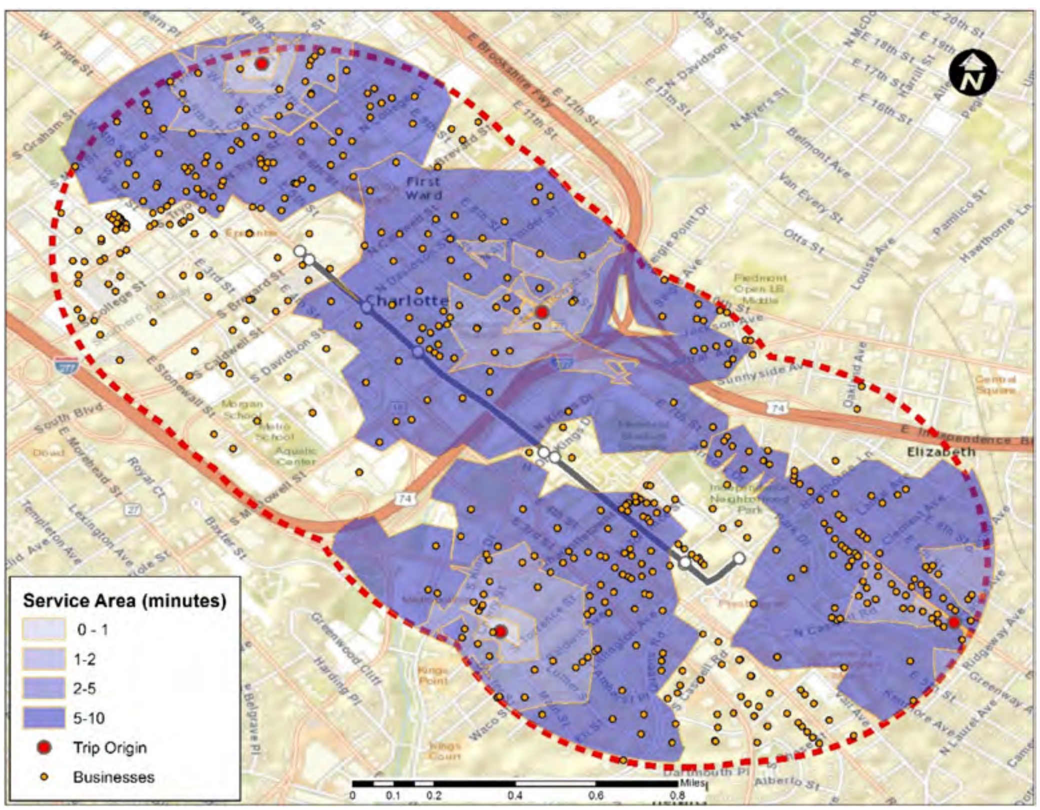


Table 9-8 *Streetcar Impact on Travel Time Shed and Job Accessibility – Charlotte CityLYNX*

Travel Time (min)	No Streetcar			Streetcar			Difference		
	Service Area (sq.mi.)	Business (#)	Jobs (#)	Service Area (sq.mi.)	Business (#)	Jobs (#)	Service Area (sq.mi.)	Business (#)	Jobs (#)
0 to 5	0.27	214	1,043	0.20	207	976	-0.07	-7	-67
5 to 10	1.06	1,361	10,774	1.11	1,385	10,933	0.05	24	159

Changes in Household Travel Times

Using the Infogroup 2016 household sample (5,208 households), the analysis estimates changes in travel times at the household level using Google Directions API, which relies on GTFS transit feeds and allows batch processing of origin/destination travel distances and travel times.[67] The API service computes directions between locations by specifying origin and destination either by address or latitude/longitude coordinates. Detailed trip information can be obtained in batch-mode processing for multiple observations with output provided in JavaScript Object Notation (JSON). The use of *ad hoc* text parsing macro modules working in SAS allows batch-mode extracting relevant trip information from the JSON file.

The trip origin is the household residential unit, and the destination is the Charlotte Transportation Center station (CTC). CTC represents the main bus connection station with a LYNX Blue Line stop. The streetcar nearest stop is the CTC Arena, about 300 feet away from the CTC. The choice of the CTC as a destination helps assess changes in accessibility to jobs for those households living in the SIA but working elsewhere. According to the U.S. Census Bureau LEHD, 71.8 percent of workers in living in the SIA work elsewhere.

The comparison of travel times with the streetcar to travel times without the streetcar applies to the following directional morning and afternoon peak and off-peak travel times:

- Morning peak (8:30 AM) – from household to CTC
- Evening off-peak (8:30 PM) – from household to CTC

The analysis compares two modal alternatives: (1) bus and (2) bus and streetcar. Route choice is based on minimizing the total travel time (option "best route") without imposing a walking time-distance threshold between modes (Google's API allows selecting an option that accounts for the preference "less walking").

Table 9-9 reports the mean and maximum household travel time savings for trips taken from residential units to all businesses located within the SIA. The results

[67] https://developers.google.com/maps/documentation/directions/intro.

confirm what is shown by the travel time sheds presented in Figure 9-20 and Figure 9-21. During peak travel, only 58 of 5,208 households (1.1%) experienced travel time savings when opting for the streetcar over fixed-route bus service. Time savings to CTC averaged about 6.4 minutes. Households earning less than $10,000 did not experience any travel time savings.

Table 9-9

Mean and Maximum Travel Time Savings – Charlotte CityLYNX Gold Line

Household Income	Peak (8:30 AM)			Off-Peak (8:30 PM)		
	Mean	*Max*	*% with Time Savings*	*Mean*	*Max*	*% with Time Savings*
Less or equal to $10,000	—	—	0.0	—	—	—
$10,001 to $21,000	3.5	10.0	0.1	—	—	—
$21,001 to $42,000	4.0	6.0	0.2	4.5	5.0	0.0
$42,001 to $89,000	4.2	11.0	0.3	4.5	5.0	0.2
$89,001 and above	10.0	11.0	0.4	4.0	4.0	0.1
Overall Sample	6.4	11.0	1.1	4.35	5.0	0.4

During the 8:30 PM off-peak period, the percentage of households enjoying travel time savings dropped to 0.4 percent. Figure 9-22 and Figure 9-23 map the households and show where time savings occur. The low incidence of streetcar being preferable to fixed route mass transit was the result of the API settings (best route option with less walking option off) and the relative distance of a given household to the nearest bus stop, current bus and streetcar schedules.

Figure 9-22

Household Travel Time Savings – Charlotte CityLYNX – Average Weekday Peak Period

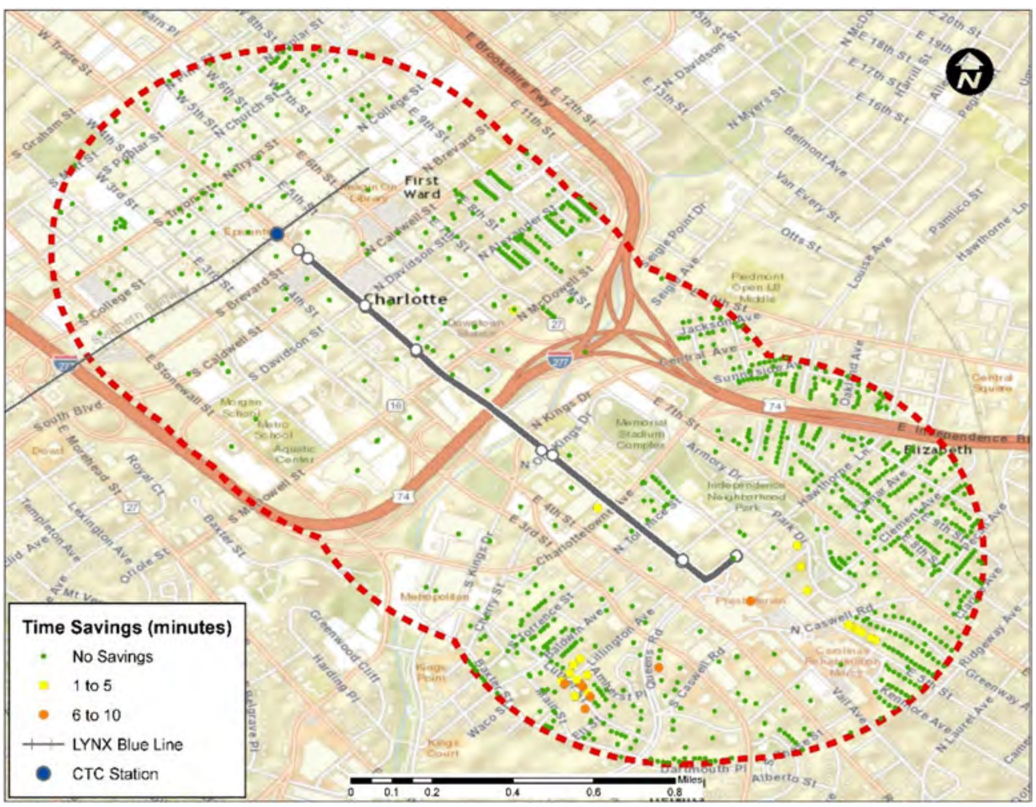
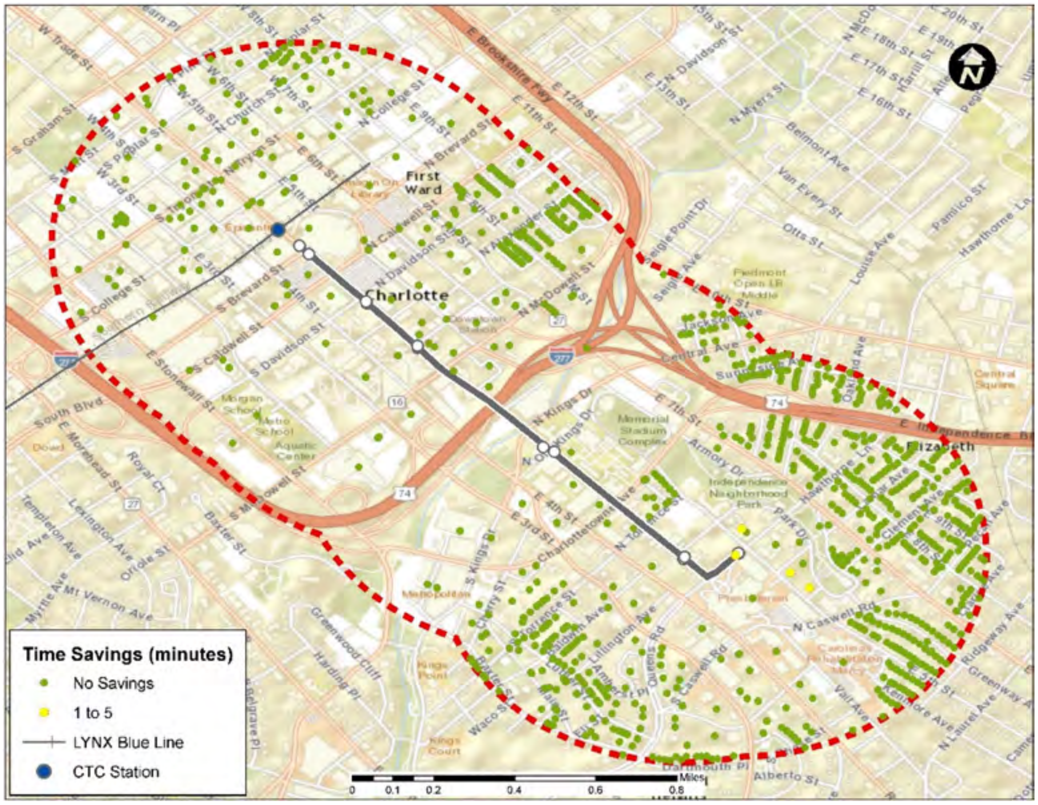


Figure 9-23

Households Travel Time Savings – Charlotte CityLYNX–Average Weekday Travel Off-Peak Period (8:30 PM)



Sun Link Tucson Streetcar

The construction of the streetcar system (Figure 9-24) can provide additional accessibility gains to households and workers residing in the area as well as to workers coming to the area from the remainder of the county. The SIA is well served by the Sun Tran extensive network of fixed-route bus. The Sun Tran system consists of 40 fixed-route bus lines served by about 250 buses and 2,200 bus stops. Bus routes 1, 3, and 9 serve the SIA linking Tucson CBD with the UAZ, with service running every 20–30 minutes during weekdays and every 30–60 minutes during weekends.

Figure 9-24

Streetcar Route – Sun Link Tucson Streetcar

The analysis relies on transit travel time data obtained from a zone-to-zone transit-travel time matrix via a simulation network model running within

ArcGIS ArcMap using Sun Tran GTFS data feeds. The O/D matrix estimates travel patterns with households as origins and businesses as destinations, using a shortest travel-time path. Walking speed is assumed at 3 miles per hour and the streetcar at 20 miles per hour (as per design). Travelers walking can use the street network in both directions, but they use the streetcar following the system route direction. The O/D matrix allows computing changes in travel times and defines two travel time sheds: one where locations are accessed by walk, bus, and streetcar and one excluding the streetcar.

Household Location Patterns

Information on households comes from the Infogroup dataset and covers the period 2007–2016. Table 9-10 summarizes the household sample descriptive statistics for year 2016. The table shows that about 82 percent of the 4,851 households consist of single-head families, with about 12 percent having one or more child. About 23 percent of households have at least one member that is age 65 or older. Households are equally split between homeowners and renters, with a mean length of residence of about 11 years. About 14 percent of the household receive an annual income at or above the metropolitan statistical area median income.[68] A high share of households, about 29 percent, lives at or below the U.S. Census poverty threshold.[69] About 5 percent of households earns an annual income that puts them at the top 5 percent income distribution.[70]

Table 9-10

Household Sample Descriptive Statistics – Sun Link Tucson Streetcar SIA

Definition	Mean	Std. Dev.	Min	Max
Household income ($000)	29,427	28,173	5,000	263,000
Households at or above top 5% income	0.047	0.211	0.000	1.000
Households at or above median income	0.137	0.344	0.000	1.000
Households at or below poverty threshold	0.295	0.456	0.000	1.000
Length of residence (years)	10.574	10.923	1.000	55.000
Household size	1.331	0.759	1.000	7.000
Household head married	0.182	0.386	0.000	1.000
Household head single	0.818	0.386	0.000	1.000
Household head age 65 and older	0.229	0.420	0.000	1.000
With children	0.121	0.327	0.000	1.000
Number of children	1.821	0.960	1.000	5.000
Property owner	0.339	0.473	0.000	1.000
Property renter	0.337	0.473	0.000	1.000

[68] According to ACS 2011–2015 5-Year Estimates (Series 1901), median household income for Tucson Metropolitan Statistical Area was $53,889.

[69] The U.S. Census Bureau publishes annual average weighted poverty threshold estimates, available at https://www.census.gov/data/tables/time-series/demo/income-poverty/historical-poverty-thresholds.html.

[70] For the entire sample (treatment and control), the top 5 percent of household in 2016 received $89,000 per year.

During 2007 and 2016, the percent of households by income group fluctuated in response to changes in generalized economic and local conditions (Figure 9-25). In these periods, the percent of households at the top 5 percent of the income distribution decreased. The percent of households living at or below the U.S. Census poverty threshold increased from 5.8 percent in 2007 to 29.5 percent in 2016. Households at or above the MSA median income declined from 28.6 percent to 13.7 percent. Overall, the figures indicate the SIA is still coming to grips with the aftermath of the Great Recession of 2008-2009 and underlying structural changes endemic to the area.

Figure 9-25

Percent of Households by Income Group, 2007 and 2016 – Sun Link Tucson Streetcar SIA

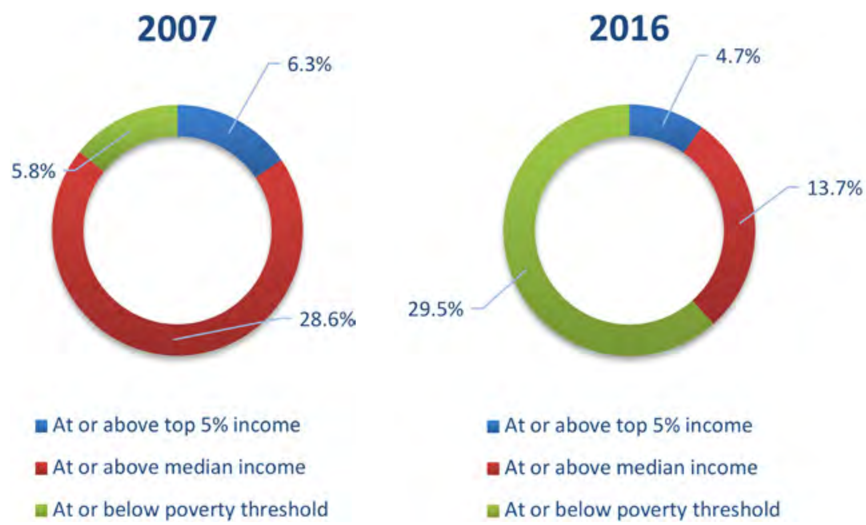


Figure 9-25 does not provide a spatial distribution of households by income group within the study area. Spatial kernel surfaces can provide a useful method for evaluating changes in the distribution of households in space and time. Kernel methods generate density surfaces that show where point features are concentrated. In this analysis, the surfaces evaluate the density of households measured in the number of households per acre, comparing the streetcar announcement year (2010) to the year after opening (2015).

Figure 9-26 and Figure 9-27 display the spatial density estimates of households at or below the threshold of poverty. Low-income households appear to be more clustered in Tucson CBD in 2010 (at the time of TIGER II grant award), than in 2016, which shows a marked increase in density within the CBD, on the western loop of the streetcar system in proximity of the Mercado San Augustin and north of the streetcar line.

Figure 9-26

Spatial Density of Households at or below Poverty Threshold – Sun Link Tucson Streetcar SIA – 2010

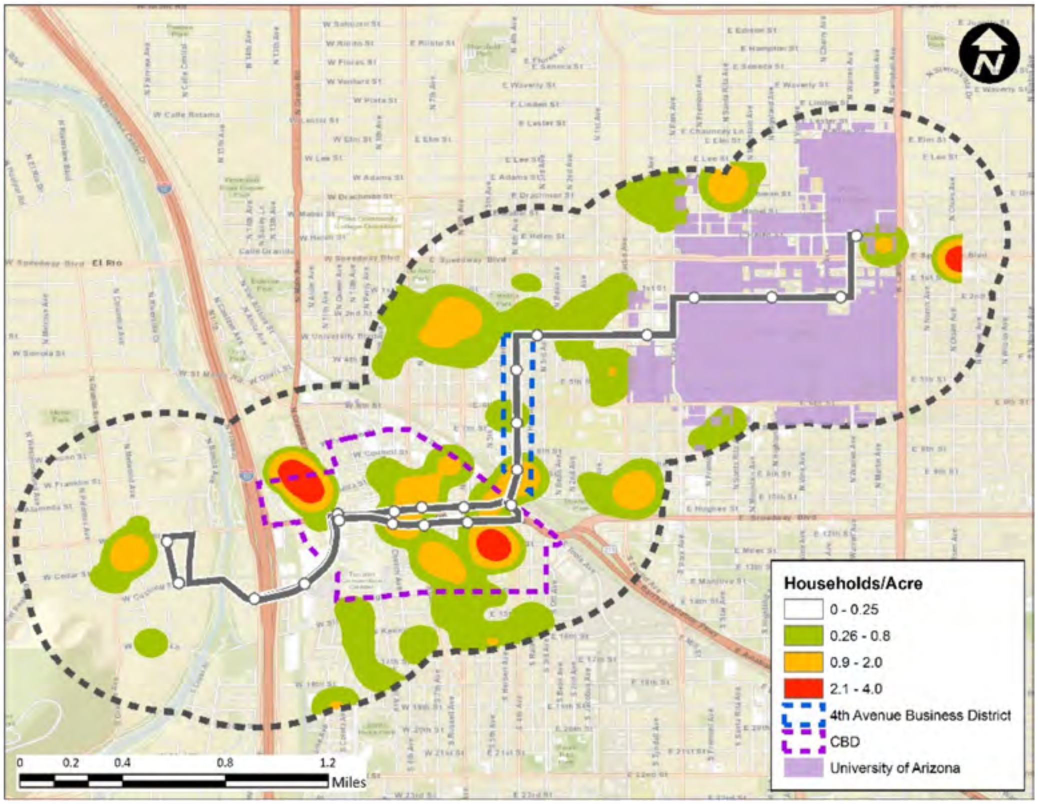
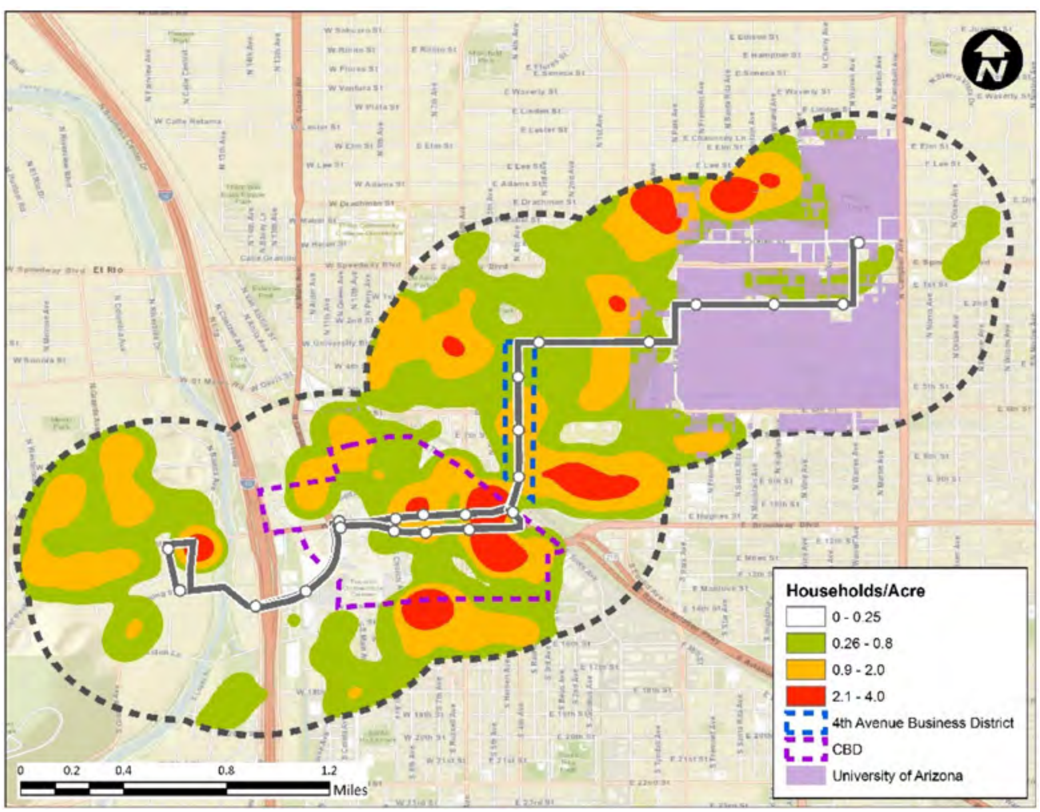


Figure 9-27

Spatial Density of Households at or below Poverty Threshold – Sun Link Tucson Streetcar SIA – 2016



The number of households at or above median MSA income decreased over the 2007–2016 period, declining from 24.0 percent to 13.7 percent of all SIA households. This outflow from the SIA is marked by a decrease in the spatial density between 2010 (Figure 9-28) and Figure 9-29 (2016). In 2010, these households were mostly concentrated in Tucson CBD and on the northern part of the SIA in proximity to UAZ. In 2016, they appear to be clustered only in the proximity of the university campus, with a marked decrease in density at the CBD.

Figure 9-28

Spatial Density of Households at or above Median MSA Income – Sun Link Tucson Streetcar SIA – 2010

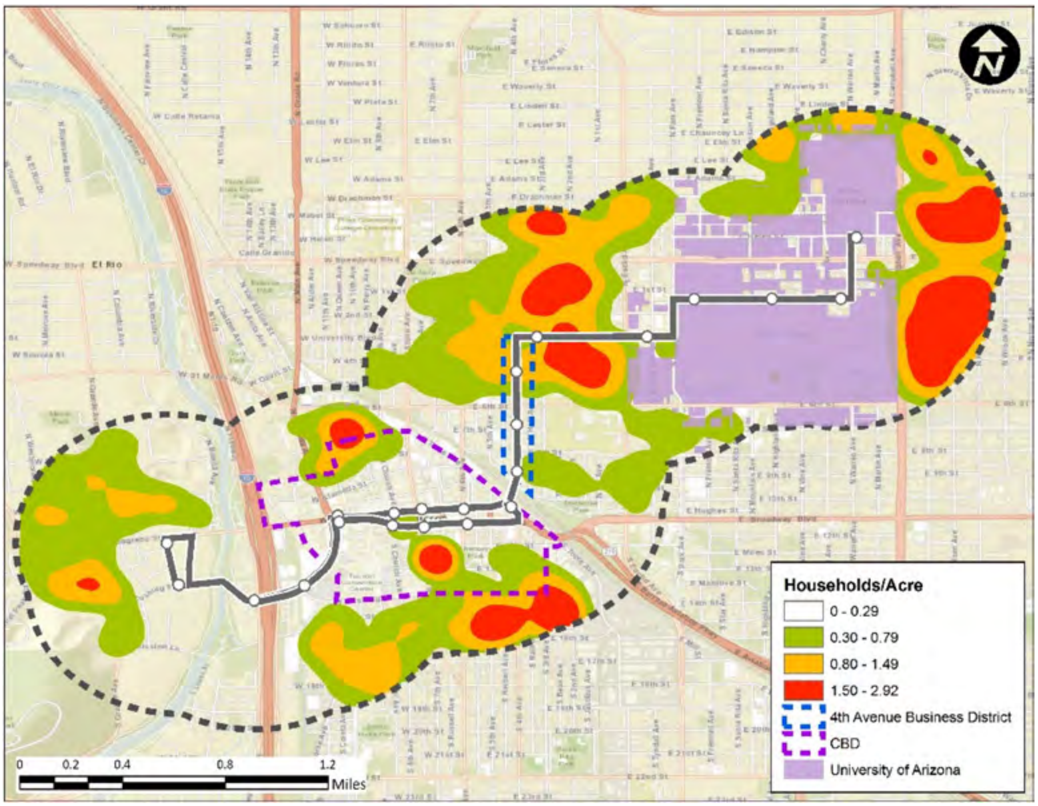


Figure 9-29

Spatial Density of Households at or above Median MSA Income – Sun Link Tucson Streetcar SIA – 2016

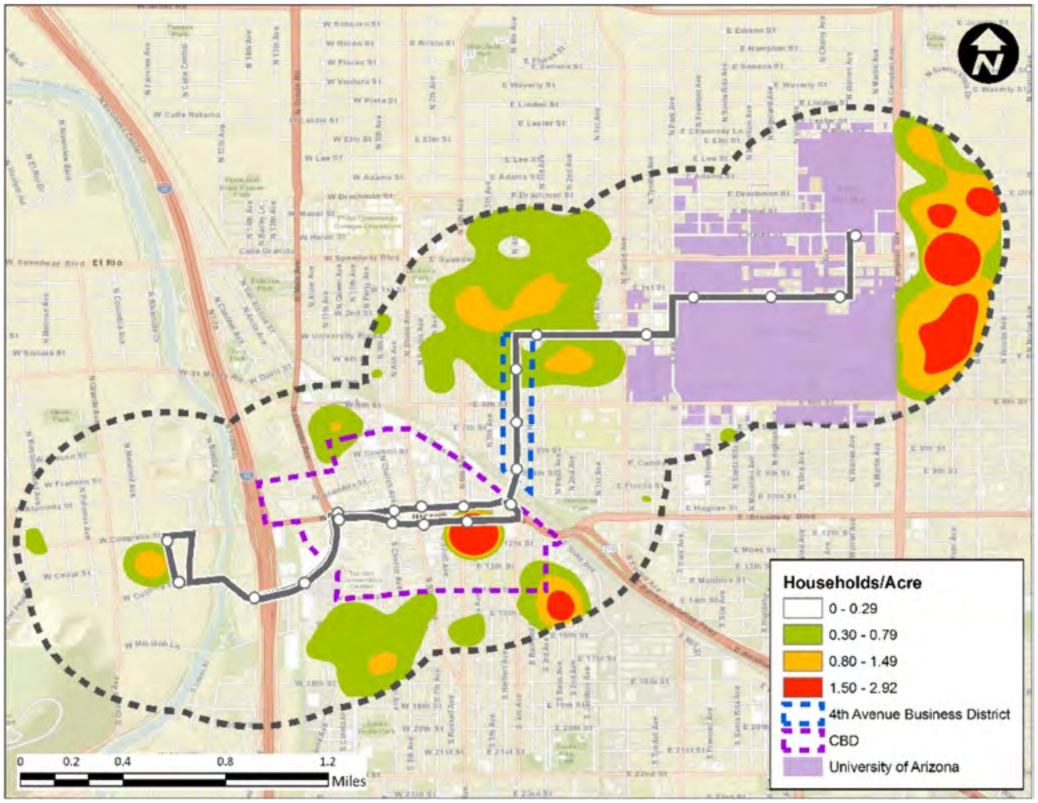


Figure 9-30 and Figure 9-31 represent the density maps of households at the top 5 percent income cohort and show no marked change in spatial density. The percentage of households in this group decreased from 5.4 percent of all SIA households in 2010 to 4.7 in 2016, while being concentrated mostly in the northern section of the SIA, east of UAZ.

Figure 9-30

Spatial Density of Households at or above Top 5% Income Distribution – Sun Link Tucson Streetcar SIA – 2010

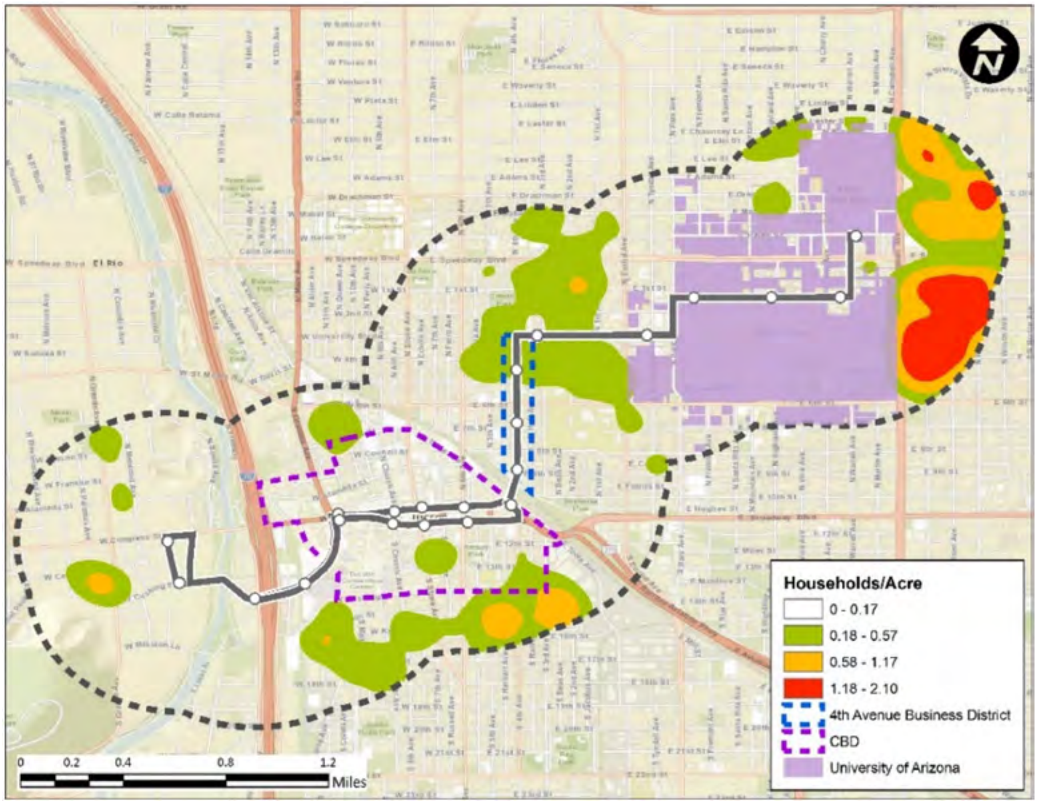
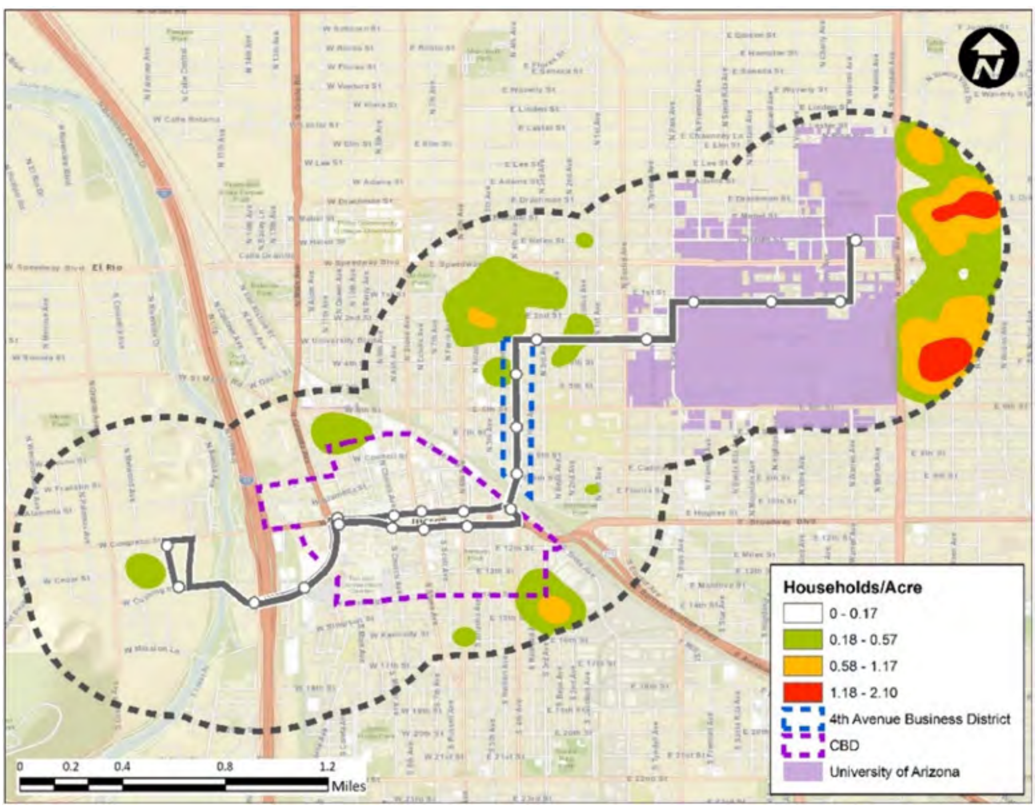


Figure 9-31

Spatial Density of Households at or above Top 5% Income Distribution – Sun Link Tucson Streetcar SIA – 2016



Changes in Job Accessibility

Using the GIS polygon defining the SIA, Table 9-11 summarizes the results of the LEHD analysis. The table provides a baseline picture of workers' travel patterns. According to LEHD, there are a 55,000 workers in the SIA, with about 7,161 living within and 65,806 working in the SIA. Of those living in the SIA, about 1,670 (23.4%) work and reside within its boundaries. About 68 percent of those workers living in the SIA but working elsewhere travel less than 10 miles and 87 percent travel up to 24 miles. About 47 percent commute within the boundaries of the city of Tucson. Some workers commute north of the SIA to Phoenix (8.9%), Catalina Foothills (2.9%), and Casas Adobes (2.7%).

Table 9-11

LEHD Commuting Patterns Analysis – Sun Link Tucson Streetcar SIA

Workers	2014
Living in SIA	7,161
Working and living in SIA	23.36%
Living in SIA and working elsewhere	76.64%
Earning $1,250 per month or less	29.40%
Traveling less than 10 miles	67.87%
Traveling 10–24 miles	18.98%
Working in Tucson	46.92%
Working in SIA, living elsewhere	65,806
Earning $1,250 per month or less	16.28%
Traveling less than 10 miles	52.07%
Traveling 10–24 miles	33.23%
Working in Tucson	22.71%

The household information in Table 9-10, Figure 9-26 through Figure 9-31, and the travel pattern numbers of Table 9-11 form the basis for evaluating the impact of the streetcar system on job accessibility. In particular, the analysis focuses on low-income households. These families are more likely to use the public transportation system either to commute to and from work or to reach non-work locations within and outside of the study area.

The estimation of travel time sheds, with and without the streetcar, is based on a transportation network simulated in ArcMap, which employs Sun Tran GTFS data. Sun Tran's GTFS data feed includes information on all bus stops, routes, trips, and schedule data. The streetcar is part of Sun Tran's GTFS data feed but is coded as a fixed route bus line in the data frame. Therefore, the modeling effort requires recoding the streetcar route and schedule using Sun Tran's GTFS data as a stand-alone mode to generate a multimodal network consisting of fixed route bus, streetcar, and pedestrian modes. Using a multiple-origin-multiple-destination algorithm, the network model computes shortest paths based on specified cutoff times or uses a fixed number of closest destinations to produce an O/D matrix. To estimate accessibility changes from the streetcar operation, the following sections use household residential location units as origin points and business locations as destinations.

Household Job Accessibility

Using the network model, the analysis estimated two travel time sheds: one with walking, bus, and streetcar and one excluding the streetcar. The trip origins are based on the location of the streetcar stations located in the Mercado San Augustin (Avenida del Convento stop) area and the station located at UAZ (Helen Street stop). The estimation of travel time sheds from the Mercado San Augustin area is of particular interest, given the current and future changes in land-use that consider mixed commercial and residential development and also because a large share of low-income households is located in this section of the SIA (see Figure 9-27).

The time sheds are based on the morning peak-hour departing time and 5-minute intervals, with an upper limit of 25 minutes total travel time. The size and shape of the time shed is a function of the multimodal network, which considers streetcar bus routes, stops, scheduling options, and feasible walking routes.

Household Accessibility from Mercado San Augustin

Figure 9-32 shows the travel time shed without the streetcar, and Figure 9-33 shows the travel time shed with the streetcar serving as an accelerator to walking and bus, with the small dots representing businesses currently in operation that can potentially be reached from the Mercado San Augustin area.

Figure 9-32

Travel Time Shed and Job Accessibility – Sun Link Tucson Streetcar: Mercado San Augustin – No Streetcar

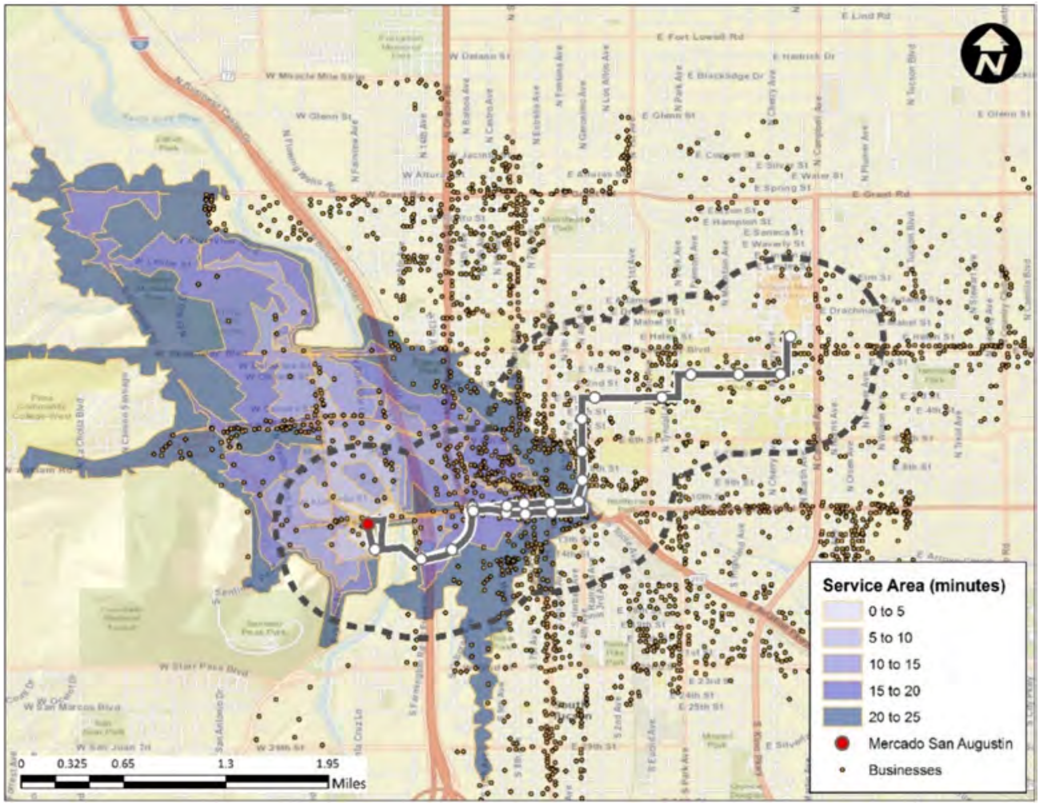
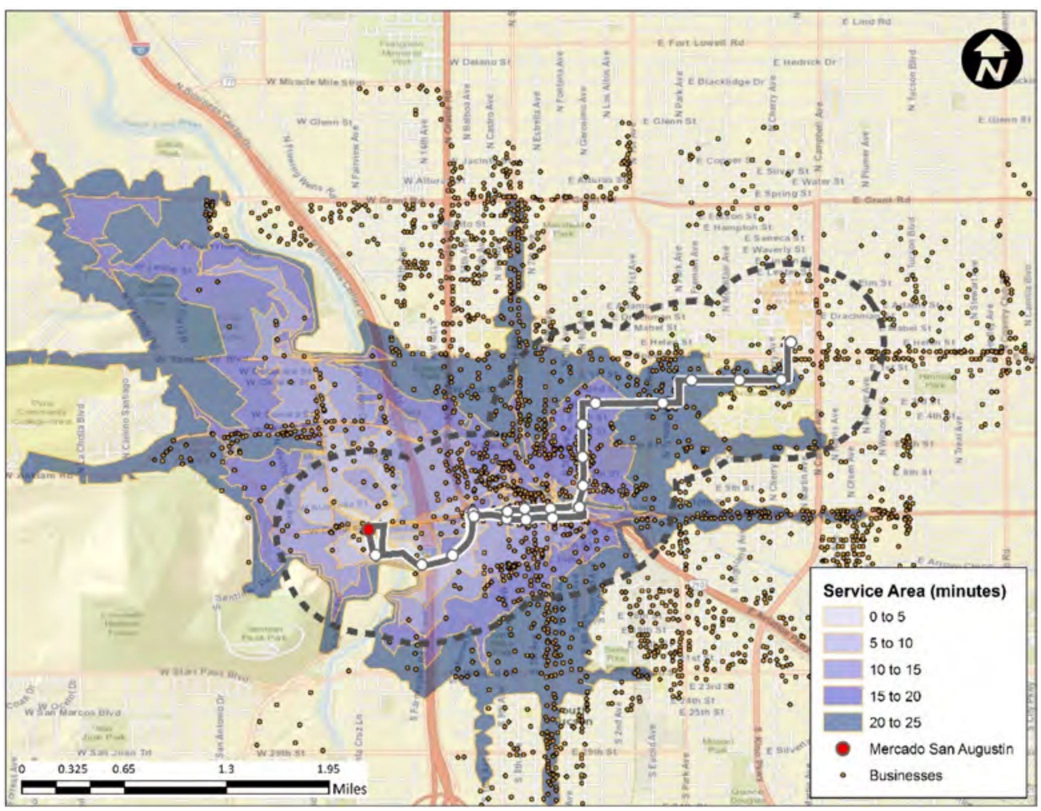


Figure 9-33

Travel Time Shed and Job Accessibility – Sun Link Tucson Streetcar: Mercado San Augustin – Streetcar



The TIGER II grant application noted the reconnection of the economically-depressed area of the western section of Downtown Tucson as one of the objectives of the streetcar project. Figure 9-33 shows how the streetcar removed this barrier, allowing households residing east of Interstate 10 to reach a number of destinations and job opportunities. Comparing the travel time sheds, it is clear that the streetcar provides access from the Mercado San Augustin area to UAZ within a 20-minute timeframe.

Table 9-12 shows that having access to the streetcar serves as an accelerator to walking, allowing travelers to reach more jobs within a 25-minute time span. The gains in job accessibility and accessibility to non-work activities (e.g., shopping and recreational activities) increase substantially once travel time extends beyond a 5-minute trip. With the streetcar, households can reach an additional 1,000 businesses and 15,000 jobs within 25 minutes of travel from their homes. About 75.4 percent of the jobs can be reached within 10–15 minutes of travel.

Table 9-12

Sun Link Tucson Streetcar Impact on Travel Time Shed and Job Accessibility – Mercado San Augustin

Travel Time (min)	No Streetcar			Streetcar			Difference		
	Service Area (sq.mi.)	*Business (#)*	*Jobs (#)*	*Service Area (sq.mi.)*	*Business (#)*	*Jobs (#)*	*Service Area (sq.mi.)*	*Business (#)*	*Jobs (#)*
0 to 5	0.1	7	39	0.1	12	96	0.1	5	57
5 to 10	0.4	113	2,059	0.6	299	a3,805	0.2	186	1,746
10 to 15	1.2	131	1,033	1.8	799	12,376	0.7	668	11,343
15 to 20	2.0	775	13,752	2.7	782	15,966	0.7	7	2,214
20 to 25	3.7	986	10,948	5.6	1,119	10,636	2.0	133	-312
Total	*7.3*	*2,012*	*27,831*	*10.9*	*3,011*	*42,879*	*3.6*	*999*	*15,048*

Table 9-13 reports the breakdown at the NAICS 2-digit level of the type of businesses and number of jobs within reach by a combination of walking and streetcar. Due to the presence of health clinics in the SIA (in proximity to UAZ), about 14.4 percent of jobs are in the health care and social assistance, followed by accommodation (8.4%), and professional and technical services (7.4%).

Table 9-13

Sun Link Tucson Streetcar Impact on Job Accessibility by NAICS 2-digit – Mercado San Augustin

Industry Sector	Travel Time (min)						
	0 to 5	*5 to 10*	*10 to 15*	*15 to 20*	*20 to 25*	*Total*	*Share*
Wholesale trade	0	2	179	71	147	399	0.9%
Retail trade	2	60	236	550	1,024	1,872	4.4%
Transportation and warehousing	0	152	14	4	132	302	0.7%
Information	0	68	234	224	614	1,140	2.7%
Finance and insurance	0	156	24	60	203	443	1.0%
Real estate and rental and leasing	5	43	181	76	131	436	1.0%
Professional and technical services	0	598	1,064	778	725	3,165	7.4%
Management of companies and enterprises	0	0	1,977	0	0	1,977	4.6%
Administrative and waste services	0	50	158	111	479	798	1.9%
Educational services	0	113	322	433	1,321	2,189	5.1%
Health care and social assistance	32	1,074	549	2,165	2,374	6,194	14.4%
Arts, entertainment, and recreation	0	11	277	90	311	689	1.6%
Accommodation and food services	10	163	1,095	986	1,417	3,671	8.6%
Other services, except public administration	0	101	287	5,155	1,055	6,598	15.4%
All other sectors	47	1,214	5,779	5,263	703	13,006	30.3%
Total Employment	*96*	*3,805*	*12,376*	*15,966*	*10,636*	*42,879*	*100.0%*
Total Businesses	*12*	*299*	*799*	*782*	*1,119*	*3,011*	

Household Accessibility from UAZ

As of 2016, there were about 500 households located within a half-mile of the Helen Street streetcar stop, which is located on the northern portion of UAZ and represents the last stop of the line. As shown in Figure 9-26 through Figure 9-31, job accessibility improvements can benefit households from all income cohorts.

Figure 9-34 shows the travel time shed without the streetcar, and Figure 9-35 shows the travel time shed with the streetcar serving as an accelerator to walking and bus, with the small dots representing businesses currently in operation that potentially can be reached from the Helen Street stop. Comparing the travel time sheds, their shape and extent are almost the same, except for the elongated shape of the travel time shed around the streetcar line (Figure 9-35). From the figure, it is clear that the streetcar provides access from UAZ to the Mercado San Augustin area within a 20-minute timeframe.

Figure 9-34

Travel Time Shed and Job Accessibility – Sun Link Tucson Streetcar: UAZ – No Streetcar

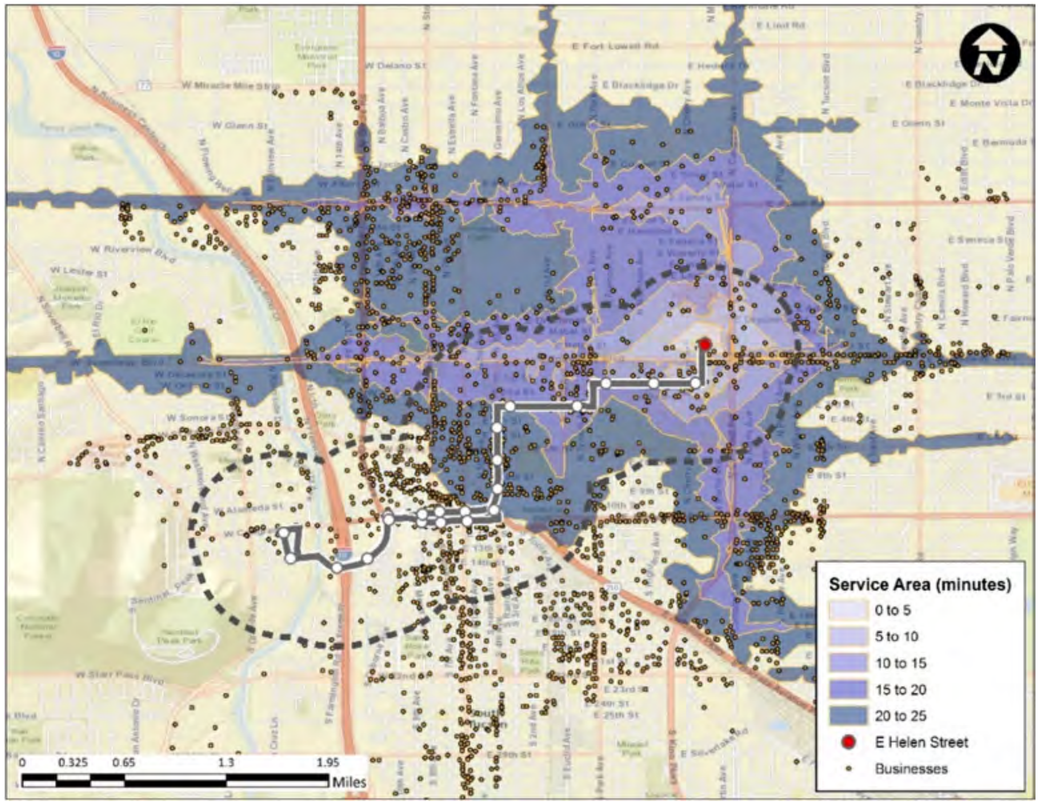


Figure 9-35

Travel Time Shed and Job Accessibility – Sun Link Tucson Streetcar: UAZ – Streetcar

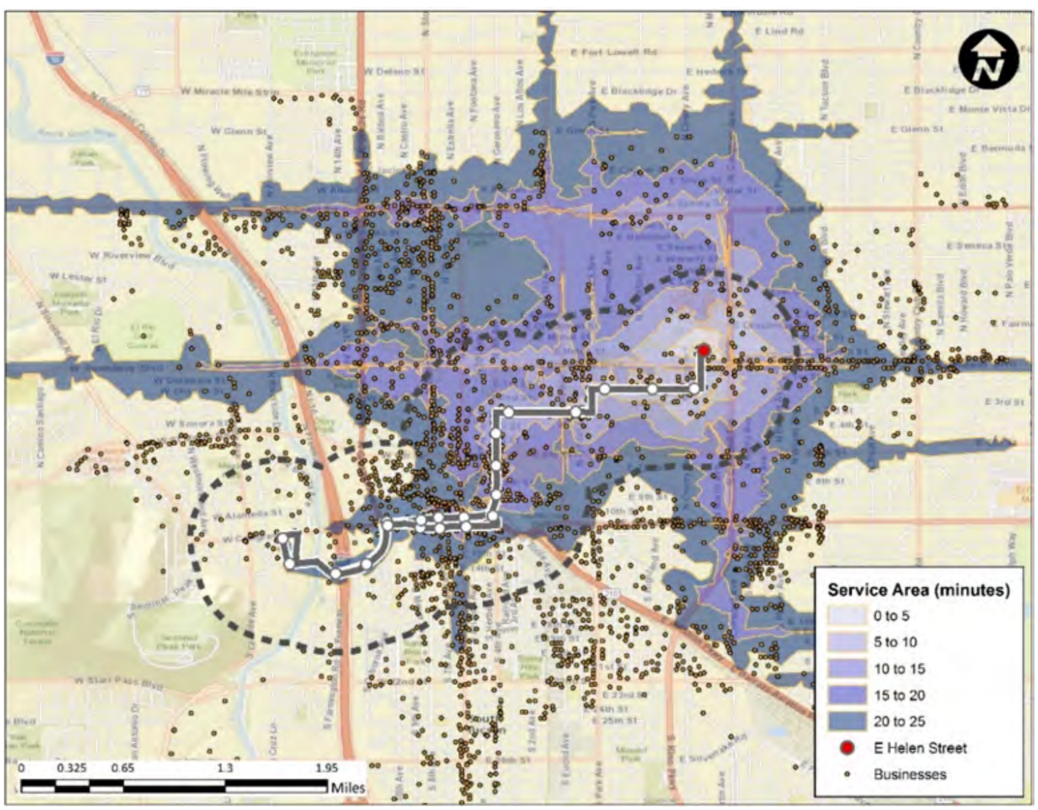


Table 9-14 shows that access to the streetcar serves as an accelerator to walking, allowing travelers to reach additional jobs within a 25-minute time span. The gains in job accessibility and accessibility to non-work activities (e.g., shopping and recreational activities) increase substantially once travel time extends beyond a 5-minute trip. With the streetcar, households can reach an additional 1,000 businesses and 15,000 jobs within 25 minutes of travel from their homes. The gains in job accessibility and accessibility to non-work activities (e.g., shopping and recreational activities) increase exponentially once travel time extends beyond 15 minutes (71.9% of jobs). This is because of the existing high concentration of establishments around the UAZ campus and the 4th Avenue Business District, which can be reached within 10 minutes by streetcar.

Table 9-14

Sun Link Tucson Streetcar Impact on Travel Time Shed and Job Accessibility – UAZ Helen Street Stop

Travel Time (min)	No Streetcar			Streetcar			Difference		
	Service Area (sq.mi.)	Business (#)	Jobs (#)	Service Area (sq.mi.)	Business (#)	Jobs (#)	Service Area (sq.mi.)	Business (#)	Jobs (#)
0 to 5	0.1	7	43	0.1	14	161	0.0	7	118
5 to 10	0.4	142	5,133	0.5	214	6,278	0.2	72	1,145
10 to 15	1.2	643	4,432	1.6	830	6,540	0.4	187	2,108
15 to 20	3.6	522	6,105	3.9	845	18,696	0.3	323	12,591
20 to 25	7.9	1,384	16,937	7.8	1,839	18,483	-0.1	455	1,546
Total	*13.1*	*2,698*	*32,650*	*13.9*	*3,742*	*50,158*	*0.8*	*1,044*	*17,508*

Table 9-15 reports the breakdown at the NAICS 2-digit level of the type of businesses and number of jobs within reach by a combination of walking and streetcar. Due the location of Helen St streetcar stop in close proximity to UAZ clinics and to the Arizona Health Sciences Center, most of the accessible jobs are within the health care and social assistance industry sector. Given the proximity of the business district, household have increased accessibility to accommodation and food services establishments.

Table 9-15 *Sun Link Tucson Streetcar Job Accessibility Impact by NAICS 2-digit – UAZ Helen Street Stop*

Industry Sector	Travel Time (min)						
	0 to 5	*5 to 10*	*10 to 15*	*15 to 20*	*20 to 25*	*Total*	*Share*
Wholesale trade	0	0	19	240	298	557	1.1%
Retail trade	0	192	279	1,471	922	2,864	5.7%
Transportation and warehousing	0	0	6	169	108	283	0.6%
Information	27	211	496	116	651	1,501	3.0%
Finance and insurance	15	32	36	221	340	644	1.3%
Real estate and rental and leasing	0	9	49	181	335	574	1.1%
Professional and technical services	2	333	785	718	1,716	3,554	7.1%
Management of companies and enterprises	0	0	0	1,977		1,977	3.9%
Administrative and waste services	0	5	0	383	654	1,042	2.1%
Educational services	25	245	796	601	676	2,343	4.7%
Health care and social assistance	0	4,307	2,815	582	1,812	9,516	19.0%
Arts, entertainment, and recreation	0	86	55	174	291	606	1.2%
Accommodation and food services	50	574	783	1,185	1,566	4,158	8.3%
Other services, except public administration	41	176	351	5,353	1,072	6,993	13.9%
All other sectors	1	108	70	5,325	8,042	13,546	27.0%
Total Employment	*161*	*6,278*	*6,540*	*18,696*	*18,483*	*50,158*	*100.0%*
Total Businesses	*14*	*214*	*830*	*845*	*1,839*	*3,742*	

Changes in Household Travel Times

Using the Infogroup 2016 household sample (4,851 households), the analysis estimates changes in travel times at the household level. The analysis is based on the estimated O/D matrix of distance and travel times from each residential unit location to all businesses located in the SIA and control areas. As in the previous section, the analysis compares multimodal alternatives in the presence and absence of the streetcar. The analysis considers typical weekday peak (8:15 AM) and off peak (9:30 AM) periods to ascertain changes in average and spatial distribution of household travel time savings.

Table 9-16 reports the mean and maximum household travel time savings for trips taken from residential units to all businesses located within the SIA.

Table 9-16

Mean and Maximum Travel Time Savings – Sun Link Tucson Streetcar

Household Income Cohort	Peak (8:15 AM)			Off Peak (9:30 AM)		
	Mean	*Max*	*% with Time Savings*	*Mean*	*Max*	*% with Time Savings*
All households	6.1	14.1	27.5%	4.3	26.2	29.7%
At or above top 5% income	4.8	9.3	1.4%	2.8	12.4	1.8%
At or above MSA median income	5.0	13.3	5.2%	3.4	16.8	5.6%
At or below poverty threshold	5.9	13.5	7.6%	4.9	26.2	8.9%

During the 8:15 AM peak period, about the same number of households enjoy travel time savings compared to the 9:30 AM off-peak period. Using the streetcar, households save about the same time during the commute and the off peak period. Lower income households save more time than the higher income cohorts.

Travel time savings are not evenly spatially-distributed. The savings depend on location and network characteristics (bus and streetcar stop location, bus line, and schedule) and are clustered at specific locations, as shown in Figure 9-36 and Figure 9-37. During the AM peak period, the western portion of the SIA near the Mercado San Augustin, where a high share of low-income households resides (single-family and condominium units), enjoys the most time savings (8–14 minutes). Households located in proximity of the 4th Avenue Business District, north of Tucson CBD, also enjoy travel time savings both during peak and off-peak periods.

Figure 9-36

Household Travel Time Savings – Sun Link Tucson StreetcarAverage Weekday Peak Period (8:15 AM)

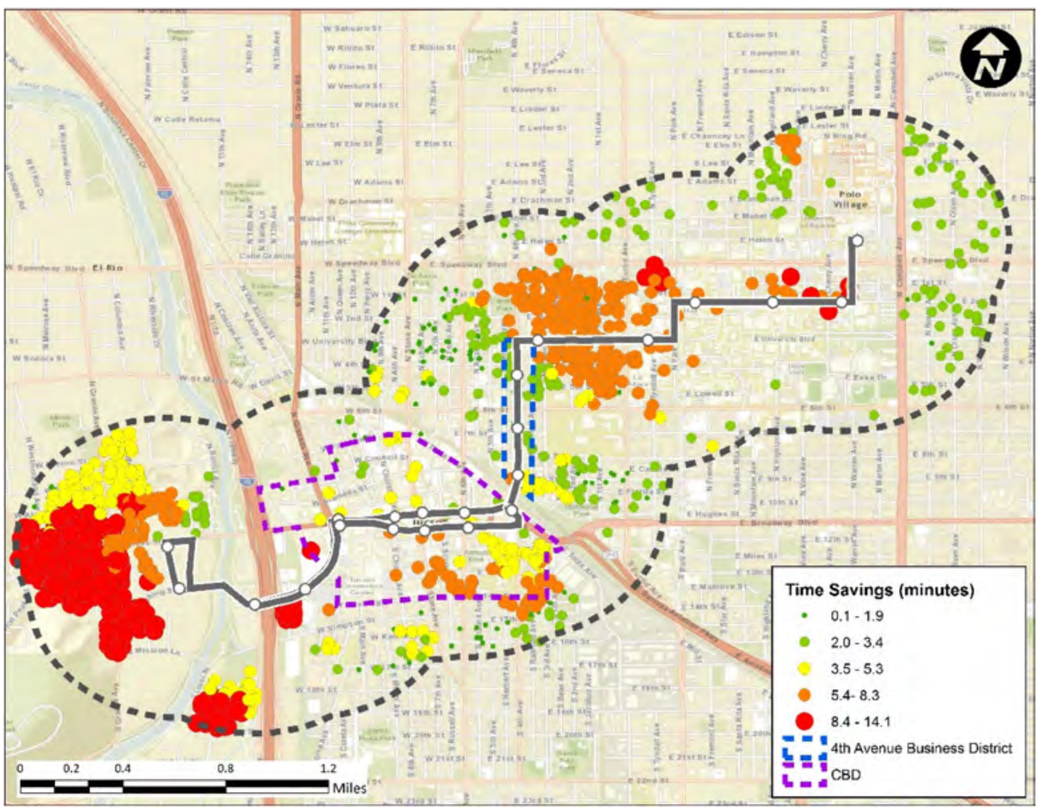
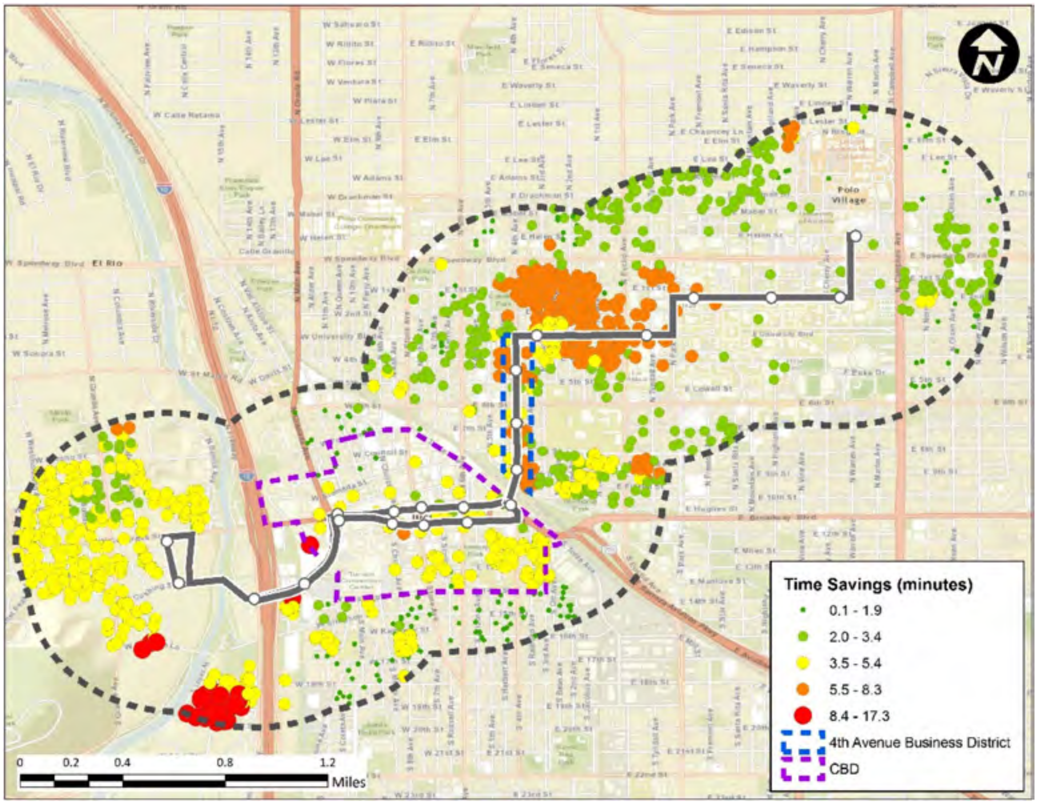


Figure 9-37

Households Travel Time Savings, Sun Link Tucson Streetcar – Average Weekday Travel Off Peak Period (9:30 AM)



Atlanta Streetcar

The introduction of the streetcar system can provide additional accessibility gains to households and workers residing in the area, as well as to workers coming to the area from the rest of the county. The SIA is well served by MARTA's extensive network of rail and bus routes. The MARTA rail system (Figure 9-38) consists of four lines with 38 stations and 48 track miles served by 336 rail cars. The bus network comprises 92 fixed routes served by 554 buses. In addition, MARTA provides complimentary curb-to-curb paratransit service to persons with disabilities through its Mobility service. Bus routes 3, 16, and 99 serve the SIA, with service running every 20–30 minutes during weekdays and every 40 minutes on weekends.

Figure 9-38

MARTA Rail Map

The analysis relies on transit travel time data obtained through a zone-to-zone transit travel time matrix via a simulation network model running within ArcGIS ArcMap. The network considers only two travel modes: walk and streetcar. Travel occurs on the local streets. The O/D matrix estimates travel patterns with households as origins and businesses as destinations, using a shortest travel-time path. Walking speed is assumed at 3 miles per hour and the streetcar at 20 miles per hour (as per design). Travelers walking can use the street network in both directions, but they use the streetcar following the system route direction. The O/D matrix allows computing changes in travel times and defines two travel time sheds: one where locations are accessed by walk and streetcar, and one excluding the streetcar.

Household Location Patterns

Information on households comes from the Infogroup dataset and covers the period 2007–2014. Table 9-17 summarizes the sample descriptive statistics for 2016. The table shows that about 95 percent of the 5,188 households consist of single-head families, with about 9 percent having one or more child. About 11 percent of households have at least one member that is age 65 or older. About 57 percent resides in rental units with a mean length of residence across the sample of about 5.7 years. About 15 percent of the households receive an annual income at or above the metropolitan statistical area median income.[71] About 14 lives at or below the U.S. Census poverty threshold.[72] About one percent of households earns an annual income that puts them at the to the top 5 percent income distribution.[73]

Table 9-17

Household Sample Descriptive Statistics – Atlanta Streetcar SIA

Definition	Mean	Std. Dev.	Min	Max
Household income ($000)	33,982	23,004	5,000	223,000
Households at or above top 5% income	0.01	0.08	0.00	1.00
Households at or above median income	0.15	0.35	0.00	1.00
Households at or below poverty threshold	0.14	0.35	0.00	1.00
Length of residence (yrs)	5.73	5.97	1.00	51.00
Household size	1.15	0.54	1.00	7.00
Household head married	0.05	0.22	0.00	1.00
Household head single	0.95	0.22	0.00	1.00
Household head age 65 and older	0.11	0.31	0.00	1.00
With children	0.09	0.28	0.00	1.00
Number of children	1.69	0.93	1.00	5.00
Property owner	0.30	0.46	0.00	1.00
Property renter	0.57	0.49	0.00	1.00

[71] According to ACS 2011–2015 5-Year Estimates (Series 1901), median household income for Atlanta Metropolitan Statistical Area was $57,000.

[72] The U.S. Census Bureau publishes annual average weighted poverty threshold estimates, available at https://www.census.gov/data/tables/time-series/demo/income-poverty/historical-poverty-thresholds.html.

[73] For the entire sample (treatment and control), the top 5 percent of household in 2016 received $116,000 per year.

During 2007–2016, the percent of households by income group fluctuated in response to changes in generalized economic conditions (Figure 9-39). During the economic downturn of the Great Recession (2008–2009), the percent of households at or below the poverty threshold increased from 8.0 percent to about 29 percent and decreased to 14.4 percent by 2016. Households at or above the MSA median income increased over time to settle at 14.7 percent of the sample.

Figure 9-39

Percent of Households by Income Group, 2007–2016 – Atlanta Streetcar SIA

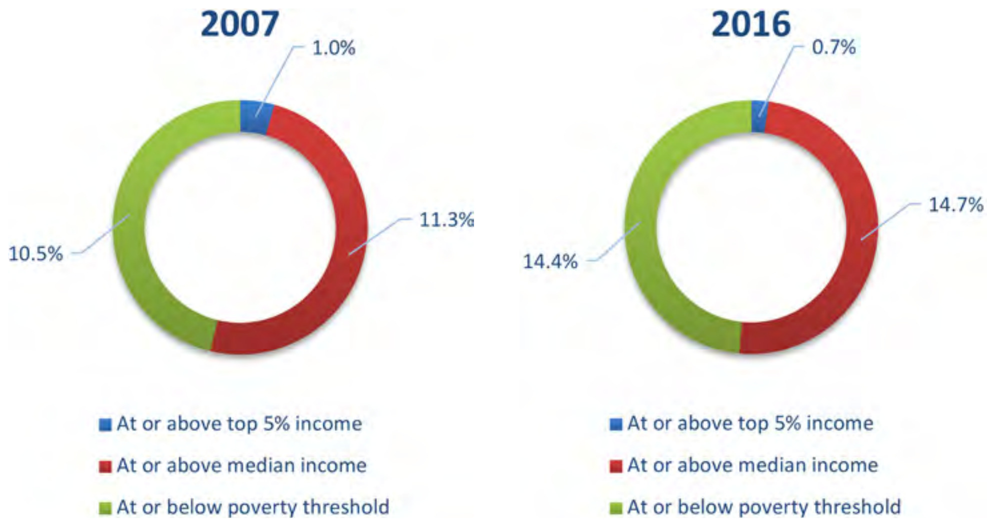


Figure 9-39 does not provide details about the spatial distribution of households by income group within the study area. Spatial kernel surfaces provide a useful method for evaluating changes in the distribution of households in space and time. Kernel methods generate density surfaces that show where point features are concentrated. In this analysis, the surfaces evaluate the density of households measured in the number of households per acre, comparing the streetcar announcement year (2010) to the year after opening (2014).

Figure 9-40 and Figure 9-41 display the spatial density estimates of households at or below the threshold of poverty. These households appear to be more dispersed in 2010, and 2016 shows a marked decrease in density at the CBD and east of Interstate 75/85 while remaining unchanged near MLK Historic site.

Figure 9-40

Spatial Density of Households at or below Poverty Threshold – Atlanta Streetcar SIA – 2010

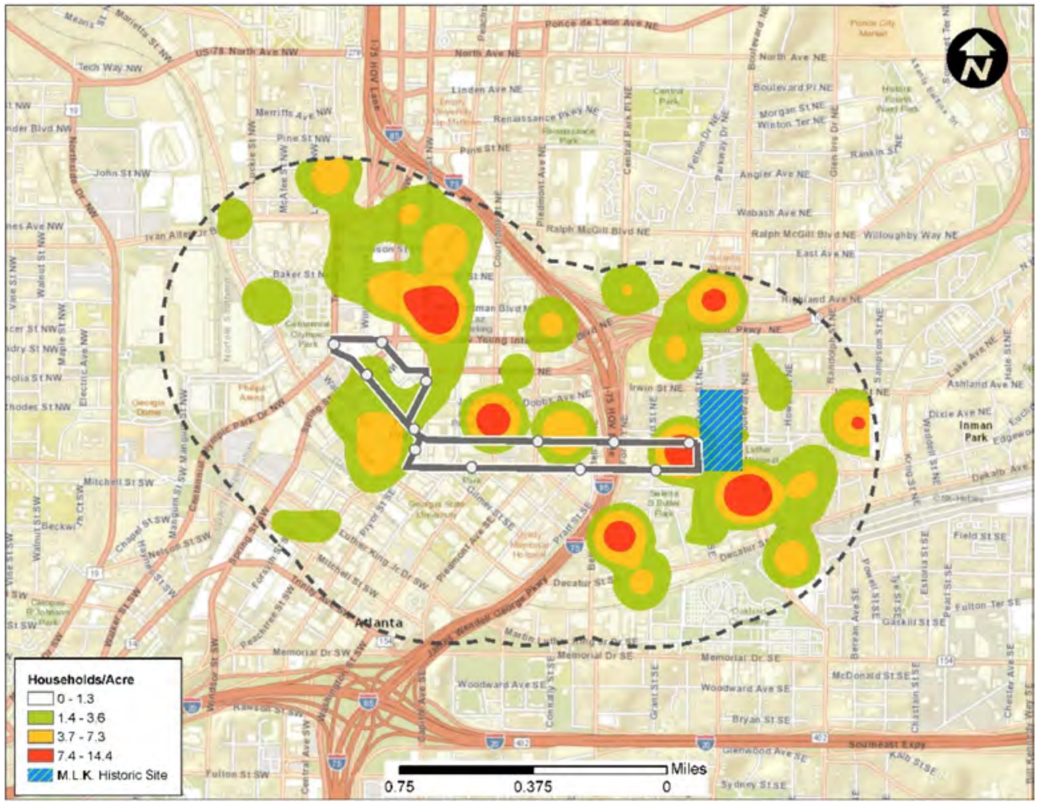


Figure 9-41

Spatial Density of Households at or below Poverty Threshold – Atlanta Streetcar SIA – 2010

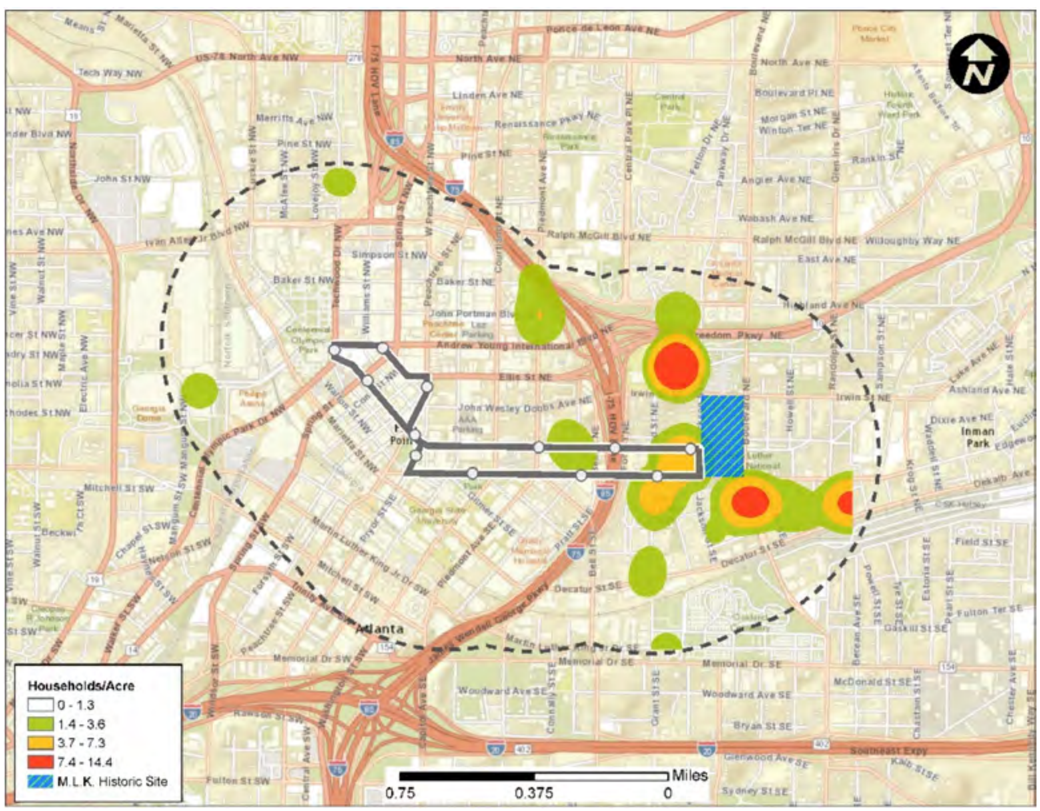


Figure 9-42 and Figure 9-43 show the density of households at or above median MSA income. In 2010, these households were mostly concentrated in the northern part of the SIA, while in 2016 they tend to be clustered in closer proximity to the streetcar alignment.

Figure 9-42

Spatial Density of Households at or above Median MSA Income – Atlanta Streetcar SIA – 2010

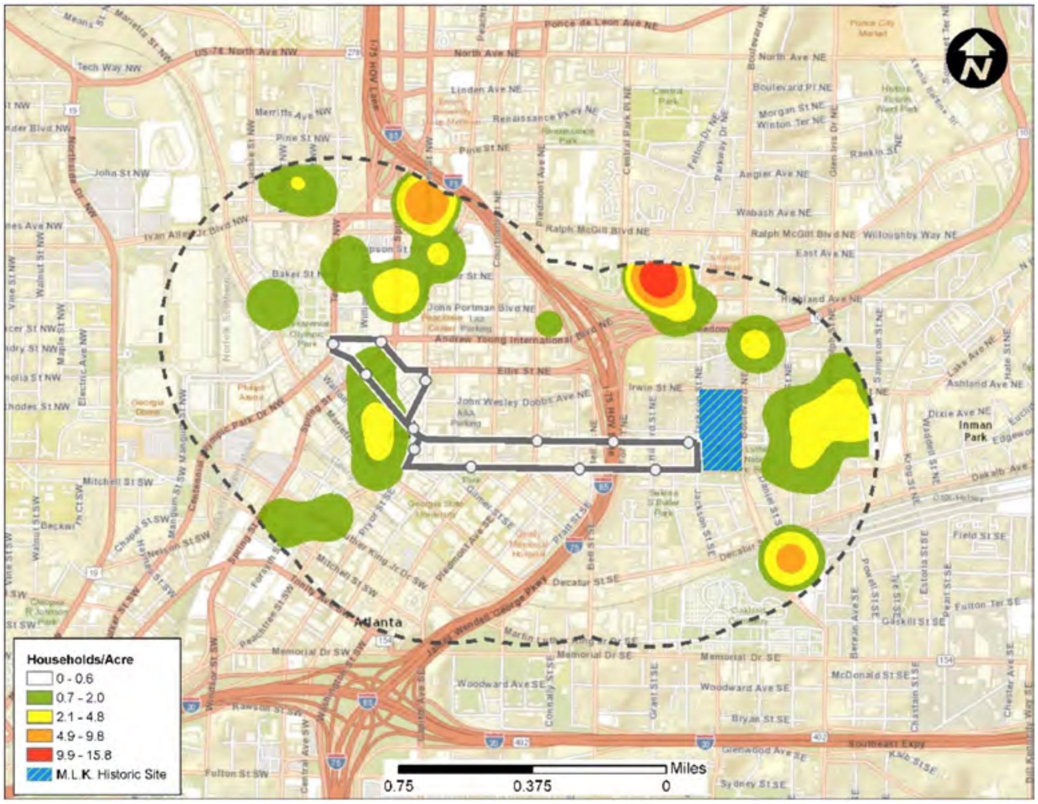


Figure 9-43

Spatial Density of Households at or above Median MSA Income – Atlanta Streetcar SIA – 2016

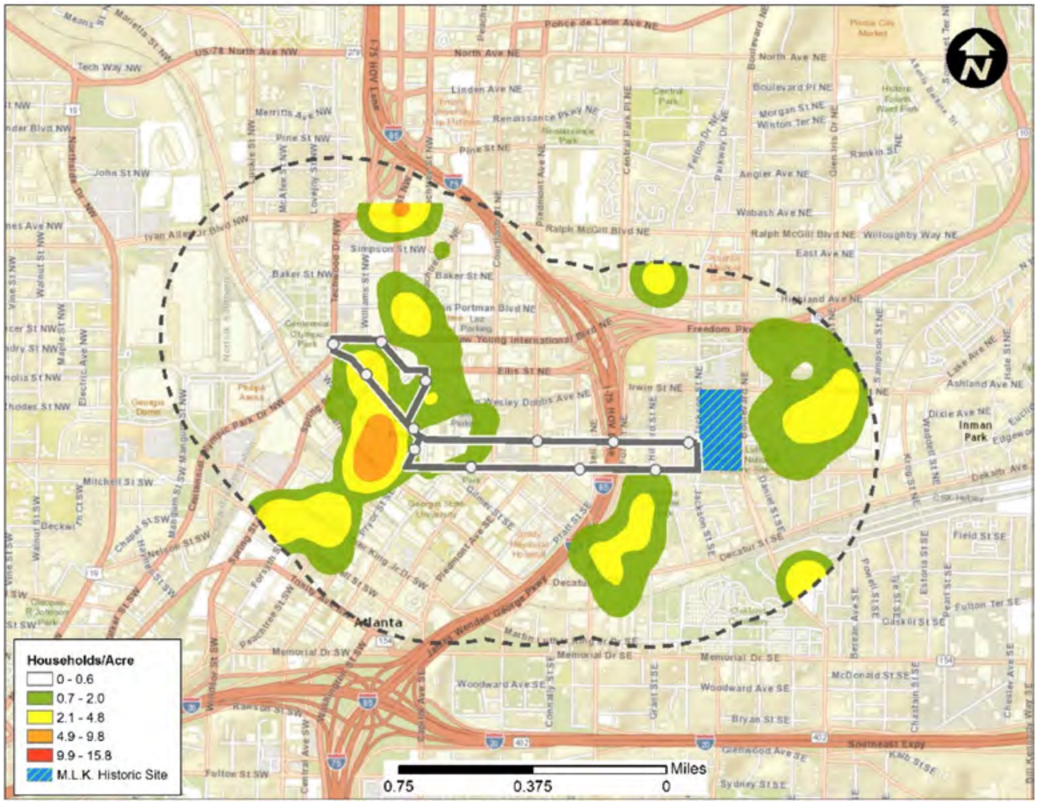


Figure 9-44 and Figure 9-45 show the density maps of households at the top 5 percent income cohort and show no change in spatial dispersion or density continued concentration at the core of Atlanta's CBD.

Figure 9-44

Spatial Density of Households at or above Top 5% Income Distribution – Atlanta Streetcar SIA – 2010

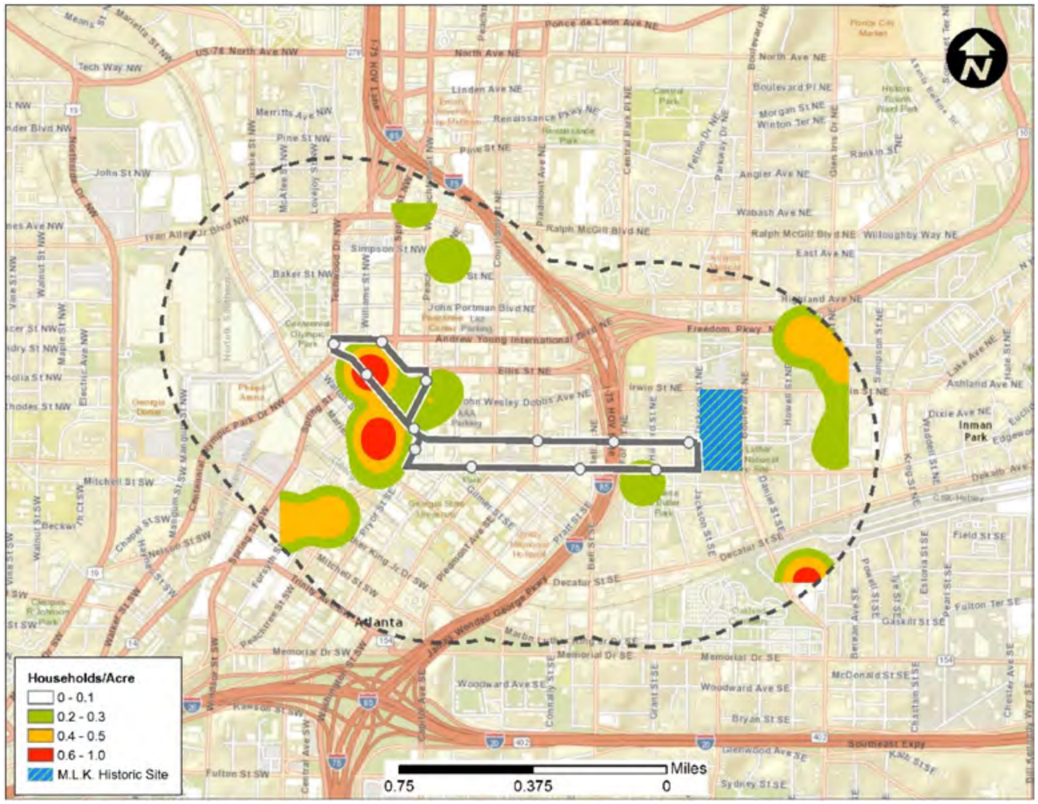


Figure 9-45

Spatial Density of Households at or above Top 5% Income Distribution – Atlanta Streetcar SIA – 2016

Changes in Job Accessibility

To understand how the streetcar system might influence household accessibility to job location and non-work activities, it is relevant to obtain information on commute travel patterns. The LEHD program allows conducting spatial analysis of workers' commuting patterns by combining federal, state, and Census Bureau data on employers and employees. Through the *OnTheMap* program, a user can import GIS-produced shapefiles identifying specific study areas (i.e., streetcar influence area) and analyze worker/job commuting patterns. The most recent data are for 2014, released in March 2016. The analysis used LEHD to obtain a baseline picture of workers' travel patterns to and from the SIA.

Using the GIS polygon defining the SIA, Table 9-18 summarizes the results of the LEHD analysis. The table provides a baseline picture of workers' travel patterns. According to LEHD, there are 99,000 workers in the SIA, with about 4,450 living within and 95,000 working within the SIA. Of those living in the SIA, about 15 percent (684) work and reside within its boundaries. About 60 percent of those workers living in the SIA but working elsewhere travel less than 10 miles, and 89 percent travel up to 24 miles to work. About 46 percent commute within the boundaries of the city of Atlanta. Some workers commute north of the SIA to Sandy Springs, Brookhaven City, and Smyrna City.

Table 9-18

LEHD Commuting Patterns Analysis – Atlanta Streetcar SIA

Workers	2014
Living in SIA	4,452
Working and living in SIA	15.36%
Living in SIA and working elsewhere	84.64%
Earning $1,250 per month or less	16.89%
Traveling less than 10 miles	60.09%
Traveling 10–24 miles	29.20%
Working in Atlanta	45.93%
Working in SIA, living elsewhere	94,797
Earning $1,250 per month or less	11.04%
Traveling less than 10 miles	32.13%
Traveling 10–24 miles	45.81%
Working in Atlanta	18.03%

The household information from Table 9-17, Figure 9 40 through Figure 9-45, and the travel pattern numbers of Table 9-18 form the basis for evaluating the impact of the streetcar system on job accessibility. In particular, the analysis focuses on low-income households. These families are more likely to use the public transportation system either to commute to and from work or to reach non-work locations within and outside the study area.

The estimation of travel time sheds, with and without the streetcar, is based on a transportation network simulated in ArcMap, which employs MARTA GTFS data. MARTA's GTFS data includes information on rail and bus transit stops, routes, trips, and schedule data. The streetcar is not part of MARTA's GTFS data because the system is operated by the City of Atlanta. Therefore, the modeling effort requires linking the streetcar route and schedule with MARTA's GTFS data to generate a multimodal network that consists of fixed route bus, rail, streetcar, and pedestrian modes. Using a multiple-origin, multiple-destination algorithm, the network model computes the shortest paths based on specified cutoff times or uses a fixed number of closest destinations to produce an O/D matrix.

Using the network model, the analysis estimated two travel time sheds: one with walking and streetcar and one excluding the streetcar.[74] The trip origins are based on the highest density location of low-income households. The time sheds are based on the morning peak-hour departing time and 3-minute intervals, with an upper limit of 12 minutes total travel time.

Table 9-19 shows that having access to the streetcar serves as an accelerator to walking, allowing travelers to reach more jobs within a 12-minute time span. The gains in job accessibility and accessibility to non-work activities (e.g., shopping and recreational activities) increase exponentially once travel time extends beyond a 5-minute walk.

Table 9-19 *Atlanta Streetcar Impact on Travel Time Shed and Job Accessibility*

Travel Time (min)	No Streetcar			Streetcar			Difference		
	Service Area (sq.mi.)	Business (#)	Jobs (#)	Service Area (sq.mi.)	Business (#)	Jobs (#)	Service Area (sq.mi.)	Business (#)	Jobs (#)
0 to 3	0.04	39	172	0.04	39	172	0.00	0	0
4 to 7	0.14	147	1,038	0.16	169	1,224	0.02	22	186
8 to 12	0.28	330	2,137	0.53	1,351	20,833	0.24	1,021	18,696

Figure 9-46 shows the travel time shed without the streetcar, and Figure 9-47 shows the travel time shed with the streetcar serving as an accelerator to walking, with the small dots representing businesses currently in operation. The TIGER II grant application noted the reconnection of the economically-depressed area of the western section of Downtown Atlanta as one of the objectives of the streetcar project. Figure 9-47 shows how the streetcar removed this barrier, allowing households residing east of Interstate 75/85 to reach a greater number of destinations and job opportunities.

[74] CUTR is currently working on a multimodal network model that links the streetcar to the GTFS data to model travel time sheds with the inclusion of rail, bus, and walk modes. The results might differ from what is reported here.

Figure 9-46

Atlanta Streetcar Impact on Travel Time Shed and Job Accessibility – No Streetcar

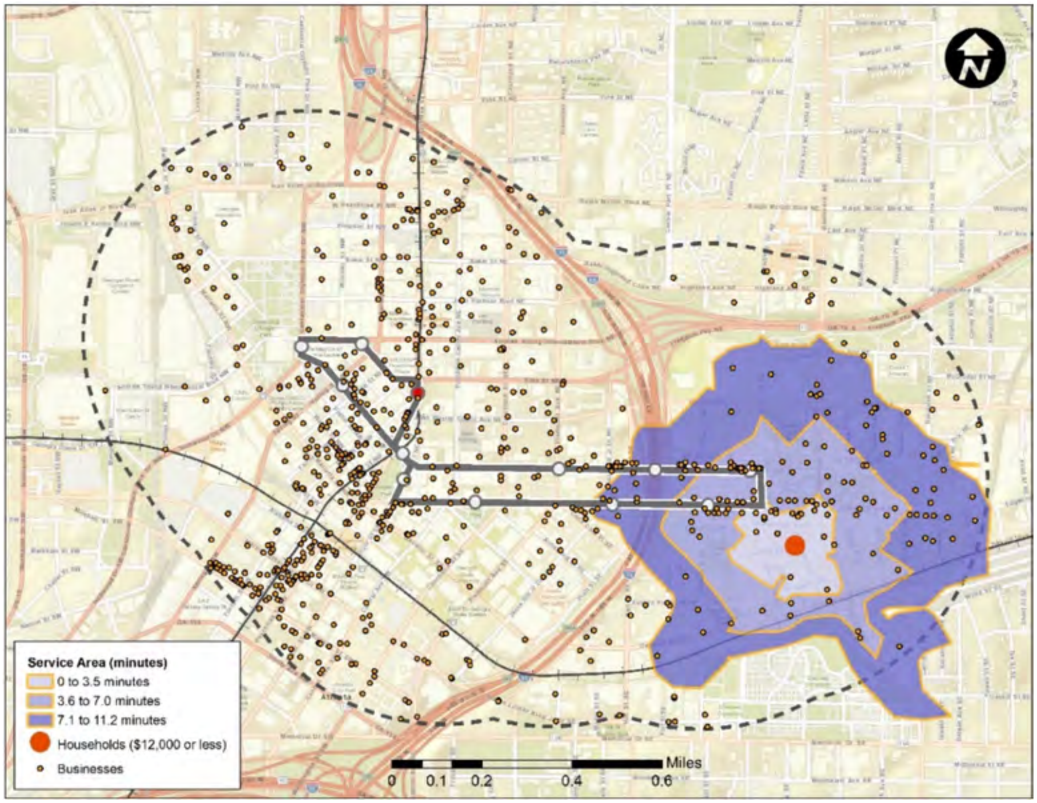


Figure 9-47

Atlanta Streetcar Impact Travel Time Shed and Job Accessibility – Streetcar

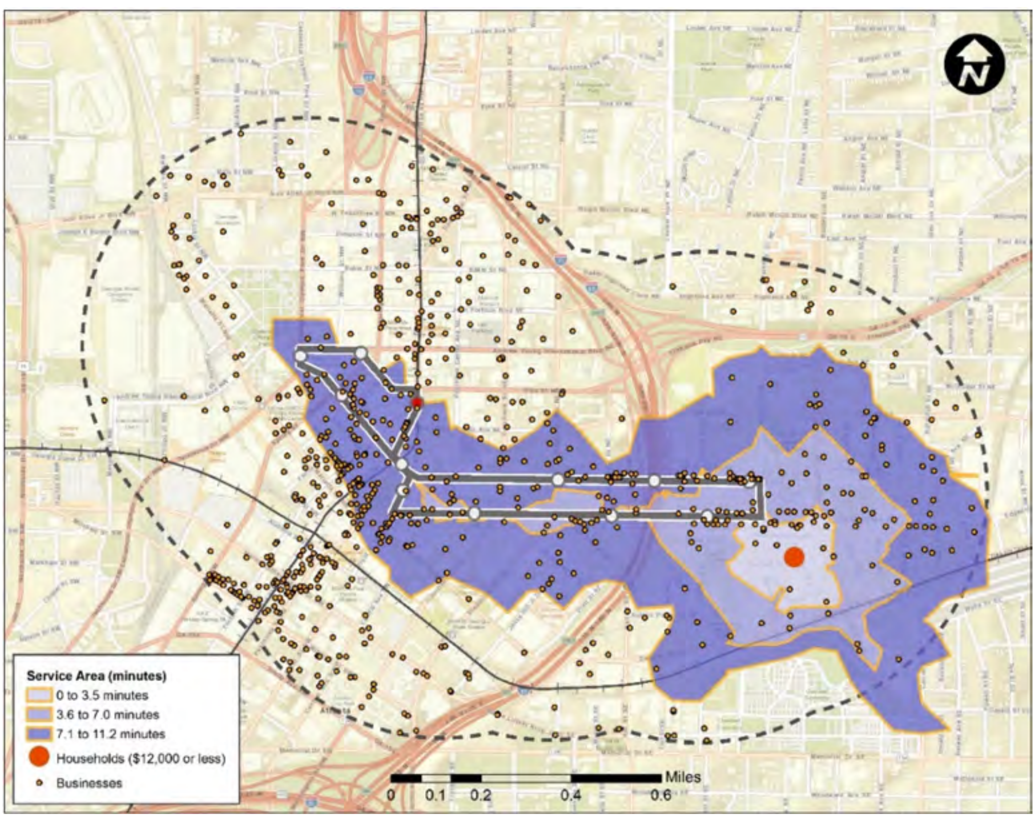


Table 9-19 reports the breakdown at the NAICS 2-digit level of the type of businesses and number of jobs within reach by a combination of walking and streetcar. Low-income households can reach about 1,350 businesses and 21,000 jobs within 12 minutes of travel from their homes. About 10 percent of these jobs are located in the accommodation and food services as well as retail trade sectors.

Accessibility to Tourist Attractions

Atlanta is a popular site for tourist attractions and convention centers, attracting millions of visitors annually. In 2016, 52 million visitors traveled to Metro Atlanta.[75] The previous year, about 2.5 million conventioneers and sport spectators visited the Georgia World Congress Center and the Georgia Dome, of which 39 percent came from out-of-state.[76] The streetcar system is located in the core of Atlanta's CBD, providing increased accessibility to several destinations and attractions. Via its route and 12 stops, the streetcar provides access from the Hotel District and the Centennial Olympic Park on the west side of the CBD to the MLK National Historic Site on the east side of Downtown, while serving historic Auburn Avenue, the birthplace of the nation's civil rights movement.

To assess the impact of the streetcar on accessibility to tourists visiting businesses and major attractions, Figure 9-48 and Figure 9-49 show the travel time sheds generated using MARTA's Peachtree Center Station as the origin for trips by walk and by streetcar/walk combination. The choice of Peachtree Station as the center of the travel time shed area is based on its proximity to the Hotel District and convention centers. The figures show how visitors using a combination of walking and streetcar can reach major attractions located east of I75/85 within 11–12 minutes of Peachtree Center Station. The availability of the streetcar makes it possible to reach the MLK Historic Site from MARTA's station in less than 10 minutes.

[75] Atlanta Convention and Visitors Bureau: http://news.atlanta.net/about/annual-report-business-plan.

[76] Georgia World Congress Center and Georgia Dome Economic Impact Analysis – FY 2014. Georgia World Congress Center Authority, September 2014.

Figure 9-48

Atlanta Streetcar Impact on Travel Time Shed and Job Accessibility to Major Attractions – No Streetcar

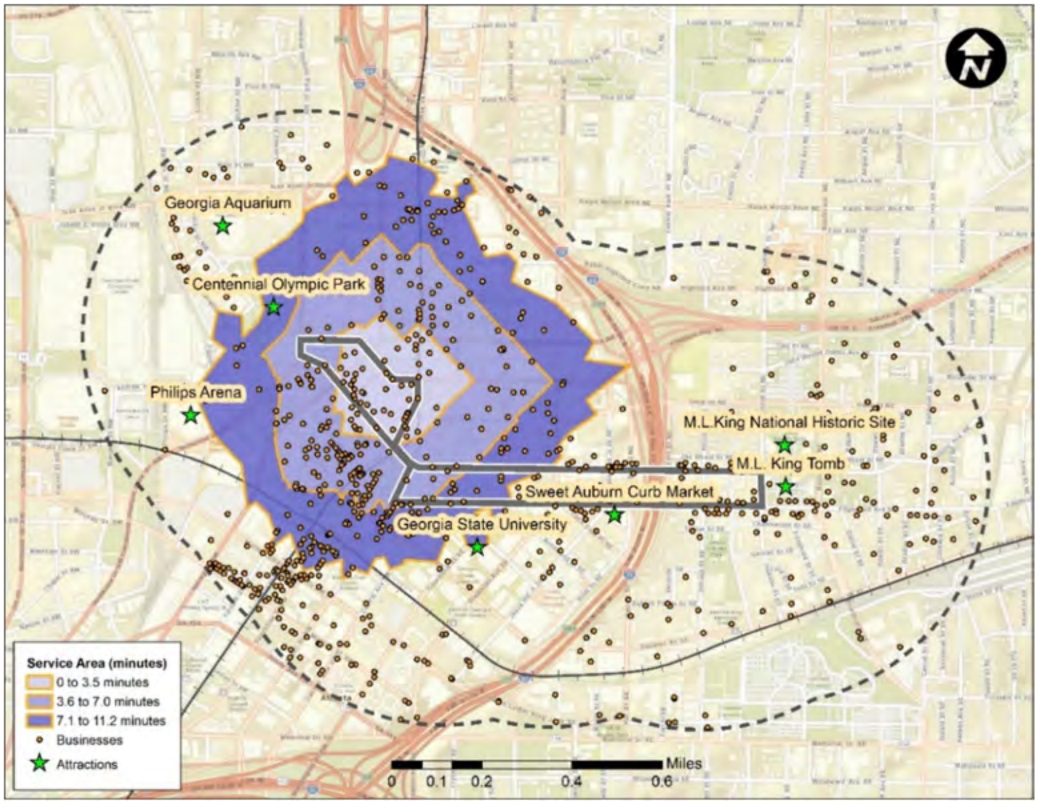


Figure 9-49

Atlanta Streetcar Impact on Travel Time Shed and Job Accessibility to Major Attractions – Streetcar

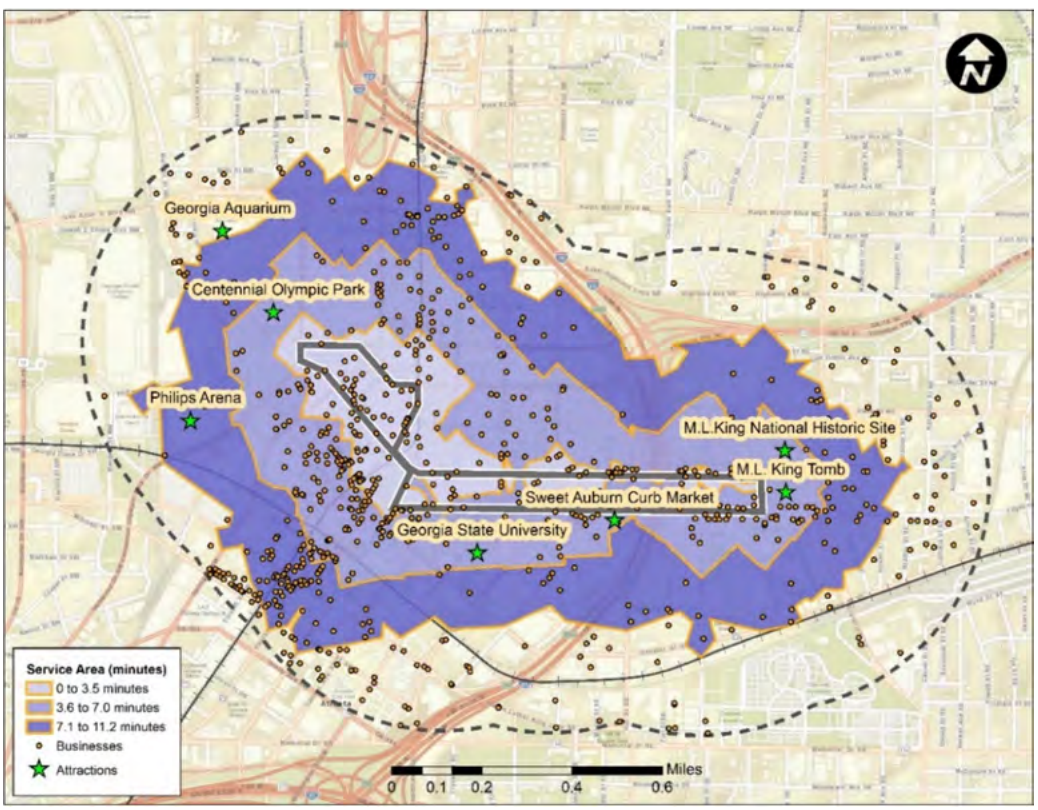


Table 9-20 shows the number of businesses accessible to tourists and visitors by walk and by combining walk with streetcar use. The streetcar allows reaching an additional 940 businesses, operating primarily in the accommodation and food services (27.7%) and retail trade (38.4%). As shown in Section 8, this increased accessibility is affecting business and employment growth in the study area.

Table 9-20 *Atlanta Streetcar Impact on Travel Time Shed and Accessibility – Businesses and Attractions*

Travel Time (min)	No Streetcar			Streetcar			Difference		
	Service Area (sq.mi.)	*Business (#)*	*Jobs (#)*	*Service Area (sq.mi.)*	*Business (#)*	*Jobs (#)*	*Service Area (sq.mi.)*	*Business (#)*	*Jobs (#)*
0 to 3	0.06	237	8,699	0.14	505	12,433	0.09	268	3,734
4 to 7	0.19	1833	34,619	0.45	2,656	54,579	0.25	823	19,960
8 to 12	0.27	2853	75,499	0.56	3,794	97,008	0.29	941	21,509

Changes in Household Travel Times

Using the Infogroup 2016 household sample (5,188 households), the analysis estimates changes in travel times at the household level. The analysis is based on the estimated O/D matrix of distance and travel times from each residential unit location to all businesses located in the SIA. As in the previous section, the analysis compares two modal alternatives: (1) walk and (2) walk and streetcar. Route choice is based on minimizing the total travel time without imposing a walking time-distance threshold.

Table 9-21 reports the mean and maximum household travel time savings for trips taken from the residential units to all businesses located within the SIA.

Table 9-21

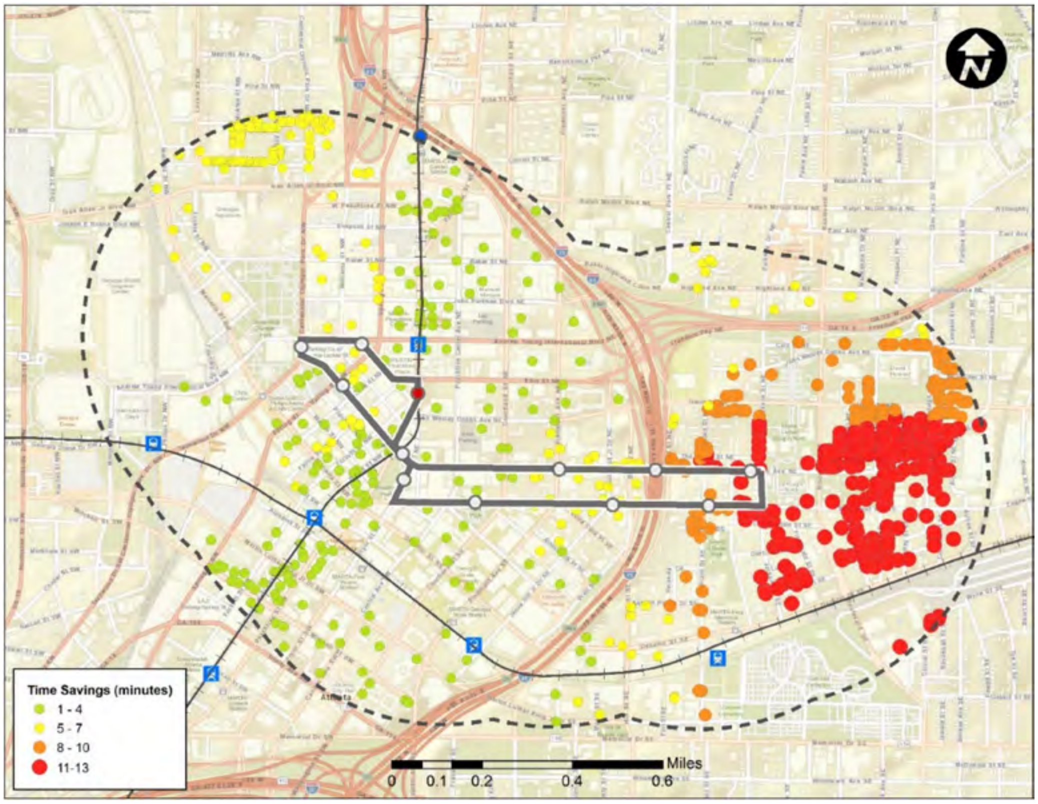
Atlanta Streetcar Impact on Mean and Maximum Travel Time Savings

Household Income Cohort	Mean	Max	% with Time Savings
All households	7.1	20.5	70.0%
At or above top 5% income	8.3	19.6	1.7%
At or above MSA median income	8.1	19.6	13.8%
At or below poverty threshold	8.1	20.5	21.5%

While clustered at specific locations, time savings are evenly distributed across income groups, as shown in Figure 9-50. The eastern portion of the SIA and nearby MLK and Edgewood at Hilliard stations, where the majority of low-income households (single-family and condominium units) reside, enjoys the most time savings (11–13 minutes). Households located on the northwest portion of the SIA also enjoy substantial travel time savings.

Figure 9-50

Atlanta Streetcar Impact on Household Travel Time Savings



Salt Lake City S-Line

The construction of the streetcar system can provide additional accessibility gains to households and workers residing in the area, as well as to workers coming to the area from the remainder of the county. The analysis relies on transit travel time data obtained through (1) Google automated protocol interface (Google Directions API) and (2) a zone-to-zone transit-travel time matrix via a simulation network model running within ArcGIS ArcMap and using Utah Transit Authority (UTA) GTFS data feeds.

Salt Lake County is currently served by an extensive fixed-route bus transit and light rail system. UTA modes include bus, bus rapid transit, commuter rail, and light rail. UTA operates 493 buses, 103 fixed-routes, and 6,273 active bus stops. The light rail

Figure 9-51

UTA Rail Map

system (TRAX) consists of 44.8 miles of tracks, 51 stations, and 114 vehicles. Two new TRAX lines opened in 2013, the 6-mile Airport TRAX and the 3.5-mile Draper TRAX. UTA's rail line is illustrated in Figure 9-51.

The streetcar influence area is served by bus routes 200 (State Street North), 205 (500 East), and 209 (900 East), which cross the SIA north/south and reach Salt Lake CBD. Bus route 21 (2100 South/2100 East) runs parallel to the streetcar along 2100 South with a stop at Central Pointe Station. Buses on these routes run every 15 minutes. In addition, a fast bus route with limited stops and park-and-ride lots (Route 307) stops at 700 East streetcar station and serves downtown and other major employment centers (University of Utah and its medical center).

Using the network model and Google API Directions, changes in travel times to and from the CBD are estimated and two travel time sheds were defined: one with all modes and one excluding the streetcar.

Household Location Patterns

Information on households comes from the Infogroup dataset and covers the period 2007–2016. Table 9-22 summarizes the sample descriptive statistics for year 2016. The table shows that about 75 percent of the 5,865 households consisted of single-head families, with about 18 percent with one or more child. About 74 percent of the households received an annual income at or below the metropolitan statistical area median income.[77] About 14 percent of the households lived at or below the U.S. Census poverty threshold.[78] About 5 percent earned an annual income that puts them at the to the top 5 percent income distribution.[79]

In 2007 and 2016, the percent of households by income group fluctuated in response to changes in generalized economic and local conditions (Figure 9-52). Over this period, the percent of households at the top 5 percent of the income distribution decreased from 17.7 percent to 5.1 percent. The percent of households living at or below the U.S. Census poverty threshold increased from 6.1 percent in 2007 to 13.8 percent in 2016. Households at or below the MSA median income show a growing trend, increasing from 62.6 percent to 73.6 percent.

According to ACS 2011–2015 5-Year Estimates (Series 1901), median household income for the Salt Lake City Metropolitan Statistical Area is $53,889.

The U.S. Census Bureau publishes annual average weighted poverty threshold estimates, available at https://www.census.gov/data/tables/time-series/demo/income-poverty/historical-poverty-thresholds.html.

For the entire sample (treatment and control), the top 5 percent of household in 2016 received $89,000 per year.

Table 9-22

Household Sample Descriptive Statistics – Salt Lake City S-Line SIA

Definition	Mean	Std. Dev.	Min	Max
Household income ($000)	36,282	22,568	5,000	150,000
Households at or above top 5% income	0.05	0.22	0.00	1.00
Households at or below median income	0.74	0.44	0.00	1.00
Households at or below poverty threshold	0.14	0.34	0.00	1.00
Length of residence (yrs)	10.44	11.01	1.00	57.00
Household size	1.51	0.99	1.00	8.00
Household head married	0.25	0.43	0.00	1.00
Household head single	0.75	0.43	0.00	1.00
Household head age 65 and older	0.17	0.38	0.00	1.00
With children	0.18	0.39	0.00	1.00
Number of children	2.02	1.08	1.00	6.00
Property owner	0.48	0.50	0.00	1.00
Property renter	0.27	0.44	0.00	1.00

Figure 9-52

Percent of Households by Income Group, 2007–2016 – Salt Lake City S-Line SIA

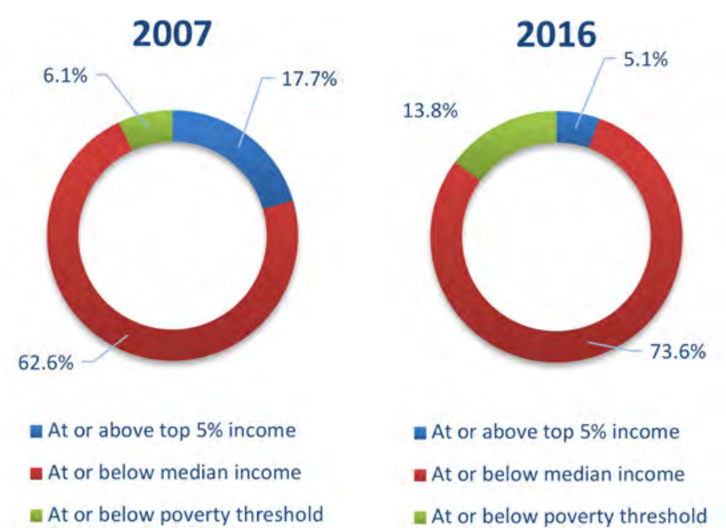


Figure 9-52 does not provide information on the spatial distribution of households by income group within the study area. Spatial kernel surfaces provide a useful method for evaluating changes in the distribution of households in space and time. Kernel methods generate density surfaces that show where point features are concentrated. In this analysis, the surfaces evaluate the density of households measured in the number of households per acre, comparing the streetcar announcement year (2010) to the year after opening (2016).

Figure 9-53 and Figure 9-54 display the spatial density estimates of households at or below the threshold of poverty. In 2010, low-income households appear to be densely clustered north of the streetcar line and in proximity of the Sugar House Shopping District. In 2016, density decreased, and these household were no longer concentrated in the shopping area.

Figure 9-53

Spatial Density of Households at or below Poverty Threshold – Salt Lake City S-Line SIA – 2010

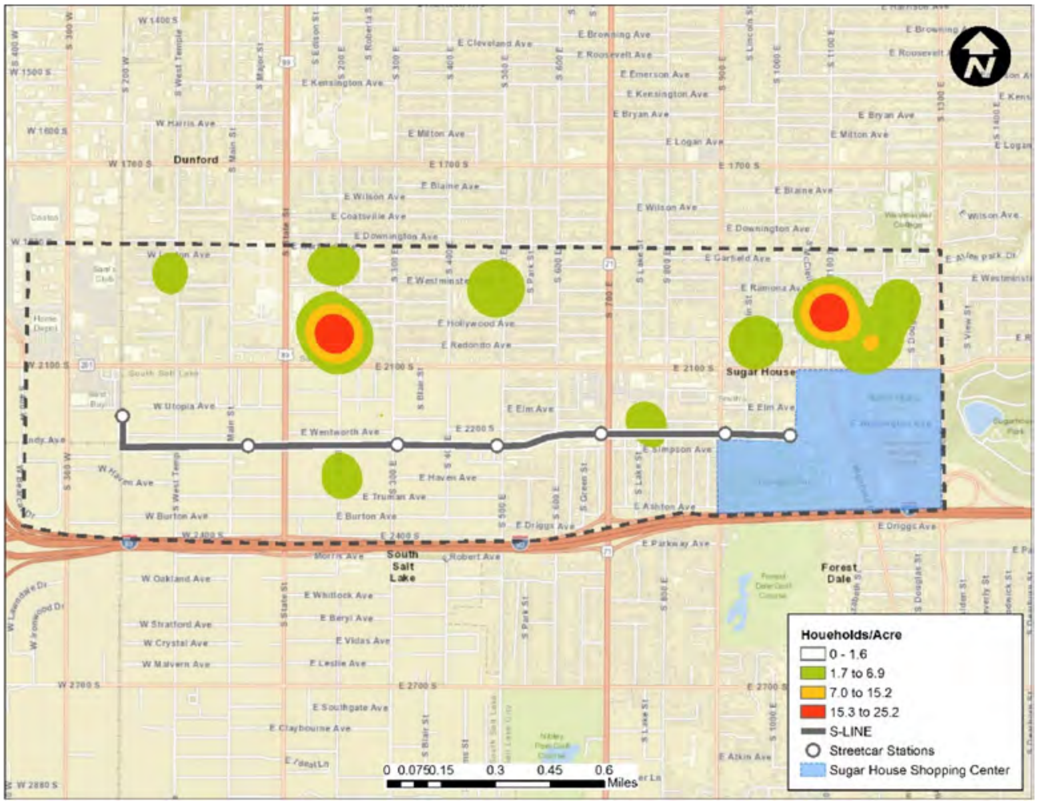


Figure 9-54

Spatial Density of Households at or below Poverty Threshold – Salt Lake City S-Line SIA – 2016

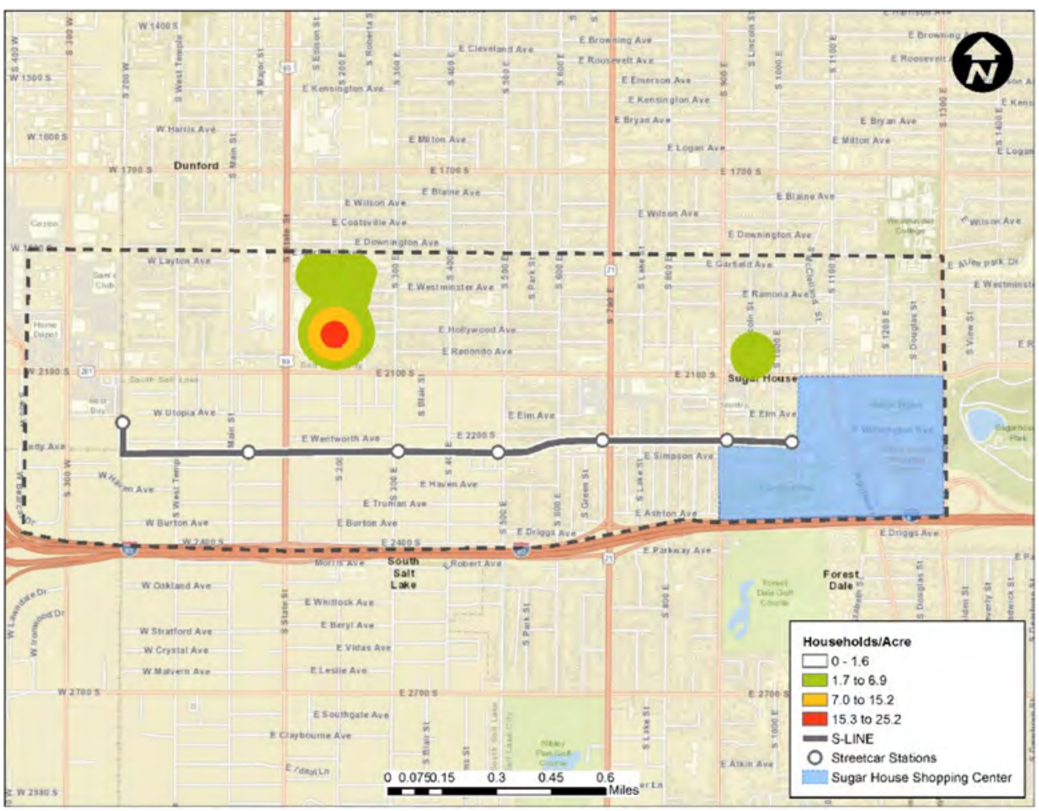


Figure 9-55 and Figure 9-56 show the spatial distribution of households at or below the MSA median income. The figures show that the spatial locations of these households are spread more evenly in the study area than the low-income households with density increasing north of the Sugar House Shopping Center in 2016. Figure 9-57 and Figure 9-58, which show the density maps of households at the top 5 percent income cohort, illustrate a marked reduction in density. The percentage of households in this group decreased from 11.4 percent in 2010 to 5.1 percent in 2016.

Figure 9-55

Spatial Spatial Density of Households at or below Median MSA Income – Salt Lake City S-Line SIA – 2010

Figure 9-56

Spatial Density of Households at or below Median MSA Income – Salt Lake City S-Line SIA – 2016

Figure 9-57

Spatial Density of Households at or above Top 5% Income Distribution – Salt Lake City S-Line SIA – 2010

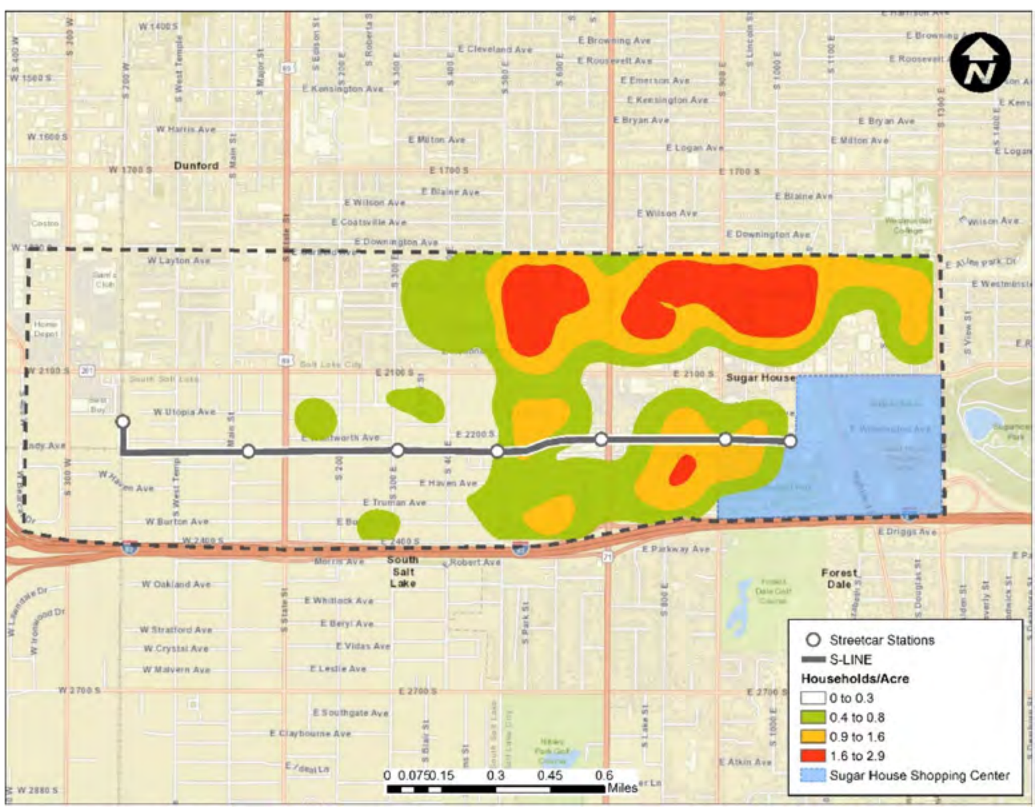
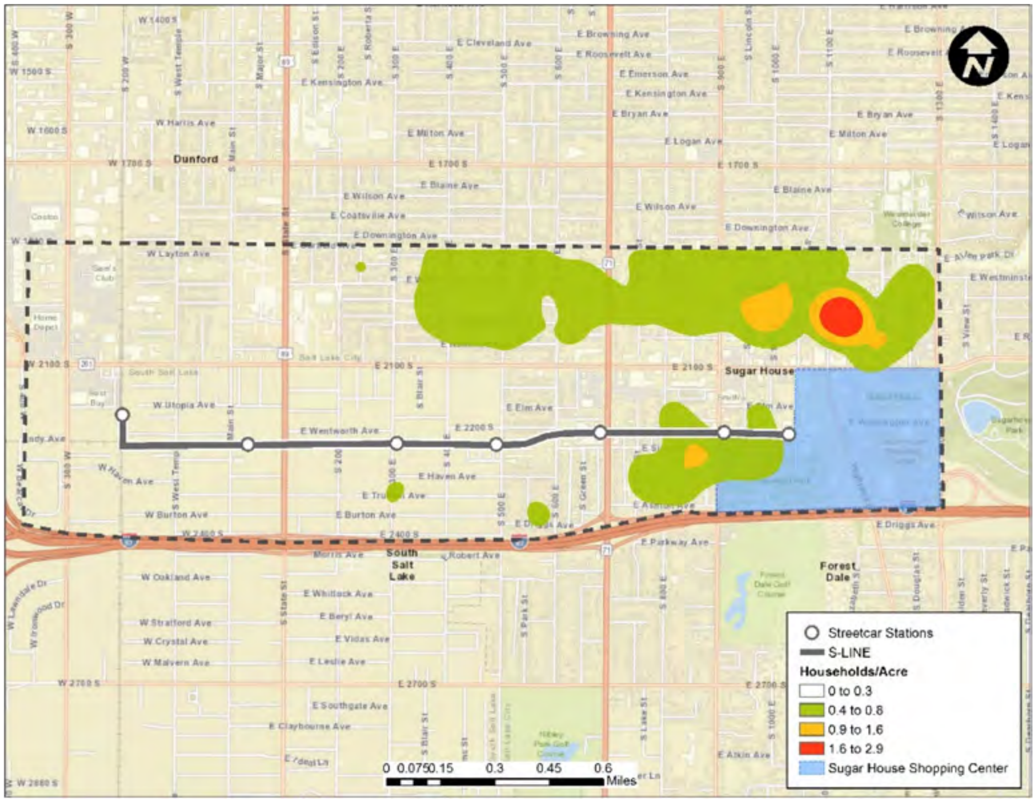


Figure 9-58

Spatial Density of Households at or above Top 5% Income Distribution – Salt Lake City S-Line SIA – 2016



Changes in Job Accessibility

Information on commute travel patterns needs to be obtained to understand how the streetcar system might influence household accessibility to job location and non-work activities.

The LEHD program allows conducting spatial analysis of workers' commuting patterns by combining federal, state, and Census Bureau data on employers and employees. Through the *OnTheMap* program, a user can import GIS-produced shapefiles identifying specific study areas (i.e., streetcar influence area) and analyze worker/job commuting patterns. The most recent data are for 2014, released in March 2016. The analysis used LEHD to obtain a baseline picture of workers' travel patterns to and from the SIA.

Using the GIS polygon defining the SIA, Table 9-23 summarizes the results of the LEHD analysis. The table provides a baseline picture of workers' travel patterns. According to LEHD, there are about 21,000 workers in the SIA, 4,434 living within the SIA, and 16,196 working in the SIA. Of those living in the SIA, about 4.26 percent work and reside within its boundaries. The majority of workers residing in the SIA (94.3%) commute to work and travel a distance less than 24 miles. About 39.7 percent commute within the boundaries of Salt Lake City. Some workers commute south of the SIA to West Valley City (9.1%), West Jordan City (7.5%), and Sandy City (5.5%).

Table 9-23

LEHD Commuting Patterns Analysis – Salt Lake City S-Line SIA

Workers	2014
Living in SIA	4,434
Working and living in SIA	4.26%
Living in SIA and working elsewhere	95.74%
Earning $1,250 per month or less	20.55%
Traveling less than 10 miles	81.98%
Traveling 10–24 miles	12.31%
Working in Salt Lake City	39.72%
Working in SIA, living elsewhere	16,196
Earning $1,250 per month or less	25.16%
Traveling less than 10 miles	57.27%
Traveling 10–24 miles	27.52%
Working in Salt Lake City	14.84%

The household information of Figure 9-53 through Figure 9-58 and the travel pattern numbers of Table 9-23 form the basis for evaluating the impact of the streetcar system on job accessibility. In particular, the analysis focuses on low-income households. These families are more likely to use the public transportation system either to commute to and from work or to reach non-work locations within and outside the study area.

The estimation of travel time sheds, with and without the streetcar, is based on a transportation network simulated in ArcMap, which employs Utah TRAX GTFS data. UTA's GTFS data feed includes information on transit stops, routes, trips, and schedule data. The network consists of fixed-route bus, light rail, streetcar, and pedestrian. Using a multiple-origin, multiple-destination algorithm, the network computes shortest paths based on specified cutoff times or uses a fixed number of closest destinations to produce an O/D matrix.

Using the network model, the analysis estimated two travel time sheds: one with all transit modes and one excluding the streetcar. The trip origins are based on the f highest density location of low-income households, corresponding to the dark red ring of Figure 9-53 and having a density of 22–28 households per acre. The transit time sheds are based on the a.m. peak hour departing time and 10-minute intervals, with an upper limit of one hour in total travel time.

Table 9-24 reports the results, showing that the introduction of the streetcar does not have an impact on the size of the time shed. These findings are in line with the findings of the travel times to the CBD. This is because the SIA is currently served by an extensive fixed-route bus system, with bus route 205 serving low-income households.

Table 9-24

Salt Lake City S-Line Impact on Travel Time Shed and Job Accessibility

Travel Times (mins)	Service Area (sq. mi.)		
	No Streetcar	*Streetcar*	*Difference*
0 to 10	0.3	0.3	-0.01
11 to 20	1.8	1.8	-0.04
21 to 30	6.6	6.6	0.05
31 to 40	14.9	14.9	0.00
41 to 50	24.2	24.2	0.00
51 to 60	34.4	34.4	0.00

Figure 9-59 shows the estimated travel time shed with the streetcar, overlaying the business dataset. Table 9-25 reports the breakdown at the NAICS 2-digit level of the type of businesses and number of jobs within reach by 10-minute time intervals. Low-income households can reach about 6,000 business and 137,000 jobs within 40 minutes of travel from their homes.

Figure 9-59

Salt Lake City S-Line Impact on Travel Time Shed and Job Accessibility

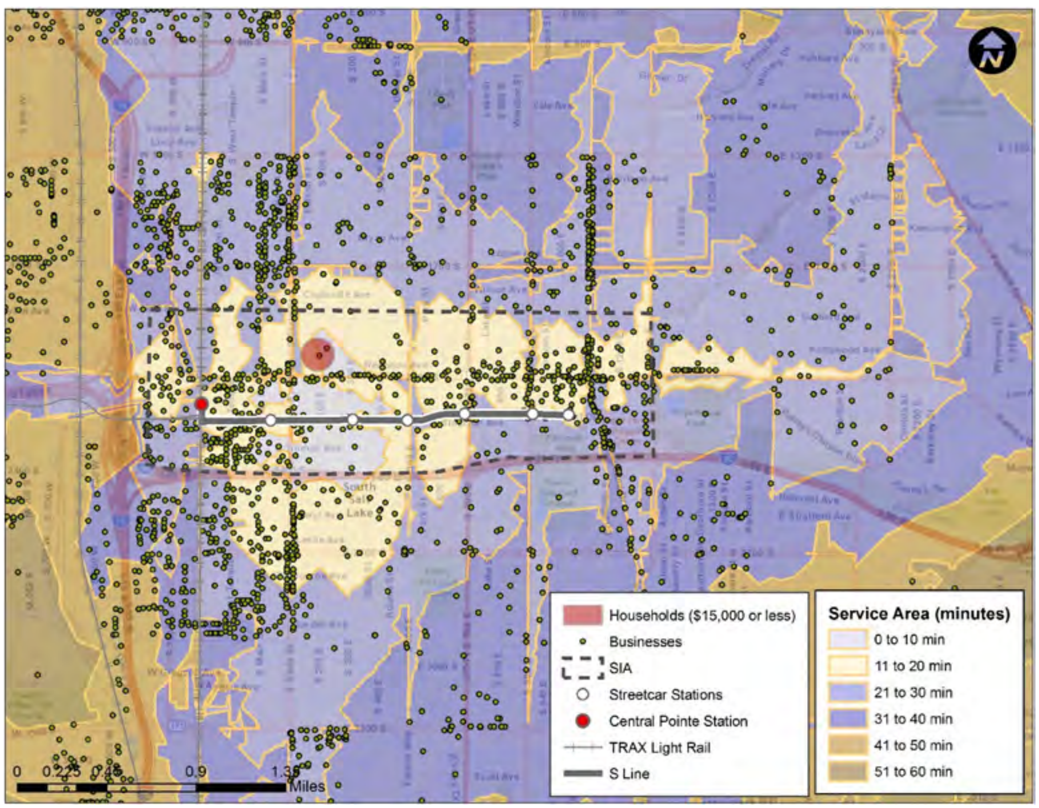


Table 9-25 *Salt Lake City S-Line Impact on Job Accessibility by NAICS 2-digit Level*

NAICS	Industry Sector	Travel Time (min)					
		0 to 10	*11 to 20*	*21 to 30*	*31 to 40*	*41 to 50*	*51 to 60*
11	Agriculture, forestry, fishing and hunting	0	0	6	48	54	62
21	Mining, quarrying, and oil and gas extraction	3	5	27	991	991	991
22	Utilities	0	6	50	9,318	9,344	9,369
23	Construction	36	323	1,023	2,317	3,557	4,239
31-33	Manufacturing	33	1,800	2,825	5,246	8,354	9,621
42	Wholesale trade	37	418	1,225	2,278	5,386	6,805
44-45	Retail trade	259	2,543	10,489	15,312	17,680	18,823
48-49	Transportation and warehousing	2	147	351	886	1,448	1,570
51	Information	4	115	919	3,790	4,452	4,698
52	Finance and insurance	51	300	829	9,655	10,786	11,125
53	Real estate and rental and leasing	50	354	954	2,123	3,233	3,514
54	Professional and technical services	25	794	1,820	9,703	11,624	11,859
55	Management of companies and enterprises	0	0	5	10,614	10,614	10,614
56	Administrative and waste services	38	674	1,345	1,957	3,073	3,548
61	Educational services	14	645	1,233	1,854	2,197	2,418
62	Health care and social assistance	82	1,135	2,473	36,558	37,069	37,433
71	Arts, entertainment, and recreation	27	296	465	732	1,160	1,269
72	Accommodation and food services	115	1,605	3,247	9,556	10,344	10,649
81	Other services, except public administration	192	652	2,375	3,954	4,621	4,931
92	Public administration	7	5,030	5,833	9,461	9,870	10,338
99	Unclassified	3	43	154	1,047	1,224	1,243
	Total Employment	*978*	*16,885*	*37,648*	*137,400*	*157,081*	*165,119*
	Total Businesses	*94*	*1,015*	*2,754*	*6,001*	*7,367*	*7,846*
	Percent of Total	*0.59*	*10.23*	*22.80*	*83.21*	*95.13*	*100.00*

Changes in Household Travel Times

Using Google Direction API, the analysis estimates changes in travel times between the SIA and Salt Lake City CBD. Relying on UTA's GTFS transit feeds, Google Directions API[80] allows batch processing of O/D travel distances and travel times. The service computes directions between locations by specifying origin and destination either by address or latitude/longitude coordinates. Detailed trip information can be obtained in batch-mode processing for multiple observations with output provided in JavaScript Object Notation (JSON). The use of ad-hoc text parsing macro modules, working in SAS, allows extracting relevant trip information from the JSON file.

[80] https://developers.google.com/maps/documentation/directions/intro.

Using the 2016 household sample (4,442 households), the analysis considered the following scenarios and assumptions to estimate changes in travel times at the household level. The choice of Salt Lake City CBD as origin/destination reflects the commute travel patterns, as indicated by Table 9 23. The comparison of travel times with the streetcar to travel times without the streetcar applies to the following directional morning and afternoon peak and off-peak travel times:

- Morning peak (6:30 AM) – from household to CBD
- Morning off-peak (10:00 AM) – from household to CBD
- Afternoon peak (6:30 PM) – from CBD to household
- Evening off-peak (8:30 PM) – from household to CBD

The analysis compares two modal alternatives: (1) bus and light rail and (2) bus, light rail, and streetcar. Route choice is based on minimizing the total travel time (option "best route"), without imposing a walking time-distance threshold between modes (Google's API allows selecting an option that accounts for the preference "less walking").

Table 9-26 shows the percent of SIA households with travel time savings. The percent of households saving time while traveling to/from the CBD ranges from 1.3–13.9 percent, with savings varying by income level. The morning peak hour produces the lowest travel time savings to households, with 6.3 percent of the SIA households having the opportunity to save time traveling to the CBD by using the streetcar. These savings remain constant through the day. The largest share of households saving time travelling to the CBD is during the evening, for trips starting after 8:30 PM, because there is a reduction in service frequency along the bus routes, while the streetcar remains at the same service frequency through 9:30 PM. Because of their relative location and larger sample share, households at or below the MSA median income are more affected by these travel time savings than all other income cohorts.

Table 9-26

Percent of Households with Travel Time Savings – Salt Lake City S-Line

Income	AM	AM	PM	PM
	Peak	*Off-peak*	*Peak*	*Off-peak*
At or above top 5% income	0.0	0.0	0.1	0.2
At or below MSA median income	1.0	1.0	6.3	11.1
At or below poverty threshold	0.3	0.3	1.8	2.3
All Households	1.3	1.3	8.4	13.9

Table 9-27 reports the mean and maximum travel time savings that a household can gain when choosing to use the streetcar. The largest savings occur in the p.m. off-peak period, with about 3.7 minutes, on average, and a maximum savings of 9 minutes.

Table 9-27 *Salt Lake City S-Line Impact on Mean and Maximum Travel Time Savings*

Income Group	AM Peak		AM Off-peak		PM Peak		PM Off-Peak	
	Mean	Max	Mean	Max	Mean	Max	Mean	Max
At or above top 5% income	9.0	27.0	9.0	27.0	6.0	8.0	5.8	8.0
At or below MSA median income	8.5	27.0	8.5	27.0	6.3	22.0	6.2	22.0
At or below poverty threshold	10.8	26.0	10.8	26.0	6.2	22.0	6.1	22.0
All Households	9.0	27.0	9.0	27.0	6.3	22.0	6.3	22.0

The travel time savings are not equally spread within the SIA, but are clustered at specific locations near the streetcar stations. Figure 9-60 and Figure 9-61 show the AM peak and off-peak savings, and Figure 9-62 and Figure 9-63 show the PM peak and off-peak savings. The largest time savings occur within 0.25 miles of the South 300, South 500, and South 700 East stations. Households residing in close proximity to the Central Pointe Station do not experience any time savings, as the station is already served by light rail. Households located in the northeast quadrant do not experience any travel time savings using the streetcar versus using fixed route mass transit services to travel to the CBD. Notably, the northeast quadrant is the area that is experiencing most real estate development and where property values are accruing.

Figure 9-60

Salt Lake City S-Line Impact on Travel Time Savings – AM Peak

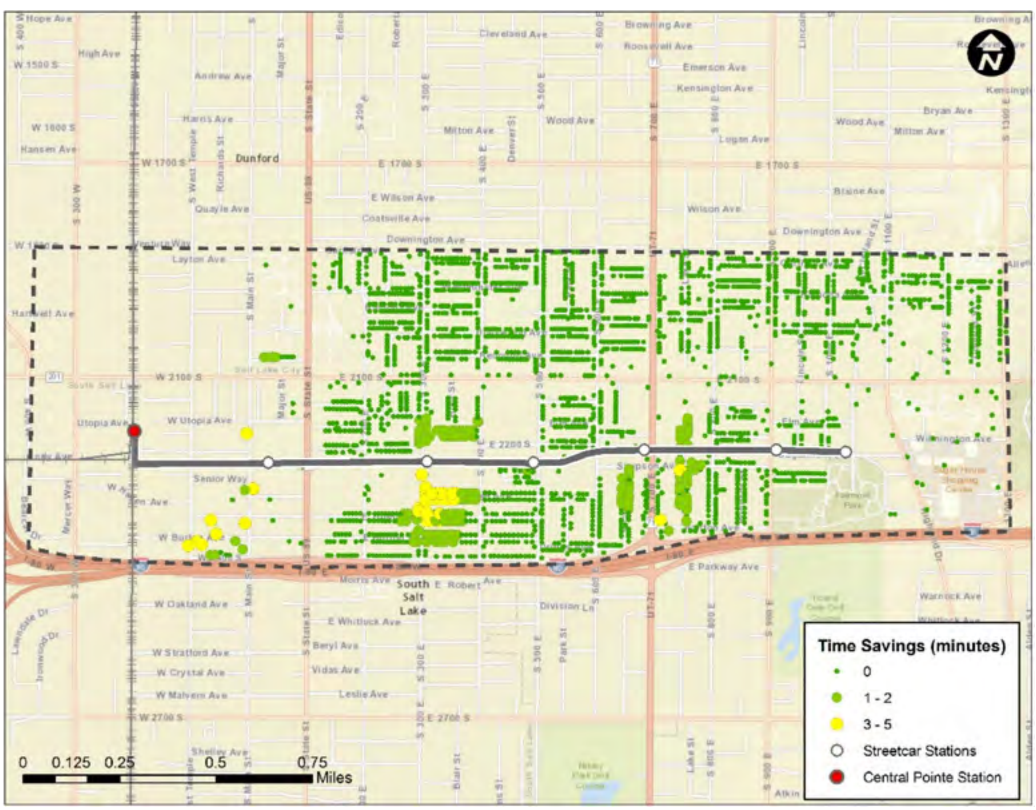


Figure 9-61

Salt Lake City S-Line Impact on Travel Time Savings – AM Off-peak

Figure 9-62

Salt Lake City S-Line Impact on Travel Time Savings – PM Peak

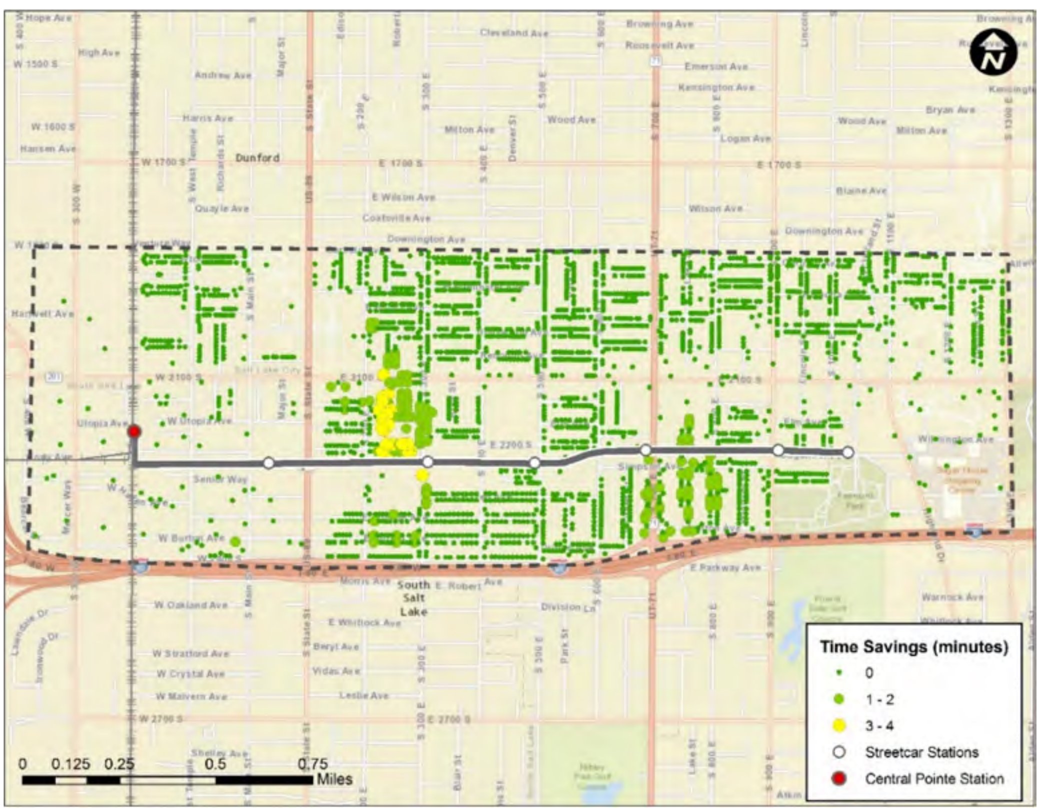
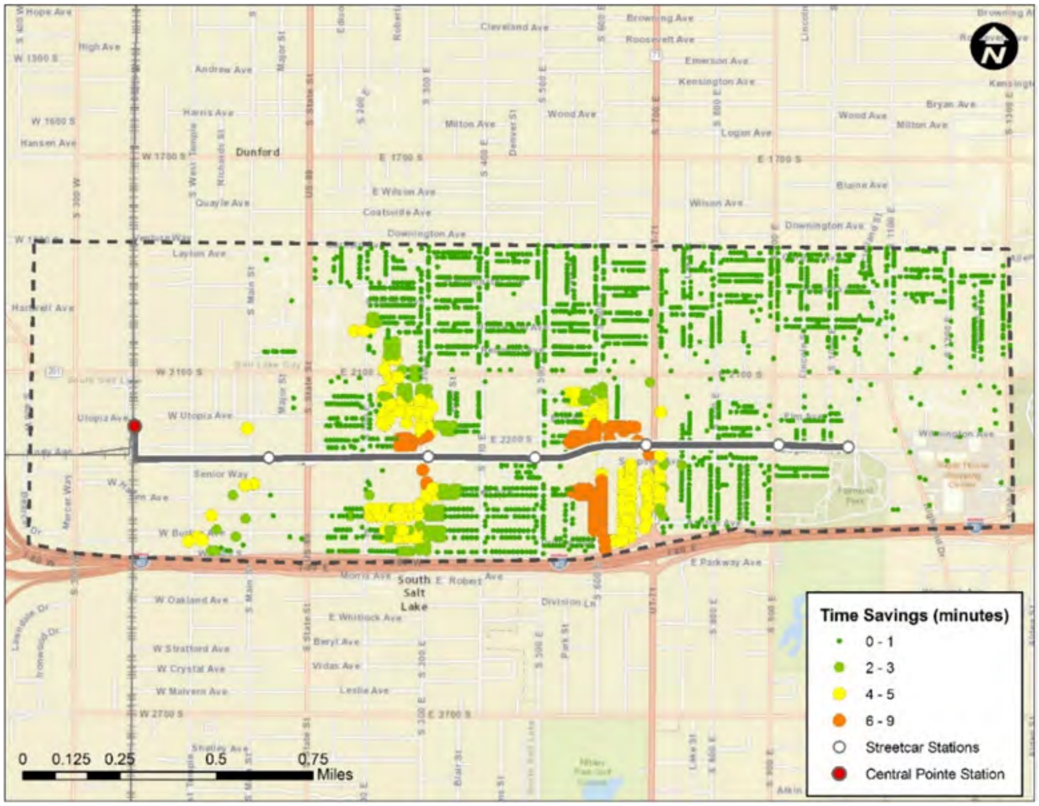


Figure 9-63

Salt Lake City S-Line Impact on Travel Time Savings – PM Off-peak



In summary, the streetcar provides mode travel time savings to the SIA households, with mean travel time reductions spanning from about two to four minutes. These savings are clustered around the streetcar stations midway between the Central Pointe and Fairmont stations.

Summary of Findings

Cincinnati Bell Connector

As of 2016, the Cincinnati SIA was home to about 7,920 households, 38.4 percent of which have an annual income that positions them below the U.S. Census poverty threshold, and where about 12.5 percent of households had one or more members age 65 or older. The analysis shows that the streetcar system does not provide increased accessibility in addition to what is already provided by the current supply of fixed-route bus service. The travel time shed analysis does not show statistically significant improvements in job accessibility and travel times to lower-income households. These results are confirmed by the analysis of household travel times from each residential unit to the Findlay Market, a gathering place for local residents and tourists, and a main hub of economic activity. The analysis of travel times to this location confirms the findings of the network simulation, showing the streetcar does not provide added savings to their residents.

Charlotte CityLYNX Gold Line

As of 2016, the Charlotte SIA was home to about 5,200 households. Most of these households (61.0 percent) earn an annual income equal or above the MSA median income ($53,168), and about 12.5 percent of households had one or more members age 65 or older. About 2 percent of the SIA households are at or below the U.S. Census poverty threshold. The analysis shows that the streetcar system does not provide increased accessibility in addition to what is already provided by the current supply of fixed-route bus service.

The travel time shed analysis does not show statistically significant improvements in job accessibility and travel times to lower-income households. These results are confirmed by the analysis of household travel times from each residential unit to the CTC station, the main transit hub of Charlotte CBD. In November 2016, the City of Charlotte approved a $94.1 million contract for the second phase of the streetcar, which will extend service by adding 11 stops to the current termini on the West End and Elizabeth Avenue. Extending the current line will affect level of service and most likely change the current results of the accessibility analysis.

Sun Link Tucson Streetcar

The Tucson SIA was home to about 4,850 households, 29 percent of which had an annual income at or below the U.S. Census poverty threshold. About 23 percent of the households had one or more members age 65 or older. The analysis shows that the streetcar system provides increased accessibility within and outside the SIA, allowing households to reach more destination and job opportunities. The travel time shed analysis shows statistically significant improvements in job accessibility and travel times for lower-income households.

Atlanta Streetcar

The Atlanta SIA identifies about 5,200 households, 4 percent of which have an annual income at or below the U.S. Census poverty threshold, and about 9 percent have one or more members age 65 or older. By connecting to the existing rail network by way of MARTA's Peachtree Station, the streetcar system provides increased accessibility to and from the SIA to both residents and visitors. The travel time shed analysis shows statistically significant improvements on job accessibility and travel times to lower-income households as well as increased mobility for tourists from the Hotel District to other recreational and tourism sites.

Salt Lake Sugar House Streetcar

By connecting to the existing TRAX light rail network by way of Central Pointe Station, the streetcar system provides increased accessibility to and from the Salt

Lake City SIA. In addition, the streetcar also is used in combination with fixed-route bus service to achieve modest gains in travel times.

The travel time shed analysis does not show statistically significant improvements in job accessibility, because the study area is served by an extensive multimodal transit system connecting the area to Salt Lake CBD and to major employment centers.

SECTION 10

Conclusions

Modern streetcars represent an emerging class of projects with objectives and expectations that are different from traditional transit projects. Since the signing of the TIGER grant program, the USDOT invested substantial resources to fund streetcar projects in major urban areas. During 2009–2016, the TIGER grant program has provided a combined $5.1 billion to 421 projects in all 50 states, the District of Columbia, Puerto Rico, Guam, the Virgin Islands, and tribal communities. The TIGER grant program awarded about six percent of the total grant funds to streetcar projects.

A review of grant applications shows that the evaluation criteria and final selection of the projects took into account short- and long-term economic development objectives. The belief was that shovel-ready projects could stimulate short-term job growth through construction multiplier effects, and long-term growth could be realized if new businesses located in proximity to streetcar stations or if existing businesses increased their gross sales and employment levels. To assist USDOT in understanding the medium- to long-term impacts of streetcars, this research evaluated five systems that received TIGER grants and other funds under the FTA Urban Circulator Program: 1) Cincinnati Bell Connector, 2) Charlotte CityLYNX Gold Line, 3) Sun Link Tucson Streetcar, 4) Atlanta Streetcar, and 5) Salt Lake S Line. The study focused on assessing the economic and development impacts of these systems.

Table 10-1 *Streetcar Impact on Establishment Growth and Employment*

System Characteristics	Cincinnati Bell Connector	Charlotte CityLYNX Gold Line	Sun Link Tucson Streetcar	Atlanta Streetcar	Salt Lake City S-Line
Total cost ($, million)	148.1	37.0	196.5	98.9	55.0
Share of federal funds (%)	30.5	67.6	37.2	48.1	47.3
Construction start year	2012	2012	2012	2012	2012
Operation start year	2016	2015	2014	2014	2013
System length (mi)	3.6	1.5	3.9	2.7	2.0
Streetcar stops	18	6	22	12	7
Cars	5	6	6	4	2
Peak-hour service (mins)	12	15	7-10	10-15	15
Off-peak service (mins)	15	20	20	30	30

Table 10-1 cont'd. *Streetcar Impact on Establishment Growth and Employment*

System Characteristics	Cincinnati Bell Connector	Charlotte CityLYNX Gold Line	Sun Link Tucson Streetcar	Atlanta Streetcar	Salt Lake City S-Line
Intermodal	Fixed-route	Light rail/ fixed-route	Fixed-route	Metro/ fixed-route	Light rail/ fixed-route
Streetcar influence area (sq. mi.)	2.2	2.9	4.0	2.0	1.9
Households	7,900	5,200	4,850	5,200	4,400
% households below poverty level	38.4	2.0	29.5	14.0	13.8
Businesses	2,900	2,250	1,900	3,500	1,100
Workers	81,000	72,000	30,000	87,000	17,800

The empirical analysis used quasi-experimental methods to assess and measure the impact of streetcar announcement and planning, construction, and operation within a half-mile of the alignment. These methods allow comparing the study areas to similar areas located elsewhere within the county where the project is located and establishing a causal link between the projects and observed impacts. The analysis focuses on estimating medium- to long-term impacts by considering changes in land use values by property type, changes in business activity levels, and changes in household job accessibility and travel times.

Impact on Property Values

This study employed statistical methods that allow distinguishing between changes in property values that would have occurred independent of the streetcar and changes attributable to the streetcar projects. Difference-in-differences hedonic regression models estimated the change in property values (sales and assessed values) within a half-mile of the streetcar alignments. The baseline for comparison was the period before any official announcement about the project (Pre-planning). Subsequent phases identified when the official decision was made to include the project into the planning process (Announcement and Planning) and include major evaluation studies such as environmental assessments and design and development. The Construction phase coincided with the beginning of construction, and the Opening phase coincided with the starting date of operation.

The models isolated and quantified the effects that can be attributed to streetcar planning, construction, and operation. The analysis revealed that streetcar investments have a positive impact on residential, commercial and vacant properties; nonetheless, the magnitude of impacts is not homogenously distributed across the five systems and project phases. Comparatively, the Charlotte GoldLYNX Streetcar was associated with the lowest premiums across all property types. The Charlotte City Lynx Gold Line was the smallest of the five systems analyzed in this study and represents the first phase of a more extensive streetcar system. The second phase of the Gold Line will extend service with the addition of 11 stops over a 2.5-mile extension that will connect several academic, business, and activity centers located in the Metro region. Further analysis might provide estimates more in line with the other streetcar systems.

Single-Family Properties

The analysis shows statistically significant evidence of positive impact in four out of five streetcar systems. Although the Charlotte GoldLYNX Streetcar regression models report positive signs associated with price appreciation during the construction and opening phase, statistical inference does not support evidence of price premiums. On the other hand, the Atlanta Streetcar exerted a large impact on property values, with premiums growing at a greater rate as the project moved from construction to operation. There is heterogeneity in the magnitude of impacts due to different local real estate market conditions and the concurrence of other transportation improvements and redevelopment initiatives. The Salt Lake City S-Line reports relatively smaller premiums. As discussed in Section 5.5, this is due to the lack of property sales data (Utah is a non-disclosure state) and the use of appraised values.

Condominium Properties

The empirical models show statistically significant evidence of positive premiums at Construction and Opening for all streetcar systems. The Cincinnati Bell Connector showed a negative sign at Announcement and Planning. The regression models seem to capture the uncertainty characterizing these phases, when the streetcar faced local opposition and implementation plans were put on hold. At opening, condominium properties exhibit premiums ranging from 15.1 to 28.0 percent.

Commercial Properties

As in the case of residential properties, the analysis found statistically significant evidence of positive premiums during all of the streetcar project phases (expect for Atlanta at Planning and Announcement), with premiums at opening ranging from 2.1 (Charlotte GoldLYNX) to 24.1 percent (Atlanta Streetcar).

Vacant Properties

With the exception of the Charlotte GoldLYNX, where data on vacant parcels were available, the analysis shows statistically significant evidence of positive premiums at construction and opening for all streetcar systems. The Cincinnati Bell Connector study area was characterized by a large share of vacant parcels, which reflects structural and secular issues affecting the City of Cincinnati economy. The Cincinnati Bell Connector planning and construction coincided with a renewed commitment by the City of Cincinnati to address a rapidly declining real estate market. The anecdotal evidence of the streetcar support to business activity was supported by the empirical models showing a positive and growing impact on vacant parcels sales premiums. Compared to similar areas in Hamilton County, vacant property sales prices in the study area increased from 6.9 percent when the Bell Connector project was announced to 25.9 percent when it opened to the public. Similar trends characterize the other streetcar systems. For example, the Tucson Sun Link Streetcar resulted in large premiums, particularly in the most underdeveloped area of Mercado San Augustin.

Table 10-2

Streetcar Impact on Property Values

Impact by Project Phase	Cincinnati Bell Connector	Charlotte CityLYNX Gold Line	Tucson Sun Link Streetcar	Atlanta Streetcar	Salt Lake City S-Line
Single-Family					
Announcement and Planning	—	—	19.2%	—	2.2%
Construction	15.0%	—	14.5%	73.3%	3.6%
Opening	27.0%	—	13.1%	48.4%	1.2%
Condominium					
Announcement and Planning	-13.1%	29.8%	—	—	5.3%
Construction	13.5%	14.2%	13.4%	10.3%	9.9%
Opening	17.7%	15.1%	19.2%	28.0%	15.4%
Commercial					
Announcement and Planning	-2.2%	1.4%	3.3%	—	3.5%
Construction	1.4%	1.8%	10.1%	11.2%	5.6%
Opening	5.6%	2.1%	13.3%	24.1%	5.1%
Vacant					
Announcement and Planning	6.9%	n.a.	2.3%	—	n.a.
Construction	17.7%	n.a.	2.5%	18.8%	8.4%
Opening	25.9%	n.a.	12.4%	20.6%	10.5%

Note: Comparison is to Pre-planning phase
n.a. indicates findings not available because of lack of data.
– denotes lack of statistically significant evidence.

Impact on Business Activity

Firm location theory shows how employment is the result of a firm's location decision, current and past levels of product demand, firm-specific market conditions, and generalized economic trends. An efficient transportation network lowers the cost of transporting goods and services and reduces commuting costs to employees, positively affecting firm location decisions, ultimately resulting in greater business competitiveness and economic growth.

This study hypothesizes that expected accessibility gains from the streetcar improvement affect firm location decisions. Increased accessibility leads to clustering of households in proximity to the streetcar. This leads to a larger pool of workers and customers, which, in turn, positively affects employment levels.

This equates to the assumption that firm clustering is either predetermined or endogenous to the process. In essence, we are trying to answer the question, can streetcars serve as a catalyst for economic growth?

These assumptions define a set of empirical models relating streetcar improvements to establishment and firm-level employment growth. The analysis compares changes in employment levels and business growth within the streetcars study area (SIA) to changes in comparable areas during planning, construction and operation. The models net out the effects of confounding factors, such as unobservable firm-specific characteristics (e.g., business-specific management structure or practices) or secular trends (e.g., generalized economic conditions such as the Great Recession of 2008–2009).

The dataset consists of primary and secondary fine-grain industry data collected over 2007–2016. Each record in the business database was geocoded and includes business name, address, employee size, actual sales volumes. Each business was classified using the North America Industry Classification System (NAICS) codes at the six-digit level, which allowed aggregating data by industry type. Firms have unique identifiers, allowing year-over-year comparisons to analyze industry changes and general economic trends over a certain period using advanced panel data methods.

The empirical analysis confirms the hypothesis that streetcar investments contribute to economic development by exerting positive effects on firm location decisions and employment growth. The range of impacts depends on the baseline industry composition and economic vitality of each study area. Overall, the study areas are home to businesses operating in industry sectors that are more clustered and specialized than counterparts located in other areas of their respective counties. Streetcars can serve as a catalyst to foster clustering and economic growth.

Impact on Establishment Growth

When pooling all the case studies, the analysis shows that streetcar investments tend to experiences higher establishment growth than comparable areas, which increase as the projects mature from announcement and planning (6.8%) to construction (23.5%), with decreasing but lingering impacts at opening and during operation (18.3%).

Impact on Employment Growth

Pooled data dynamic panel models of firm-level employment provide similar evidence, showing positive impacts ranging from 2.4 percent at announcement and planning to less than one percent at opening and operation. The presence of the lagged adjustment in employment (0.83) allows estimating the long run impact on employment growth. Over the long run, I find the impact on firm level-employment growth to be about 4.2 percent.

Looking at each site separately, the models find mixed evidence with some sites showing no statistically significant evidence of impacts at project announcement, during construction or no evidence of impacts lingering at the project's opening and operation. In some sites, as business growth reaches maturity, employment levels do not increase. In other sites, employment growth is driven by a growing customer base.

Table 10-3 *Streetcar Impact on Business Activity*

Impact by Project Phase	Cincinnati Bell Connector	Charlotte CityLYNX Gold Line	Tucson Sun Link Streetcar	Atlanta Streetcar	Salt Lake City S-Line	Pooled Data
Establishment Growth						
Announcement and Planning	6.4%	16.2%	9.10%	—	—	6.8%
Construction	23.0%	25.2%	19.8%	19.2%	24.4%	23.5%
Opening	12.7%	13.2%	—	12.6%	20.3%	18.3%
Employment Growth						
Announcement and Planning	—	2.5%	—	3.8%	3.0%	2.4%
Construction	2.9%	2.5%	6.8%	3.0%	—	2.8%
Opening	—	3.8%	1.8%	—	2.3%	0.7%

Note: Comparison is to Pre-planning phase
n.a. indicates findings not available because of lack of data.
– denotes lack of statistically significant evidence.

Impact on Accessibility

Streetcar systems can provide additional accessibility gains to households and workers residing in the area, as well as to workers coming to the area and residing elsewhere.

To measure changes in job accessibility and household travel times, this study developed a series of multimodal network models that generate zone-to-zone travel time matrices. Using the network models, the analysis estimated two travel time sheds: one with all available transit modes and one excluding the streetcar. The transit time sheds reflect average weekday peak and off-peak travel conditions specific to the SIAs.

The analysis of household travel time relies on actual travel times estimated using data from Google directions automated protocol interface (API) using fine-grain residential datasets that provide information on households, such as address-level location, socio-demographic and life-cycle information over the 2007–2016.

The analysis revealed that streetcar investments do not inherently result in accessibility gains to households and workers. In general, streetcar alignments do not marginally increase accessibility if the study area is currently well served by an extensive fixed-route bus system. On the other end, streetcars that integrate with a regional light rail light rail or metro system provide minor added gains.

Table 10-4 *Streetcar Impact on Accessibility*

Accessibility Measure	Cincinnati Bell Connector	Charlotte CityLYNX Gold Line	Tucson Sun Link Streetcar	Atlanta Streetcar	Salt Lake City S-Line
Access to jobs	No change	No change	15,000 jobs within 25 min	1,350 businesses and 21,000 jobs within 12 min	No change
Travel time savings	No change	No change	6–14 min	7– 9 min	2–9 mins on off-peak travel

Limits of the Analysis and Directions for Further Work

This study used historical data to uncover any causality between streetcar investments, economic development, and accessibility. Comprehensive parcel-level datasets, fused with layers of spatial data, helped inform a set of empirical models to test the hypothesis of positive impacts on property values.

To study the impact on business and employment growth, the research implemented advanced panel data methods that rely on fine-grain commercial databases of business activity in terms of number of establishments, employment and sales. The accessibility analysis relies on a third-party commercial database providing fine-grain data on households living in the study areas, allowing the study of changes in household location patterns and the impact of streetcar alignment and job accessibility and travel times to non-work locations. All of the datasets cover the period 2007–2016 to assess the impact of streetcar through planning, construction and opening.

The data cover at least two years of operation for three streetcar systems, one year of operation for the Charlotte City Lynx Gold Line and less than a year of operation for the Cincinnati Bell Connector. The empirical literature on the impact of light rail and commuter rail investments on property prices usually focuses on mature systems (i.e., in operation for two years or more), which allows gauging medium- to long-term impacts.

As the streetcar systems mature, the analysis and empirical models can be re-estimated to assess and quantify the lingering effects of these infrastructure investments. The models could be augmented to account for ridership and travel time reliability to disentangle relevant effects and further reduce bias on the parameter of interest.

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APPENDIX

A

Quasi-Experimental Approach to Select Treatment and Control Units

This appendix details the quasi-experimental approach to select treatment and control units for the statistical modeling of property values and changes in business patterns and employment levels of each case study. The approach to case study analysis consist of the following steps.

1. Identification of Treatment Area
    a. Identification of streetcar influence area (SIA)
    b. Selection of treatment census block groups within SIA
2. Collection of block group-level data
    a. Socio-demographic data – U.S. Census American Community Survey (ACS) 2005–2009
    b. housing and transportation cost data – Department of Housing and Urban Development Location Affordability Index (LAI)
3. Identification of Control Areas
    a. Collection of socio-demographic, housing and transportation costs data
    b. Application of propensity-score matching (PSM) to match control to treatment block groups
    c. Final check of PSM selection validity
    d. Final selection of matched control block groups to treated block groups
4. Data Collection (Treatment and Control)
    a. Residential parcels
    b. Commercial parcels
    c. Business patterns
    d. Household patterns
5. Statistical Analysis
    a. Difference-in-differences regression property values
        i. Multiple regression modeling
        ii. Spatial hedonic regression

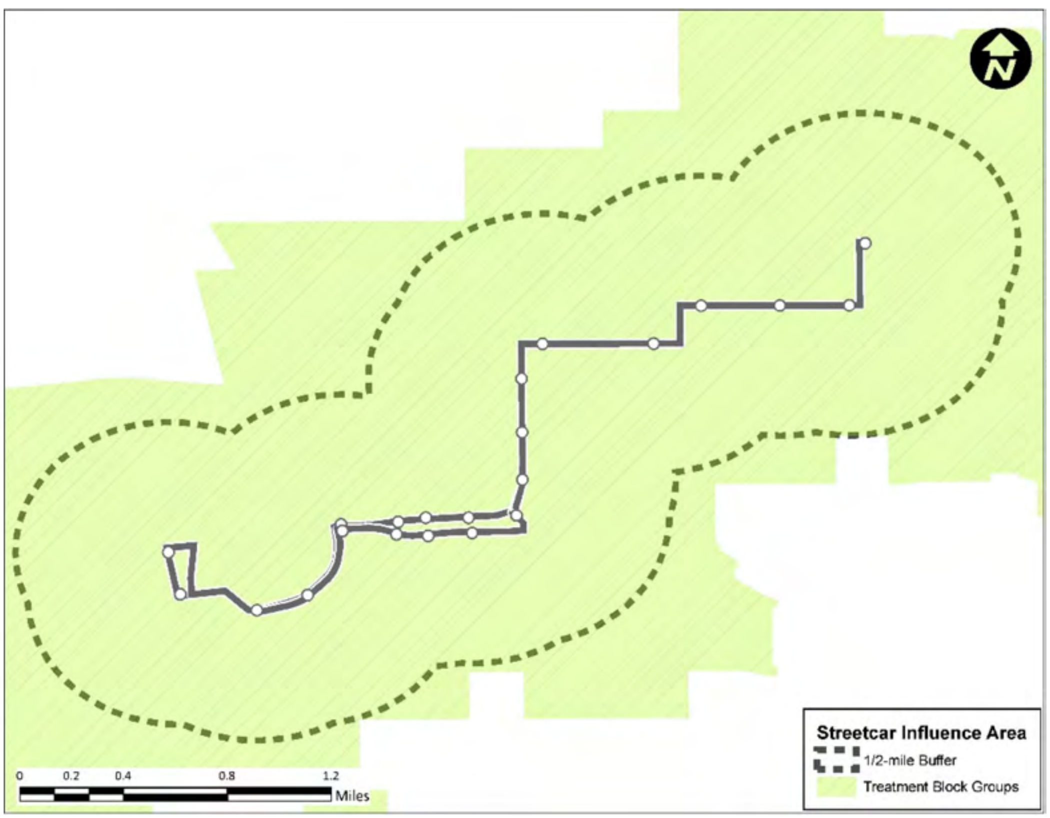
b. Difference-in-differences regression of business employment patterns
   i. Changes in employment and sales
c. Multivariate analysis of changes in residential location patterns

Identification of Treatment Area

For each case study, the streetcar influence area (SIA) or treatment area consists of a 0.5-mile radius buffer around the stations and streetcar line. In many instances, streetcar stations are often less than half-mile apart, resulting in a seamless buffer around the stations and the streetcar route. The SIA is defined using Arc-GIS mapping tools using the geographic coordinates of the proposed stations as available from the Center for Transit-Oriented Development (CTOD) National TOD Database or directly from the agency responsible for the streetcar planning and construction. When a streetcar system is in operation and maintained by a transportation authority, the station coordinates are obtained using the GTFS. Imposing the SIA layer over the Census block group layer allows identifying the control block groups, as displayed in Figure A-1.

Figure A-1

Sample Treatment Location



Identification of Control Areas

To substantially reduce the potential for biased results, each study employs propensity-score matching (PSM) methods to select control areas that closely match the treatment areas, using socio-demographic and housing-transportation cost data.

PSM is a non-experimental method employed to select comparable units of observation for estimating intervention impacts using comparison group data. Since first introduced by Rosenbaum and Rubin [19], PSM techniques have been applied in several fields of research, such as to study the impact of training on labor wage differentials and to estimate the impact of welfare programs [20]. It has also been used to evaluate the impact of transportation investment improvements on employment and population growth. For example, Funderburg et al. [13] use PSM to select a set of comparable census tracts to use as controls in evaluating the impact of transportation infrastructure investments on employment and population growth. PSM has been applied in several fields of research, such as to study the impact of training on labor wage differentials and to estimate the impact of welfare programs. It has also been used to evaluate the impact of transportation investments [23, 24] on employment and population growth [25, 26].

Quasi-experimental approaches have been increasingly used to reduce estimation bias and to economize on behavioral specification complexity and data requirements. For example, Rephann and Isserman [12] devise methods to match control to treatment counties for policy evaluation of infrastructure investments on county development. At a less aggregate level, Funderburg et al. [13] use propensity-score matching to analyze the impact of transportation infrastructure improvements on census tract employment and population growth.

Propensity Score Estimation

To identify suitable control areas for parcel data comparison, the first step is to estimate the propensity score for each county's census block group by running a logistic regression with the dependent variable set to $Y=1$ if the block group is part of the treatment group (i.e., within the SIA) and $Y=0$ if otherwise (i.e., the rest of the county where the streetcar is located), and using as set of controls as explanatory variables. In a parametric model the propensity score is the predicted probability:

$$\hat{p} = \frac{e^{(\hat{\alpha}+\hat{\beta}'x)}}{1-e^{(\hat{\alpha}+\hat{\beta}'x)}} \quad (1)$$

where $\hat{\alpha}$ indicates the intercept parameter estimate, $\hat{\beta}$ represents the vector of parameter estimates, and x is the vector of explanatory variables (e.g., the socio-demographic variables).

To ensure the best selection of controls, this study employs a data-driven approach, to derive a non-parametric propensity score. This study uses the nonparametric conditional density estimation method discussed in Li and Racine [34] and implemented by the R *np* package [35]. The use of nonparametric generated propensity score in addition to the logistic regression generated propensity score is intended to ensure a robust selection of matched controls.

Choice of Explanatory Variables and Data Sources

To estimate the propensity score is necessary to specify the vector of explanatory variables of equation (1), to be included in the right-hand side of the equation. The selection of these variables should strike a parsimonious balance between the theoretical underpinnings of housing choice and the transportation mode preference, as well as the predictive power of the model. Given the objectives of this study, the explanatory variables should be representative of the factors affecting household location choices (housing and neighborhood specific preferences), factors affecting the household-transport cost balance. Taken together, these factors also define the SIA businesses customer base, and therefore provide and underlying picture of the business composition of the area.

Socio-demographic and Housing-stock Explanatory Variables

Socio-demographic and housing stock variables come from the U.S. Census American Commuter Survey (ACS) 5-Year Averages for the period 2005–2009. ACS provides a host of socio-demographic and housing variables to portray a historical perspective of neighborhood characteristics. The use of the 2005–2009 ACS 5-Year averages covers a period preceding the planning and construction of the TIGER-funded streetcar projects [36].

Housing and Transport Cost Explanatory Variables

The U.S. Department of Housing and Urban Development (HUD) developed the location affordability portal, a comprehensive database to describe and quantify the balance of housing and transportation costs of U.S. households. Transportation, housing, and job accessibility data are stratified by household income and are available at the census block group level [37].

Choice of Matching Algorithms

The logistic regression and the nonparametric regression scores are used to in the next step to find the matching controls by applying a set of matching algorithms.

Using the estimated propensity scores (from the logistic and from the nonparametric regressions), we apply three different matching algorithms: 1) a nearest neighbor matching (one-to-one without replacement); 2) the global minimization algorithm based on Ming and Rosenbaum [38]; and, 3) the genetic matching method of Abadie and Imbens [39]. Matching is conducted using the MatchIt package [40].

The nearest neighbor employs a "greedy" algorithm to cycle through each treatment unit (T) one at a time, selecting the control unit (C) with the smallest distance to the treatment unit (T). The global minimization algorithm treats the distance between treatment and potential controls as a cost from going from one node to another over a network. The problem requires assigning distances to each node and finding the path that minimizes the total distance. Rosenbaum and Rubin [41] argue that the collection of matches found using optimal matching can have substantially better balance than matches found using greedy matching, without much loss in computational speed. Genetic matching automates the process of finding by implementing matching with replacement using the method of Abadie and Imbens [39] where balance is determined by a set of two univariate tests, paired t-test for dichotomous variables and a Kolmogorov-Smirnov test for multinomial and continuous variables.

We match using all three algorithms and the results and use the post-matching balance measures he package MatchIt provides to check to assess the accuracy of the matching process. These include the comparison of the differences in means of before vs. after matching and summaries based on quantile-quantile plots that compare the empirical distributions of each explanatory variable.

Finally, we rank the matched control block groups based on the number of matching algorithms. This allows further selecting a subset of matched control block groups based on the number of matched algorithms.

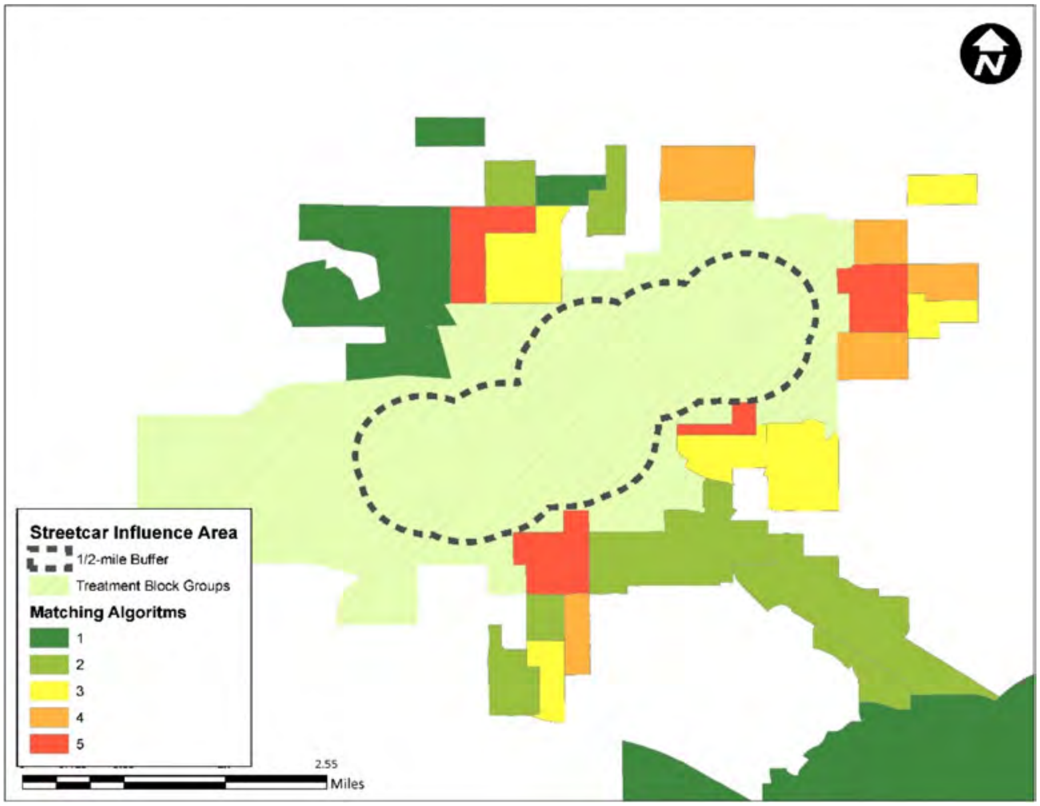
Non-parametric regression produces a second propensity score upon which the matching algorithms are applied to select the matched controls. Finally, the matched controls identified with the logistic regression score are compared to those identified using the non-parametric regression score. The matched control block groups are then used in ArcGis to identify the observational units of interest for subsequent modeling:

- Treatment and control parcels for hedonic regression of property sales
- Treatment and control businesses to conduct dynamic panel regression
- Treatment control household to analyze location patterns and changes in accessibility

Figure A-2 shows a sample of matched control block groups to the treatment block groups of Figure A-1, ranked by the frequency of match.

Figure A-2

Matched Control Block Groups



Difference-in-Difference Analysis of Changes in Property Values

Urban economic theory suggests that transportation improvements influence urban growth patterns through land prices. If new transit services improve accessibility, they generate a premium that is reflected in higher land and property prices. Empirical studies demonstrate that there is generally a positive relationship between accessibility improvements and property values, although results vary by area, investment type, and evaluation method. Proponents of transit-oriented development (TOD) argue that successful transit investments generate increases in property values that are resilient to exogenous economic shocks [20, 21]. Empirical analyses demonstrate that there is generally a positive relationship between accessibility improvements and property values, although results vary by area, investment type, and evaluation method. Early research summarized by Huang [42]and Ryan [43] shows that new highways make land that is farther from the urban center more suitable for residential development by reducing the commute-travel costs. This translates into increasing premia that users pay for residential and other properties. Being too close to a rail line can also negatively affect housing prices and reduce accessibility premia, due to increased noise and pollution exposure.

The basic framework to empirical investigation relies on the use of a hedonic price function relating sale price changes to transportation accessibility improvements, after controlling for housing and location attributes. The hedonic equation usually employs a control either in the form of a dichotomous variable to classify parcels based on buffer distances from the accessibility improvements, or in the form of a continuous variable measuring Euclidean distance from the improvement (a highway, public transit stop, etc.).

To study the impact of urban circulators on residential and commercial property values, we adopt a model recently developed by the principal investigator to study changes in commercial and residential property values resulting from transport infrastructure improvements [28]. A detailed in the previous section, the model relies on a propensity-score based quasi-experimental design to test for the empirical evidence of price differentials before, during, and after construction and operation of network improvements. This method can be generalized to study the impact of transit investments, or any other type of network improvement intervention.

To analyze the impact on property prices, the proposed general functional specification is based on an extension of the hedonic function as:

$$y_i = \alpha_0 + \alpha_1 T + \alpha_2 YR + \alpha_3 TYR + \beta_k x_{ik} + u_i \qquad (2)$$

where y_i is the price of property (i); T is a categorical variable indicating that the parcel belongs to the treatment group ($T=1$) receiving the roadway improvement or to the control group ($T=0$); YR is a time period categorical variable indicating treatment phase ($YR=1$ treatment phase, $0=$ base or reference); and, x_{ik} is a vector of controls for housing and neighborhood characteristics.

The parameter of interest (α_3), the difference-in-differences estimator (DID), measures the difference in housing price over treatment phases and is equal to

$$\hat{\alpha}_3 = \left(\bar{y}_{YR=1,T=1} - \bar{y}_{YR=1,T=0}\right) - \left(\bar{y}_{YR=0,T=1} - \bar{y}_{YR=0,T=0}\right) \qquad (3)$$

The parameter (α_3) measures the difference in average price between treatment and control parcels as a result of changes in accessibility, after controlling for exogenous shocks in sale prices over time, assuming that treatment and control properties do not appreciate at different rates for other reasons not accounted for by the model. Essentially, by estimating $\hat{\alpha}_3$, the question we will seek to answer is: What would have happened to the treatment parcels had they not implemented the streetcar project? When applied to the study of residential and commercial property values, the empirical models also account for spatial autocorrelation among parcel units. Failing to account for the presence of spatial factors affecting sales leads to omitted bias adversely affecting the reliability of parameter estimates.

Controlling for Spatial Correlation in Property Price Regression

The multivariate regression models used to estimate the parameter $\hat{\alpha}_3$ do not account for spatial autocorrelation that might exist between parcel units. For example, the final sale price of a house could have spillover effects on similar adjacent properties. Failing to account for the presence of spatial factors affecting sales leads to omitted bias adversely influencing the reliability of parameter estimates. Following Anselin [44], we implement a spatial-autoregressive model with spatial disturbances (SARAR) of the form:

$$y_i = \lambda \sum_j^n w_{ij} y_j \, \alpha_0 + \alpha_1 T + \alpha_2 YR + \alpha_3 TYR + \beta_k x_{ik} + u_i \quad (4)$$

$$u_i = \rho \sum_j^n m_{ij} u_j + \varepsilon_i \quad (5)$$

where λ is an autoregressive parameter (spatial-lag); ρ is the autoregressive error term parameter (error lag); and, the parameters w_{ij} and m_{ij} represent spatial weights.

Spatial econometric methods require *a priori* specification of a weighting matrix of spatial relations between observations. The choice of a specific relationship is arbitrary, although some guidance exists in the literature [45, 46]. For example, in analyzing the effect of highway proximity on real estate values, Heider and Miller [47] assume that spatial spillover effects on property prices are confined to a 2-km radius, assuming that house values are not correlated beyond this distance. We adopt inverse-distance weights, restricting spatial dependence to a radius of three kilometers. This restriction is justified based on the quasi-experimental approach, which allows spatial dependence between parcels located within the treatment areas, and assumes spatial independence between treatment and control areas. The STATA [48] command *spmat* [49] generates the inverse distance matrices W and M, and the command *spreg* [50] allows estimating generalized least-square models that account for heteroscedasticity. By default, *spreg* assumes homoscedastic errors and utilizes maximum likelihood methods. Given the heteroscedasticity issues discussed earlier, we employ the generalized least-square estimator (command *gs2sls*) with the *heteroscedastic* option.

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