Economic Impacts of Transit Investments, Social Challenges, and Strategies for Sustaining High Ridership – Part I

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Eleni Bardaka, Ph.D., et al.
Assistant Professor
Department of Civil, Construction, and Environmental Engineering
North Carolina State University

NC STATE UNIVERSITY

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RESEARCH & DEVELOPMENT

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16. Abstract
This study examined three main topics: (i) identifying the spatiotemporal impacts of urban rail on the price of nearby residential properties, (ii) exploring the ways urban rail investments impact surrounding neighborhoods based on those neighborhoods' initial socioeconomic characteristics, and (iii) developing a methodological framework for quantifying transit-induced commercial gentrification. We study the light rail system in Charlotte, NC, which includes an original line and its extension. A dataset comprised of the single-family house sales from the last thirty years is compiled for the study area, which contains neighborhoods in the vicinity of the light rail and two comparison areas. Our results consistently indicate highest positive impacts for properties located within 0.25 and 0.5 miles of a transit station. Differential effects are identified between the original light rail line and its extension, such as lack of anticipation effects for the line extension. In terms of neighborhood change and residential gentrification, we find that neighborhoods with low and high socioeconomic status experience disproportionate changes associated with gentrification (compared to the control groups), while neighborhoods with medium socioeconomic status are not impacted. Finally, the study of commercial gentrification in Charlotte revealed fewer exits and smaller turnover for service businesses and businesses offering frequently consumed goods and services located between 0.25 and 0.5 miles of light rail stations compared to the control area. It is possible that fewer businesses left the area during the post-announcement and construction periods in anticipation of benefits and higher revenue after the beginning of light rail operation. Based on the analysis of the entries, exits, and turnover of retail and service businesses and their subcategories related to frequency of consumer visits and necessity of the products, strong evidence of transit-induced commercial gentrification is not found for the Original Blue light rail line in Charlotte.

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RP 2020-37: Economic Impacts of Transit Investments, Social Challenges, and Strategies for Sustaining High Ridership — Volume I

Summary Report

PI: Dr. Eleni Bardaka, Assistant Professor

Graduate Research Assistants

Chang Liu, Ph.D. student

Adam Schmidt, Ph.D. student

Undergraduate Research Assistant

Jonathan Pelletier

EXECUTIVE SUMMARY

As the successful design and implementation of alternative mechanisms for funding transit infrastructure, such as value-capture schemes, are becoming more critical, identifying the timing, duration, and spatial extent of the capitalization of accessibility benefits for nearby communities is becoming more and more important. This research makes a significant contribution to the analysis of the spatiotemporal impacts of transit systems by quantifying variations in the spatial distribution of causal effects from project announcement to long-run operation. We study the light rail system in Charlotte, NC, which includes an original line and its extension. A dataset comprised of the single-family house sales from the last thirty years is compiled for the study area, which contains neighborhoods in the vicinity of the light rail and two comparison areas. Our results consistently indicatehighest positive impacts for properties located within 0.25 and 0.5 miles of a transit station. Differential effects are identified between the original light rail line and its extension, suchas lack of anticipation effects for the line extension.

We also study the ways investments in transit infrastructure impact surrounding neighborhoods based on those neighborhoods' initial socioeconomic characteristics, hypothesizing that neighborhoods experience changes associated with gentrification differently based on their initial attributes. We use a quasi-experimental approach, and specifically the difference-in-differences model, to examine the impacts of the first segment of thelight rail transit (LRT) system in Charlotte, NC at the block group level, using educational attainment, rate of individuals working in professional occupations, racial mix of neighbor- hood residents, household income, and single-family home property prices as measures of neighborhood change. We use a social index to classify neighborhoods based on their initial characteristics and find that neighborhoods with low and high social index experience disproportionate changes associated with gentrification (compared to the control groups),while neighborhoods with medium social index are not impacted.

Very little is known about how new transit projects and transit-oriented development affect nearby businesses and whether they contribute to commercial gentrification. We present a quasi-experimental econometric framework for studying transit-induced commercial gentrification from project announcement to long-term operation using businessmicrodata covering a 20-year period. Previous urban economics and planning research informs the identification of retail and service business categories associated with the phenomenon of commercial gentrification, including local businesses, chain stores, and

businesses offering non-essential or upscale products. Negative binomial models with a difference-in-differences specification enable the temporal and spatiotemporal analysis of business entries, exits, and turnover and the estimation of transit-induced impacts. The econometric analysis results provide evidence of fewer exits and smaller turnover for service businesses and businesses offering frequently consumed goods and services located between 0.25 and 0.5 miles of light rail stations in Charlotte compared to the control area.It is possible that fewer businesses left the area during the post-announcement and construction periods in anticipation of benefits and higher revenue after the beginning of light rail operation. Based on the analysis of the entries, exits, and turnover of retail and service businesses and their subcategories related to frequency of consumer visits and necessity of the products, strong evidence of transit-induced commercial gentrification is not found forthe Original Blue light rail line in Charlotte.

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CHAPTER

1

INTRODUCTION

1.1 Background

The US experienced a rise in automobiles and became a highly car-dependent country in the middle of the twentieth century; meanwhile, privately owned public transportation was gradually replaced by automobiles, and transit ridership declined (Mathur 2016; Whitt and Yago 1985). Driving alone has been the primary transportation mode for daily travel over the past decades in the US (NHTS 2017). The high dependence on personal vehicles has contributed to several problems in metropolitan areas, including traffic congestion, waste of energy resources, air pollution, and health problems (Katzev 2003). It therefore comes as no surprise that many metropolitan areas have been turning their focus towards the development of public transportation systems. Extensive adoption of more sustainable and active travel modes, such as public transportation, is expected to reduce pollution and the use of fossil fuels, as well as improve physical health (Frank et al. 2006; Chaix et al. 2014;Shannon et al. 2006).

At the same time, research has shown that large-scale transit investments may affect property values and induce socioeconomic changes in the surrounding neighborhoods

(Bardaka et al. 2018). New transit stations reduce transportation costs and improve a location's accessibility. This can benefit individual households seeking more sustainable and economic ways to commute. It can also benefit nearby businesses and enable them to access a larger pool of potential customers, assuming transit ridership is high (Schuetz 2015). Simultaneously, areas surrounding new transit stations commonly undergo (re)development, such as the construction of high-end apartments, condos, and mixed-use developments, the renovations of existing properties, and the formation of a more pedestrian and cyclist-friendly environment around stations (Cervero et al. 2004). These new amenities tend to attract upper-class residents and increase the value of nearby properties as well as changes in the character and sociodemographic composition of the surrounding neighborhoods (Zuk et al. 2015; Bardaka et al. 2018; Padeiro et al. 2019). Past studies have shown that the price of residential and commercial properties can shift after the announcement of a newrail line in anticipation of higher demand for housing and commercial space and continueto change throughout construction and operation (Cervero and Duncan 2002b; Debrezion et al. 2007; Mohammad et al. 2013; Ryan 2005; Ko and Cao 2013; Xu et al. 2016).

Proximity to transit does not only impact nearby neighborhoods on the residential side, but also the commercial side. Prior studies have investigated the changes in the value of commercial properties nearby urban rail stations and have found a significant price premium in transit neighborhoods after the operation of transit in most cases (Cervero and Duncan 2002b; Ryan 2005; Ko and Cao 2013; Xu et al. 2016; Mohammad et al. 2013; Debrezion et al. 2007). Furthermore, recent literature has shown that the neighborhoods near urban rail stations attract new business starts after the LRT operation (Credit et al. 2018; Yao and Hu 2020; Noland et al. 2014). Businesses usually expect positive impacts (e.g. more consumers) from being close to transit due to increased visibility and a pedestrian-friendly built environment (Fan and Guthrie 2013). Rail stations are usually accompanied by transit-oriented development (TOD), which encourages mixed land-use developments that can be supportive to businesses. At the same time, the construction of transit infrastructure can reduce the visibility of businesses and accessibility by consumers (Tornabene and Nilsson 2021). Moreover, businesses that are older and have smaller sale volumes could be priced out of the transit neighborhoods due to increased rents and property values (Fan and Guthrie 2013).

1.2 Research objectives

North Carolina's transportation system has been gradually transforming into a multimodal system. One of the modes that is expected to experience major changes and serve as a multimodal hub is public transportation. There are multiple short-term and long-term plans for larger and smaller-scale transit investments for the urban areas in North Carolina. These transit investments are expected to mitigate congestion while increasing transportation connectivity and accessibility for everyone. Simultaneously, large transit investments bring changes in the local economic environment and may affect households and businesses in a multitude of ways.

This research has the following objectives:

- Analyze the spatiotemporal impacts of the Charlotte light rail on residential property prices to:
  - capture the temporal distribution of the transit impacts over an extended period of time, spanning from project announcement through long-term operation,
  - quantify the spatial distribution of effects at varying distances from station locations,
  - assess whether the distribution of effects in space varies over time, from the original announcement, to construction and then operation milestones of an LRT project.
- Study how the Charlotte light rail has impacted the surrounding neighborhoods over time and by the neighborhood socioeconomic status prior to the arrival of the light rail.
- Develop a methodology for capturing and assessing the diverse angles of transit-induced commercial gentrification and applying it to the Charlotte light rail to quantify the potential impacts on commercial properties.
- Conduct a preliminary analysis on the impacts of bus rapid transit systems on residential property prices.
- Review past research on developments close to transit that can help sustain high ridership.
- Identify the data that NCDOT should be collecting as part of the Atlas database before and after project implementation.

1.3 Report organization

This research project is conducted as a collaboration between North Carolina State University (NCSU) and University of North Carolina, Charlotte. This volume of the report reflects the effort of the NCSU research team led by Dr. Eleni Bardaka. The remaining of the report is structured as follows:

- Chapter 2: Transit impacts on property prices (Graduate research assistant: Adam Schmidt, research partially funded by the Eisenhower Graduate Fellowship)

  This chapter includes a literature review of the transit impacts on property prices, the methodology we used to study the spatiotemporal effects of the Charlotte light rail on residential property prices as well as the analysis, results, and conclusions related to this work.

- Chapter 3: Transit and residential gentrification (Graduate research assistant: Adam Schmidt, research partially funded by the Eisenhower Graduate Fellowship)

  This chapter focuses on the relationship between public transportation investments and neighborhood change. A literature review is first presented, which discusses how gentrification is defined and measured and what we know so far about transit impacts on neighborhoods. The methods used to study the impacts of the Charlotte light rail are then introduced, followed by the data description, analysis, results, and conclusions. Policy recommendations are also provided at the end.

- Chapter 4: Transit and commercial gentrification (Graduate research assistant: Chang Liu)

- Chapter 5: Development strategies to sustain high ridership (Graduate research assistant: Chang Liu)

  This chapter contains a review of prior studies on the effectiveness of transit-oriented development, affordable housing, and land uses to support transit ridership.

- Chapter 6: Bus rapid transit and property value uplift: A preliminary analysis (Undergraduate research assistant: Jonathan Pelletier)

  This chapter includes a preliminary analysis on the impacts of bus rapid transit on residential property prices using Richmond, Virginia as a case study.

- Chapter 7: ATLAS database recommendations

  This chapter discusses the data that should be included in the Atlas database so that NCDOT or other public agencies in NC can assess the potential socioeconomic impacts of transit projects.

CHAPTER

2

TRANSIT IMPACTS ON PROPERTY PRICES

2.1 Introduction

Light rail transit (LRT) systems benefit the areas they serve by increasing accessibility, reducing congestion, and stimulating economic activity (Mohamed et al. 2016). These projects require significant public investment, often reaching in the billions of dollars (Billings 2011; Hess and Almeida 2007; Smith and Gihring 2006). The expensive and immovable nature of LRT projects represents both a significant opportunity and risk to local communities. They showcase a city's commitment to providing affordable transportation options, but they also may catalyze neighborhood change and potentially gentrification (Bardaka et al. 2018). As cities seek to balance economic development with transportation equity, it is vital to understand the social and economic impacts LRT systems have on the communities they serve. One aspect of these impacts is the presence or absence of a premium that individuals pay for houses in proximity to LRT stations. Although numerous studies have been published on the relationship between rail infrastructure and home values (Debrezion et al. 2007; Mohammad et al. 2013), only a few have used quasi-experimental approaches that can reliably infer the causal impacts of LRT systems on nearby properties

(Billings 2011; Pilgram and West 2018; Ransom 2018; Wagner et al. 2017; Yen et al. 2018). Earlier studies on the subject estimated price gradients with the use of hedonic modeling to demonstrate how prices change with increasing distance to a rail station (Cervero and Duncan 2002a; Hess and Almeida 2007; Yan et al. 2012; Atkinson-Palombo 2010). But lately, researchers have acknowledged the limitations of these approaches and have resorted instead to quasi-experimental methods to explore the hypothesis of capitalization of accessibility benefits into property values for LRT systems. Specifically, recent studies have used difference-in-differences (DID) models to estimate such impacts (Pilgram and West 2018; Wagner et al. 2017; Yen et al. 2018). DID models account for the effect of unobserved factors, such as national and regional economic forces, over time through the use of a comparison area ("control group") that has similar characteristics to the area potentially affected by the LRT system ("treated group") (Rubin D. B 1974).

Nowadays, alternative mechanisms to fund transit infrastructure, such as value-capture schemes, have become attractive. Their design and successful implementation not only require the use of appropriate methods for causal inference of property premiums, but also the clear identification of the timing, duration, and spatial extent of the expected effects. Our research takes a comprehensive approach to the analysis of the spatiotemporal impacts of transit systems through the use of advanced DID specifications that enable us to (i) capture the temporal distribution of the transit impacts over an extended period of time, spanning from project announcement through long-term operation, (ii) quantify the spatial distribution of effects at varying distances from station locations, and (iii) assess whether the distribution of effects in space varies over time, from the original announcement, to construction and then operation milestones of an LRT project. Past research that studied temporal effects have typically focused on a subset of these project milestones (Billings 2011; Pilgram and West 2018; Wagner et al. 2017), and a detailed analysis of temporal variations is still missing. In addition, our study provides a more complete view of the long-run effects of LRT systems on properties, a topic that has not been thoroughly explored (the majority of past analyses are restricted to approximately five years post beginning of operation). Lastly, our research contributes a better understanding of the potentially heterogeneous effects of transit investments in space and their temporal variation, compared to existing literature (Bardaka et al. 2018; Dubé et al. 2018; Pagliara and Papa 2011; Yen et al. 2018); through extensive analysis accompanied by visualization with two and three-dimensional plots, our study makes a notable contribution to the investigation of the spatiotemporal impacts induced by transit investments. Our methodology is applied to the LRT system in Charlotte, NC, which was constructed in two stages over the last two decades.

This research can provide valuable insight for the development of value capture strategies to finance future infrastructure projects. Value capture leverages the additional property tax revenue cities will receive because of the expected increase in the value of properties close to transit projects to help pay for those same projects, and could serve as a means for communities to finance future transit projects (Smith and Gihring 2006; Zhao et al. 2012; McIntosh et al. 2014). Cities considering their first major investment in rail transit are likely to be especially interested in understanding the associated economic impacts. This is why our study using data from Charlotte, NC, a fast-growing city in the Southern United States, is especially apt.

2.2 Urban rail in the City of Charlotte

The City of Charlotte has been working towards making transit improvements for some time, and in 1997 published its 2025 Integrated Transit/Land-Use Plan. This plan called for the construction of light rail transit along several potential corridors (City of Charlotte 1998). The same year the plan was published, Mecklenburg County residents approved a one-half cent increase to the county sales tax in support of transit projects. This tax revenue helped fund initial planning operations for the city's first LRT line, the LYNX Blue Line. The selected corridor and station locations were announced in September 2000, construction began in 2005, and the line opened to the public in November 2007. This became known as the "Original" section of the LYNX Blue Line, when it became necessary to differentiate this section from an extension to the northeast of the city's CBD (Figure 2.1). The Blue Line Extension was announced in 2006, construction began in 2013, and the line opened to the public in March of 2018. The Blue Line Extension added 11 stations and 9.3 miles of track to the LYNX Blue Line, bringing the total length of the line to 18.9 miles with 26 stations (Figure 2.2). To date, the total cost of the LYNX Blue Line is approximately $1.5 billion, with funding provided by federal, state, and local governments. The LRT system serves around 29,900 passengers per day as of 2019.

In addition to the LRT, the Charlotte Area Transit System also operates a streetcar line near the City's CBD. The CityLYNX Gold Line is a 1.5-mile-long streetcar route with 6 stops that opened in 2015. Construction to extend the line is ongoing. Line extensions are planned to occur in two phases to bring the line to a total length of 10 miles with 37 stops; as of August 2021, 11 stops are operational on a 4-mile corridor. Anecdotally, private development along the CityLYNX Gold Line has not been significant so far (Dunn 2019a,b). Additional expansions to the transit system are planned along the original transit corridors identified in the 2025 Integrated Transit/Land-Use Plan, including a 5.5 mile southern extension to the Blue Line with 5 new stations, the light rail LYNX Silver Line to the southeast and west and commuter rail LYNX Red Line to the north (Charlotte Area Transit System 2019). Funding for these envisioned projects has not yet been identified, and no firm implementation timelines have been announced.

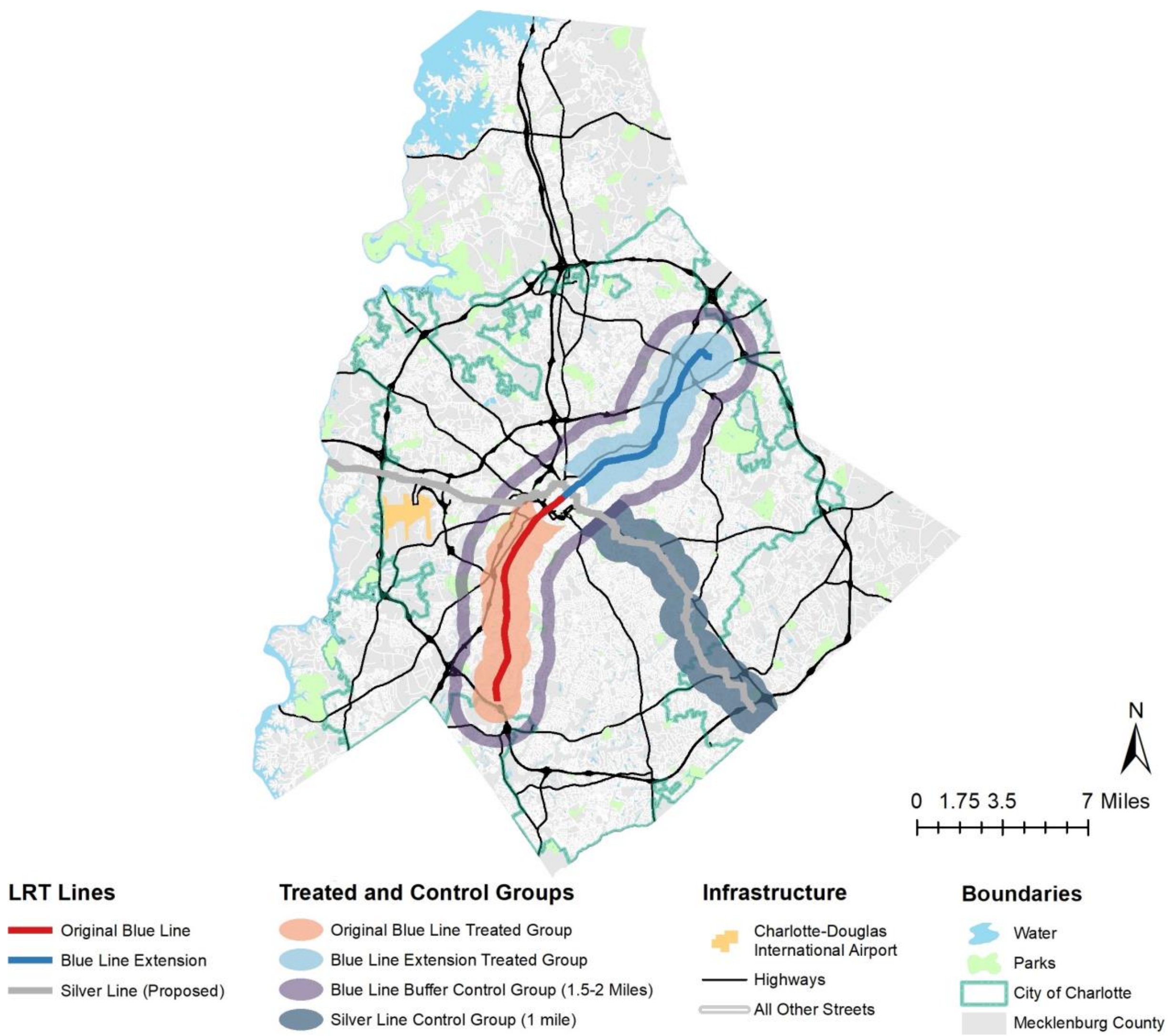


FIGURE 2.1 Mecklenburg County, North Carolina

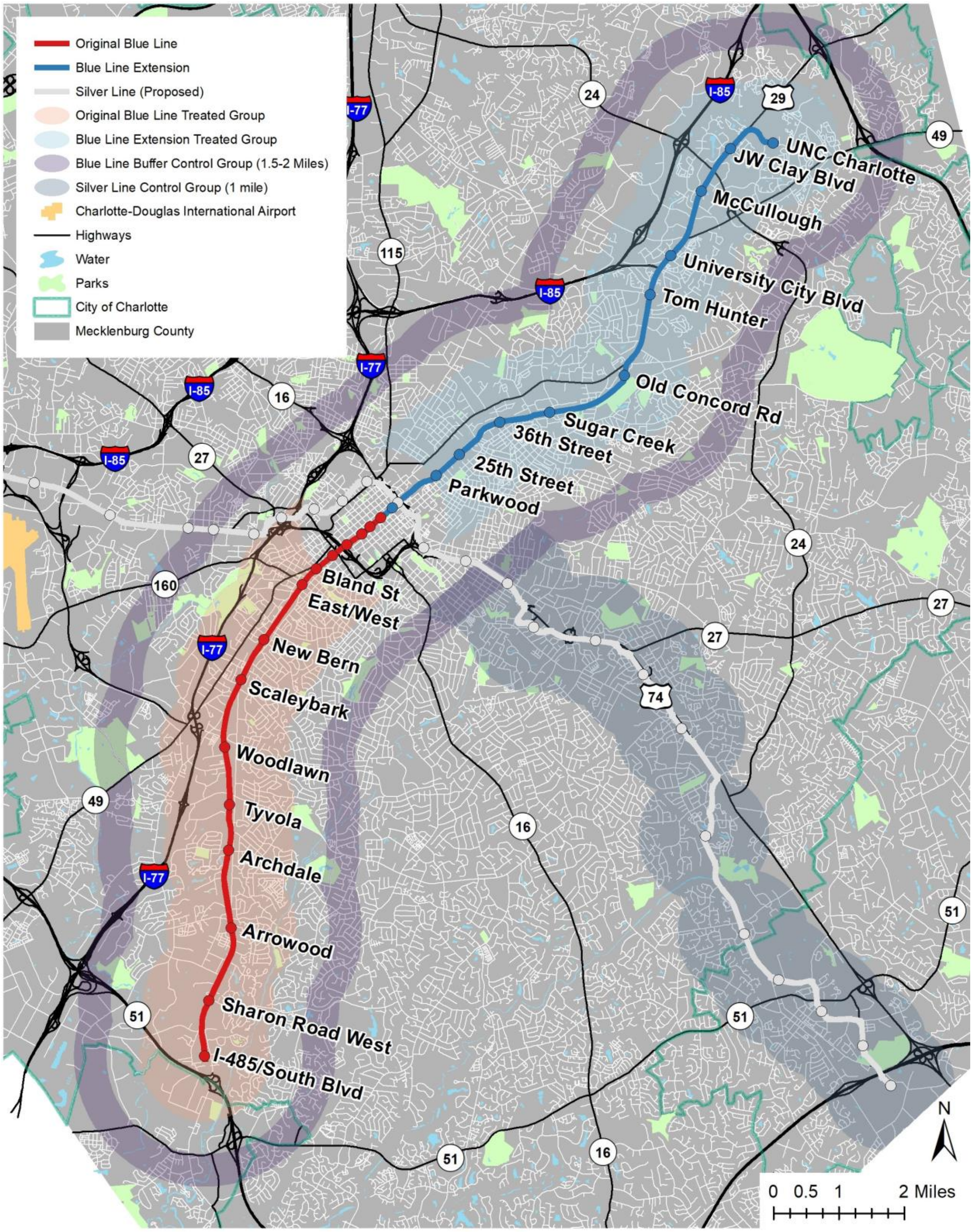
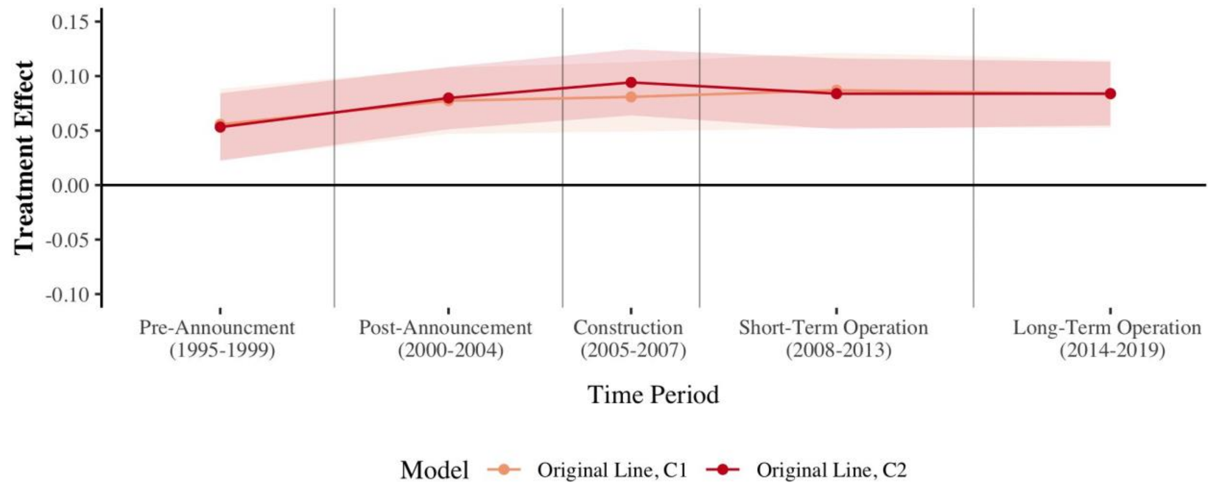
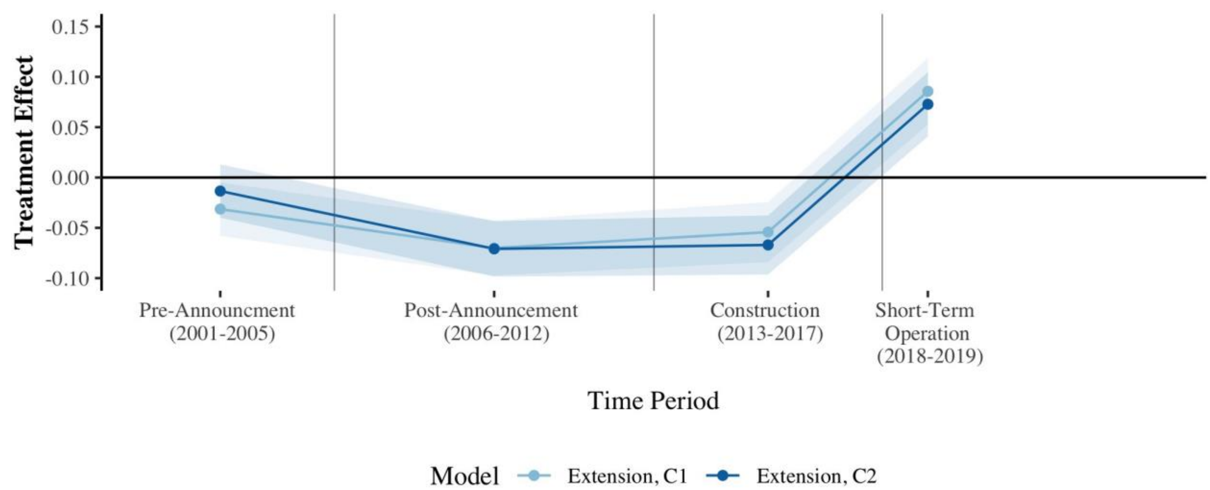


FIGURE 2.2 Study area

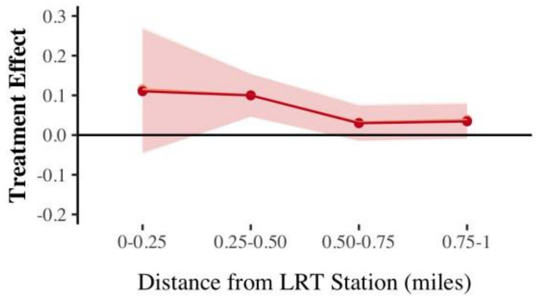


((a)) Original Blue Line, Charlotte, NC

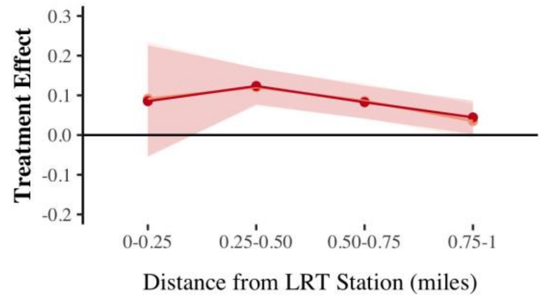


((b)) Blue Line Extension, Charlotte, NC

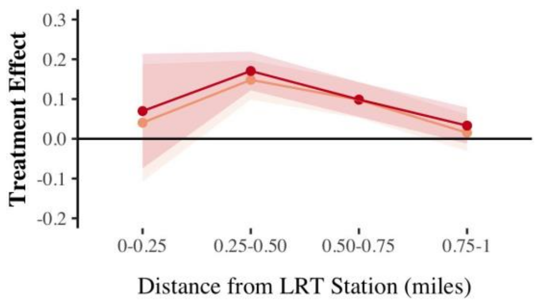
FIGURE 2.3 Average treatment effects by time period and 95% confidence intervals. Treated group: properties within 1 mile of an LRT station; C1: properties between 1.5 and 2 miles of an LRT station; C2: properties within 1 mile of the planned southeastern Silver Line.



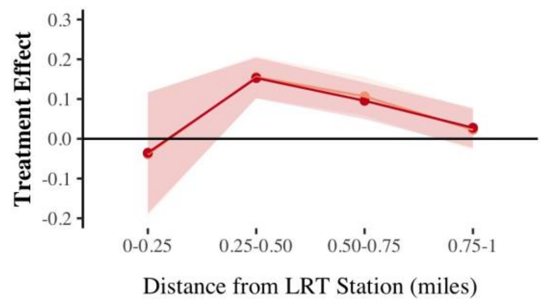
((a)) Pre-announcement (1995-1999)



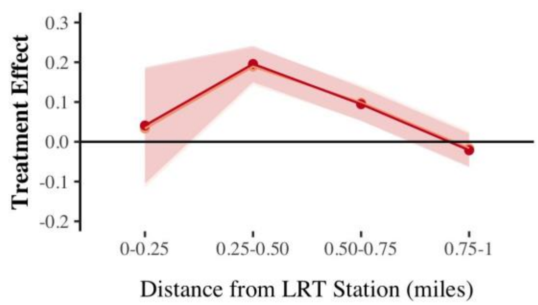
((b)) Post-announcement (2000-2004)



((c)) Construction (2005-2007)



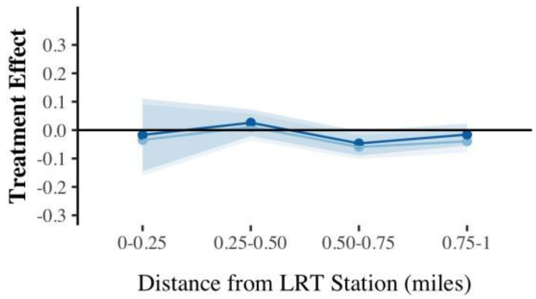
((d)) Short-term operation (2008-2013)



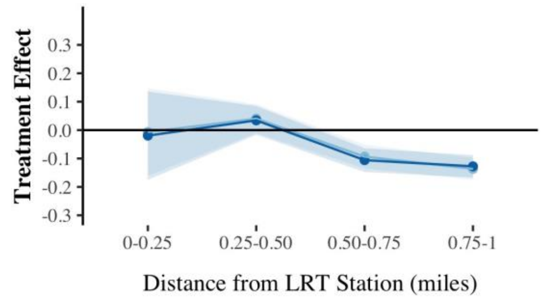
((e)) Long-term operation (2014-2019)

Model — Original Line, C1 — Original Line, C2

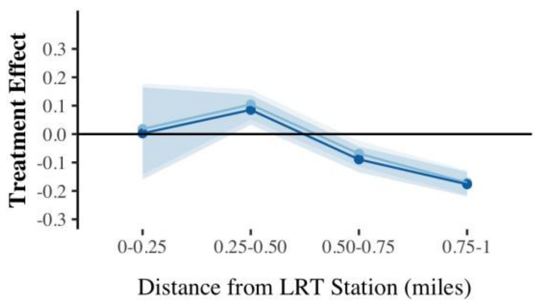
FIGURE 2.4 Average treatment effects by distance to the nearest light rail station and time period, and 95% confidence intervals for the Original Blue Line, Charlotte, NC. Treated group: properties within 1 mile of an LRT station; C1: properties between 1.5 and 2 miles of an LRT station; C2: properties within 1 mile of the planned southeastern Silver Line.



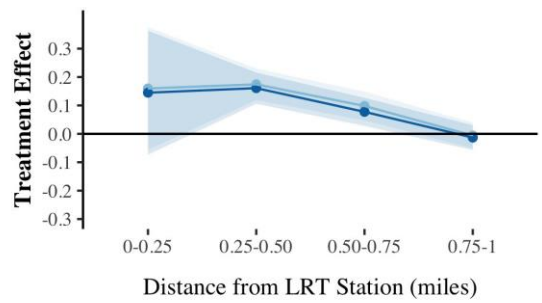
((a)) Pre-announcement (2001-2005)



((b)) Post-announcement (2006-2012)



((c)) Construction (2013-2017)



((d)) Short-term operation (2018-2019)

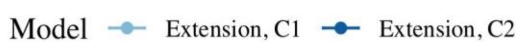


FIGURE 2.5 Average treatment effects by distance to the nearest light rail station and time period, and 95% confidence intervals for the Blue Line Extension, Charlotte, NC. Treated group: properties within 1 mile of an LRT station; C1: properties between 1.5 and 2 miles of an LRT station; C2: properties within 1 mile of the planned southeastern Silver Line.

2.3 Results

The average treatment effects by time period shown in Figure 2.3 allow us to more easily discern the temporal distribution without the interference of annual fluctuations. We find positive and statistically significant treatment effects five years prior to the announcement of the Original section of the Blue Line, which increase during the post-announcement and construction period and remain relatively stable after the line starts operating. These sale price premiums reflect a 5.5% to 9.9% price increase compared to the pre-treatment period (1990-1994). On the contrary, our results indicate that the residential properties close to the Blue Line Extension experienced a decline in price (5.6% to 7.3%) after the line's official announcement and during the LRT construction. After the opening of the line in 2018, property prices increased by approximately 8%, compared to the pre-treatment period (1996-2000). In general, these results are robust to the choice of control group. Our analysis indicates that effects on property prices can substantially differ even within the same metropolitan area, potentially due to variation in the socioeconomic composition of neighborhoods that creates different potential for attracting higher-income residents.

In addition, for the Original section of the LYNX Blue Line, we find that price premiums materialize for homes between 0.25 and 0.75 miles away from LRT stations in the years immediately after the announcement of the LRT line. These premiums remain consistently positive during construction and operation, and grow from a 8.6%-13.1% price increase in the post-announcement period to a 9.9%-21.6% increase, six to 12 years after the beginning of operation. Interestingly, these premiums remained intact during the Great Recession –a shock that led to the sharp collapse of the city's real estate market, in spite of the deep uncertainty on the prospects for sustained strength of the newly invigorated markets in close proximity to the Lynx stations. In addition, our results indicate that, for all time periods, the properties located between 0.25 and 0.5 mile of a station experience the highest price increase. In general, significant impacts are not found for properties closer than 0.25 mile or farther than 0.75 mile of an LRT station. The overall shape of the spatial distribution of the average treatment effects is more flat in the years before the beginning of construction and develops increasing curvature with time.

Consistent premiums are not the case for the Blue Line Extension, however. Similar to what the temporal analysis revealed, the impacts on single-family homes are mainly insignificant or even negative before the beginning of operation. This being said, during the first two years of operation, our results suggest that properties located between 0.25 and 0.75 mile of an LRT station experienced an 8.1%-19.1% increase in price, compared to the pre-treatment period (1996-2000). During the Great Recession, the corridor behaved much like the control groups and confidence remained consistent, overcoming the concerns on the future growth trajectory of the corridor at the end of the recession. Similar to the findings for the Original Line, the highest positive effect is experienced by the properties located in the 0.25-0.5 distance band; this positive effect is also present during the LRT construction period but smaller in magnitude (8.9%-11.0%) compared to the post-operation period (17.5%-19.1%).

The history of land development in Charlotte and the socioeconomic geography of the city make it much more likely that the differential treatment effects are related to differences in the initial land-use and socioeconomic characteristics of the neighborhoods surrounding the stations. As previously mentioned, the Original Blue Line corridor was less developed than that of the Extension at the time of the LRT implementation, providing more opportunities for TOD along the former. Furthermore, from the time it was announced, the Original Blue Line was seen as a major innovation in Charlotte's land development business community and many developers rushed for an early entry into this new market, including national developers. As competition was heating up and as the early developments met strong demand, prices skyrocketed, fueling a further development frenzy. Also, effects for the Original Blue Line may have been amplified because of its close proximity to older residential neighborhoods that were already undergoing gentrification (Yonto and Thill 2020). Given the citywide conditions of the real estate market in the mid-2000s, and the strong dynamism of the Original Blue Line corridor, the announcement of the Blue Line Extension failed to translate into a major uptick of the market along the Blue Line Extension. The Great Recession of 2007-2009 exacerbated the relative draw of the Original Blue Line and further delayed the awakening of the market along the Blue Line Extension.

CHAPTER

3

TRANSIT AND RESIDENTIAL GENTRIFICATION

3.1 Introduction

Many municipalities across the United States have recently invested in or are planning to invest in light rail transit (LRT) systems, since these LRT systems are thought to increase transportation accessibility, reduce congestion, and stimulate economic activity (Mohamed et al. 2016). Oftentimes, municipalities aim to maximize the impact of their investment by attempting to ensure that transportation disadvantaged communities will be able to access new LRT options. However, research has shown that new LRT systems can increase home prices in the areas around new transit stations (Billings 2011; Pilgram and West 2018; Yen et al. 2018; Schmidt et al. 2022) and spur other, larger social and economic neighborhood changes, such as gentrification (Chapple et al. 2009; Kahn 2007; Grube-Cavers and Patterson 2015; Zuk et al. 2015; Bardaka et al. 2018; Chava and Renne 2022).

To date, much of the research on the neighborhood changes that new transit projects can bring has assumed that effects are homogeneous across neighborhood typologies, making it difficult for engineers, planners, and policymakers to predict which neighborhoods may most experience the changes associated with new public transit projects. This research challenges that assumption, studying the relationship between neighborhood change, gentrification, and neighborhood socioeconomic status prior to the arrival of LRT. We apply the quasi-experimental difference-in-differences framework and a social status index to investigate how neighborhoods of varying socioeconomic characteristics may be differently impacted by the arrival of LRT systems. We apply our methodology to the first section of the LRT system constructed in Charlotte, NC, and find that neighborhoods of low- and high-social status see the largest changes associated with gentrification, while middle- social status neighborhoods see few changes. Our work stands to benefit engineers, planners, policymakers, and the public as local governments aim to maximize the benefit for public investment in new transit infrastructure while mitigating the externalities that may arise from those projects.

3.2 Rail Transit in Charlotte

We hypothesize that block groups within one kilometer of LRT stations may experience different neighborhood changes after the arrival of LRT infrastructure on the basis of their initial socioeconomic status. To test this, we define analysis units whose centroid is within a one kilometer Euclidean distance of an LRT station as being ”treated.” We subdivide our treated group on the basis of each block group’s social status at the beginning of our study time period, so that block groups with a social status index (SSI) in the bottom 33% of the County’s SSI distribution in the year 1990 are considered to have a ”low” socioeconomic status, block groups in the middle 33% of the distribution are considered to have a ”medium” socioeconomic status, and block groups in the upper 33% of the distribution are considered to have a ”high” socioeconomic status. We estimate the effect of LRT on each of these groups using a DID model and include 2 control areas in our analyses.

The first of these control areas, which we call ”C1,” is composed of neighborhoods in a 2.5 - 3.5 kilometer buffer area along the entirety of the LYNX Blue Line corridor. The second of our control areas, ”C2,” includes neighborhoods from around Mecklenburg County that we identify using PSM. We estimate that, after conditioning on a number of observable covariates, these neighborhoods had a similar likelihood of treatment in the years before the first LRT route was announced. For C2, the use of matching ensures these neighborhoods are similar in terms of the observable characteristics used to operationalize the matching process. Wile there may be unobservable differences between the treated area and C2, time-invariant unobservable characteristics are differenced out by the DID. Further, we use spatial fixed effects (indicators for high school districts) in all of our models that account for geography-specific effects. Our study area and control groups are shown in Figure 3.1.

We include 5 dependent variables in our study: the educational attainment of neighborhood residents, the rate of residents working in professional occupations, median household income, the racial mix of neighborhoods, and the sales price of single-family homes.

3.3 Summary of results

Our analysis begins 10 years before the announcement of the LRT line in Charlotte, NC (1990), and ends with data from the 5-year American Community Survey ending in 2018, 9 years after the LRT opened. We estimate average treatment effects in the years 2000, 2010, and 2016 to correspond to data from the 2000 Decennial Census, the 2010 Decennial Census, and the 2014-2018 American Community Survey (median year of 2016), respectively.

We find statistically significant estimates of the average treatment effect for Low SSI block groups across all of the gentrification measures taken from the Census and find those estimates to be similar in magnitude between both of the control groups studied. Those changes include a 24.2 percentage point increase in the percentage of neighborhood residents with a college degree between the period prior to LRT announcement and 2010, as well as a 36.2 percentage point increase between the pre-announcement period and 2016. Though smaller in magnitude, we observe similar trends in terms of the percentage of individuals working in professional occupations, finding a 18.59 percentage point and 26.3 percentage point increase between the LRT pre-announcement period and 2010 and 2016, respectively. We further observe that the arrival of LRT in neighborhoods near the LYNX Blue Line in Charlotte was associated with a decrease in the percentage of neighborhood residents that identify as people of color, with the amount of nonwhite residents decreasing by as much as 46.4% for low social status neighborhoods. Estimates of the effect of LRT on income in low social status neighborhoods are not statistically significant for both control groups at the 5% level in 2010, but our results show that incomes in those neighborhoods doubled by 2016 (a 110% increase) as compared to the pre-announcement period.

We observe similar trends for the high social status neighborhoods. The arrival of LRT

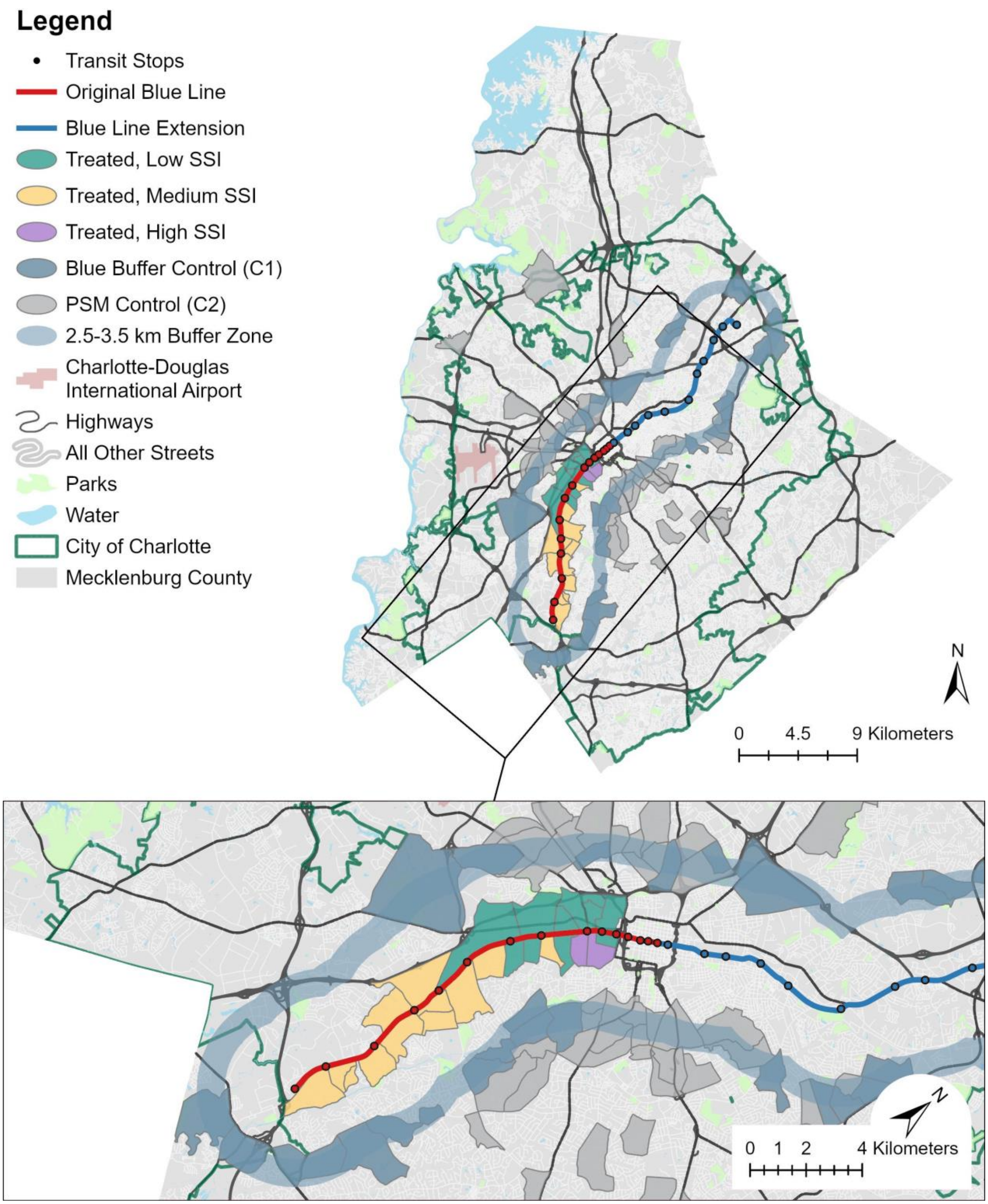
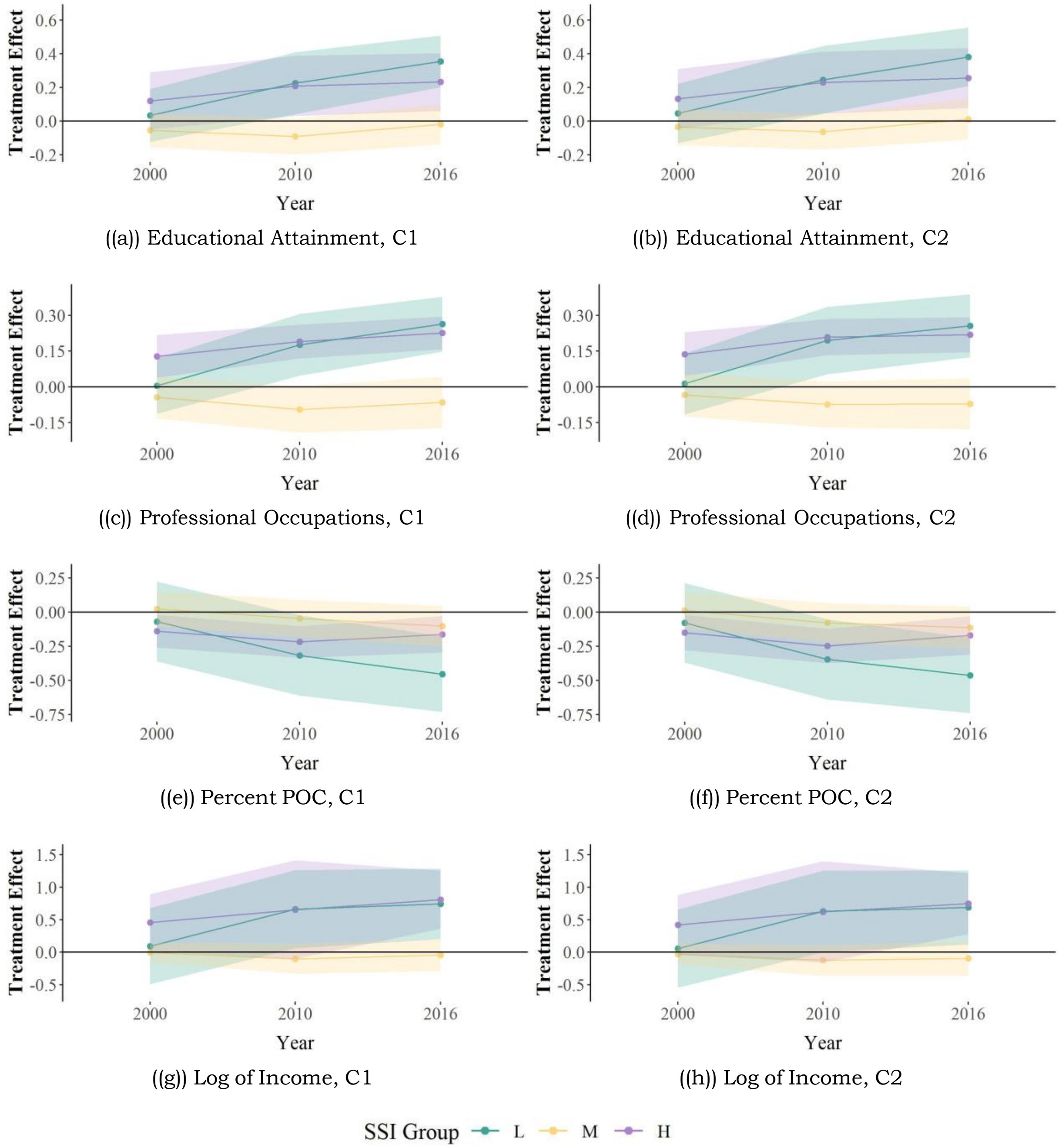


FIGURE 3.1 Overview Map

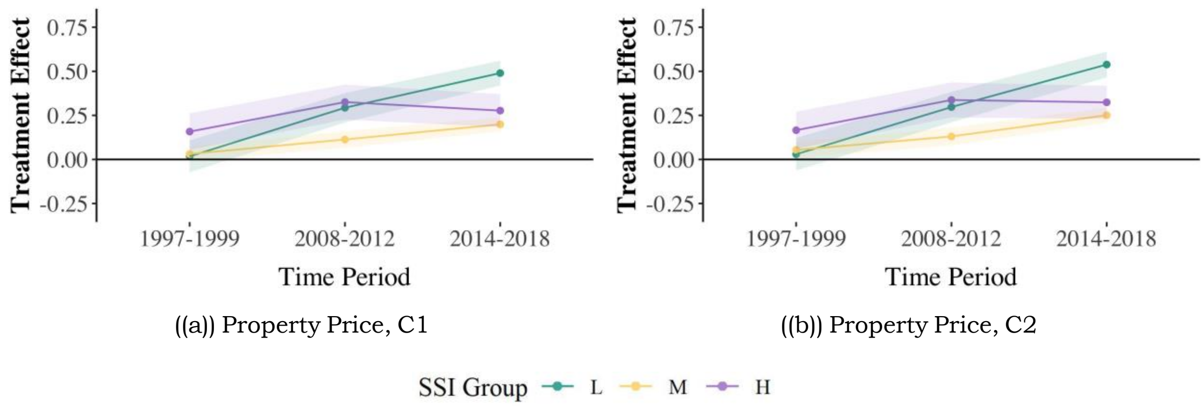
was associated with a 22.9 percentage point increase in the percentage of adults with a college degree in 2010 as compared to the pre-announcement period, and a 25.6 percentage point increase in 2016. We also find increases in neighborhood median income of 111% for high social status neighborhoods by 2016 as compared to the pre-announcement period. Our results show clear impacts for the lowest social status communities, minimal impacts for middle social status neighborhoods, and mixed impacts for higher social status areas.

In addition, regression results show statistically significant single-family home price increases for low and medium SSI neighborhoods in the years just after the LYNX Blue Line opens and nearly a decade after. Effects are larger for the low SSI groups then the medium SSI groups, and both neighborhood types see larger effects in the years around 2016 than in the years around 2010. Treatment effect estimates for 2010 range from 34% increases in price for single-family homes in low SSI neighborhoods to 13.9% increases for medium SSI neighborhoods. Effect estimates for 2016 are larger, with low SSI neighborhoods seeing a 71.3% increase in single-family home price as compared to period prior to LRT announcement, and medium SSI neighborhoods seeing a 28.5% increase.



((a)) Educational Attainment, C1
((b)) Educational Attainment, C2
((c)) Professional Occupations, C1
((d)) Professional Occupations, C2
((e)) Percent POC, C1
((f)) Percent POC, C2
((g)) Log of Income, C1
((h)) Log of Income, C2

FIGURE 3.2 Average treatment effects with 95% confidence intervals. Treated group: Census block groups with centroids within 1 km of stations along the Original Blue Line; C1: Census block groups with centroids between 2.5 and 3.5 km of LRT stations along the entire Blue Line; C2: Census block groups matched to the treated group using Propensity Score Matching (PSM)



((a)) Property Price, C1

((b)) Property Price, C2

FIGURE 3.3 Average treatment effects with 95% confidence intervals. Treated group: Census block groups with centroids within 1 km of stations along the Original Blue Line; C1: Census block groups with centroids between 2.5 and 3.5 km of LRT stations along the entire Blue Line; C2: Census block groups matched to the treated group using Propensity Score Matching (PSM)

3.4 Policy Recommendations

Several municipalities across the US have attempted to create market conditions that require or incentivize private developers to build affordable housing in the areas near transit stations. Some municipalities have adopted inclusionary zoning ordinances in an attempt to create a greater supply of affordable housing, including near transit stations. Generally, these ordinances require developers building multifamily developments with more than a specific number of units to set aside a percentage of the units they build to rent at below market rates. Municipalities across the US including San Francisco, California; Montgomery County, Maryland; San Diego, California; and New York, New York have adopted these ordinances to mixed degrees of success. Zhu et al. (2021) found that the inclusionary zoning program in Los Angeles had little effect on the number of building permits issued for new developments and showed through a theoretical financial analysis that inclusionary zoning ordinances may make building new housing projects more attractive for developers. Hamilton (2021) also found that inclusionary zoning ordinances in municipalities in the Washington, D.C. metro area had little effect on the number of building permits issued for new housing developments, but found that inclusionary zoning ordinances raised housing prices for market-rate units in the area. Municipalities in North Carolina are not able to implement inclusionary zoning programs because of state laws that prohibit municipalities from establishing any form of rent control (North Carolina General Statute Chapter 42), but Charlotte has given height bonuses for developments in their transit oriented development districts for projects that devote a percentage of developed floor space to affordable housing (City of Charlotte 2020) and Raleigh has recommended a similar program for use in districts around their proposed bus rapid transit (BRT) routes (City of Raleigh 2020). Some municipalities, such as Portland, have created tax abatement programs to incentivize developers to meet a specific set of conditions for new development (Dueker and Bianco 1999). To our knowledge, these height bonuses and developer tax abatement programs have not been evaluated in a research context, and little literature exists evaluating their effectiveness in other areas across the US.

Municipalities hoping to encourage the development of affordable housing around transit stops also have opportunities to act more directly. Early on the transit planning process, local governments and transit agencies can engage in ‘’land banking” and purchase land in proximity of future transit stops. Local governments and transit agencies can then later develop affordable housing on that land, ground lease that land to developers willing to develop projects with an affordable housing component, or sell that land to developers under an agreement that requires a number of housing units be affordable. For local governments not able or wanting to engage in this practice directly, some cities have had success working with community land trusts (CLTs), which are typically nonprofit organizations that aim to promote housing affordability by holding land ”in trust” and then leasing it to individuals that meet certain criteria for affordable housing. While CLTs often raise funds independently, some local governments have provided funding in exchange for work that CLTs do near transit stations. Cities including Atlanta, Denver, Minneapolis, and St. Paul have had success working with land trusts to foster equitable development in the areas around new transit lines (Hickey 2013).

Ensuring a sufficient supply of affordable housing is an important aspect of ensuring neighborhood residents are not displaced as neighborhoods change, but it does not necessarily help people stay in their homes. Instead, it ensures people have homes to move to if they are displaced. For local governments and transit agencies wanting to help individuals stay in their existing homes after new transit options arrive, several policy options exist. First among those options is property tax relief. The impact of new LRT systems on home prices has been well-studied (Billings 2011; Pilgram and West 2018; Yen et al. 2018; Schmidt et al. 2022), and researchers have found that the price of homes near LRT stations generally increase. This can create difficulties for neighborhood residents who could afford the property tax payments on their homes prior to the arrival of LRT but may struggle todo so after their home increases in value. Local governments can create property tax relief programs that aim to minimize these impacts for the individuals that may most struggle to afford a larger tax burden. While property tax relief programs exist in various forms across the US, we do not know a program that specifically targets the areas around transit stations. Other policy options meant to help individuals stay in their homes include legal assistance funds, meant to primarily to help renters know their rights in landlord-tenant disputes, and education programs meant to help homeowners understand the value of their homes, their rights, and ensure they are not victim of a predatory purchase by a developer wanting to capitalize on an investment near a transit line. While the City of Raleigh has proposed legal assistance and education programs like those described above (City of Raleigh 2020), we do not know of a municipality that has targeted these programs in the areas around new transit lines or evaluated their effectiveness.

CHAPTER

4

TRANSIT AND COMMERCIAL GENTRIFICATION

4.1 Introduction

A new transit system and the construction of residential, commercial, and office space in its proximity as part of transit-oriented development (TOD) efforts can impact local economic activity in many different ways. The higher pedestrian traffic from transit users and TOD residents as well as the (re)development of commercial space may attract businesses to open or move close to the new transit stations (Credit 2018; Schuetz 2015). At the same time, existing business may be negatively impacted due to escalating property prices (Mohammad et al. 2013), disruptions during the project construction (Ray 2017), and increased competition with new establishments. Recently, studies have revealed that neighborhoods close to transit attract upper-class residents and can undergo residential gentrification (Bardaka et al. 2018; Liang et al. 2022), which may not only impact vulnerable residents but businesses as well. The introduction of more affluent residents with potentially different consumption preferences compared to existing residents could contribute to an increase in businesses that satisfy the new residents, such as stores providing upscale, recreational, or nonessential goods and services (Meltzer and Ghorbani 2017). On the other hand, local or minority-owned stores may experience declining demand and struggle to cover rising rent expenditures (Meltzer 2016).

Commercial gentrification, a phenomenon which entails increasing numbers of high-priced, specialty, and chain stores and decreasing numbers of small, local, and essential stores (Meltzer 2016; Meltzer and Ghorbani 2017; Zukin et al. 2009), has not been thoroughly studied in the context of transit-rich neighborhoods. Three prior studies have shown how urban rail construction may negatively impact nearby businesses (Ray 2017; Tornabene and Nilsson 2021; Sukaryavichute et al. 2021), and only two studies have examined commercial gentrification after the beginning of transit operation using quantitative approaches (Chapple et al. 2017; Lin and Yang 2019). We identify three major limitations of previous research related to commercial gentrification. First, no previous work to our knowledge has attempted to quantify the causal relationship between large-scale transit investments and commercial gentrification. This hinders our ability to precisely quantify the impacts of transit investments on businesses. Although causal inference has been used to identify the effects of transit on new business starts (Credit 2018; Yao and Hu 2020), transit-induced commercial gentrification has only been explored using correlative approaches. Second, prior studies have not explored how impacts on businesses may vary over time and during the different project development phases, including the rail line announcement and construction as well as after the beginning of operation. Third, because commercial gentrification constitutes a complex, multifaceted phenomenon that could involve changes in business dynamics as well as the business composition in an area, interviews or surveys from small samples of establishments have served as the dominant approach in the general literature (Jeong et al. 2015; Özdemir and Selçuk 2017; Rodríguez-Barcón et al. 2018), with a few key exceptions (Meltzer 2016; Meltzer and Capperis 2017).

Our study focuses on addressing these limitations by developing a methodology for capturing and assessing the diverse angles of transit-induced commercial gentrification grounded on former urban economics and planning research (Meltzer 2016; Meltzer and Ghorbani 2017; Meltzer and Capperis 2017) and quasi-experimental design principles (Athey and Imbens 2017). We concentrate our work on the retail and service sectors, which have been primarily related to commercial gentrification (Thrash 2001; Zukin et al. 2009), and the use of business microdata, which can provide rich, historical information on the businesses in an area, including physical address and business classification. A difference-in-differences (DID) specification is embedded in negative binomial models of business entries, exits, and turnover, to investigate how transit and TOD could affect the business environment and contribute to commercial gentrification over time and at multiple distances from stations. To comprehend and disentangle the various forms commercial gentrification could take in different environments, businesses are studied based on (i) product necessity (whether they fulfill essential needs or provide more recreational or non-essential goods and services), (ii) frequency of product consumption (whether they are frequently or infrequently visited by customers), and (iii) local status (whether they are a single-location business or part of a chain). We demonstrate our methodological approach through the study of transit-induced commercial gentrification in Charlotte, NC, where the LYNX Blue light rail line has been in operation since 2007.

This research contributes to the limited knowledge of how transit investments may be impacting nearby businesses, when those impacts materialize or peak and at what distance from transit stations. The present lack of quantitative studies and statistical evidence in this domain may be related to the very few policies and action taken so far to prevent or mitigate negative externalities. As of today, the few business assistance programs for transit corridors are primarily focused on supporting businesses during transit construction. One example is the Central Corridor Funders Collaborative, a partnership founded to support businesses, among others, during the construction of the Minneapolis and St. Paul's Green light rail line through training programs, technical assistance, and loans (Saint Paul & Minnesota Foundation 2016).

4.2 The LYNX Blue Line in Charlotte, NC

The effects of the LYNX Original Blue Line and TOD investments (excluding the CBD area) are assessed for the businesses within 0.5 miles of the light rail stations using Data Axle's historical business database (1998-2019). Business counts are aggregated in 0.25×0.25-mile grid cells to measure the number of business entries, exits, and turnover within a constant spatial unit. Our analysis suggested that only the commercial areas located within 0.5 miles of the planned stations of the southeastern Silver Line can serve as an appropriate comparison group. We hypothesize that the light rail affected businesses differently during the various project phases. We therefore estimate average treatment effects for the following four time periods: (i) post-announcement (2001-2004), (ii) construction (2005-2007), (iii) short-term operation (2008-2012), and (iv) long-term operation (2013-2019). Impacts are estimated as differences with the pre-announcement period (1999-2000) and the control

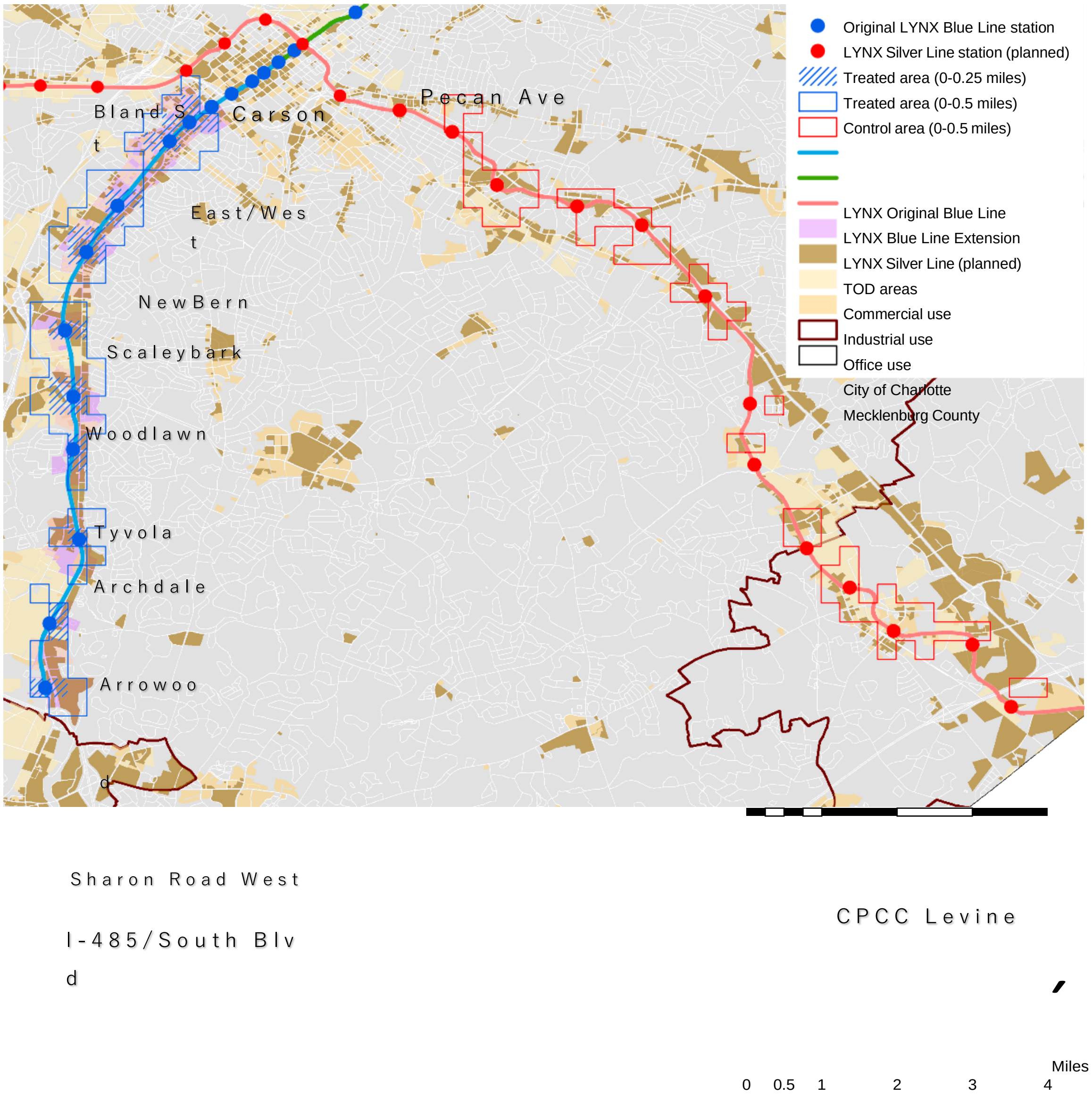


FIGURE 4.1 Treated and control grid cells

areas using the DID specifications described in Section 4.3. The analysis of local and non-local businesses is limited due to issues with missing information before 2004. For this reason, impacts during the post-announcement period cannot be assessed, and the year 2004 serves as a base for identifying differences with future time periods, including the construction and post-operation periods.

4.3 Summary of results

We study transit-induced commercial gentrification using business microdata. Temporal and spatiotemporal analysis based on difference-in-differences methods is used to evaluate the impacts of transit investments on business entries, exits, and turnover over space and time. We use Data Axle's historical business database and compile data for individual businesses within 0.5 miles of the light rail stations and the control area, aggregated at 0.25×0.25-mile grid cells for the years 1998-2019.

The results of the descriptive analysis indicate a substantial increase in retail and service employment density in the areas close to the light rail after the beginning of operation while business density remained relatively stable. A contributing factor could be the potentially higher customer demand due to increased population density and pedestrian traffic close to the light rail that would necessitate a higher number of employees. An additional contributing factor could be the substantial increase in the entries of non-local businesses during the light rail construction and post-operation periods. The density of discretionary businesses within 0.25 miles of stations increased during the light rail construction but returned to its original levels around three years after the beginning of operation. The density of infrequently visited service and retail businesses steadily increased between 1999 and 2017 for the neighborhoods located a quarter to half mile away from stations, primarily due to fewer businesses closing or moving out of that area. Frequent and essential businesses demonstrated increasing trends over time for both 0-0.25 mile and 0.25-0.5 mile proximity zones and experienced fewer exits and move-outs compared to the control area.

The econometric analysis results provide evidence of fewer exits and smaller turnover for service businesses and businesses offering frequently consumed goods and services located between 0.25 and 0.5 miles of light rail stations compared to the control area. It is possible that fewer businesses left the area during the post-announcement and construction periods in anticipation of benefits and higher revenue after the beginning of light rail operation. In the case of frequently visited businesses, the decrease in exits after the first five years of operation (61%) was higher than the decrease experienced in the post-announcement and construction period, indicating positive benefits due to the light rail operation and TOD. We also find a 72% decrease in new service businesses entering the areas within 0.25 miles of light rail stations during the light rail construction (compared to the pre-announcement period and the control group) and similar but lower changes for the remaining time periods. However, disproportionate, negative impacts on existing service businesses (such as higher exits) are not identified. Based on the analysis of the entries, exits, and turnover of retail and service businesses and their subcategories related to frequency of consumer visits and necessity of the products, strong evidence of transit-induced commercial gentrification is not found for the Original Blue light rail line in Charlotte. We refrain though from reaching conclusions about local and non-local businesses given the lack of information before the year 2004.

Additional studies on transit-induced commercial gentrification are needed so that results for other transit systems become available for policy development. A horizontal comparison between different metropolitan areas would provide valuable insights to urban and transportation planners in terms of the types of businesses negatively impacted and the timing of these impacts with respect to the different project development phases. Although there are programs for supporting small and minority-owned businesses in general (City and County of San Francisco 2022; City of Chicago 2022; Economic Development Administration 2022), programs specifically designed and implemented for transit corridors are scarce. Support for local and disadvantaged businesses is frequently mentioned in TOD vision plans (City of Charlotte 2018; LA Metro 2016), but implementation is still lacking.

CHAPTER

5

DEVELOPMENT STRATEGIES TO SUSTAIN HIGH RIDERSHIP

In this section, we review prior studies and discuss the development strategies that can sustain high transit ridership. Three main strategies are included, transit-oriented development (TOD), affordable housing, and other general development, such as built environment and land use.

5.1 TOD and transit ridership

This section discusses past research on how the TOD factors and the characteristics of TOD residents impact transit ridership.

The Association of Bay Area Governments (2014) conducted a survey about transit usage for residents of affordable housing in both TOD and non-TOD areas in the Bay area, CA. The results suggest that TOD residents always use transit more and drive less than their counterparts in non-TOD sites. In addition, low-income households that earn less than the Median Family Income (MFI) in both neighborhoods use transit more compared to the higher-income households.

Cervero (2007) discussed the ridership of transit by TOD residents in California based on a survey that interviewed about 1000 residents living within a half mile of rail stations in 2003. Binomial logit models are used to predict transit choices for commuting trips of TOD residents. Results suggest that comparative travel times by car versus transit, having a flexible work schedule, connectivity levels at the destination, and preference of living near transit are all positively correlated to transit ridership. Meanwhile, having a chained trip, job accessibility by auto, subsidized car expenses by the employer, and auto ownership are negatively associated with transit ridership. The study also found changes in the travel behavior of those residents moving from non-TOD to TOD neighborhoods; results suggested that once people moved to TODs, the vehicle miles traveled (VMT) decreased by 42%, on average.

Dill (2008) investigated the travel behavior of 300 residents of TODs near rail stations in the Portland area, Oregon. The interviewed residents mainly lived in market-price units with a high household income. Overall, about 20% of the residents indicated that they switched from non-transit modes to transit after moving to TODs. 26% of the respondents used transit for commuting trips, which is 7 to 13 percentage points higher than the overall region. The parking pricing at the destination appeared to be positively associated with transit use; for those who have to pay for parking at the destination, 52% of them commute by transit, while only 17% do so if there is no parking fee. As for the non-commute trips, the use of transit is higher for those residents living closer to the downtown area.

Sung and Oh (2011) explored the association between TOD planning factors and transit ridership in Seoul, Korea. Four factors, including transit supply service, land use, street network, and urban design at each rail station area, were considered and the authors developed regression models to study the association between transit ridership and these factors. Results suggested that the rail station areas with a higher land-use mix tend to have higher bus and rail-transit ridership. In addition, pedestrian-friendly streets are associated with higher transit ridership.

In summary, prior studies have suggested that living in TODs is positively associated with transit ridership (Association of Bay Area Governments 2014; Cervero 2007; Dill 2008; Sung and Oh 2011) and people use transit more after moving to TOD neighborhoods (Cervero 2007). However, there are several factors that can affect the commuting mode choices by TOD residents. TOD residents choose to commute by transit more when the accessibility to transit from origins and the level of connectivity to destinations are high (Cervero 2007; Sung and Oh 2011; Dill 2008). In addition, policies related to personal vehicles impact commuting mode choices. For example, the parking prices at the destination are positively associated with transit use (Cervero 2007; Dill 2008); however, if the employer subsidizes the car expenses, personal vehicles are more likely to be used for commuting trips (Cervero 2007).

5.2 Affordable housing and transit ridership

Barajas et al. (2020) surveyed and compared the travel behavior of 613 residents who lived in market-rate or affordable houses in the San Francisco bay area, CA. These houses are either within a quarter of urban rail stations (transit-oriented developments, TOD) or between one and two miles of stations (non-TOD). This study compared results across both housing locations (TOD or non-TOD) and affordability (market-rate or affordable). Over one-third of the trips for TOD residents were by public transportation (urban rail or bus), while only a quarter of non-TOD residents did so. TOD residents were more likely to travel by urban rail than non-TOD residents; 37% and 22% of market-rate and affordable TOD residents traveled by urban rail, respectively, while less than 20% of non-TOD residents did so. 15% and 8% of the affordable non-TOD and TOD residents take buses compared to 2% of market-rate residents.

Bardaka and Hersey (2019) conducted a study investigating the travel behavior of residents within a 10-min walk of an urban rail station in Denver, CO. In total, this study compared 1113 low-income units with 1305 market-rate units. A low-income unit is defined as an income-restricted unit occupied by a household earning less than 60% of the average median income (AMI). Market-rate units are units without income restrictions that are occupied by households earning over 60% AMI. Overall, two-thirds of low-income unit residents traveled the most distance by public transportation while less than 20% of market-rate unit residents did so. 60% of the low-income unit respondents used public transit at least once per week, while less than 21% of market-rate residents did so. In addition, 69% and 32% of market-rate residents indicated that they never used the bus and rail, respectively, in the past 30 days.

When exploring the impact of LRT on transit use in Minneapolis, Cao and Schoner (2014) found that the residents of LRT neighborhoods use transit more frequently compared to those in non-LRT neighborhoods. The use of transit also depends on land use, built environment, and types of housing units near the LRT, and results suggested that being around industrial facilities, pedestrian-unfriendly environment, and market-rate condominiums are all negatively associated with transit use.

Overall, prior studies have shown that residents of affordable housing use transit more compared to market-rate residents in the US context (Barajas et al. 2020; Bardaka and Hersey 2019; Cao and Schoner 2014). However, affordable TOD residents are more likely to use buses instead of urban rail (Barajas et al. 2020; Bardaka and Hersey 2019). Living near urban rail also affects the choice of using rail by affordable housing residents. About 6 percentage points fewer affordable non-TOD residents use the urban rail compared to those living within TOD neighborhoods in the San Francisco bay area, CA (Barajas et al. 2020).

5.3 General development and transit ridership

Chakraborty and Mishra (2013) developed a model that estimated the association between daily transit ridership and land use types for the entire state of Maryland. Transit ridership increases with household density and employment density. This is expected, as the majority of employment is located in the urbanized area with a high density of transit. Household density is not significantly associated with ridership in suburban areas, while employment density is not significant in rural areas. Furthermore, the ridership decreases with the increase in the recreation square footage.

Demissie and Kattan (2022) explored the interactions of land-use patterns and transit ridership at the bus-stop level and zonal level in the City of Calgary, Canada. Six types of land uses were used (city center, commercial, institutional, residential, recreational, and industrial areas). The city center, institutional and residential areas have morning and afternoon peaks in terms of transit ridership. In addition, the city center and institutional areas have more alighting passengers in the morning while more boarding passengers in the afternoon. The residential area experiences a reverse pattern. The industrial area has three peaks, morning, afternoon, and evening. The morning and afternoon peak experience similar patterns as the city center and institutional areas, however, the industrial area experiences another alighting wave in the evening. As for the commercial area, a boarding wave is found before the opening of the shopping center, which can be associated with elderly programs that allow this socially disadvantaged population to use the mall in the early morning.

Kwoka et al. (2015) analyzed whether working near the light rail station influences the travel behaviors of workers differently than those living near the station by using survey data from Denver, Colorado. Three thresholds are identified to determine whether a place is proximate to a station: 0.5-mile buffer, 1-mile buffer, and, 15-minute walkshed. Places within a 15-minute walkshed have a much higher percentage of using non-car commute modes than the other two thresholds (7.7% to 26.9%). In addition, if the work is near a transit station, commuters are less likely to drive to work than those living near transit. People who both live and work near the transit use non-car modes more frequently for all trips.

Mohamad Zulkifli et al. (2017) evaluated land use diversity and passenger ridership within 1000 meters of an LRT system in Malaysia. This study considered residential, commercial, and institutional land uses when measuring land use diversity. (The greater the diversity index value, the greater the land use mix in the area.) The results indicated that land use diversity is positively associated with daily transit ridership. In other words, a more diverse neighborhood tend to have higher transit ridership.

Ryan and Frank (2009) investigated the association between the walkability environment and transit ridership in the San Diego region. There are four components in their measure of walkability, including land use, residential density, retail floor-area ratio, and intersection density. The results indicated that the higher levels of walkability in the station area are associated with higher bus ridership.

Sung et al. (2014) investigated the impacts of land use on urban rail transit ridership in the city of Seoul, South Korea. Five types of land use are considered in this study, residential, small-scale neighborhood, large-scale commercial, large-scale public service, and office. A small-scale neighborhood generally includes living facilities, such as supermarkets or restaurants with less than 150-1000 square meters of floor area. Large-scale commercial areas can include a large supermarket or a big-box store. Large-scale public service areas include facilities that can host cultural or educational functions. Office uses include public and private offices, and financial, and banking facilities. The residential land uses are positively associated with rail transit ridership up to the 1.5-km boundary of a station. In addition, large-scale public service land uses are positively associated with ridership up to a 1 km distance. The other three land uses are also positively associated with ridership up to 750 meters of a station.

Thompson et al. (2012) explored the determinants of transit ridership demand in Broward County, Florida. The results of a count-data model illustrated the relationship between transit ridership and both origin and destination zone variables. For the origin zone variables, the total population was found to be positively related to the ridership, while median housing income negatively impacted the ridership. Furthermore, the destination areas with more jobs and higher parking fees experience more transit trips.

In this section, we discussed the association between general development and transit ridership. Prior studies mainly focused on land use types, such as commercial, institutional, and residential neighborhoods (Chakraborty and Mishra 2013; Demissie and Kattan 2022; Mohamad Zulkifli et al. 2017), as well as the built environment, such as intersection density and job density (Ryan and Frank 2009; Thompson et al. 2012). Diverse neighborhoods that mix different types of land typically have high transit ridership (Mohamad Zulkifli et al. 2017). However, land use types impact transit trip attributes, including trip time and direction of trips. For example, the city center and institutional areas have more alighting passengers in the morning while more boarding passengers in the afternoon, while the residential area experiences a reverse pattern (Demissie and Kattan 2022). In addition, each land use type has different catchment areas of transit and the residential neighborhoods has the largest catchment areas (1.5 kilometers) (Sung et al. 2014). As for the other factors, the neighborhoods that have higher population and job density, lower median housing income, and larger retail floor-area ratio have a higher transit usage (Chakraborty and Mishra 2013; Kwoka et al. 2015; Ryan and Frank 2009; Thompson et al. 2012)

CHAPTER

6

BUS RAPID TRANSIT AND PROPERTY VALUE UPLIFT: A PRELIMINARY ANALYSIS

6.1 Introduction

The metropolitan areas of North Carolina are among the most rapidly growing regions of the United States. Recently, several Metropolitan Planning Organizations (MPO) across North Carolina have included funding for mass rapid transit projects such as the Durham-Orange Light Rail and the Lynx Red Line, which have fallen through. This has prompted MPOs to develop less expensive forms of rapid transit. Successful projects from around the United States and the world have pushed BRT to the forefront of its transportation strategies. It will be useful to know what effects the implementation of BRT will have on the communities they serve and whether property value capture policies would be effective. This preliminary study will attempt to identify relationships between the implementation of BRT and property value uplift.

6.2 Preliminary Study

Publicly available data was used to perform this analysis. Parcel data was acquired from the County of Henrico Finance Department Real Estate Assessment Division and the City of Richmond Assessor of Real Estate. This included the shapefiles used to run the spatial analysis and the property attribute data used to run the descriptive analysis.The Richmond Virginia Open Data Portal provided a Greater Richmond Transit Company (GRTC) Bus Routes and Stops shapefile. The Hull Street and Cary Street centerlines shapefile was acquired from the City of Richmond Geohub. The distances from each parcel to the nearest BRT. Property values were adjusted for inflation using the US Bureau of Labor Statistics' Consumer Price Index for All Urban Consumers: All Items in US City Average retrieved from FRED, Federal Reserve Bank of St. Louis. Inflation was calculated using February 2021 as a datum.

Control corridors were chosen to represent certain attributes of the Pulse BRT corridor. Cary Street and Hull Street are both corridors that feature similar uses to that of the Pulse BRT corridor, such as a mix of commercial and residential, parts that are located in downtown, and locations near major employment centers (VCU, VA Hospital). The limits of the Cary Street corridor were chosen so as not to capture effects attributed to the BRT corridor. The limits of the Hull Street corridor were restricted to keep the entire corridor within the Richmond city limits for the ease of procurement of data. Figure 1 shows the locations of the corridors. The section of Cary Street chosen for this study is located entirely within the defined limits of Downtown, so it was not included in the analysis of downtown effects. Finally, the sections of the BRT route which featured dedicated guideways (bus-only lanes) were compared to sections without bus-only lanes. Figure 3 shows the locations of these sections.

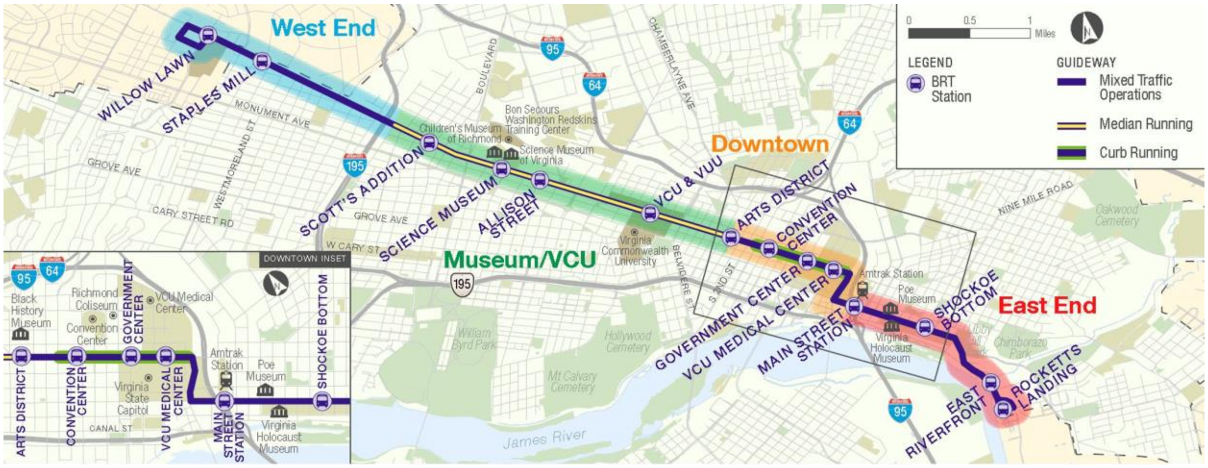


Figure 3. Guideway types of the Pulse BRT (GRTC, 2020)

Table 2 compares the changes in property values along the BRT corridor against changes in property values along Cary Street and Hull Street. Property value uplift occurred between the announcement of the BRT project and the beginning of construction, followed by a decrease in property values during construction, and then another, larger increase upon commencement of operations. Property values along Hull Street and Cary Street stayed level during the post-announcement period, then increased during the construction and operational periods.

	BRT			Cary			Hull		
Period	Mean	SD	% change from pre-announcement	Mean	SD	% change from pre-announcement	Mean	SD	% change from pre-announcement
Pre-Announcement	390792	345101		310038	180128		106351	64439	
Post-Announcement	485843	493583	24.32%	325921	172469	5.12%	108154	121832	1.69%
Construction	338935	241543	-13.27%	383763	239977	23.78%	138300	119141	30.04%
Operation	618930	518731	58.38%	422497	277702	36.27%	149707	166822	40.77%

Table 2. Corridor effects

Table 3 compares the property value changes in the Downtown areas of the BRT and Hull Street corridors. Downtown is defined in Figure 2. The changes in property values along the BRT corridor were similar when comparing the Downtown and Not Downtown areas, whereas there was a marked difference in property value changes between the Downtown and Not Downtown areas of Hull Street. Downtown Hull Street saw a drop in property values in the post-announcement period followed by a large increase in property values during the construction period and leveling off in the post-construction period.

Period	BRT						Hull					
	Downtown			Not Downtown			Downtown			Not Downtown		
	Mean	SD	% change from pre-announcement	Mean	SD	% change from pre-announcement	Mean	SD	% change from pre-announcement	Mean	SD	% change from pre-announcement
Pre-Anouncement	236416	40639		393761	347706		147800	60582		86277	56239	
Post-Announcement	321156	33163	35.84%	492108	501827	24.98%	125182	58840	-15.30%	102988	134979	19.37%
Construction	203245	31300	-14.03%	350566	248207	-10.97%	265874	189010	79.89%	102042	48856	18.27%
Post-Construction	373992	68954	58.19%	632242	529241	60.57%	251737	141519	70.32%	129176	164138	49.72%

Table 3. Downtown effects

Table 4 compares changes in property value along dedicated lane and mixed traffic portions of the BRT. Values of properties near dedicated BRT lanes rose in the post-announcement period, decreased during construction, and increased again after the commencement of operations. In contrast, areas where the BRT runs in mixed traffic saw a larger increase in prices during the post-announcement period, but then experienced a leveling off of prices during the construction and operational periods.

Period	Dedicated Lane			Mixed Traffic		
	Mean	SD	% change from pre-announcement	Mean	SD	% change from pre-announcement
Pre-Anouncement	442727	386743		256744	127019	
Post-Announcement	565753	564351	27.79%	353769	306977	37.79%
Construction	329372	245779	-25.60%	369753	231374	44.02%
Post-Construction	740209	597701	67.19%	383724	125799	49.46%

Table 4. Guideway effects

6.3 Conclusions

The changes of property value between Cary and Hull Streets seem sufficiently similar that the differences in those of the BRT corridor can be explained by the construction of the BRT. Property value uplift in the BRT treated corridor is greater than that of the control corridors in the post-announcement and operational stages. Property values decreased in the BRT corridor during construction, however, while they continued to increase in the control corridors. This indicates that there are two opportunities for value capture inthe BRT development process: the time between the announcement of a new BRT systemand the beginning of construction, and the time immediately after the system opening.

Additionally, while the entire length of the BRT corridor experienced land value uplift, the portions of the corridor that had dedicated BRT lanes had a larger overall land value uplift after operations commenced as well as larger swings in between each period analyzed, indicating that land value capture efforts might produce higher returns in these areas.

As Wake BRT continues to develop, this study will provide vital information to planners and developers who want to maximize their investments in the communities they serve. The timing and location of the implementation of policies will be vital to maximizing the communities' ability to glean the most benefits. The most optimal scenario is for policies to be implemented and real estate development to happen around the areas of heaviest corridor improvement as soon as a new transit line is officially announced. Doing this will ensure that the communities will take maximum advantage of the new BRT system, strengthening the region as a whole.

CHAPTER

7

ATLAS DATABASE RECOMMENDATIONS

7.1 Recommended additions to the ATLAS database

The research team reviewed the list of layers in the ATLAS database (as of December 2022) to provide recommendations to NCDOT about the type of layers that would be useful in the analysis of the socioeconomic impacts of transit investments.

First, it is important that longitudinal data is maintained in the database, not just the latest data for each layer, to enable before-and-after comparisons. For example, the database includes layers on population by race, but it is critical that these layers include all the datasets at the block group level available from Census and the American Community Survey (ACS) over time. Because the Census geography changes over time, NCDOT could consider purchasing the data at constant census geography from private providers so that temporal comparisons could be easily accomplished.

Second, important socioeconomic variables that researchers used to identify residential gentrification or to develop social indices are currently missing from the ATLAS database. We propose the addition of the following variables (longitudinally) from the U.S. Census and the ACS 5-year estimates to the database:

- median household income
- educational attainment
- individuals in professional occupations
- unemployment rate
- median house value
- housing density

Third, data related to businesses and employment are absent from the ATLAS database. One source of publicly available data is the Longitudinal Employer-Household Dynamics (LEHD) Census database which includes workforce dynamics data over time at the block level.

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