8-2022

The Relationship Between Distance to the Woodward Avenue Streetcar and Real Estate Prices in Central Detroit

Alex Biles
Western Michigan University

THE RELATIONSHIP BETWEEN DISTANCE TO THE WOODWARD AVENUE STREETCAR AND REAL ESTATE PRICES IN CENTRAL DETROIT

Alex Biles, M.S.

Western Michigan University, 2022

In recent decades, cities across the United States have pursued streetcars not only for their transportation benefits, but also with the goal of revitalizing downtowns and nearby neighborhoods by stimulating economic development and boosting property values. In Detroit, construction of the Woodward Avenue streetcar, also known as the QLine, was unprecedented due to the outsized involvement of private investors. Although the announcement of the QLine attracted substantial investment, ridership has largely fallen short of projections, and impacts on nearby property values were unclear. The purpose of this study was to estimate the effects of distance to QLine stations on real estate prices within a 1-mile buffer in central Detroit. Data were collected for 209 commercial and 477 residential property transactions and a logarithmic transformation was applied to the response and focus variables. A combination of ordinary least squares (OLS) and geographically weighted regression techniques (GWR) were used to estimate the impacts of station distance on real estate prices, determine how the relationship varied across space, and whether commercial and residential properties were affected differently. The results revealed a significant, positive relationship between QLine station proximity and real estate prices for both types of properties. The largest commercial impacts were observed in Downtown and Midtown Detroit, while the largest residential impacts were found in the New Center and North End neighborhoods. Overall, percentage increases in appraised value were greater for residential than for commercial properties. Although the QLine has succeeded in boosting the property values of private actors who hold business interests in Downtown Detroit, evidence suggests that these gains have come at the expense of speed, reliability, and social equity considerations.

THE RELATIONSHIP BETWEEN DISTANCE TO THE WOODWARD AVENUE STREETCAR AND REAL ESTATE PRICES IN CENTRAL DETROIT

by

Alex Biles

A thesis submitted to the Graduate College
in partial fulfillment of the requirement
for the degree of Master of Science
Geography
Western Michigan University
August 2022

Thesis Committee:

Benjamin Ofori-Amoah, Ph.D., Chair
Gregory Veeck, Ph.D.
Kathleen Baker, Ph.D.

ACKNOWLEDGMENTS

First and foremost, I would like to take this opportunity to thank my parents, Maria Peraza and James Biles, whose sacrifice and support allowed me to pursue a graduate degree.

I would also like to express my gratitude to my thesis committee members, Dr. Benjamin Ofori-Amoah, Dr. Gregory Veeck, and Dr. Kathleen Baker. Their guidance and wisdom helped me to refine my ideas, and without their words of advice, this project would not have been possible. Furthermore, I would like to thank all of the faculty and staff of the Department of Geography who made my time at Western Michigan University a productive and enjoyable one. In particular, I learned a lot from classes I took with Dr. Adam Matthews and Dr. Chansheng He. I owe all of my instructors a debt of gratitude for preparing me, not only for this thesis, but for a future career in geography.

Alex Biles

TABLE OF CONTENTS

Table of Contents — continued

CHAPTER

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

Proponents of mass transit systems frequently justify their construction by citing the benefits they will provide. Some examples of these benefits include economic development, reductions in carbon emissions that harm the environment, and improved mobility for residents and tourists alike (Litman, 2021). In recent decades, streetcar systems have experienced a resurgence, with more than a dozen cities across the United States opening lines in the hopes that this mode of transit will revitalize downtowns and nearby neighborhoods by stimulating economic development, increasing the local tax base, and boosting property values (Mendez and Brown, 2019). However, observers have noted that despite their popularity, streetcars are slower, transport fewer passengers, and are more expensive to build and operate than other modes, such as rail or bus (Brown et al., 2015). In many cities, streetcars have experienced lower than expected ridership as a result of these factors (Mendez and Brown, 2019). Some scholars have explained this phenomenon by arguing that streetcars are not being pursued solely for the transportation improvements they may provide, but rather as a tool for development and tourism amenity (Brown et al., 2015; Mendez and Brown, 2019). Furthermore, observers have noticed that the primary drivers behind the streetcar's renaissance have been private actors with business interests in downtown areas (Ramos-Santiago et al., 2016).

Studies have shown that investments in mass transit can yield significant economic returns (American Public Transportation Association, 2020). For instance, a study of Portland, Oregon's streetcar estimated that private developers invested $3.5 billion along a transit corridor within the first seven years of the system's operation (Portland Bureau of Transportation, 2019). Advocates have frequently used Portland's experience as a model of the streetcar's transformative potential. While it is true that Portland's streetcar has managed to simultaneously stimulate development while attracting a high level of ridership, it is unique among American streetcar systems, as the majority of its passengers are residents commuting to school or work. Additionally, the Portland streetcar has been successfully integrated into a multi-modal, regional transportation system (Mendez and Brown, 2019). Researchers have argued that the more effective a streetcar system is as a transit service, the more likely it is to provide economic benefits (Mendez and Brown, 2019). That being said, a streetcar alone will not automatically spur development, since other considerations such as land availability, zoning, and other location-specific factors also contribute to economic development.

The opening of the Woodward Avenue streetcar (2017) in Detroit, commonly known as the QLine, is unprecedented due to the outsized involvement of private investors, who donated the majority of funds for its construction (Lowe and Grengs, 2020). Like many streetcar systems across the country, the QLine's design process prioritized increasing property values and boosting economic development over other considerations, such as speed, reliability, or social equity (Lowe and Grengs, 2020). The influence of private actors is perhaps most visible in the decision to adopt a curb-running alignment over the exclusive, median right-of-way that was overwhelmingly preferred by the public and transportation planners alike. Civic leaders have defended their decision to opt for a shared-lane design by citing the benefits of increased foot traffic on property values (Lowe and Grengs, 2020). While the announcement of the QLine attracted substantial investment along Woodward Avenue, the system has been plagued by a number of issues since its opening in May 2017, namely service delays and ridership figures that have failed to meet projections (Neavling, 2019). The project's boosters hoped that the streetcar would increase nearby property values, but thus far, the long-term impacts of the QLine along the Woodward Avenue corridor remain unclear.

Although many studies have been conducted on the relationship between proximity to rail transit and property values, it is only in recent years that researchers have adjusted their models to accommodate for spatial autocorrelation and heterogeneity (Hewitt and Hewitt, 2012). Early attempts to examine this association applied global models to the entire study area, failing to account for spillover effects and assuming a fixed relationship between explanatory variables (Dziauddin, 2015). In contrast, spatially weighted techniques, such as geographically weighted regression (GWR), have revealed a complex relationship that varies across space. Recent studies have shown that proximity to transit facilities may have a positive effect on property values in some areas, and a negative influence in others (Hewitt and Hewitt, 2012).

The purpose of this study was to examine the effects of proximity to QLine stations on commercial and residential real estate prices in central Detroit using a one-mile buffer around streetcar stops. Data was collected for 209 commercial and 477 residential property transactions taking place between January 18, 2013 and March 11, 2022, all located within one mile (1609.34 meters) of QLine stops. The goal of the study was to estimate the relationship between real estate prices and distance from QLine stations using a combination of ordinary least squares (OLS) and geographically weighted regression (GWR) techniques. Logistic transformation of sale prices and distance to QLine stops was used to eliminate heteroscedasticity among residuals and to convert response variable regression coefficients from absolute dollar values into percent change in prices. The research centered on three key questions: What effects has distance to QLine stations had on commercial and residential real estate prices within a 1-mile buffer in central Detroit? How does the relationship between distance to QLine stations and real estate prices vary across space? How has distance from streetcar stops affected commercial and residential real estate prices differently? This study contributes to the existing literature, as it is the first known study to analyze the effects of the Woodward Avenue streetcar or the effects of any rail transit on property values in Detroit specifically. Moreover, it is one of only a handful of studies to examine the impacts of streetcars, and perhaps the first to use spatially weighted techniques to do so.

Some of the terminology used in this study should be defined to avoid confusion. Property values are defined as a property's selling price, rather than its assessed value, and this thesis uses the terms 'property values,' 'sale prices,' and 'real estate prices' interchangeably. Conversely, the terms 'distance' and 'proximity' are interpreted as having opposite meanings in relation to sale prices, with 'distance' referring to how far away a property was located from a station and 'proximity' referring to how close a property was located. As a result, a negative association between distance and sale price is interpreted as a positive association between proximity and sale price, and thus, a positive impact derived from the station's presence.

This thesis has six chapters, including this introduction. Chapter two provides detailed context about the study area, beginning with a history of mass transit in Detroit, followed by a summary of the current state of Detroit mass transit, and lastly, a history of the QLine specifically. Chapter three examines the growing body of academic research surrounding the relationship between rail transit and property values. Chapter four summarizes the methodological approach applied for this research, including the selection of explanatory variables, logarithmic transformation, and spatial regression techniques involved. Chapter five shares the results of the research. Finally, chapter six establishes the findings of the research and their implications, while providing a summary of the study's limitations, as well as recommendations for future research.

CHAPTER 2
BACKGROUND

Before exploring the relationship between the Woodward Avenue streetcar and property values, it is important to provide context surrounding the uniquely fragmented and severely inadequate nature of mass transit in Southeast Michigan, a region of more than 4.3 million people (U.S. Census, 2020). It is against this backdrop that the QLine was conceived. This chapter is divided into five sections. The first two sections will provide a broad overview of mass transit in the region, including a brief history of mass transit in Detroit; a summary of the current state of mass transit in Detroit, with an emphasis on regional mobility and socioeconomic considerations. The final three sections are dedicated exclusively to the QLine, including an overview of the streetcar's service area; the planning and construction phases of the QLine; and finally, a summary of the streetcar's performance since it began operations, with an emphasis on social equity, regional mobility, and economic development.

2.1 A History of Mass Transit in Detroit

The history of public transportation in Detroit has been characterized by ineffective political leadership, as well as long-standing racial and socioeconomic tensions between the city and its suburbs that have hindered the creation of a regional transit system. This section will summarize how Detroit's once-extensive mass transit system was reshaped and eventually reduced to its current state by a combination of political, economic, and cultural forces.

In its earliest years, transit service in Detroit was provided by horse-drawn trolleys, which were introduced in the 1860s and subsequently replaced by electric streetcars in 1894 (Hanifin and Douglas, 2013). A hodgepodge of independent, for-profit streetcar operators soon became consolidated under the banner of the Detroit United Railway (DUR), and a decades-long struggle ensued, as the city sought to take over this private monopoly. Led by Mayor James Couzens, the city opened its first municipal streetcar lines in 1920, and two years later, successfully acquired the existing DUR lines (Hanifin and Douglas, 2013). This combination of public and formerly private streetcar lines was soon refashioned into a municipal department known as the Department of Street Railways (DSR). In 1922, the DSR represented the largest city-owned streetcar system in the country, with over 363 miles of track (Hanifin and Douglas, 2013) (Figure 2.1). However, the widespread adoption of cheap automobiles and a 30-year campaign waged by General Motors to replace rail cars with rubber-tire buses rendered these street railways obsolete, and streetcar service ended in 1956 (Jackson, 1987; Hanifin and Douglas, 2013).

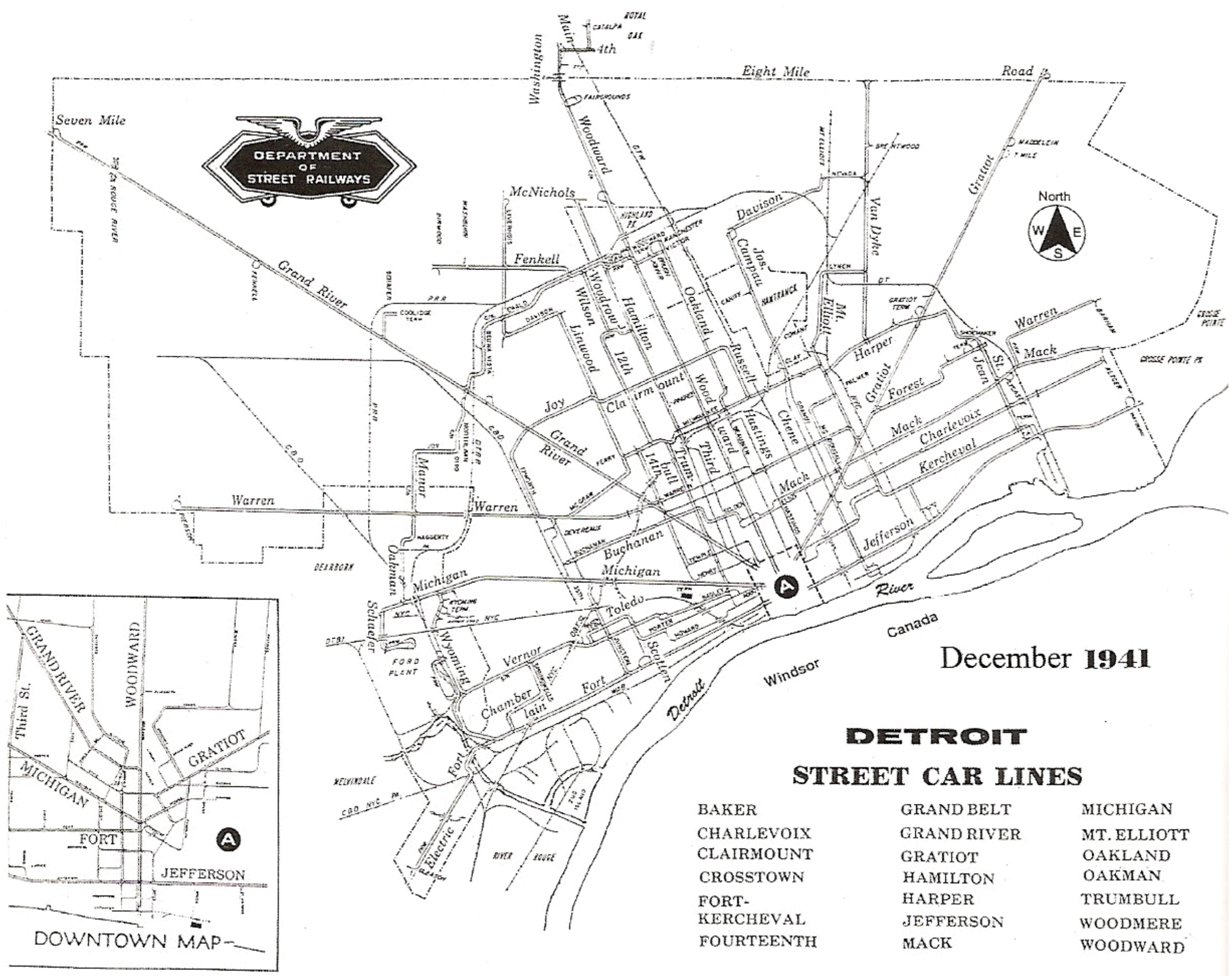

Figure 2.1: Detroit Department of Street Railways (DSR) Map (1941)
Source: https://detroitography.files.wordpress.com/2013/09/dsr-map_railservice-1941.gif

During the 1950s, roads increasingly began to be seen as a public good, while buses and trains were deemed private businesses unworthy of government funding (Jackson, 1987). The construction of Detroit's vast freeway network had the dual effect of fueling white flight to the suburbs, as well as displacing thousands of the city's poorest, predominantly black residents. Urban renewal initiatives demolished public housing projects and destroyed entire neighborhoods, such as the redevelopment of Black Bottom, which replaced a thriving African-American community with Lafayette Park and the Chrysler Freeway (Goodspeed, 2004). These factors, combined with rising unemployment, housing discrimination, and police brutality led to the 1967 Detroit Riots, a watershed moment that simultaneously fueled further racial segregation and served to highlight the growing chasm between city and suburbs (Sugrue, 2014). Post-hoc attempts to establish a robust, regional transportation system were repeatedly rejected by suburban voters, many of whom disliked the prospect of providing poor black Detroiters transit access to suburban neighborhoods and subsidizing transportation for residents of the distant, inner city (Hanifin and Douglas, 2013).

In the wake of the riots, piecemeal reforms were made possible through state legislation and the influx of federal dollars, beginning with the 1967 consolidation of crumbling public and private transit agencies under the umbrella of Metro Detroit's first regional transit entity: the Southeast Michigan Transportation Authority (SEMTA). Despite the 1973 election of Detroit's first black mayor, Coleman Young—a development that exacerbated white voter resentment toward SEMTA—a series of investments in public transit replaced outdated buses in suburban areas and initiated a short-lived commuter rail line between Downtown Detroit and Pontiac (Hanifin and Douglas, 2013). However, a battle for state and federal resources soon developed between SEMTA and the Detroit Department of Transportation (DDOT). Competing visions for a Woodward Avenue rail line emerged, yet neither managed to secure federal funding, as the city resisted the Reagan's Administration push to merge its bus system with SEMTA (Hanifin and Douglas, 2013). These structural challenges killed any momentum towards regional transit. The Detroit-Pontiac commuter line ceased operations in 1983 and the frustration of state legislators with the regional transit agency led to SEMTA's dissolution in 1987 (Hanifin and Douglas, 2013). Although SEMTA made significant contributions towards integrated, multi-modal transportation, it was not a true regional transit authority, since it lacked the power to levy taxes and attempts to merge the agency with DDOT were unsuccessful. As a result of this fractured organizational structure, Detroit would remain the only major city in the United States to lack a regional transportation authority.

Following its break-up, SEMTA was reorganized as the Suburban Mobility Authority for Regional Transportation (SMART), its scope reduced to providing bus service across Macomb, Oakland, and Wayne Counties, excluding the city of Detroit. Although regional transit entities were unable to raise funds for a Woodward Avenue rail line, the federal government provided a consolation prize by financing construction of the People Mover, a circulator system that was designed to connect bus and rail systems in central Detroit, as well as to integrate the recently constructed Renaissance Center into the rest of downtown (Hanifin and Douglas, 2013). During the 1990s, a number of attempts were made to expand regional service, including a plan to merge city and suburban bus routes, and a Michigan Department of Transportation (MDOT) proposal to reinitiate commuter rail service. These aspirations were met with resistance from voters and policymakers alike, who considered them too expensive. Further efforts to create a regional transportation authority were shot down by Governor John Engler (2003) and the Michigan Supreme Court (2006) (Hanifin and Douglas, 2013).

Figure 2.2: Detroit People Mover track across from Grand Circus Park (2022)
Source: Photo taken by author.

Despite suffering numerous setbacks, the campaign to create a regional transit authority received an unexpected boost from Detroit's business community, beginning in 2006. A coalition of local elites from business and non-profit organizations formed a partnership that would eventually be known as M-1 Rail. This consortium of civic leaders endorsed a 3.3-mile streetcar line along Woodward Avenue, extending from Downtown Detroit to Grand Boulevard, and pledged to cover the bulk of capital expenses. The project's investors argued that the streetcar system would be a first step towards an integrated, regional transportation system (Lowe and Grengs, 2020). Although the plan was nearly scrapped in favor of less expensive bus rapid transit (BRT), the streetcar proposal was able to secure financing from the United States Department of Transportation (USDOT), on the condition that a new regional transit agency be created. In November 2012, the Michigan State Legislature approved the creation of the Regional Transit Authority of Southeast Michigan (RTA). The Woodward Avenue

Streetcar, also known as the QLine, eventually opened on May 12, 2017. Under the initial agreement, M-1 Rail would fund the rail line for ten years, with RTA taking over its future operations in 2027 (Lowe and Grengs, 2020). For the time being, however, the RTA is a regional transportation authority in name only. The majority of voters in Macomb and Oakland Counties continue to resist expansion of regional transit service, as evidenced by the narrow failure of a 2016 millage that would have financed transit improvements (Witsil and Lawrence, 2016). The struggle of policymakers to build a wide coalition of support, combined with DDOT's reluctance to merge with a regional entity, and the growing financial liabilities of the QLine have raised concerns about the viability of the RTA going forward.

2.2 The Current State of Mass Transit in Detroit

The inability of political leaders to create a regional transportation system in Metro Detroit is reflected in the current state of its mass transit network, which is severely fragmented and uniquely inadequate for a region with more than 4.3 million people (U.S. Census Bureau, 2020). Currently, the region is served by four agencies: the Detroit Department of Transportation (DDOT); Suburban Mobility Authority for Regional Transportation (SMART); the Detroit Transportation Corporation (People Mover); and M-1 Rail (QLine). The largest providers of public transportation are DDOT and SMART buses, which predominantly operate within the city of Detroit and in the suburbs, respectively. The 2019 operating budgets for both agencies was comparable, although DDOT ridership was roughly two-and-half-times that of SMART buses (USDOT, 2019).

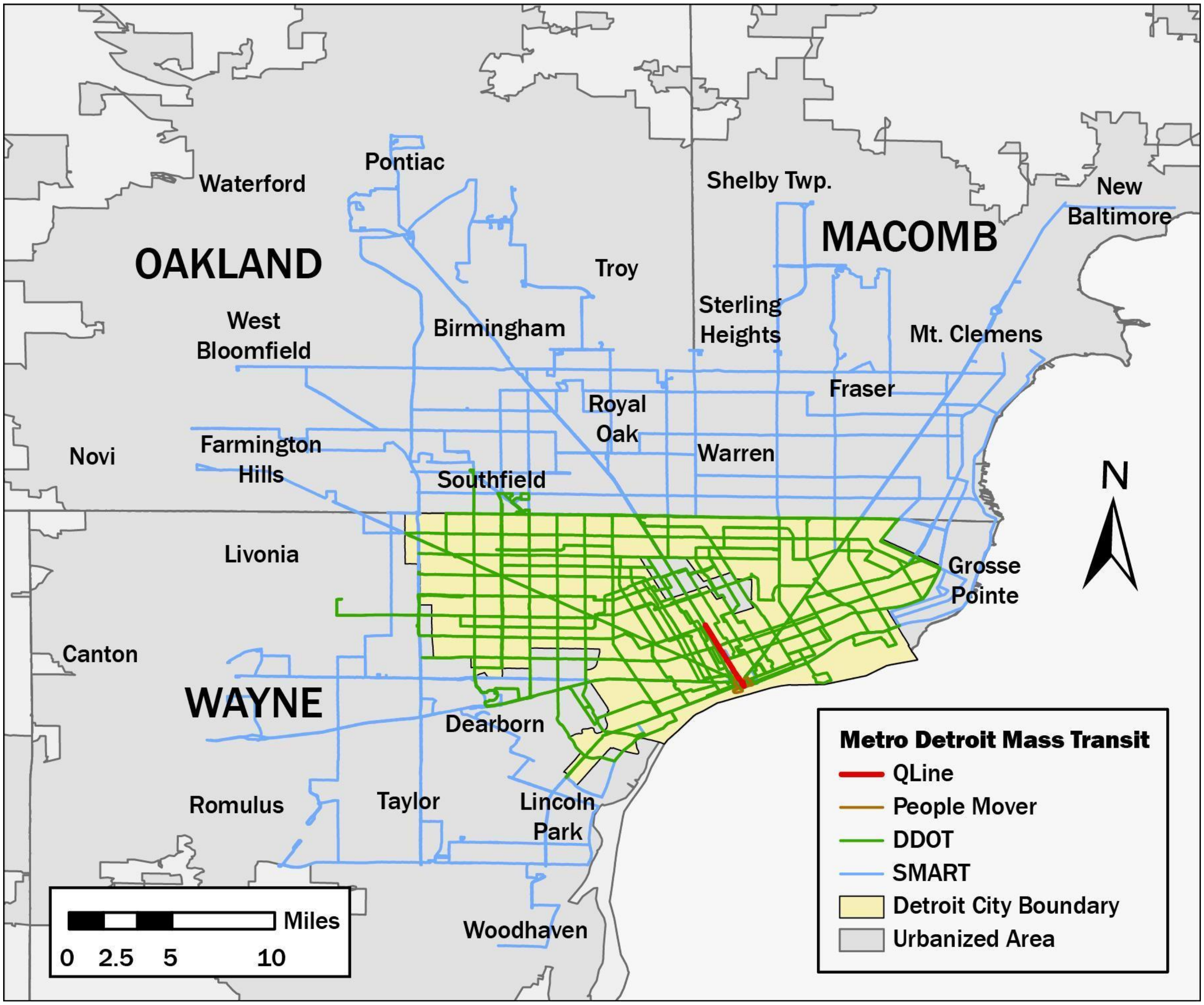

Figure 2.3: Mass transit in the Metro Detroit region (2019) before the COVID-19 Pandemic, with the QLine highlighted in red.
Source: Map created by author.

While most of Detroit city proper is reasonably accessible by bus, one study estimated that only 3 percent of residents have access to a DDOT bus that runs every 15 minutes or less—and that's a figure that has worsened as recent pandemic-related cuts to bus service have reduced their frequency (Neavling, 2019; Rahal, 2021). Additionally, late-night service is highly limited, with only a few bus routes that run once an hour. Furthermore, large tracts of suburban Detroit have zero access to SMART buses, since 53 communities in Oakland and Wayne Counties have opted out of transit funding (Finley, 2020). Despite these shortcomings, SMART buses experienced a 20 percent increase in ridership in the two years prior to the pandemic, largely due to three ‘express’ bus routes that connect suburban areas with Downtown Detroit (SMART, 2020).

Figure 2.4: The largest provider of public transit in Detroit is DDOT, which operates 35 bus routes, such as #4 Woodward, seen here traveling above the QLine’s tracks (2021).
Source: Michael Barera, Wikimedia Commons

Meanwhile, the People Mover has struggled to attract riders, failing to meet its expectations of being a multimodal connector. Ridership has generally hovered around 10 percent of its capacity since the year 2000 and critics have highlighted the fact that less than 30 percent of its passengers live in Detroit (“Detroit People Mover,” 2019). Some have gone as far as to call the automated train, “perhaps the single most absurd public transit project in the country” (Gleaser, 2011, p. 45). In recent years, the passenger cost-per-mile surpassed eight dollars, making it one of the least cost-effective transit systems in the United States (USDOT, 2019).

While Detroit spends approximately $68 per capita on public transportation, many Midwestern cities spend two to three times as much (Milwaukee: $109; Cleveland: $169; Chicago: $176) (USDOT, 2019). There are 43 metropolitan areas with over a million people in the United States and Southeast Michigan ranks 39th in public transit spending (Transportation Riders United, 2016). Lack of spending has hindered Metro Detroit's economic development, as evidenced by Amazon's decision to pass over Detroit as the location of its second headquarters, partially due to the region's underinvestment in public transportation (Livengood, 2018). Despite the pre-pandemic increase in SMART ridership, mass transit remains underutilized. Within the city of Detroit, only 7.5 percent of employed residents travel to work using public transit, a number that pales in comparison when compared to Chicago (28.4%) or Philadelphia (25.5%). When including the suburban tri-county area (Macomb, Oakland, Wayne), this figure drops to 1.5 percent (U.S. Census Bureau, 2019).

The lack of mass transit usage may be explained by the fact that existing options fail to meet the needs of Detroiters. Approximately one-third of Detroit households do not own an automobile, and 36 percent of households without a vehicle have expressed dissatisfaction with existing transit options (Gerber et al., 2017). The failure to provide frequent, reliable service for transit-dependent populations can have devastating consequences. According to a report by the Detroit Food Policy Council, an estimated 30,000 residents do not have easy access to a full-service grocery store (Hill and Kuras, 2017). Poor accessibility to employment is another theme throughout the region, since 77 percent of the jobs in Metro Detroit are located at least 10 miles away from downtown (Kneebone, 2013).

It is within this context of a fragmented and inadequate regional transportation system that the Woodward Avenue Streetcar was conceived. While the opportunity to improve Detroit's mass transit generated a great deal of excitement, it also revealed competing visions between stakeholders as to whom the project would serve. The next three sections will be dedicated exclusively to the QLine: (2.3) an overview of the transit corridor; (2.4) the planning and construction stages of the QLine; and lastly, (2.5) a summary of the streetcar's performance since operations began in 2017.

2.3 The QLine: An Overview

The QLine is a 3.3-mile streetcar system that runs along Woodward Avenue, the main arterial thoroughfare in the city of Detroit. The streetcar route extends from Congress Street in Downtown to Grand Boulevard in the New Center/North End district. A total of 20 stations service 12 stops along the route (most stops have stations on each side of Woodward, while a few stops consist of stations located in the road's median that are shared by northbound and southbound streetcars). The streetcar travels through four main neighborhoods: (1) Downtown; (2) Midtown; (3) New Center; and (4) North End. Downtown is Detroit's central business district (CBD) and the primary financial and entertainment center for the Southeast Michigan region. Some of the region's largest employers, such as General Motors and Rocket Mortgage, have their headquarters here. North of downtown lies a mixed neighborhood called Midtown, home to some of the city's most prominent institutions, such as Wayne State University, the Detroit Institute of Arts, and Little Caesars Arena (Lowe and Grengs, 2020). The northern terminus of the QLine is located between the New Center and North End neighborhoods. New Center is a residential and commercial district that was initially conceived as a second business hub due to its convenient location between downtown and outlying factories (Fogelman, 2004). The visions of its planners are visible in this district's art deco high-rises, the Fisher Building and Cadillac Place, with the latter once serving as the world headquarters for General Motors. North End is a lower density neighborhood with a rich historic fabric and the highest proportion of African-American residents among the four neighborhoods. Beginning in 1950, the district began to see economic decline. However, since 2000, the neighborhood has become the site of increased development (Archambault, 2013).

Figure 2.5: The QLine Streetcar at Congress Street in Downtown Detroit (2022).
Source: Photo taken by author.

Compared to other neighborhoods in the city, the area served by the QLine has witnessed an economic resurgence in the last two decades as the result of significant public and private redevelopment efforts. In particular, Midtown has experienced a wave of gentrification in recent years, as measured by the influx of white, college-educated adults (Gallagher, 2019). As a result, the QLine travels through neighborhoods that are not demographically representative of the city as a whole. For instance, in

Midtown, whites make up 35 percent of the population (compared to 14 percent citywide) and blacks make up 59 percent (compared to 77 percent citywide) (Lowe and Grengs, 2020).

The construction of the QLine is noteworthy, as it was the first major transit project in the United States to be led and funded by a public-private partnership (Kresge Foundation, 2017). While the civic leaders who funded and planned the streetcar had high expectations for the system, its impacts have been mixed. According to boosters, the announcement of the QLine contributed to more than $7 billion in economic development along the Woodward corridor, including a brand new sports arena (Nichols and Walsh, 2017). However, since operations commenced in 2017, streetcar ridership has generally fallen short of projections. Promises to create an integrated, regional, world-class, transit system between Detroit and its suburbs have yet to come to fruition (Lowe and Grengs, 2020). And perhaps most strikingly, the streetcar has failed to improve transit accessibility for the majority of Detroit's poor, African-American residents who are most dependent on mass transit. The following section will focus on the history of the QLine, with a detailed summary of its planning and construction phases.

Figure 2.6: The QLine traveling southbound on Woodward Avenue towards downtown Detroit (2022). Source: Photo taken by author.

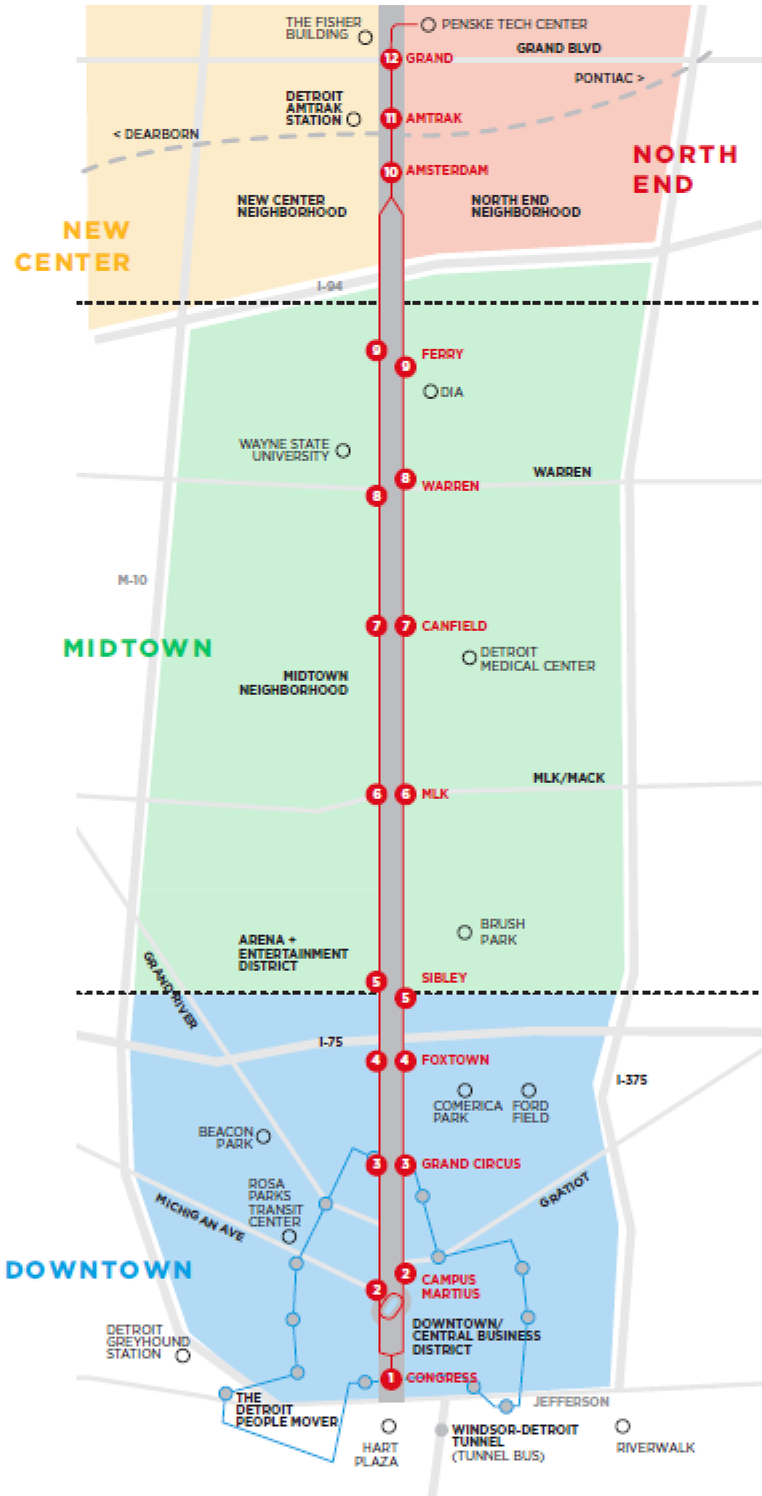

Figure 2.7: The QLine stretches 3.3 miles from Congress Street in Downtown Detroit to Grand Boulevard. A total of 20 stations service 12 stops along the route.
Source: M-1 Rail, 2022.

2.4 Planning and Construction of the QLine

The QLine's origins can be traced to 2006, when the Detroit Department of Transportation (DDOT) commissioned a study to explore an expansion of transit options along Woodward Avenue. The city proposed constructing a 9.3-mile rail line along Woodward Avenue, running from the Rosa Parks Transit Center in downtown to the outer city limits along 8 Mile Road (Transportation Riders United, 2011). The estimated cost for this municipal plan was $528 million. Around the same time, a public-private consortium of local civic leaders, eventually called M-1 Rail (2012), pledged financial support for the construction of a shorter, less expensive, 3.3-mile rail line extending from downtown to Grand Boulevard. This group included many of Detroit's wealthiest citizens, including Dan Gilbert of Rocket Mortgage (formerly known as Quicken Loans); the Ilitch family, owners of Little Caesars, the Detroit Red Wings, and the Detroit Tigers; Roger Penske of the Penske Corporation; and Rip Rapson of the Kresge Foundation (Lowe and Grengs, 2020). Penske and Gilbert would go on to serve as the chairman and vice chairman of M-1 Rail, respectively, while Matt Cullen—a close associate of Gilbert's and leading figure in the redevelopment of Downtown Detroit—would serve as CEO (Shea, 2015).

Although M-1 Rail expressed initial resistance to the 9.3-mile rail line, civic leaders eventually agreed to support the longer proposal (Nichols and Walsh, 2017). Private investors were able to attract additional funding for the project, including $35 million from the Kresge Foundation. However, the plan garnered insufficient support from the Federal Transit Administration, and over time, the fiscal realities of constructing a $528 million light rail line became readily apparent (Grengs and Lowe, 2020). In December 2011, Detroit Mayor Dave Bing and Governor Rick Snyder abruptly abandoned the light rail proposal in favor of a less expensive bus rapid transit (BRT) system. The mayor, in particular, became convinced that streetcars were a frivolous idea and pushed hard for expanded bus service. "We need reliable transit that reaches the neighborhoods, where people most need it," said Bing (Neavling, 2019).

In response to the cancellation of the original light rail proposal, and shift towards buses, M-1 Rail aggressively lobbied the federal government, producing a series of reports to convince officials of the project's merits. They also created a ten-year endowment to maintain operations through 2027 (Lowe and Grengs, 2020). Members of M-1 Rail criticized the BRT proposal by claiming that the buses would not stimulate economic development. One committee member said that while buses might be a more efficient transit option, "rich, white people don't ride buses" (Lowe and Grengs, 2020). The USDOT eventually gave in, and the 3.3-mile proposal was resurrected, contingent on the establishment of a regional transportation authority for Metro Detroit (Lowe and Grengs, 2020). In November 2012, the state legislature approved the creation of the Regional Transit Authority for Southeast Michigan (RTA) (Oosting, 2012). The final price tag for the construction of the Woodward streetcar was $142 million (Frank, 2017). The USDOT contributed a total of $37.2 million towards the project and another $41 million in public support came from the state of Michigan, Wayne County, Wayne State University, and the Detroit Downtown Development Authority. Overall, about 42 percent of the QLine's startup costs came from public and public-private sources (Lowe and Grengs, 2020). Quicken Loans purchased naming rights to the line for $5 million and announced the name in March 2016 (Lawrence, 2016).

Construction of the QLine officially began on July 28, 2014. The question of where to place the rails along Woodward Avenue spurred a contentious debate. The USDOT, regional planners, and citizens pushed for having a median right-of-way dedicated solely to QLine traffic, citing its speed and the safety risks posed to bicyclists from rails being placed in curbside lanes (Lowe and Grengs, 2020). On the other hand, M-1 Rail supported a curb-running design, due to fears that a center alignment would create a physical barrier to crossing the street and a belief that a side-running streetcar would better support foot traffic to local businesses (Lowe and Grengs, 2020). Many other cities involved in the streetcar resurgence have used similar justifications for placing rails along curbs, arguing that the slower nature of streetcars allows passengers to more clearly see their surroundings, turning them into potential consumers for development along the streetcar route (Mendez and Brown, 2019).

Table 2.1: M-1 Rail Streetcar — Largest Capital Funding Sources

Funding Source	**Status**	**$ (Millions)**
Kresge Foundation	Private (non-profit)	49.6
U.S. Department of Transportation (USDOT)	Public	37.2
Bedrock, Inc. / Quicken Loans	Private (for-profit)	11.4
State of Michigan	Public	10.0
New Market Tax Credit proceeds	Public	9.4
Detroit Downtown Development Authority	Public-private	9.0
Penske Corp.	Private (for-profit)	7.0
Michigan Economic Development Corporation	Public-private	7.0
Ilitch Holdings, Inc.	Private (for-profit)	6.0
Ford Foundation	Private (non-profit)	4.0
Wayne County	Public	3.0
Wayne State University	Public	3.0
Blue Cross / Blue Shield	Private (non-profit)	3.0
FCA Foundation	Private (non-profit)	3.0
Detroit Medical Center	Private (non-profit)	3.0
Henry Ford Health System	Private (non-profit)	3.0
Ford Motor Co.	Private (for-profit)	3.0
General Motors	Private (for-profit)	3.0
Other		12.7
Total		**187.3**

Source: Shea, 2016.

Despite the fact that public commenters favored a center lane design by a 9-to-1 margin, a shared-lane alignment was selected at the behest of business leaders, namely Dan Gilbert (Lowe and Grengs, 2020). One outreach staff member for M-1 Rail commented: "We were really baffled at why [M-1 Rail] were so insistent about putting it on the side…They were not looking for speed or reliability. Their goal was not to move people as quickly or reliably as possible…their number one goal was the boost in property values and the convenience of attracting more people to local businesses" (Lowe and Grengs, 2020). Another source alleges that Gilbert and Penske grew enamored of the economic development spurred by Portland's side-running streetcar and decided to model the QLine after it (Lowe and Grengs, 2020). According to a member of the QLine's advisory board, a recurring theme of the design process was the private nature of the decision making despite the illusion of public input (Lowe and Grengs, 2020).

The fact that M-1 Rail leaders prioritized property values over transit accessibility during the QLine's planning stages was not surprising, given the dozens of properties owned by Gilbert and Ilitch family companies in central Detroit (Feloni, 2018; Aguilar, 2019). Between 2011 and 2021, Gilbert-affiliated companies acquired more than 150 properties located within half a mile of a streetcar stop, primarily through the commercial real estate firm, Bedrock, Inc. (City of Detroit, 2022). The majority of these transactions took place before the QLine began operations in May 2017. Most of the parcels are located in Downtown Detroit, although Bedrock is also working on the 22-acre Brewster-Douglass and 8.4-acre City Modern redevelopment projects, both located in the Brush Park section of Midtown. Meanwhile, *The Detroit News* has identified at least 391 properties owned by Ilitch-linked companies in central Detroit. Despite promises to transform these properties into a new neighborhood, known as District Detroit, many of these parcels remain abandoned (Aguilar, 2019). While the Ilitches have been active in the redevelopment of Downtown Detroit since 1987, they have acquired more than a hundred properties along the streetcar corridor since the beginning of 2011 (City of Detroit, 2022). Some of these parcels were purchased specifically for the construction of Little Caesars Arena, which opened in 2017. The QLine stops right outside the $863 million basketball and hockey arena, which was primarily financed by the Ilitches. The fingerprints of Gilbert and the Ilitches are readily apparent on the streetscape of Woodward Avenue, as evidenced by the plethora of Rocket Mortgage billboards and the Mike Ilitch School of Business at Wayne State University. Ultimately, the business leaders who were most heavily involved in securing financing and designing the streetcar line, have also been the most active investors along the Woodward Avenue corridor. Figure 2.7 shows a non-exhaustive map of properties acquired by Gilbert and the Ilitch Family between 2011 and 2021.

2.5 Operation Phase of the QLine

The QLine commenced service on May 12, 2017. The original projections from M-1 Rail estimated that the streetcar would transport between 5,000 and 8,000 passengers a day (Crain's Detroit Business, 2017). Riding the streetcar was initially free, as fares were waived until September 2017. During this inaugural four-month period, ridership actually met expectations with an average of 5,438 daily trips (Neavling, 2019). However, once a $1.50 fare was implemented, the number of passengers declined significantly. In 2018 and 2019, ridership for the QLine averaged 3,376 and 3,011 riders a day, respectively. (Neavling, 2019; Williams, 2021). Observers have noted that the streetcars, despite their capacity of 125 riders, are nearly empty on weekdays, often carrying between one and five passengers (Neavling, 2019). The widespread effects of the COVID-19 Pandemic on mass transit across-the-board have only exacerbated slumping ridership numbers. From March 2020 to September 2021, streetcar service was completely suspended (Nagl, 2021).

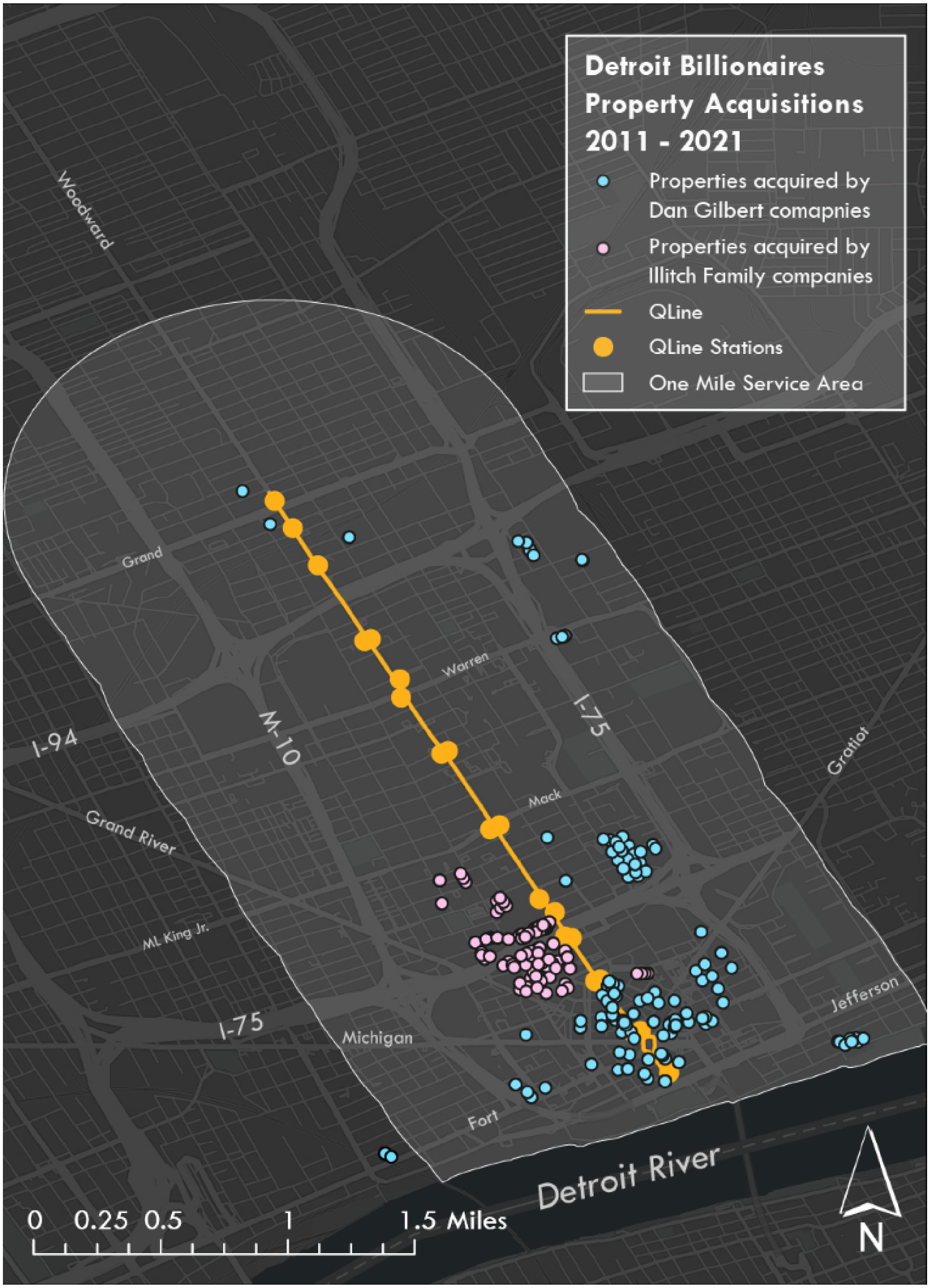

Figure 2.8: Between 2011 and 2021, billionaires Dan Gilbert and the Ilitches—who were heavily involved in the financing and planning of the QLine—acquired more than 300 properties, many within a quarter mile of a streetcar stop.
Source: City of Detroit Open Data Portal

A major factor behind the QLine's lackluster ridership has been slower than expected travel times stemming from low speeds and frequent service delays. These issues have only been exacerbated by the decision to opt for a shared-lane design, which has contributed significantly to slower than expected travel times. The curbside alignment inherently means that the streetcar must compete with automobile, bicycle, and bus traffic. Streetcars are held up by roadwork, car accidents, delivery trucks, illegally parked cars, and emergency vehicles. At times, these delays have lasted for several hours (Neavling, 2019). Even Mayor Mike Duggan, elected in 2016, has weighed in on the flaws of the side alignment, promising that "If I had been mayor about a year earlier, it would have been a dedicated lane down the middle of the street" (Livengood, 2018). Placing streetcar tracks in the curbside lanes of the road has also resulted in injuries to bicyclists, including one Wayne State University student who fell over her handlebars and landed on her face, requiring reconstructive surgery (Neavling, 2019).

Some of the QLine's biggest shortcomings appear to stem from the limitations of streetcars themselves. Nationwide, the average speed of a streetcar is roughly 6.8 miles per hour (mph), which is not much faster than walking (Neavling, 2019). A Florida State University study of streetcars in seven cities observed that the majority of systems operated at less than half the speed of buses (Brown, 2013). In the case of Detroit, the QLine travels at approximately 8.3 mph, which is roughly 50 percent slower than its proponents promised (Neavling, 2019). According to a USDOT study, automobiles can travel the same stretch of Woodward Avenue in about a third of the time (Neavling, 2019).

M-1 Rail promoted the streetcar line as the first step toward a larger, more connected transit system, but a robust regional transportation network has yet to emerge, despite the establishment of a transit authority. In 2016, residents of the four counties served by the RTA—Macomb, Oakland, Washtenaw, and Wayne—voted on a property tax increase that would raise $3 billion over 20 years to fund several regional transportation initiatives. These projects included dedicated express lanes for cross-county bus routes and a commuter train from Detroit to Ann Arbor (Witsil and Lawrence, 2016). The ballot measure was narrowly rejected by voters and failed by a mere 18,000 votes out of 1.8 million cast. Not surprisingly, suburban voters in Macomb and Oakland Counties were most likely to oppose the plan (Witsil and Lawrence, 2016). Some scholars have wondered whether the limited reach of the QLine actually poses a hindrance to a regional system, since suburban voters will be unlikely to subsidize a transit system that only serves Downtown Detroit (Lowe and Grengs, 2020). After all, the private endowment created by M-1 Rail business leaders is only meant to fund the QLine until 2027, when the brunt of operation expenses will fall onto the RTA and by extension, suburban taxpayers.

Furthermore, the QLine offers little to transit-dependent populations, due to its limited reach as well as its failure to connect to suburban areas where most of the region's jobs are located (Kneebone, 2013). The announcement of a Woodward Avenue rail project was initially the source of much excitement for average Detroiters, since it provided an opportunity to improve mobility for poor residents most reliant on mass transit. However, the decision to prioritize economic development and property values over social equity failed to take into account the community's needs. Perhaps most glaringly, the streetcar services gentrifying neighborhoods that are not demographically representative of the city as a whole. This is most obvious in Midtown, where whites make up over 35 percent of the population, compared to 14 percent citywide (Lowe and Grengs, 2020). Despite the narrative promoted by civic leaders that Detroit is a city on the rise, the benefits of reinvestment have largely accrued to affluent, white residents who live or work near downtown, while poor, outlying neighborhoods continue to fall behind (Lowe and Grengs, 2020). The design process for the QLine would have undoubtedly benefited from greater, more inclusive public input, particularly from residents who rely on mass transit. Ultimately, the QLine's limited reach into transit-dependent neighborhoods, mixed ridership figures and long travel times, along with its inability to facilitate interconnected, regional mobility have resulted in a transportation system that has largely fallen short of the promises made by civic leaders.

Despite these deficiencies, the QLine has not been a total failure, and in some ways, the system has shown signs of improvement. While the streetcar has hardly served as a regional transit catalyst, the Dart pass was introduced in 2019, which allows riders to seamlessly transfer between the streetcar and the DDOT and SMART bus system (Frank, 2019). Slight improvements in travel times have come from the transit-only lanes installed in Midtown along a short stretch of the streetcar route, and changes in traffic lights that give the QLine priority at some intersections. Since QLine service was reinitiated in September 2021, fares have been waived, and ridership has exceeded 2018 and 2019 figures. When the author of this thesis drove down Woodward Avenue on a Wednesday evening in May 2022, many of the stops had 5 to 10 passengers waiting for the QLine. While the streetcars were not exactly overflowing with passengers, M-1 Rail has claimed that the QLine attracts 5,000 to 8,000 passengers a day when fares are waived, consistent with its ridership projections. Overall, the Woodward Streetcar has been able to attract more daily passengers than many other streetcar systems across the country, such as Atlanta (900), Cincinnati (1,300), and Milwaukee (2,400) (Neavling, 2019). In fact, only a handful of cities including New Orleans, Portland, Seattle, and Kansas City have systems that attract upwards of 5,000 riders a day ("List of United States light rail systems by ridership," 2022).

Boosters of the QLine are quick to point out the economic investment stimulated by the streetcar. According to the Kresge Foundation, more than $7 billion in new investment was allocated or planned for more than 200 development projects along the Woodward corridor between 2013 and 2017 (Nichols and Walsh, 2017). About $4.5 billion of that investment has taken place in Downtown Detroit, while another $863 million was spent on the construction of Little Caesars Arena. These claims are consistent with other cities that have introduced streetcars, such as Portland, where private developers invested

$3.5 billion along a transit corridor within the first seven years of the system's operation (Portland Bureau of Transportation, 2019). A number of projects, ranging from residential and retail developments to the expansion of the Henry Ford Hospital, have generated economic activity along the Woodward Corridor (Nichols and Walsh, 2017). At the same time, there is reason to question the figures provided by boosters. A significant amount of the economic investment along Woodward has come from the very same private investors who funded the streetcar's construction, the most obvious example being Gilbert's commercial real estate firm, Bedrock, Inc., which has purchased dozens of properties along the QLine corridor. Overall, Gilbert-linked companies have invested more than $350 million acquiring properties along the streetcar corridor from 2011 to 2021 (City of Detroit, 2022). Construction of the $863 million Little Caesars Arena was mostly financed by the Ilitch family, members of which also serve on the board of M-1 Rail. These facts suggest that the $7 billion figure may be slightly misleading, since much of the economic development along the Woodward Avenue corridor has come from self-serving interests of local businessmen, rather than spontaneous investment activity. While there's no denying that the announcement of the QLine has stimulated economic activity along Woodward Avenue, the matter of how much the streetcar has contributed to increases in property values remains in question.

Over the last 50 years, a substantial body of research has emerged on the relationship between proximity to transit facilities and property values. The earliest studies of rail transit impacts on real estate prices relied on monocentric models that were derived from classical theories of agricultural land use. Eventually, researchers applied global regression models that included numerous explanatory variables, but failed to accommodate for spatial variation. The most recent work on the subject applies localized spatial techniques that take into account autocorrelation and allow for relationships between explanatory variables to vary across space. The next section will provide an overview of the academic literature on this topic.

CHAPTER 3
LITERATURE REVIEW

This literature review addresses three main areas related to the association between rail transit and real estate. The first section provides a summary of the earliest theories on the topic, which consist of monocentric models of land cost and distance from a central business hub. The second section provides a summary of case studies of the relationship between proximity to rail transit and real estate prices, from cities around the world. Finally, the last section focuses on the most recent research and techniques, which use geographically weighted techniques to accommodate spatial variation among explanatory variables, accounting for spillover effects such as autocorrelation in the process.

3.1 Theoretical Expectations

The earliest attempts to explain the relationship between transportation and land values are based on von Thunen's theory of agricultural land use (1826), which assumed an isolated market with flat land, uniform transportation, and rational economic agents (Debrezion, 2007). Von Thunen postulated that outside the market center, the land uses with the highest transport costs would be located nearest to the market, in order to minimize costs. Land uses with lower transport costs would be located further away. These theoretical expectations provided the basis for the urban land economists of the 1960s, who argued that travel costs should increase when distances between households and places of employment and services increase (Alonso, 1964; Muth, 1969). Therefore, they argued, any significant improvement in the transportation system that reduces travel costs and increases accessibility should be reflected in property values. These early theories follow a basic theory on real estate prices that argues that as a location becomes more attractive, demand increases and a bidding process leads to higher prices. Travel costs were assessed in terms of distance to the central business district (CBD).

In reality, cities are polycentric and far too complex to be represented by classical, monocentric models. Because of this, travel costs for mass transit passengers can only be accurately assessed with perfect information about their final destinations. Since a new transit system may not actually take people where they want to go (or as quickly, for that matter), some authors have argued that actual measures of travel times are better reflections of travel costs than distances to transit facilities, such as streetcar stops (Ryan, 1999). By this token, the assumption that distance to a transit facility is positively correlated with travel costs can only be met if it is shown that a facility is adequately serving riders. Otherwise, if a transit facility does not improve travel times, we should not expect property values to change (Ryan, 1999). However, incorporating travel costs into regression models presents a challenge for researchers. Not only is it difficult to obtain perfect information about passenger destinations, but when distance to transit facilities and travel times are both used as predictor variables in the same model, issues of multicollinearity emerge since both variables are likely to be highly correlated. Finally, as the streetcar resurgence has shown, transit projects are no longer pursued primarily for the transportation benefits they may provide, but rather for aesthetic, placemaking, and development purposes. Since systems like the QLine were not designed for the explicit purpose of reducing travel costs, it is not reasonable to expect travel times to decrease.

3.2 Case Studies

The last three decades of studies estimating the impacts of rail transit on property values have been characterized by inconsistent results. The majority have focused on residential properties, and many have found a positive premium for real estate prices derived from proximity to transit facilities, albeit one that varies substantially depending on housing type and location. However, other researchers have found a mixed or negative association between proximity to rail transit and sales prices. Recent studies have raised even more questions, as spatially weighted techniques have suggested that the impacts of rail transit facilities can be both positive or negative across the same study area. What these studies share is a reliance on hedonic price modeling (HPM), which is based on the idea that the price of a complex good can be expressed as a function of its extrinsic and intrinsic attributes (Rosen, 1974). When analyzing property values, a hedonic approach might incorporate a host of housing and locational variables, such as a home's square footage, the neighborhood crime rate, or distance to schools and grocery stores. In its standard form, HPM is conveyed through ordinary least squares (OLS) regression, where the coefficients of explanatory variables reflect their implicit price. An OLS regression model using HPM would be expressed by the following equation:

$$y_i = \alpha + \beta_1(x_1) + \sum_{k=1}^{j} \beta_k(x_k) + \epsilon_i \qquad i = 1, \ldots, n, \tag{1}$$

Where the response variable y was the adjusted sale price for each location i; α is a constant; β_1 is the coefficient for the station distance variable; x_1 is station distance, measured as the network distance to the nearest QLine station; j is the number of parameters to be estimated, excluding the constant and station distance; β_k is the coefficient for the kth parameter; x_k is the value of the kth parameter; ϵ_i is a normally distributed random error with a mean of zero; and n is the number of observations (Yan et. al, 2012).

Although many studies have analyzed the effects of light rail transit (LRT), subways (Metro), and heavy rail transit (HRT) on property values, very few have looked at streetcars. One analysis of Portland's streetcar found that housing prices increase with proximity to streetcar facilities, although this study also factored in LRT and bicycle infrastructure (Welch et al., 2016). Another study on the impacts of streetcar systems along transit corridors found a significant increase in Tucson sale prices, but virtually no change in Atlanta when compared to control group corridors (King, 2014).

Furthermore, only a handful of studies have analyzed the different ways in which rail transit impacts commercial and residential properties, and results have been mixed. Some scholars found that residential properties experienced increases in prices, while results for commercial properties were insignificant (Landis et. al, 1995; Billings, 2011). Other researchers have found positive effects on commercial properties and mixed impacts for housing (Cervero, 2006). Finally, at least one study has found similarly positive impacts on both commercial and residential observations (WMATA, 2011).

Despite the inconsistencies in results, the body of academic literature on the relationship between rail transit access and land values can be characterized by a few recurring themes. First, and perhaps most obviously, study areas located closer to transit facilities, such as a quarter or half-mile buffer, are more likely to experience increases in property values as a result of transit proximity than those located one mile or beyond (Nelson, 1998; Ryan, 1999). Second, the mean property value premiums derived by proximity to transit facilities are greatest for HRT, followed by metro, and then LRT (Cervero and Duncan, 2002; Zhang et al., 2014). Third, the extent of premiums derived by residential properties is highly dependent on the housing type. Positive effects from proximity to rail stations tend to be greater for condominiums and multi-family housing compared to single-family homes (Cervero, 2006; Billings, 2011). Fourth, nuisance effects from rail transit, such as noise, pollution, and crime, are often statistically significant and can adversely affect sale prices, although they are typically outweighed by the positive premiums derived by improved accessibility (Chen, 1997; Dueker and Bianco, 1998). And finally, increases in property values due to rail transit proximity are usually greater in high-income neighborhoods than they are in low-income areas (Gatzlaff and Smith, 1993; Bowes and Ihlanfeldt, 2001; Hess and Almeida, 2007). This is perhaps explained by the fact that the wealthy are more likely to use commuter rail for their work commute. Table 3.1 summarizes many of the studies conducted on the rail transit and property value relationship.

Table 3.1: A Summary of Studies on the Relationship Between Rail Transit Access and Property Values

Year and Author	Location	Transit Type	Propert y Type	Buffer	Analytic Technique	Findings
1991 Voith	Philadelphia (USA)	HRT	R	N/A	Global, HPM, OLS	Positive. A premium of 6.4% for properties located close to commuter rail stations
1992 Nelson	Atlanta (USA)	HRT	R	1.7 x 2.7 mile study area	Global, HPM, OLS	Mixed. Positive effects on property values in lower income tracts. Nuisance effects may outweigh benefits in higher income neighborhoods.
1993 Gatzlaff and Smith	Miami (USA)	HRT	R	½ mile	Global, HPM, OLS, repeat sales indices	Mixed. Insignificant increase for properties in wealthier neighborhoods compared to lower-priced neighborhoods
1995 Landis et al.	Sacramento, San Jose, Santa Clara, Bay Area (USA)	LRT, HRT	C, R	< 20 miles	Global, HPM, OLS	Mixed. Significant premiums for housing located near HRT stops; weak increases near LRT stops. No effect found for commercial properties.
1996 Benjamin and Sirmans	Washington, D.C. (USA)	Metro	R	0.6 mile	Global, HPM, OLS	Positive. Property values decline by 2.6% for every tenth mile increase in distance from Metro stations.
1996 Forrest et al.	Manchester (UK)	LRT	R	City boundary	Global, HPM, OLS, semi-log	Negative effects on residential property values.
1997 Lewis-Workman and Brod	New York, Portland, San Francisco (USA)	Metro, LRT, HRT	R	1 mile	Global, HPM, OLS	Positive effects found for properties near transit stations in New York and San Francisco. Small positive effects from Portland LRT were only observed 0.5 to 1 mile from stations.
1998 Chen et al.	Portland (USA)	LRT	R	1000 meters	Global, HPM, OLS	Positive. Even when controlling for potential nuisance effects, which were negative, study finds a premium for property values located closer to stations.
1999 Nelson	Atlanta (USA)	HRT	C	Midtown district boundary	Global, HPM, OLS	Positive. Prices decline by $75 for every meter distance from stations. Additional premium for special public interest districts.

Table 3.1 — continued

Year and Author	Location	Transit Type	Property Type	Buffer	Analytic Technique	Findings
1999 Dueker and Bianco	Portland (USA)	LRT	R	1000 meters	Global, HPM, DID	Positive. Modest increases in housing prices with proximity to LRT stations.
2001 Bowes and Ihlanfeldt	Atlanta (USA)	HRT	R	¼ mile to 3 miles	Global, HPM, OLS, combined price effects	Mixed. Effects on property value depend on distance to CBD and distance to station. High-income neighborhoods place greater premium on proximity to stations.
2002 Cervero and Duncan	Santa Clara (USA)	LRT, HRT	C	¼ mile	Global, HPM, OLS	Positive. A mean premium of 23% for commercial properties located near LRT stops and 120% for properties located near HRT.
2003 Bae et al.	Seoul (South Korea)	Metro	R	Seoul city boundary	Global, HPM, OLS	Mixed. Positive effects on housing prices were only found before line opening.
2005 Gibbons and Machin	London (UK)	LRT, HRT, Metro	R	20 to 30 kilometers	Global, HPM, OLS	Positive. A 1.5% decrease for every 1 km increase in distance from stations.
2006 Cervero	San Diego (USA)	LRT	C, R	¼ to ½ mile	Global, HPM, OLS	Positive effects for commercial properties near LRT. Mixed effects for homes depending on housing type and corridor.
2007 Hess and Almeida	Buffalo (USA)	LRT	R	½ mile	Hybrid (global/local), HPM, OLS, assessed property values	Mixed. Small premium for homes within half mile of LRT stops. Individual OLS equations show that proximity effects are positive in high-income areas, negative in low-income areas.
2011 Billings	Charlotte (USA)	LRT	C, R	1 mile	Global, HPM, DID	Mixed. A premium for residential properties that depends on housing type. No effect on commercial prices.
2011 WMATA	Washington, D.C. (USA)	Metro	C, R	½ mile	Global, HPM, OLS	Positive. 6.8% and 9.4% premiums for single-family and multi-family housing, respectively. 8.9% premium for commercial properties.

Table 3.1 — continued

Year and Author	Location	Transit Type	Property Type	Buffer	Analytic Technique	Findings
2012 Du and Mulley	Newcastle (UK)	LRT	R	Local district boundaries	Local, HPM, GWR	Mixed. Varies spatially. Some housing prices were affected positively by proximity to stops while others were affected negatively.
2012 Hewitt and Hewitt	Ottawa (Canada)	LRT	R	4000 meters	Local, HPM, spatial lag, GWR	Mixed. Varies spatially. Some housing prices were affected positively by proximity to stops while others were affected negatively.
2012 Yan et al.	Charlotte (USA)	LRT	R	1 mile	Global, HPM, OLS, temporal comparison	Positive. Property values increased as the system became operational.
2014 Zhang et al.	Beijing (China)	LRT, Metro	R	800 to 1600 meters	Global, HPM, OLS	Positive. $15.57 (per sqft) premium for housing within 800m of LRT stops. A $39.41 (per sqft) for properties within 1600m of Metro stops.
2015 Dziauddin	Kuala Lumpur (Malaysia)	LRT	R	2 kilometers	Local, HPM, GWR	Mixed. Varies across study area depending on local desirability, neighborhood income & pre-existing transport options.
2016 Welch et al.	Portland (USA)	LRT, Streetcar	R	City of Portland boundary	Local, HPM, spatial lag, spatial error	Positive. Home prices increase as proximity to LRT, streetcar, and bicycle infrastructure increases.
2017 Pilgram and West	Minneapolis (USA)	LRT	R	½ mile	Global, HPM, DID, repeat sales indices	Positive. Premiums for housing sold near stops, but disappeared within 7 years.
2017 Wagner at al.	Norfolk (USA)	LRT	R	1500 meters	Global, HPM DID	Negative. Mean sales prices of houses sold within 1500 meters of LRT experienced a 7.8% decline.
2019 Song et al.	London (UK)	LRT	R	1000 meters	Global, HPM, OLS	Positive. Premium of .09 to .35% for homes per 100m proximity to LRT stops.

Table 3.1 — continued

Year and Author	Location	Transit Type	Property Type	Buffer	Analytic Technique	Findings
2021 Singhal and Tyagi	Delhi (India)	HRT	C	½ mile	Global, HPM, OLS, quasi experimental, repeat sales	Positive after operational phase. $3.22-$9.58 premium for every meter in proximity to stations.
2021 Vichiensan et al.	Bangkok (Cambodia)	HRT	R	3000 meters	Local, HPM, GWR	Positive. Varies spatially. Higher premiums ($200 per sqm) for properties located in city-center than properties ($80 per sqm) in suburbs.

Notes: 1. Property type: C = commercial, R = residential. 2. Analytic technique: HPM = hedonic price method, OLS = ordinary least squares regression, DID = difference in differences estimation, GWR = geographically weighted regression.
Source: Compiled by author.

Researchers have attempted to account for discrepancies in property value premiums by controlling for location-specific attributes unrelated to transportation, such as crime rates, neighborhood income levels, or distance to schools (Debrezion, 2007). However, some authors have argued that the most important determinants of urban property values are factors including demand for commercial space, economic growth, and availability of land (Knight and Trygg, 1977). Despite the widespread acknowledgement of these factors, research has suffered, since controlling for these variables can be difficult due to limited data availability. An alternative explanation for the heterogeneity of rail impacts suggests that the marginal utility of transportation investments declines over time (Landis et al., 1995). Immediately after the introduction of a new transit system, there may be increases in nearby property values, but over time, the land markets adjust to travel cost savings brought about by the introduction of a particular transportation technology. This phenomenon has been observed in later research, such as the case of the Minneapolis Blue Line, where property value premiums derived from the introduction of a light rail system appear to disappear over time (Wagner et al., 2017).

Ironically, the biggest issue with much of the previous research may not be the inconsistent nature of its findings, but rather that results have not been varied enough. The problem with an OLS approach is that it applies a single, global estimate to the entire study area, and assumes a fixed relationship between property values and other possible explanatory variables across the board. Global estimates can be misleading for several reasons, such as the presence of spatial autocorrelation, which occurs when a variable measured at a specific location is correlated with the same variable located nearby (Dziauddin, 2015). Spillover effects like autocorrelation are especially common in real estate markets, where a property's value can be directly influenced by that of its neighbor's. Additionally, global estimates do not take into account spatial heterogeneity, since any number of factors besides proximity to rail stations can affect housing prices differently in varying locations (Dziauddin, 2015). Indeed, recent work on the subject has not only suggested a non-stationary relationship where property values and other variables can and do vary across space, but also that the rate of change varies across the study area as well (Hewitt and Hewitt, 2012). Recent studies have established that the relationship between property values and proximity to mass transit is spatially defined and the interplay between variables, far too complex for a global OLS approach. The general trend in recent transportation literature has been a shift towards local, weighted techniques that properly account for spatial variation among variables. The following section will focus on the findings of recent studies based on a spatially weighted type of analysis known as geographically weighted regression (GWR).

3.3 Spatial Approaches

In order to deal with the spatial effects of the land market, a group of techniques known as spatial econometrics have been developed to include spatiality within hedonic property models (Dziauddin, 2015). These techniques include the spatial expansion method (Casetti, 1972), multilevel modeling

(Goldstein, 1987), spatial autoregressive model (also known as spatial lag model) (Anselin, 1988), and most recently, geographically weighted regression (GWR) (Brunsdon et al., 1998). Unlike OLS, where a single parameter estimate is applied across the study area, GWR allows parameter estimates to vary across space, accommodating the spatial context in which a specific property is located. GWR treats each observation as an individual feature at a specific geographic point, and fits a unique regression equation to every feature in a dataset, allowing for parameter estimates to vary across space. It accomplishes this by incorporating the response and explanatory variables of all features falling within a particular bandwidth (also known as a neighborhood) of each target feature. Using a decay function, features nearest to the target are assigned a greater weight than those further away. Since GWR applies a linear regression equation to every point in the study area, all of the OLS assumptions apply to GWR.

The GWR model follows a similar format to the formula for hedonic OLS regression, but includes longitude and latitude coordinates, since it is specific to each observation. The GWR model at location *i* would be expressed by the following formula:

$$y_i = \alpha(u_i, v_i) + \beta_1(u_i, v_i)(x_1) + \sum_{k=1}^{j} \beta_k(u_i, v_i)x_k + \epsilon_i \quad i = 1,\ldots, n, \tag{2}$$

Where the response variable y is the adjusted sale price for each location i; (u_i, v_i) denotes the coordinates of location i; α is a constant; β_1 is the coefficient for the station distance variable; x_1 is the network distance to the nearest QLine station; j is the number of location-specific parameters to be estimated, excluding the constant and station distance; β_k is the coefficient for the kth location-specific parameter; x_k is the value of the kth location-specific parameter; ϵ_i is a normally distributed random error with a mean of zero; and n is the number of observations (Crespo et al., 2011; Yan et al., 2012).

Although the use of GWR in estimating rail transit impacts is relatively new, researchers that have used it to estimate the effect of rail transit systems on property values have concluded that it is a superior methodology. For instance, Du and Mulley (2012, p. 49) have argued that, “GWR has been identified as providing more rigorous analysis of change over other spatial analytical tools if its significant data demands can be met." As a result, an increasing number of studies have made use of this technique. A geographically weighted analysis of urban rail transit on housing prices in Ottawa, Canada, found that proximity to rail stations does have an impact on pricing, but one that is spatially dependent, with housing prices in some areas being positively affected and others negatively affected by proximity to O-Train stations (Hewitt and Hewitt, 2012). Similar findings were observed when studying the impacts of an LRT system in the Tyne and Wear region of England (Du and Mulley, 2012). GWR has also been utilized to estimate property value premiums derived from a light rail system in Kuala Lumpur, Malaysia. The authors concluded that premiums varied widely across the study area, as they were influenced by local factors such as an area's income characteristics, neighborhood desirability, the quality of legacy transport systems, and proximity to the CBD (Dziauddin, 2015). In a more recent study incorporating GWR, researchers estimating the effects of Bangkok's LRT found that property values increased across the entire study area, although benefits were greater in the city center than in suburban areas (Vichiensan et al., 2021). The use of GWR also validates earlier studies suggesting that variations in the impact of a transit facility can be dependent on factors like the type of housing or a neighborhood's income level or housing type (Gatzlaff and Smith, 1993; Billings, 2011).

The realization that land values are spatially defined and the subsequent adoption of spatial techniques, such as GWR, have marked an improvement over OLS-based price models. When OLS and GWR techniques have been used in tandem, GWR has consistently proved to be a more accurate method, as evidenced by higher R-squared values (Hewitt and Hewitt, 2012; Dziauddin, 2015). However, GWR is not without its limitations. Even when spatial techniques account for heterogeneity and autocorrelation of the response variable, hedonic approaches must also ensure that all relevant explanatory variables influencing the determination of property values are included. Otherwise, models are likely to suffer from omitted variable bias (Osland, 2013). Of course, incorporating all relevant variables into a HPM is often difficult, since some property attributes may be unobservable or uncollectible to researchers (Osland, 2013).

The academic literature on the impacts of rail systems on property values has been largely defined by attempts to estimate the relationship between distance to transit facilities and real estate prices. These inquiries have included a number of considerations, such as the mode of transit and the zoning type of the property, as well as more specific land uses. Study areas have ranged from transit-adjacent parcels all the way to municipal boundaries. The earliest studies of this relationship relied almost exclusively on global OLS regression models, which assumed that the relationship between variables was fixed across space. More recently, researchers have adopted local GWR techniques, which take into account spatial effects as well as autocorrelation and heterogeneity. Quasi-experimental approaches like DID have also become increasingly popular.

This study estimated the effects of Detroit's streetcar system on property values within a 1-mile buffer. Property transactions were divided into commercial and residential subgroups based on zoning type and land use codes. A combination of global OLS and local GWR techniques were used to analyze the relationship between the QLine and nearby real estate prices. The following section provides a detailed overview of the methodological techniques used for this research, including the logistic transformation of the sale price and station distance variables, the explanatory variables that were considered, and the spatial approaches that were used to capture the impacts of the QLine across space.

CHAPTER 4
METHODOLOGY

This chapter details the research methods used in this thesis and is divided into four sections. The first section provides a description of the study area. The second section describes the data collection and preparation procedures, including the response and explanatory variables. The third section describes the methods of data analysis. The fourth section provides a summary and conclusion.

4.1 Study Area

The research undertaken for this study was conducted in Detroit, Michigan. Detroit is the largest city in Michigan and the 27th largest city in the United States with a population of 639,111 (U.S. Census, 2020). The QLine is a 3.3-mile streetcar system that runs along Woodward Avenue in Central Detroit, and travels through four main districts: Downtown, Midtown, New Center, and North End. The study area consists of a one-mile (1609.34 meters) buffer around each of the 20 QLine stations (12 stops) located along Woodward Avenue. One mile was selected because the literature has consistently shown that transit facility impacts are extremely small beyond this point (Ryan, 1999; Yan et al., 2012; Zhong and Li, 2016). Compared to a quarter- or half-mile buffer, the one-mile buffer addressed potential issues with statistical significance by providing a larger sample size. Finally, recent studies using GWR to analyze longer LRT systems have used buffers ranging from 2000 to 4000 meters. Therefore, a slightly smaller 1609-meter buffer seemed appropriate.

4.2 Data Collection and Preparation

4.2.1 Response Variable

The response variable in this analysis was sale price of commercial and residential properties. Data for sale prices was obtained from the Detroit Open Data Portal, which contained more than 358,000 records of property transactions ranging from January 1, 2011 to March 11, 2022. The USDOT publicly announced they would finance the QLine on January 18, 2013, so that date was used as the lower boundary for the study period. Research has shown that the announcement of a proposed transit system can influence the local real estate market (Knaap et al., 2001; McMillen and McDonald, 2004). The acquisition of dozens of parcels along the streetcar corridor by Dan Gilbert and the Ilitch Family in anticipation of the QLine's opening were consistent with these findings. Therefore, the study period ranged from January 28, 2013 to March 11, 2022. Transactions before this time period were removed.

In addition to sale price, the Detroit Open Data Portal provided data on the sale terms, assessed land value, lot size, floor area, year built, as well as zoning and use codes. This information was used to drastically refine the dataset in an effort to eliminate any below-market sales. Transactions under $5000, family sales, estate sales, foreclosures, government sales, and any transactions where the assessed land value was more than five times the sale price were removed, as were duplicate records. Vacant lots and any property for which lot size or floor area values were null were also excluded. Properties where the lot size exceeded 100,000 square feet were eliminated, including multi-parcel transactions where just one of the parcels exceeded this number. The remaining property transactions were divided into commercial and residential subgroups based on zoning and use code data. During this process, properties that were neither commercial nor residential were removed from the dataset. Finally, network distance from each boundary to the closest QLine stations was calculated using ArcGIS Pro 2.7. A one mile buffer (1609.34 meter) buffer was drawn around each of the 20 QLine stations, and only properties sold within the buffer zone were selected. The total sample size included 477 residential transactions and 209 commercial transactions for a total of 686 property transactions.

Property sales values were all adjusted for inflation to January 2022 dollars using the Consumer Price Index (CPI). In the case of multi-parcel transactions, where adjacent properties were listed as sold on the same date, but under the same exact price, the sales price for each property was multiplied by the floor area proportion of each property involved in the transaction in order to average out the total price among each of the parcels. Floor area was used rather than lot size to account for the fact that the majority of buildings in central Detroit are multi-story structures. A large number of repeat sales were present in the dataset. For these transactions, a simple mean of the inflation-adjusted selling price was taken and the most recent date was recorded, consistent with the approach taken by Hewitt and Hewitt (2012). Finally, the inflation-adjusted sale price variable was transformed by taking its natural logarithm. Adopting a logarithmic model eliminated heteroscedasticity and allowed the estimated sale price to vary proportionally with different components of explanatory variables.

4.2.2 Explanatory Variables

A host of explanatory variables were used to model fluctuations in price for commercial and residential properties. The focus variable in the analysis was station distance, which was calculated as the natural logarithm of the network distance between a parcel and the nearest QLine stop. Network distance was preferred to Euclidean distance, since the former served as a more accurate measure of walking distance in central Detroit. By adopting a logarithmic model, coefficients could be converted to percent change in sale price for every 10 percent change in station distance using the following expression below (Benoit, 2011).

$$e^{Coefficient\ of\ Station\ Distance_i * log(1.1)} - 1 \qquad (3)$$

Furthermore, the transformed station distance variable also captured the rapidly diminishing influence of a streetcar stop that occurs as one moves outside easy walking distance (Yan et al., 2012).

A number of building attributes, such as lot size, floor area, and year built were provided by the Detroit Open Data Portal and incorporated into the analysis. A building age variable was calculated by subtracting the year built from the current year (2022). The parcel data also provided land use codes, which were introduced into the model as dummy variables. For commercial properties, these uses included bars or restaurants, office buildings, and retail stores. Residential land uses included single-family housing, multi-family housing, and apartments or condominiums.

Dummy variables were also used to denote parcels that were purchased by companies affiliated with Dan Gilbert or the Ilitch Family, the Detroit billionaires who were also heavily involved in securing funding and designing the QLine. The owners of these properties were identified in the City's parcel data and shell companies were cross-referenced with external sources, such as *Crain's Detroit Business* and the Bedrock website. In addition, dummy variables were used to classify properties that were 'flipped' (sold more than once within the study period), as well as transactions based on their location among the four neighborhoods of the streetcar corridor (Downtown, Midtown, New Center, and North End). Lastly, dummies were used to classify properties based on 100-meter increments (200m, 300m, etc.) from the nearest streetcar stop from 200 meters up to the 800-meter mark.

Crime data was obtained from the Detroit Open Data Portal and was spatially aggregated at the census tract (2010) level. The per capita crime rate was calculated by taking the total number of criminal incidents for 2019, dividing by the population of the census tract, and then multiplying by 1,000 residents. Data reporting median household income, percentage of white residents, percentage of black/African-American residents, and change in population (2010-2019) were obtained from the 2010 and 2019 American Community Surveys. This data was spatially aggregated at the census tract (2010) level and median household income was converted to January 2022 dollars. In an attempt to control for the effects of Woodward Avenue, data on annual average daily traffic (AADT) was obtained from Michigan GIS Open Data. A traffic variable was calculated by taking the mean AADT values for the four segments of Woodward Avenue located in the study area for each given year.

Vector data for grocery stores, hospitals, schools, parks, and Wayne State University was obtained from the Detroit Open Data Portal. Shapefiles for freeways were obtained from Michigan GIS Open Data. Euclidean distance (in meters) from each parcel boundary to the nearest public or charter school, hospital, full-line grocery store, freeway, park, Wayne State University, and the CBD (represented by Campus Martius Park) were calculated using QGIS. A comprehensive list of the explanatory variables that were incorporated into the analysis for both subgroups can be viewed on the following pages (Table 4.1).

Table 4.1: List of Explanatory Variables

			Commercial Properties		Residential Properties	
	Description	**Units**	**Mean**	**St. Dev.**	**Mean**	**St. Dev.**
Response variable						
Ln (Sale Price)	Natural logarithm of the property sale price, adjusted for inflation	Natural log units	13.79	1.48	11.87	1.57
Explanatory variables						
AGE	Age of structure	Years	84.00	27.12	110.45	16.92
APT_CONDOS	Apartment or condominium	Dummy (0 or 1)	-	-	.19	.39
BAR_REST	Bar or restaurant	Dummy (0 or 1)	.12	.33	-	-
BLKPOP	% African-American population (2019), by census tract	Percent	59.18	21.32	69.93	17.99
CBD_DIST	Distance from parcel to Campus Martius Park	Meters	2578.88	1900.51	4445.10	1594.38
CRIME_RATE	Number of crimes by census tract in 2019 per 1000 residents	Number	256.04	136.74	161.73	72.13
DOWNTOWN	Parcel located in Downtown Detroit	Dummy (0 or 1)	.30	.46	.03	.16
FLR_AREA	Floor area	Square Feet	33984.02	86879.00	7571.29	17075.74
GILBERT	Owned by Gilbert-affiliated companies	Dummy (0 or 1)	.07	.26	-	-
GROC_DIST	Distance from parcel to nearest grocery store	Meters	806.30	514.47	818.66	404.63
HOSP_DIST	Distance from parcel to nearest hospital	Meters	1484.67	691.08	1287.62	547.60
HWY_DIST	Distance from parcel to nearest freeway	Meters	427.78	230.35	534.62	284.25

Table 4.1 — continued

			Commercial Properties		Residential Properties	
	Description	**Units**	**Mean**	**St. Dev.**	**Mean**	**St. Dev.**
ILITCH	Owned by Ilitch companies	Dummy (0 or 1)	.00	.07	-	-
INCOME	Median household income, by census tract (2019)	$USD (2022 dollars)	$37,624.51	$21,004.37	$26,035.13	$7,564.67
LOT_SIZE	Square footage of lot	Square feet	13763.20	13555.00	6683.00	7265.81
MIDTOWN	Parcel located in Midtown neighborhood	Dummy (0 or 1)	.25	.43	.20	.40
MULTI_FAM	Multi-family housing	Dummy (0 or 1)	-	-	.34	.47
NEW_CENTER	Parcel located in New Center neighborhood	Dummy (0 or 1)	.17	.38	.21	.41
NORTH_END	Parcel located in North End neighborhood	Dummy (0 or 1)	.14	.35	.39	.49
OFFICE	Office building	Dummy (0 or 1)	.42	.50	-	-
PARK_DIST	Distance from parcel to nearest park	Meters	386.70	224.57	371.66	188.92
POPDIFF	Net difference in population, by census tract (2010-2019)	Number	281.90	509.58	31.10	623.11
QLINE	Properties sold after QLine service began	Dummy (0 or 1)	.48	.50	.68	.47
REPEAT	Properties that sold more than once (2013-2022)	Dummy (0 or 1)	..20	.40	.27	.45
RETAIL	Retail store	Dummy (0 or 1)	.31	.46	-	-
SALE_YEAR	Sale year of property	Year	2016.77	2.30	2017.90	2.29
SCH_DIST	Distance from parcel to nearest charter or public K-12 school	Meters	503.43	267.40	634.67	304.40

Table 4.1 — continued

			Commercial Properties		Residential Properties	
	Description	**Units**	**Mean**	**St. Dev.**	**Mean**	**St. Dev.**
SINGLE_FAM	Single-family housing	Dummy (0 or 1)	-	-	.48	.50
Ln (Station distance)	Natural logarithm of network distance (meters) from parcel to nearest QLine stop	Natural log units	6.29	.70	6.86	.48
WAYNE_DIST	Distance from parcel to Wayne St. University	Meters	2111.00	865.79	2049.44	743.59
WHITEPOP	% white population (2019), by census tract	Percent	33.60	15.94	26.22	14.13
YR_BUILT	Year structure was built	Year	1938.00	27.12	1911.55	16.92
200M	Properties located within 200 meters from nearest QLine stop	Dummy (0 or 1)	.09	.29	.00	.07
300M	Properties located within 300 meters from nearest QLine stop	Dummy (0 or 1)	.19	.39	.02	.15
400M	Properties located within 400 meters from nearest QLine stop	Dummy (0 or 1)	.32	.47	.08	.27
500M	Properties located within 500 meters from nearest QLine stop	Dummy (0 or 1)	.43	.50	.13	.33
600M	Properties located within 600 meters from nearest QLine stop	Dummy (0 or 1)	.54	.50	.17	.38
700M	Properties located within 700 meters from nearest QLine stop	Dummy (0 or 1)	.64	.48	.24	.43
800M	Properties located within 800 meters from nearest QLine stop	Dummy (0 or 1)	.71	.46	.30	.46

4.3 Methods of Data Analysis

Since real estate prices are determined by a combination of factors, ranging from square footage and age of structure to neighborhood characteristics and proximity to transit facilities, a hedonic approach was used to estimate property values. Ordinary least squares (OLS) regression was used in conjunction with Global Moran's I and geographically weighted regression (GWR) techniques in order to estimate the impacts from station distance for both the commercial and residential subgroups.

First, global OLS regression models were performed using SPSS 28.0. The purpose of using OLS regression was to test explanatory variables for statistical significance and to identify potential issues with multicollinearity. The global model for the 209 commercial properties included six explanatory variables: *floor area*, *lot size, acquired before or after QLine opening*, *office building land use*, *distance to CBD*, and the log-transformed focus variable: *Ln(station distance)*. Meanwhile, the global model for the 477 residential transactions included nine explanatory variables: *floor area*, *lot size*, *distance to CBD*, *percentage of white population*, *acquired before or after QLine opening*, *located in North End neighborhood*, *apartment or condominium land use*, *median household income*, and the log-transformed focus variable: *Ln (station distance)*. For the OLS regression models, significance was ascertained from the coefficient p-values provided in the SPSS output.

While the OLS regression models were helpful for determining the statistical significance of potential predictor variables and estimating the impacts of streetcar proximity at a global level, they were not sufficient for drawing conclusions about the local relationship between proximity to QLine stations and property values because they do not account for spatial autocorrelation and heterogeneity within the study area. A spatial dependence test known as Global Moran's I was conducted on *Ln (sale price)* and the residuals of the OLS regression models to test the commercial and residential datasets for autocorrelation using ArcGIS Pro 2.8. For residuals, a positive Moran's index and a statistically significant p-value ($p < .05$) would confirm the presence of autocorrelation, violating a key assumption of OLS regression. In this case, it is expected that a spatial model that takes autocorrelation into account would provide an improved estimate of the streetcar's effects.

Finally, GWR models for commercial and residential transactions were performed in ArcGIS Pro 2.8 in order to provide a local estimate of the relationship between station distance and real estate prices. In this analysis, an adaptive bisquare kernel technique was used, which was based on a constant number of neighbors from each target feature. The adaptive approach was selected over a fixed kernel technique, since the calculated density values for a fixed bandwidth may have different statistical variances as the number of observations for each neighborhood varies from feature to feature. Unlike the fixed bandwidth, the adaptive kernel assigns each feature a constant number of neighbors, which increases the statistical stability and makes the results more comparable (Shi, 2010). The number of neighbors were selected so that each feature was influenced by roughly 50 percent of the data. The 50 percent kernels were selected since issues with local multicollinearity emerge when less than 40 percent of commercial or residential neighbors are included. Furthermore, the size of the study area (6.6 square miles) was relatively small compared to similar studies of transit facility impacts, which used roughly 30 percent of neighbors (Hewitt and Hewitt, 2012; Dziauddin, 2015). Therefore, it would make sense for individual observations in a smaller area to be influenced by a larger proportion of neighboring features.

As a result, the GWR model for the 209 commercial properties incorporated data from the 104 nearest points and included six explanatory variables: *distance to CBD*, *floor area*, *lot size*, *office building land use*, whether the property was acquired *before or after the opening of the QLine*, and the log-transformed focus variable: *Ln (station distance)*. The residential GWR model for 477 properties incorporated data from the 238 nearest neighbors and incorporated eight explanatory variables. Six of the nine predictors from the global model were included: *floor area, lot size*, *distance to CBD*, *percentage of white population*, *acquired before or after QLine opening*, and the log-transformed focus variable: *Ln (station distance)*. In addition, *crime rate* and *age of structure* were added, as they strengthened the model's R-squared and AIC values. Meanwhile, *median household income*, *located in the North End neighborhood*, and *apartment or condominium land use* were dropped, as these variables measurably weakened the model. Since ArcGIS does not provide p-values for individual points, statistical significance for each observation was calculated by dividing its coefficient by the standard error. The resultant t-values were used to determine whether coefficients were significant at the $p < .05$ level. The following section will provide a detailed summary of the study's results.

CHAPTER 5
RESULTS

This chapter presents the findings of the research into the impacts of the QLine streetcar on commercial and residential properties in central Detroit. In the first section, an ordinary least squares (OLS) regression model was performed for both the commercial and residential datasets. Next, Global Moran's I tests were conducted on both datasets to test for the presence of response variable and residual autocorrelation. The third section of this chapter used geographically weighted regression (GWR) to provide a local estimate of the relationship between station distance and property values.

5.1 OLS Regression Model

First, an OLS regression model was performed on the 209 commercial properties. This global model included six explanatory variables: *floor area*, *lot size, acquired before or after QLine opening*, *office building land use*, *distance to CBD*, and the focus variable: *Ln(station distance)*. The predictors for this model were all significant at the $p < .05$ level. Overall, the global R-squared value indicated that the model was able to explain about 71 percent of the variation in property sale prices (Table 5.1). Among the explanatory variables, *floor area*, *lot size, acquired after QLine opening*, *office building land use*, and *distance to CBD* were all positively correlated with sales price. The only variable that was negatively correlated with sales price was *Ln(station distance)*. The coefficient of -.411 for *Ln (station distance)* was interpreted as a 1.69 percent decrease in property values for commercial properties for 10 percent increase in distance from a QLine station (Table 5.2). These findings were significant at the $p >$ .05 level, indicating that station distance was a significant predictor of commercial property values in central Detroit. Overall, the t-values indicated that the most important predictors of commercial property values were *distance to CBD*, closely followed by *lot size*. Interestingly, the model also suggested that commercial properties in the study area sold for 76 percent more in the years after the opening of the QLine, since $e^{.566} = 1.761$.

Table 5.1: OLS Regression Model Summary — Commercial Properties

Statistic	
Sample size (*n*)	209
R	.843
R-squared	.710
Adjusted R-squared	.701
AIC	515.301
Std. Error of Estimate	.811

Table 5.2: OLS Regression Coefficients Summary — Commercial Properties

Variable	Coefficient	Std. Error	Std. Coefficient	T-statistic	Sig. (p-value)
(Constant)	16.006	.540	-	29.625	<.001
ln (station distance)	-.411	.084	-.195	-4.917	<.001
Floor area	3.838E-6	.000	.225	4.897	<.001
Lot size	4.382E-5	.000	.400	9.187	<.001
Before or after QLine	.566	.114	.191	4.982	<.001
Office land use	.443	.120	.148	3.700	<.001
Distance to CBD	.000	.000	-.409	-10.215	<.001

Next, an OLS regression model was performed for 477 residential property transactions. The global OLS model for residential property transactions included nine explanatory variables: *floor area*, *lot size*, *distance to CBD*, *percentage of white population*, *acquired before or after QLine opening*, *located in North End neighborhood*, *apartment or condominium land use*, *median household income*, and the focus variable: *Ln (station distance)*. Overall, the model was able to explain about 67 percent of the variation in property sales across the study area (Table 5.3). The nine predictors for the model were all significant at the $p > .05$ level. Among the explanatory variables, *floor area*, *lot size, distance to CBD*, *acquired after QLine opening*, *percentage of white population*, *located in North End neighborhood*, and *apartment or condominium and use* were all positively correlated with sales price. The *median household income* and *Ln (station distance)* were negatively correlated. The *Ln (station distance)* coefficient value of -4.10 was interpreted as a 1.68 percent decline in residential sale prices for every 10 percent increase in distance from a QLine station (Table 5.4). This value was nearly identical to the coefficient in the commercial model. The most significant attribute in determining residential sale price was whether or not the property was acquired after the QLine opened in 2017. According to the model, residential properties acquired after May 2017 were 158 percent more valuable than those acquired in the four years before.

Table 5.3: OLS Regression Model Summary — Residential Properties

Statistic	
Sample size (*n*)	477
R	.823
R-squared	.678
Adjusted R-squared	.671
AIC	1263.594
Std. Error of Estimate	.898

Table 5.4: OLS Regression Coefficients Summary — Residential Properties

Variable	Coefficient	Std. Error	Std. Coefficient	T-statistic	Sig. (p-value)
(Constant)	14.658	.782	-	18.749	<.001
ln (station distance)	-.410	.108	-.127	-3.804	<.001
Lot size	2.045E-5	.000	.095	2.471	.014
Floor area	1.588E-5	.000	.173	4.071	<.001
Distance to CBD	.000	.000	-.194	-4.929	<.001
Percentage, white population	.016	.004	.147	3.950	<.001
Before or after QLine	.949	.089	.284	10.673	<.001
Apartment or condominium land use	.994	.146	.249	6.811	<.001
Median household income	-1.427E-5	.000	-.069	-2.149	.032

5.2 Global Moran's I

The results of the Moran's I test for commercial properties suggested that a significant level of autocorrelation was present in the sales price variable, but not in the residuals (Table 5.5). Since these results met the assumption of normally distributed residuals, we would not expect a spatial model to be a marked improvement for commercial properties. On the other hand, the Global Moran's I test indicated a significant level of autocorrelation in both the sales price variable and residuals of the residential OLS model. These findings suggested a significant degree of clustering in the study area and did not meet the assumptions of normally distributed residuals. As a result, it was expected that a local, spatially weighted approach, such as GWR, would provide a more accurate estimate of the streetcar stop's impacts for residential properties.

Table 5.5: Global Moran’s I Results — Commercial Properties

Statistic	*Ln (sale price)*	*Residuals*
Moran’s Index	.404	.032
Expected Index	-.004	-.004
Variance	.002	.002
z-score	9.641	.873
p-value	.000	.383

Table 5.6: Global Moran’s I Results — Residential Properties

Statistic	*Ln (sale price)*	*Residuals*
Moran’s Index	.457	.095
Expected Index	-.002	-.002
Variance	.000	.000
z-score	22.475	4.742
p-value	.000	.000

5.3 Spatial Regression Model

The GWR model for commercial properties included six explanatory variables: *distance to CBD*, *floor area*, *lot size*, *office building land use*, *Ln (station distance)* and whether the property was acquired *before or after the opening of the QLine*. Overall, the local GWR estimate was able to explain about 74 percent of the variability in commercial property values (Table 5.7). When adjusted to reflect the number of predictors in the model, this figure dropped slightly to 70 percent. The composite R-squared value for the local GWR model was about 4 percent greater than the OLS model, which suggested that the spatial model was a slightly better fit for the dataset than its global counterpart. However, the AIC value of

532.90 was slightly higher, which indicated the opposite. This fact was not surprising given the fact that a Global Moran's I test indicated that commercial residuals were not autocorrelated.

Table 5.7: GWR Regression Model Summary — Commercial Properties

Statistic	
Sample size (*n*)	209
Number of neighbors	104
R-squared	.741
Adjusted R-squared	.697
AIC	532.90
Sigma	.814
Sigma squared	.663

The strength of the commercial model varied throughout the study area, as evidenced by local R-squared values that ranged from 0.58 to 0.76 (Figure 5.1). The model performed strongest in Downtown, where it was able to explain between 69 and 76 percent of the variability in business property values. Slightly lower R-squared values between 0.63 and 0.69 were observed in the New Center and North End neighborhoods. On the flip side, the model performed poorest in the area of Midtown between I-75 and Mack Avenue, where R-squared values ranged between 0.58 and 0.63. However, in some areas of Midtown, the R-squared values eclipsed 0.70. The variability in Midtown may be related to the lower density of observations in this area. Overall, the local R-squared values suggest that the model's ability to explain variability in commercial sales price ranges from moderate to high, depending on the location within the study area.

Coefficient values were converted from natural log units to percent change in sale price for every 10 percent increase in station distance. The coefficients for the local commercial model were negative, suggesting that increased distance from streetcar stops had a negative impact on real estate prices throughout central Detroit (Figure 5.2). However, coefficients ranged from -0.072 to -0.029, indicating that the strength of station distance as a predictor variable was spatially dependent. The commercial properties that saw the largest declines in value as a result of station distance were located in Downtown and Midtown. To be specific, most parcels located west of Woodward in these neighborhoods saw decreases in value between 5.6 and 7.2 percent for every 10 percent increase in distance from a QLine stop. The majority of properties east of Woodward saw more modest declines in value ranging between 4.3 and 5.6 percent. Property transactions occurring in New Center and North End experienced the smallest decreases as a result of distance from a streetcar stop. In these areas, real estate prices decreased between 2.9 and 4.3 percent for every 10 percent increase in station distance. Another way to interpret these findings was to say that commercial properties experienced increases in value with proximity to QLine stations. The most pronounced gains for commercial properties were observed in Downtown and Midtown, while more modest benefits were accrued by businesses in New Center and North End.

To evaluate the coefficient values for statistical significance, local coefficients were divided by their standard error. The resultant t-values revealed that the findings of the GWR model for commercial properties were significant throughout the study area (Figure 5.3). All of the coefficients in the New Center and North End neighborhoods were significant at the $p < .01$ level. Generally speaking, as one traveled southbound down Woodward Avenue towards Midtown and Downtown, the values became less significant. However, the majority of observations in these neighborhoods remained significant at the $p < .05$ level. Only a handful of observations east of Downtown along Gratiot and Jefferson Avenues were not significant at the $p < .05$ level (although their p-values were below .10). Overall, the local t-values suggest that station distance was a strong and significant predictor of real estate prices for commercial properties in central Detroit.

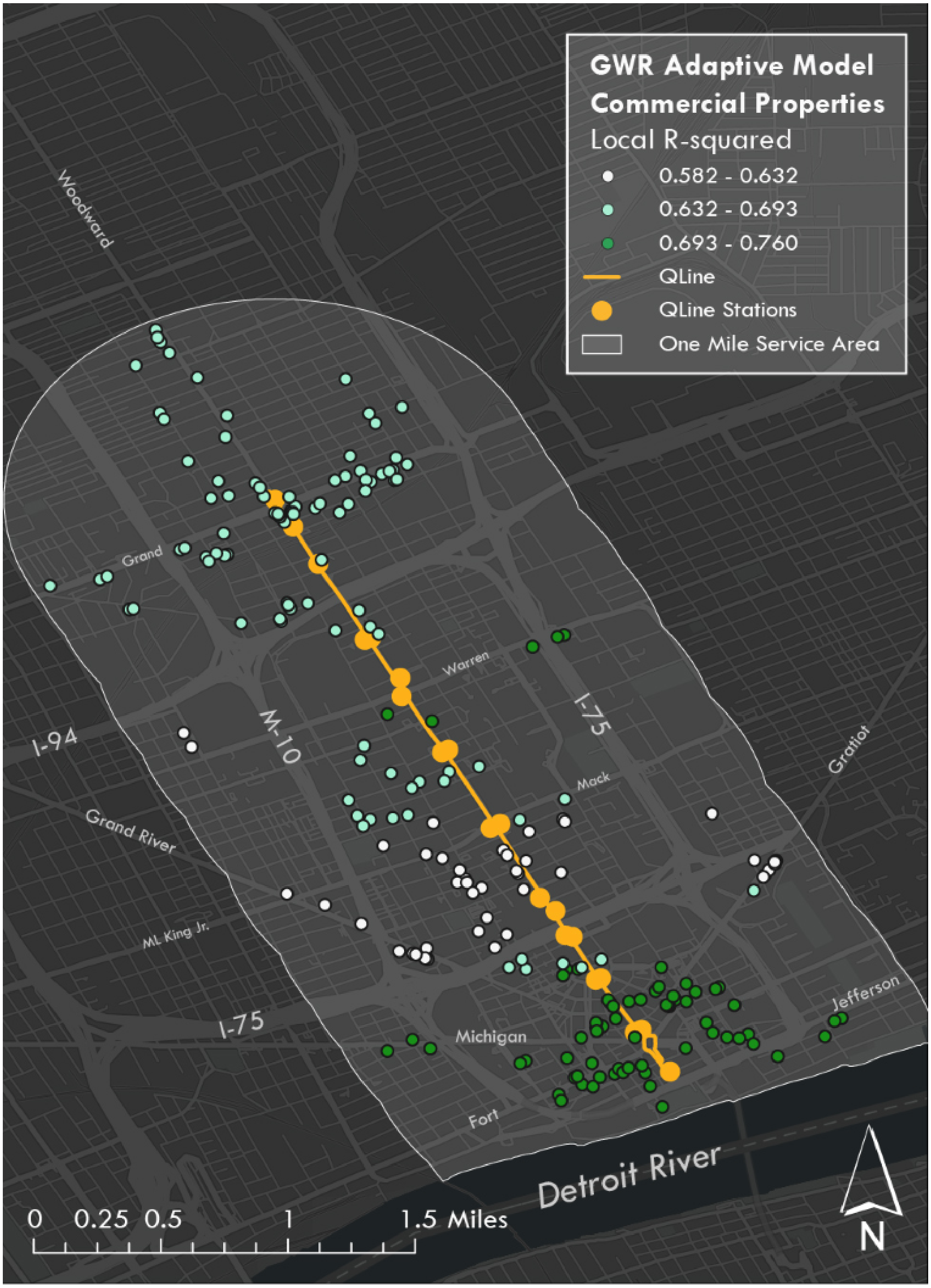

Figure 5.1: Local R-squared values for commercial property sales located within one mile of QLine stops.

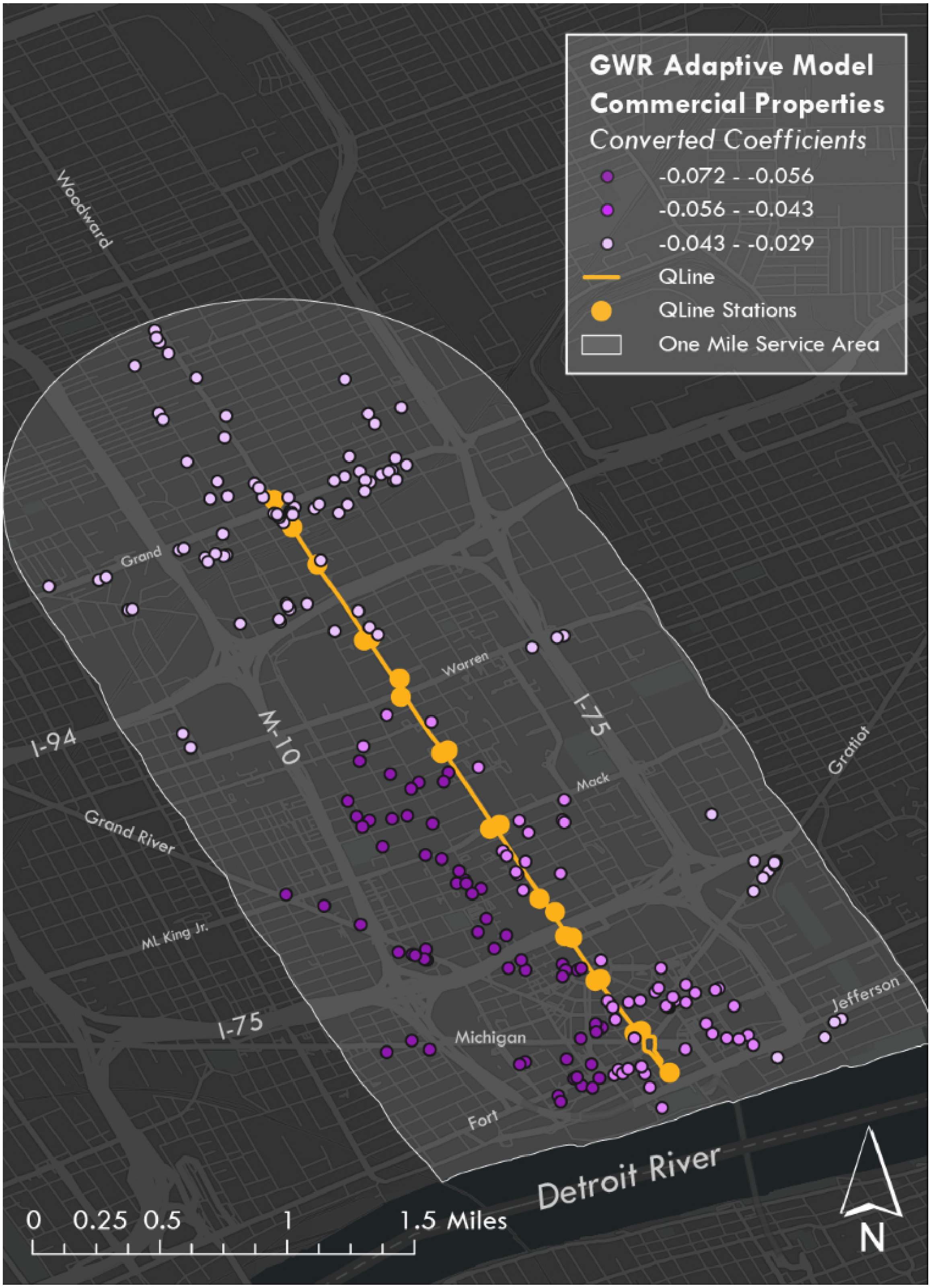

Figure 5.2: Coefficients for *Ln (station distance)* were converted to percent change in commercial sale price for every 10 percent increase in station distance. A coefficient value of -0.072 was interpreted as a 7.2% decrease in property value for every 10% increase in distance from a streetcar stop.

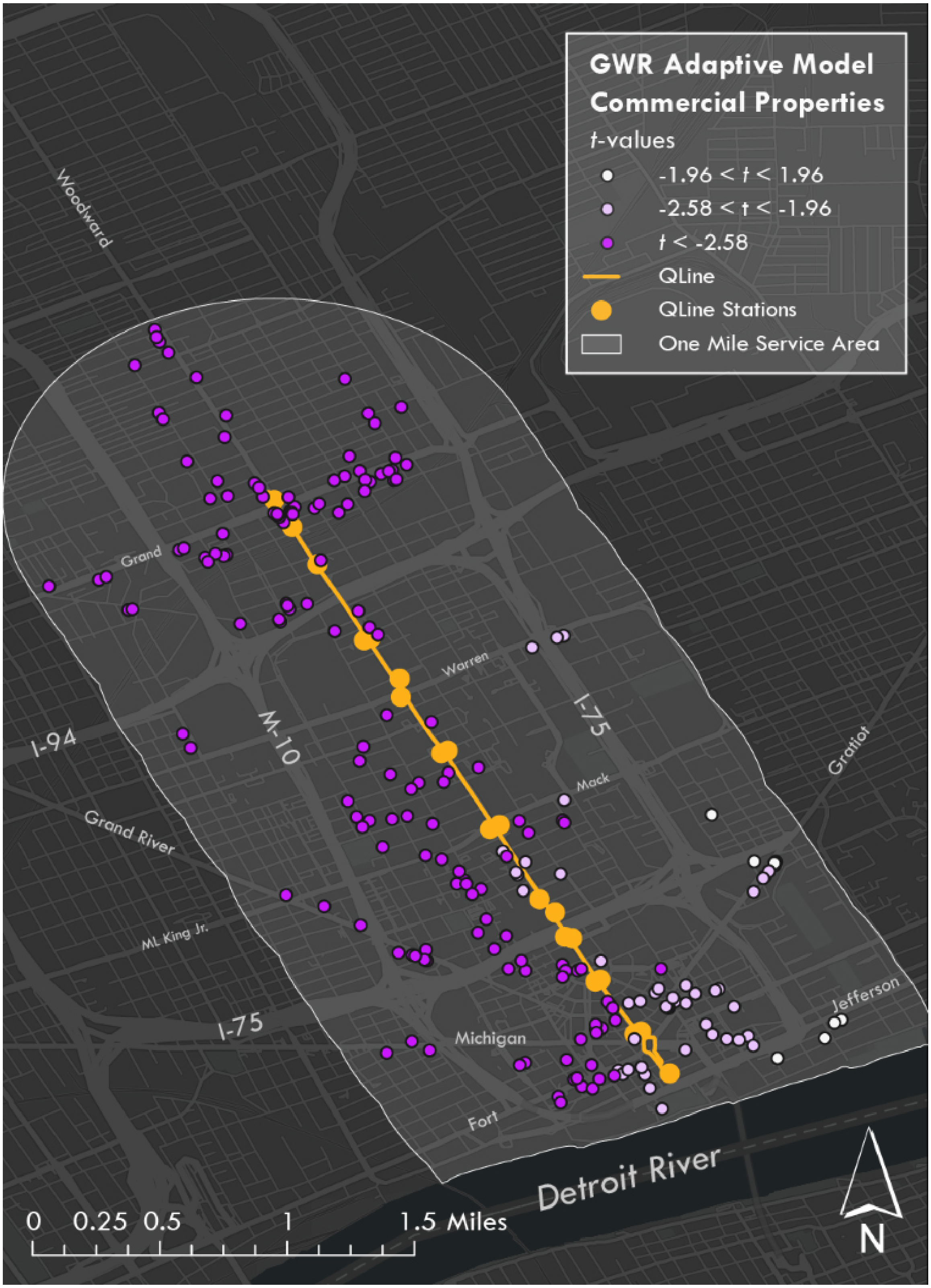

Figure 5.3: Local t-values for station distance coefficients. T-values below -2.58 denote coefficients that were statistically significant at the $p < .01$ level. T-values between -1.96 and -2.58 were significant at the $p < .05$ level. T-values above -1.96 did not meet the $p < .05$ significance threshold.

The spatial model for residential property transactions incorporated eight explanatory variables. Six of the nine predictors from the global were included: *floor area, lot size*, *distance to CBD*, *percentage of white population*, *acquired before or after QLine opening*, and the focus variable: *Ln (station distance)*. *Crime rate* and *age of structure* were added to the GWR model, while *median household income*, *located in the North End neighborhood*, and *apartment or condominium land use* were removed.

Compared to the global estimate, the GWR model for residential transactions was a slightly better fit for the data. The coefficient of determination, or R-squared value, for the residential GWR model was .722, indicating that the model was able to explain about 72 percent of the variability in the property values across both time periods. When adjusted to reflect the number of predictors in the model, this figure dropped slightly to 69 percent. The R-squared value for the GWR model was about 4 percent greater than the OLS model. Furthermore, the AIC of 1245.93 for the spatial model was a small improvement over its global counterpart, another indication that the GWR model was a better fit.

Table 5.8: GWR Regression Model Summary – Residential Properties

Statistic	
Sample size (*n*)	477
Number of neighbors	238
R-squared	.722
Adjusted R-squared	.695
AIC	1245.934
Sigma	.864
Sigma squared	.746

Local R-squared values for residential transactions were mapped, revealing variation in the explanatory power of the model across the study area (Figure 5.4). The model performed strongest in New Center, where it was able to explain between 61 and 73 percent of the variation in real estate prices for property transactions. The model was less effective in Downtown and Midtown, where it was only able to explain between 56 and 61 percent of the variation in property values. Finally, the model's performance in North End was characterized by variation in R-squared values that ranged from 0.50 to 0.66. R-squared values decreased as distance from the Grand Boulevard streetcar stop increased. Similar to the commercial model, local R-squared values for residential transactions suggested that the model possessed moderate to high strength in explaining sales price variability, depending on location.

Once again, coefficients were converted from natural log units to percent change in sale price for every 10 percent increase in station distance. Coefficients for station distance were negative across most of the study area, suggesting that residential property values decreased as the distance from QLine stops increased (Figure 5.5). However, the strength of coefficients varied considerably across space. The negative impacts from station distance were most pronounced north of Grand Boulevard, in North End, where sales prices decreased between 6.7 and 23.3 percent for every 10 percent increase in distance from a QLine stop. Housing prices also showed considerable declines in New Center, where property values declined between 3.3 and 18.8 percent for every 10 percent increase in distance from the line. Meanwhile, in Downtown and Midtown, residential prices decreased between 3.3 and 6.7 percent given an identical distance increase. Relatively neutral impacts, ranging from a 3.3 percent decline to 0.8 percent increase were observed for a handful of transactions located along Interstate 94. Decreases in property value as a result of station distance could also be interpreted as increases in value with proximity to streetcar stops. From this perspective, the most pronounced gains for housing values were found in North End and New Center. Modest increases from station proximity were present throughout

Downtown and much of Midtown, except for the few properties along Interstate 94 where coefficients were positive.

Similar to the commercial model, coefficients generated by the analysis of residential properties may be evaluated for statistical significance by calculating local t-values. The resultant t-values indicated that the findings of the spatial model for residential properties were statistically significant for a large portion of the study area vis-à-vis the commercial property model (Figure 5.6). Nearly all coefficients in Downtown and Midtown were found to be significant at the $p < .01$ level, suggesting that station distance was a significant predictor of property values in these areas. On the other hand, a handful of t-values in New Center and along Interstate 94 did not meet thresholds for statistical significance. In North End, the majority of t-values for all variables incorporated in the model were significant at the $p < .05$ level. Compared to commercial properties, a slightly lower proportion of residential transactions were significant. Outside of two small areas, the observations of residential transactions met thresholds for statistical significance. These findings suggested that station distance was a significant predictor of residential sales prices throughout the study area, and a particularly strong predictor in the Downtown and Midtown neighborhoods.

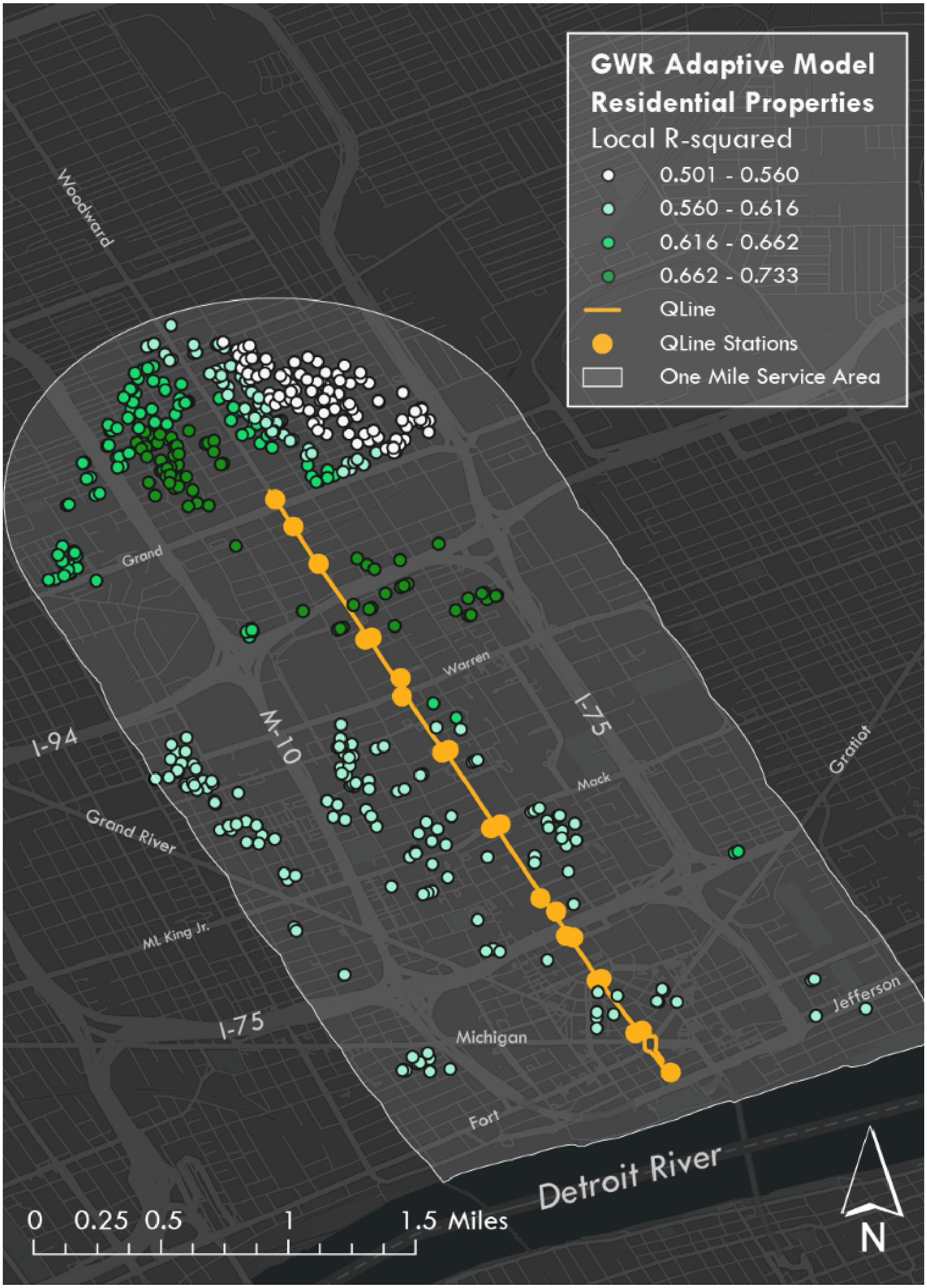

Figure 5.4: Local R-squared values for residential property sales located within one mile of QLine stops.

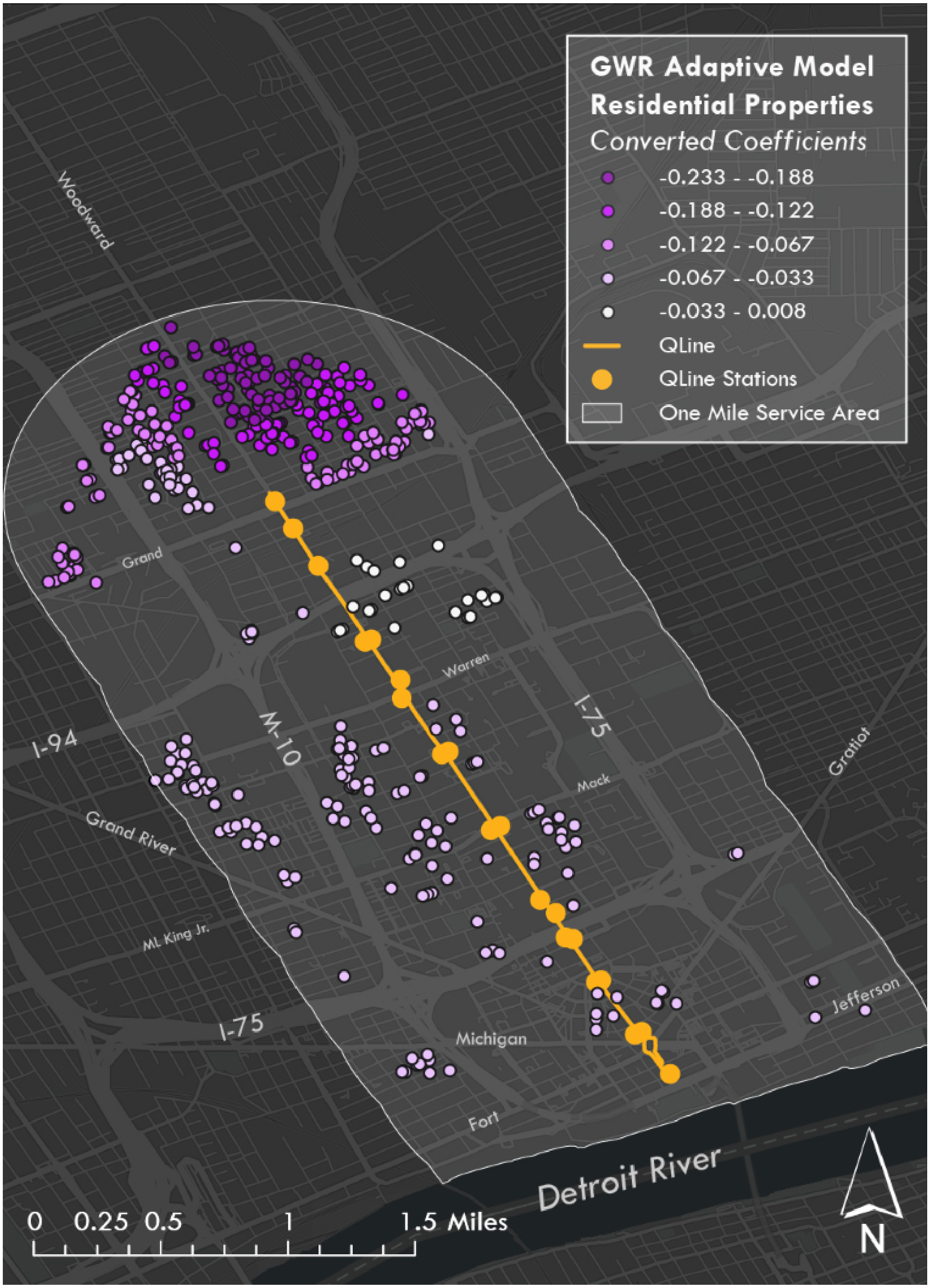

Figure 5.5: Coefficients for *Ln(station distance)* were converted to percent change in residential sale price for every 10 percent increase in station distance. A coefficient value of -0.067 was interpreted as a 6.7% decrease in property value for every 10% increase in distance from a streetcar stop.

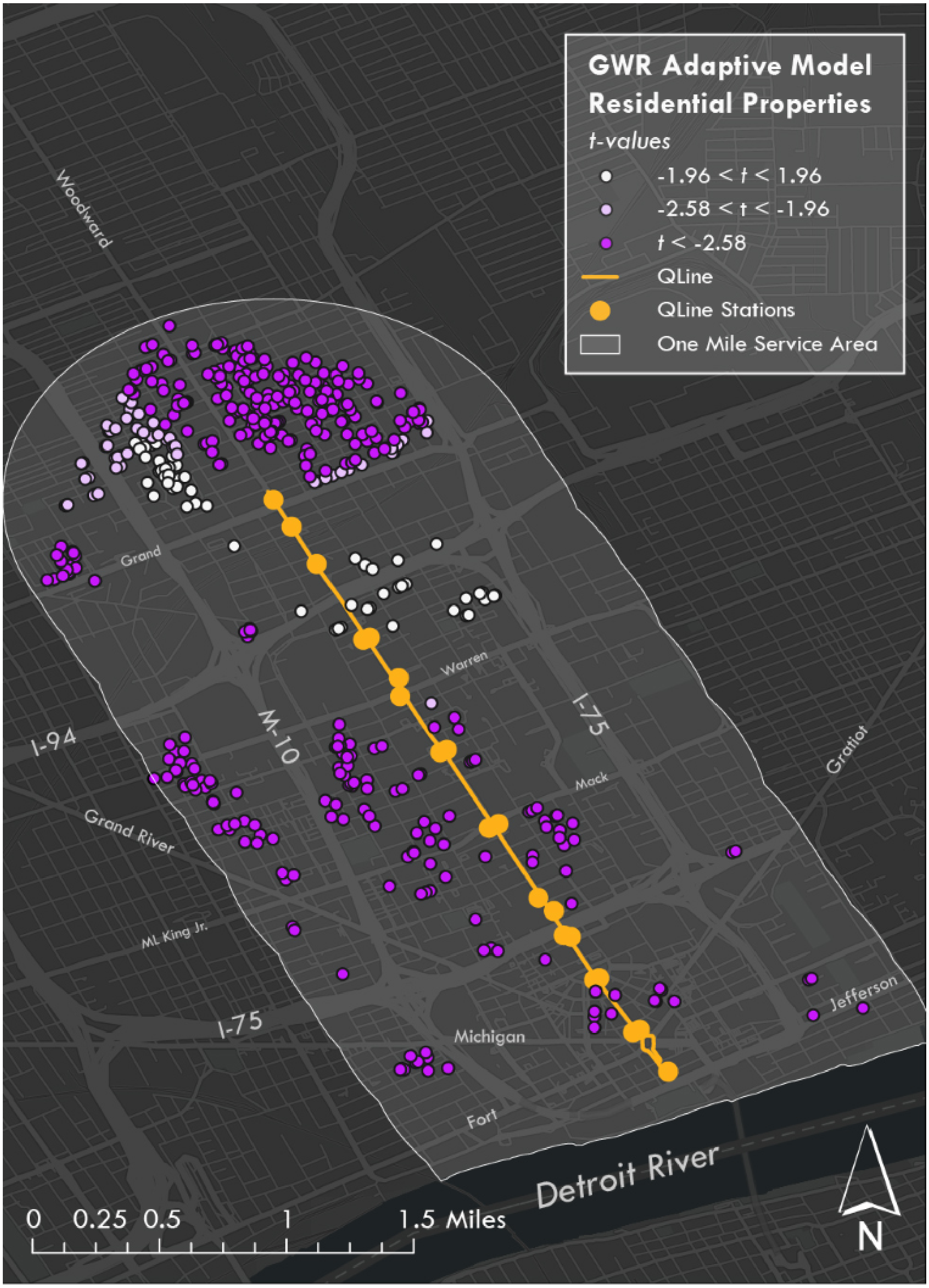

Figure 5.6: Local t-values for station distance coefficients. T-values below -2.58 denote coefficients that were statistically significant at the $p < .01$ level. T-values between -1.96 and -2.58 were significant at the $p < .05$ level. T-values above -1.96 did not meet the $p < .05$ significance threshold.

CHAPTER 6
CONCLUSION

In recent years, a growing number of cities have invested in streetcar systems, citing the diverse benefits provided by mass transit. However, unlike legacy streetcar systems from a century ago, which were built with the goal of minimizing transport costs, the current streetcar resurgence has prioritized economic development, boosting property values, and aesthetic concerns over speed, reliability, or social equity considerations. In Detroit, a 3.3-mile streetcar system commonly known as the QLine commenced service in 2017. The project was noteworthy due to the outsized role played by private investors such as Dan Gilbert in securing funding and leading the design process. Although numerous studies have examined the effects of heavy rail transit (HRT), light rail transit (LRT), and metro systems on property values, very few have focused on the impacts of streetcars. The purpose of this thesis was to analyze the relationship between distance from QLine stations and property values within a 1-mile buffer in central Detroit. Researchers studying the impacts of transit facilities on nearby real estate prices have found an inconsistent relationship that is spatially dependent and contingent on a variety of factors, including housing attributes, zoning type, and neighborhood characteristics. This thesis followed a quantitative research design, using a cross-sectional approach to analyze Detroit real estate data across a nine-year time period that included the QLine's planning, construction, and operation phases. Property transactions were divided into commercial and residential subgroups based on zoning and use codes provided by the Detroit Open Data Portal. A combination of global, ordinary least squares (OLS) and local, geographically weighted regression (GWR) techniques were utilized in an attempt to answer three key research questions, using the 3.3-mile Woodward Avenue streetcar as a case study: What effects has distance to QLine stations had on commercial and residential real estate prices within a 1-mile buffer in central Detroit? How does the relationship between distance to QLine stations and real estate prices vary across space? How has distance from streetcar stops affected commercial and residential real estate prices differently? This chapter summarizes the findings of the research in detail and discusses the implications of the results, the study's limitations, as well as recommendations for future research.

6.1 Findings

To answer the above questions, 477 residential and 209 commercial property transactions were analyzed using global, ordinary least squares (OLS) and local, geographically weighted regression (GWR) models. Overall, the research findings suggested that sale prices for both commercial and residential properties declined as the distance from streetcar stops increased. The effects of distance from QLine stations were found to vary across space, depending on the property type. Broadly speaking, observed impacts of distance on property transaction value were larger for residential properties than for commercial transactions. This section examines the findings of the research in greater detail, as well as the implications of these findings.

A total of 209 commercial property transactions were analyzed in global and local regression models. The global OLS model for businesses suggested that sale prices increased by 1.69 percent for every 10 percent increase in distance from QLine stations, a statistically significant finding. A Global Moran's I test was conducted, which indicated the presence of autocorrelation among sales prices, but not among residuals. As a result, it was not expected that a spatial model would provide a marked improvement. Nonetheless, a GWR model was created to estimate the impacts of station distance for commercial properties on a local scale. The R-squared and AIC values confirmed the comparable strength of the global and spatial regression models. Coefficients from the local GWR model revealed a spatially defined relationship that varied considerably across central Detroit. The largest impacts were apparent in Downtown and Midtown Detroit, where properties decreased between 4.3 and 7.2 percent for every 10 percent increase in distance from a QLine stop. Sale prices for commercial properties in New Center and North End declined between 2.9 and 4.3 percent for every 10 percent increase in distance from a stop. Local t-values confirmed that these results were significant. The strongest t-values were found in New Center and North End, with slightly weaker values in Downtown and Midtown. An alternative interpretation of these results would conclude that commercial properties increased in value between 2.9 and 7.2 percent for every 10 percent increase in proximity to the nearest streetcar stop. The most pronounced benefits from QLine proximity were evidenced in Downtown and Midtown, with modest benefits in other neighborhoods. Overall, distance to streetcar stops was a significant predictor of commercial real estate prices in central Detroit.

Estimates of station distance's impact on residential property values were made based on a sample of 477 residential property transactions. The global OLS model for residential parcels indicated that sales prices decreased by 1.68 percent for every 10 percent increase in distance to a streetcar stop, a finding nearly identical to that of the commercial model. This result was also statistically significant. The output of a Global Moran's I test suggested that spatial autocorrelation was present in both the sales price variable and the residuals of the OLS model. When a local GWR model was used to analyze the streetcar's impacts on residential properties, the resultant coefficients corroborated the negative relationship between sales price and station distance observed in the global model. The strength of the negative relationship varied substantially across the study area, ranging from a 23.33 percent decline to a 0.8 percent increase in sale price for every 10 percent increase in distance from a streetcar stop. Housing prices in North End experienced the largest decrease in value as distance from QLine stations increased, with declines between 6.7 and 23.3 percent. Residential parcels in New Center also experienced relatively large decreases in property value with increased distance. Smaller coefficients were observed in Downtown and Midtown, with decreases in value ranging between 3.3 and 6.7 percent for every 10 percent distance increase. Local t-values revealed that nearly all of these observations were statistically significant at the $p < .05$ level. Only a handful of property sales in New Center and along Interstate 94 exhibited relatively neutral impacts from station distance ranging from a 3.3 percent decline to a 0.8 percent increase in property value for every 10 percent distance. The transactions along Interstate 94 did not meet thresholds for statistical significance. Another interpretation of these results suggested that the value of residential properties increased with every 10 percent increase in proximity to streetcar stops, with the most pronounced gains observed in the North End neighborhood. More modest benefits from QLine proximity accrued to residential properties in the Downtown and Midtown neighborhoods. Overall, distance to QLine stations was a significant predictor of residential sale prices throughout much of the study area.

A number of factors may explain these findings. Although station distance was a significant predictor of both commercial and residential property values, the local GWR model indicated that the impacts of proximity to the QLine were more pronounced for residential properties. This may be due to the fact that commercial properties exhibit a delayed response to transit investments that only occurs after residential development along the corridor (Billings, 2011). If that is the case, the full impact of QLine station proximity on commercial real estate may not become apparent for a few more years. Next, the fact that station distance had a greater impact on commercial properties in Downtown and Midtown Detroit may be explained by the relatively high level of development activity in these neighborhoods compared to New Center or North End, as well as the heightened interest of buyers such as Dan Gilbert and the Ilitches. As a result of agglomeration effects, businesses in these neighborhoods may be in a better position to capitalize on proximity to the streetcar line. Lastly, the spatial model for residential properties suggested that housing in North End and New Center experienced the greatest benefits from proximity to the QLine. This may be due to the fact that North End had the lowest mean parcel sale price in the dataset, and as a result, any equivalent increases in property value derived from the streetcar line would be proportionally larger in North End compared to other neighborhoods. Furthermore, transit benefits of the QLine may be greatest for residents at the end of the streetcar line, located at the boundary between New Center and North End. As a result, it is possible that housing in New Center and North End capitalized streetcar proximity into increased property values more than residential properties in the Midtown or Downtown neighborhoods.

6.2 Implications

The results of this study can be summarized in three key conclusions, all of which have serious implications for planners and policymakers pursuing or evaluating the impact of streetcar systems. First, proximity to QLine stops has a significant, positive effect on real estate prices for both commercial and residential properties, a finding observed using both local and global regression models. These results add to the currently sparse literature on the impacts of modern-day streetcars, supporting the findings of Welch et al. (2016) that Portland housing prices increased with proximity to a streetcar system. These outcomes are consistent with previous studies that observed a positive relationship between commercial property values and proximity to rail transit facilities (Cervero and Duncan, 2002; Cervero, 2006; WMATA, 2011; Singhal and Tyagi, 2021). Moreover, the results are also consistent with several studies that find a positive, significant relationship between proximity to rail stations and residential sale prices (Benjamin and Sirmans, 1995; Dueker and Bianco, 1999; Gibbons and Machin, 2005; Song et. al., 2019).

Second, observed impacts are spatially dependent on the location of the property within the study area, as well as zoning type. These findings are consistent with previous research that used GWR to estimate the effect of light rail on property values, and found that the direction and strength of transit facility impacts varied across space (Du and Mulley, 2012; Hewitt and Hewitt, 2012; Dziauddin et al., 2015; Vichiensan et al., 2021). For instance, the largest premiums for commercial properties as a result of streetcar proximity were observed in Downtown and Midtown Detroit. This suggested that the dozens of properties acquired by billionaire Dan Gilbert over the last decade saw larger percentage increases in value as a result of the QLine when compared to commercial properties in New Center or North End. When viewed within the larger context of the QLine's financing and design process—influenced heavily by Gilbert—this observation corroborated the claims of Lowe and Grengs (2020), as well as interviews with M-1 Rail staff, who suggested that the QLine's private investors prioritized boosting their own property values above all other concerns. This finding affirms a disconcerting trend among cities that have pursued streetcar projects that serve the private interests of business leaders over the needs of transit-dependent populations (Ramos-Santiago et al., 2016).

Third, for the majority of cases, observed impacts from station distance are greater for residential properties than they are for commercial properties. The fact that Detroit's streetcar system has disportionately impacted the prices of nearby housing more than local businesses may have critical implications for planners and decision-makers considering a streetcar project of their own. For example, residential properties in North End and New Center experienced the largest increases in real estate prices as a result of streetcar proximity, with some prices increasing by more than 23 percent for every 10 percent increase in proximity to a QLine station. On one hand, proximity to the streetcar seems to be boosting property values for nearby home owners. On the other hand, the presence of QLine stops may be fueling gentrification by raising rents, displacing the predominately African-American residents who call North End and New Center home. Most discussions surrounding social equity and the QLine have revolved around the system's limited reach into transit-dependent neighborhoods, but this result suggests that the QLine may also be widening inequalities and displacing longtime North End residents by accelerating gentrification.

6.3 Limitations

Although the findings of the GWR model are significant for both commercial and residential properties, there were several limitations to the study. The first and perhaps most glaring limitation was the inability to differentiate the impacts of the streetcar stations from the effects of Woodward Avenue. The QLine runs concurrent with Woodward, which is the main arterial avenue in Detroit, and the street itself may exert a potentially considerable influence on the nearby real estate market. A predictor variable for Woodward Avenue average annual daily traffic was tested, but ultimately did not meet thresholds for statistical significance. A variable representing distance to Woodward Avenue from each parcel was dropped due to multicollinearity issues with the QLine station distance variable.

A second limitation in the research was the small number of observations. In total, the property data set contained 477 residential transactions and 209 commercial transactions. The number of commercial transactions in New Center and North End was especially limited. The same is true for residential observations in Downtown. It is likely that the limited number of observations influenced the results of the spatial model, which was reliant on an adaptive kernel technique. More specifically, the number of neighbors used in the study made it so the two ends of the study area were weighted more heavily than the center.

An additional limitation to the commercial and residential models was the moderate R-squared values. In broad terms, the models were only able to explain between 50 and 75 percent of the variability in real estate prices. The commercial GWR model performed strongest in Downtown and weakest in Midtown, while the residential model performed strongest in New Center and weakest in North End.

These results strongly suggested that at least one explanatory variable relevant to commercial properties in Midtown and residential properties in North End is missing from the analysis. For instance, the presence of existing business clusters in Midtown was not included in the model.

A fourth limitation to the research was the relatively short length of the QLine. Compared to other rail transit systems that have been studied, the Woodward Avenue Streetcar is much shorter, clocking in at 3.3 miles. Studies of LRT, for example, typically work with transit corridors that are at least twice that length. This reality created a unique situation, as the CBD occupied a relatively larger proportion of the study area. As a result, there were fewer residential observations than in previous studies, especially among single-family households. Had the original 9.3 mile proposal for the QLine been completed, it is likely that the land use relationship between commercial and residential properties would look different than the results that emerged from this study.

Lastly, a final limitation was the study's failure to control for any effects of the COVID-19 Pandemic. Transactions from April 2020 to September 2021 were included in the model, and assumed to have occurred while the QLine was operational, despite the fact that streetcar service was suspended during this period.

6.4 Recommendations for Future Research

Although the results of this research provide an estimate of the relationship between access to a new streetcar system and real estate prices in Detroit, more research on the impacts of the QLine is needed. Ideally, the next study on the QLine will have considerably more observations. A greater number of transactions may increase the accuracy of the model, especially areas where the number of observations was sparse. In addition, extending the study period would minimize any economic distortions caused by the COVID-19 Pandemic and allow the commercial real estate market more time to adjust for residential development in central Detroit.

Future studies of the QLine should incorporate more field work particularly in regards to classifying land uses and identifying relevant predictor variables. For example, the study did not consider the presence of existing business clusters along the Woodward Corridor. Also, it was possible that land use codes in the property dataset were incorrect or overly broad. Spending more time in the study area and compiling more attributes about properties would likely address some of the limitations associated with omitted variables and ultimately strengthen the model. This was an obvious drawback from the study, as evidenced by the moderate R-squared values for both the commercial and residential regression models.

Another technique for mitigating omitted variable bias would be to incorporate a quasi-experimental design such as difference in differences (DID) estimation. This approach would incorporate another transit corridor to serve as a control group. In the case of Detroit, Jefferson Avenue seems like a promising candidate. Adopting a DID approach would provide the added benefit of controlling for any effects that are specific to Woodward Avenue. Without a control group, it was impossible to conclude whether the findings were truly the result of the QLine itself, or if real estate prices would have followed a similar trajectory in the absence of a streetcar line. In recent years, a small, but growing number of researchers have used a spatial DID approach that also takes into account autocorrelation and spillover effects (Dubé, 2014).

Finally, the results of this thesis provide promising avenues for future research. Both spatial models exhibited interesting patterns that should be investigated, such as the heightened impacts of station distance for commercial properties located west of Woodward Avenue, compared to properties located east of the thoroughfare. Furthermore, as the resurgence of streetcars spreads to cities across the country, more studies are necessary to determine the degree to which streetcars influence economic development and property values, as well as the benefits (or lack thereof) derived by poor, vulnerable populations that are most dependent on mass transit. The extent to which Gilbert-associated firms and those of the Ilitches, as well as other private actors who have profited financially from mass transit investments also warrants further investigation. Additionally, future research that is able to effectively isolate the impacts of the QLine may be able to more accurately determine impacts on real estate prices, as well as whether or not the streetcar is directly responsible for fueling gentrification in the form of increased rents. In particular, it would be useful to look at eviction and social vulnerability statistics in nearby neighborhoods before and after the announcement of the streetcar.

REFERENCES

Aguilar, L. (2019, October 10). A Rare Look at All the Empty Detroit Properties Linked to Ilitch Group. *The Detroit News*. https://www.detroitnews.com/story/news/local/detroit-city/2019/10/11/ilitch-group-linked-to-147-empty-detroit-properties/3932609002/

Alonso, W. (1964). *Location and Land Use: Toward a General Theory of Land Rent*. Harvard University Press.

Anselin, L. (1988). *Spatial Econometrics: Methods and Models.* Berlin: Springer Science & Business Media.

Archambault, D. (2013, February 26). *North End neighborhood rising*. Model D. https://www.modeldmedia.com/features/northend213.aspx

Bae, C. H., Jun, M. J., & Park, H. (2003). The impact of Seoul's subway Line 5 on residential property values. *Transport Policy*, *10*(2), 85–94. https://doi.org/10.1016/s0967-070x(02)00048-3

Benjamin, J.D., & Sirmans, G.S. (1996). Mass Transportation, Apartment Rent and Property Values. *Journal of Real Estate Research*, *12*(1), 1-8.

Benoit, K. (2011). *Linear Regression Models with Logarithmic Transformations*. Methodology Institute, London School of Economics. https://kenbenoit.net/assets/courses/ME104/logmodels2.pdf

Billings, S. B. (2011). Estimating the value of a new transit option. *Regional Science and Urban Economics*, *41*(6), 525–536. https://doi.org/10.1016/j.regsciurbeco.2011.03.013

Bowes, D. R., & Ihlanfeldt, K. R. (2001). Identifying the Impacts of Rail Transit Stations on Residential Property Values. *Journal of Urban Economics*, *50*(1), 1–25. https://doi.org/10.1006/juec.2001.2214

Brown, J. (2013). The Modern Streetcar in the U.S.: An Examination of Its Ridership, Performance, and Function as a Public Transportation Mode. *Journal of Public Transportation*, *16*(4), 43–61. https://doi.org/10.5038/2375-0901.16.4.3

Brown, J., Nixon, H., & Ramos, E.. (2015). *The Purpose, Function, and Performance of Streetcar Transit in the Modern U.S. City: A Multiple-Case-Study Investigation*. https://transweb.sjsu.edu/sites/default/files/1201-streetcar-transit-in-modern-US-cities.pdf

Brunsdon, C., Fotheringham, S., & Charlton, M. (1998). Geographically Weighted Regression. *Journal of the Royal Statistical Society: Series D (The Statistician)*, *47*(3), 431–443. https://doi.org/10.1111/1467-9884.00145

Cassetti, E. (1972). Generating models by the expansion method: Applications to geographical research. *Geographical Analysis, 4*(1), 81-92.

Cervero, R. (2006). Office Development, Rail Transit, and Commuting Choices. *Journal of Public Transportation*, *9*(5), 41–55. https://doi.org/10.5038/2375-0901.9.5.3

Cervero, R., & Duncan, M. (2002). Transit's Value-Added Effects: Light and Commuter Rail Services and Commercial Land Values. *Transportation Research Record: Journal of the Transportation Research Board*, *1805*(1), 8–15. https://doi.org/10.3141/1805-02

Chen, H., Rufolo, A., & Dueker, K. J. (1998). Measuring the Impact of Light Rail Systems on Single-Family Home Values: A Hedonic Approach with Geographic Information System Application. *Transportation Research Record: Journal of the Transportation Research Board*, *1617*(1), 38–43. https://doi.org/10.3141/1617-05

City of Detroit (2022). *Property Sales* [data set]. City of Detroit Open Data Portal. Retrieved April 4, 2022 from https://data.detroitmi.gov/datasets/detroitmi::property-sales-1/about

Crain's Detroit Business. (2017, May 7). Quick QLine: What you need to know. *Crain's Detroit Business*. https://www.crainsdetroit.com/article/20170507/NEWS/170509859/quick-qline-what-you-need-to-know

Crespo, R., & Grêt-Regamey, A. (2013). Local Hedonic House-Price Modelling for Urban Planners: Advantages of Using Local Regression Techniques. *Environment and Planning B: Planning and Design*, *40*(4), 664–682. https://doi.org/10.1068/b38093

Debrezion, G., Pels, E., & Rietveld, P. (2007). The Impact of Railway Stations on Residential and Commercial Property Value: A Meta-analysis. *The Journal of Real Estate Finance and Economics*, *35*(2), 161–180. https://doi.org/10.1007/s11146-007-9032-z

Detroit People Mover. (2022, March 4). In *Wikipedia*. https://en.wikipedia.org/wiki/Detroit_People_Mover#Ridership

Dubé, J., Legros, D., Thériault, M., & des Rosiers, F. (2014). A spatial Difference-in-Differences estimator to evaluate the effect of change in public mass transit systems on house prices. *Transportation Research Part B: Methodological*, *64*, 24–40. https://doi.org/10.1016/j.trb.2014.02.007

Dueker, K. J., & Bianco, M. J. (1999). Light-Rail-Transit Impacts in Portland: The First Ten Years. *Transportation Research Record: Journal of the Transportation Research Board*, *1685*(1), 171–180. https://doi.org/10.3141/1685-22

Dziauddin, M. F., Powe, N., & Alvanides, S. (2014). Estimating the Effects of Light Rail Transit (LRT) System on Residential Property Values Using Geographically Weighted Regression (GWR). *Applied Spatial Analysis and Policy*, *8*(1), 1–25. https://doi.org/10.1007/s12061-014-9117-z

Feloni, R. (2018, August 18). *Quicken Loans Founder Dan Gilbert Has Invested $5.6 Billion in Detroit*. Business Insider. https://www.businessinsider.com/quicken-loans-dan-gilbert-detroit-2018-8

Finley, N. (2020, March 4). Get SMART About Regional Mass Transit. *The Detroit News*. https://www.detroitnews.com/story/opinion/columnists/nolan-finley/2020/03/05/finley-get-smart-regional-mass-transit/4953692002/

Fogelman, R. (2004). *Detroit's New Center* (1st ed.). Arcadia Publishing.

Forrest, D., Glen, J., & Ward, R. (1996). The Impact of a Light Rail System on the Structure of House Prices: A Hedonic Longitudinal Study. *Journal of Transport Economics and Policy*, *30*(1), 15–29. https://www.jstor.org/stable/20053094

Frank, A. (2017, May 12). Hopes High As QLine Officially Opens. *Crain's Detroit Business*. https://www.crainsdetroit.com/article/20170512/NEWS/170519939/hopes-high-as-qline-officially-opens

Frank, A. (2019, August 9). QLine to Join DDOT, SMART Public Transit Payment System Dart. *Crain's Detroit Business.* http://www.crainsdetroit.com/transportation/qline-join-ddot-smart-public-transit-payment-system-dart.

Gallagher, J. (2019, July 18). Study Reveals Surprising Results About Detroit Gentrification. *Detroit Free Press*. https://www.freep.com/story/money/business/john-gallagher/2019/07/18/detroit-gentrification-study/1755180001/

Gatzlaff, D. H., & Smith, M. T. (1993). The Impact of the Miami Metrorail on the Value of Residences near Station Locations. *Land Economics*, *69*(1), 54-66. https://doi.org/10.2307/3146278

Gerber, E., Morenoff, J., & Smith, C. (2017). *Detroiters' Views on Transportation and Mobility*. Detroit Metropolitan Area Communities Study, University of Michigan. https://poverty.umich.edu/files/2018/05/W2-Transportation-F.pdf

Gibbons, S., & Machin, S. (2005). Valuing rail access using transport innovations. *Journal of Urban Economics*, *57*(1), 148–169. https://doi.org/10.1016/j.jue.2004.10.002

Goldstein, H. (1987). *Multilevel models in education and social research.* Charles Griffin & Co. Oxford University Press.

Goodspeed, R.C. (2004). *Urban Renewal in Postwar Detroit the Gratiot Area Redevelopment Project: A Case Study*. [Masters Thesis, University of Michigan]. goodspeedupdate.com/RobGoodspeed-HonorsThesis.pdf.

Hanifin, L. & Douglas, S. (2013). *Transit Politics and Leadership in Detroit (1862-2007)*. [Chapter 3, Detroit Transit History]. University of Detroit Mercy Transit Research Team. https://eng-sci.udmercy.edu/research/udmtc-pdfs/Transit_Study_Detroit_History_1-15-13_FINAL.pdf

Hess, D. B., & Almeida, T. M. (2007). Impact of Proximity to Light Rail Rapid Transit on Station-area Property Values in Buffalo, New York. *Urban Studies*, *44*(5–6), 1041–1068. https://doi.org/10.1080/00420980701256005

Hewitt, C., & Hewitt, W. (2012). The Effect of Proximity to Urban Rail on Housing Prices in Ottawa. *Journal of Public Transportation*, *15*(4), 43–65. https://doi.org/10.5038/2375-0901.15.4.3

Hill, A.B., & Kuras, A. (2017) *Detroit Food Metrics Report*. Detroit Food Policy Council and Detroit Health. https://www.scribd.com/document/373207033/Detroit-Food-Metrics-Report.

Jackson, K. T. (1987). *Crabgrass Frontier: The Suburbanization of the United States* (1st ed.). Oxford University Press.

King, W.T. (2014). *The Economic Development Impacts of Streetcars: Measuring the Impact of Streetcar Projects and Identifying the Factors Necessary For Stimulating Development in Streetcar Corridors.* [Masters Thesis, University of North Carolina at Chapel Hill]. https://cdr.lib.unc.edu/concern/masters_papers/6t053h846

Knaap, G. J., Ding, C., & Hopkins, L. D. (2001). Do Plans Matter? *Journal of Planning Education and Research*, *21*(1), 32–39. https://doi.org/10.1177/0739456x0102100103

Kneebone, E. (2013). *Job Sprawl Stalls: The Great Recession and Metropolitan Employment Location*. Brookings Institute. https://www.brookings.edu/research/job-sprawl-stalls-the-great-recession-and-metropolitan-employment-location/

Knight, R.L. & Trygg, L.L. (1977). *Land Use Impacts of Rapid Transit: Implications of Recent Experience*. U.S. Department of Transportation. https://www.scipedia.com/public/Knight_Trygg_1977a

Kresge Foundation (2017, May 4). *New Detroit streetcar system, the QLINE, opens to the public*. Kresge Foundation. https://kresge.org/news-views/new-detroit-streetcar-system-the-qline-opens-to-the-public/

Landis, J., Guhathakurta, S., Huang, W., Zhang, M., & Fukuji, B. (1995). *Rail Transit Investments, Real Estate Values, and Land Use Change: A Comparative Analysis of Five California Rail Transit Systems*. Retrieved from https://escholarship.org/uc/item/4hh7f652

Lawrence, E.D. (2016, March 25). Detroit's M-1 Rail Line Now to Be Called the QLINE. *Detroit Free Press.* http://www.freep.com/story/news/local/michigan/detroit/2016/03/24/m-1-rail-name-announcement/82205026.

Lewis-Workman, S., & Brod, D. (1997). Measuring the Neighborhood Benefits of Rail Transit Accessibility. *Transportation Research Record: Journal of the Transportation Research Board*, *1576*(1), 147–153. https://doi.org/10.3141/1576-19

List of United States light rail systems by ridership. (2022, April 20). In *Wikipedia*. https://en.wikipedia.org/wiki/List_of_United_States_light_rail_systems_by_ridership

Litman, T. (2021). *Evaluating Public Transit Benefits and Costs*. Victoria Transport Policy Institute. http://www.vtpi.org/tranben.pdf.

Livengood, C. (2017, September 28). 40% of QLine Riders Paying as Ridership Falls. *Crain's Detroit Business.* http://www.crainsdetroit.com/article/20170922/news/639976/40-of-qline-riders-paying-as-ridership-falls.

Livengood, C. (2018, May 12). A Year Later, Delays Still Plague QLine. *Crain's Detroit Business.* http://www.crainsdetroit.com/article/20180506/news/660016/a-year-later-delays-still-plague-qline.

Livengood, C. (2018, August 27). Duggan Wants Dedicated QLine Lane on Woodward. *Crain's Detroit Business*. http://www.crainsdetroit.com/article/20180826/news/669301/duggan-wants-dedicated-qline-lane-on-woodward.

Livengood, C. (2018, January 21). On Amazon Bid, Doubters Were Right, but so Were the Backers. *Crain's Detroit Business*. http://www.crainsdetroit.com/article/20180118/blog026/650416/on-amazon-bid-doubters-were-right-but-so-were-the-backers.

Lowe, K., & Grengs, J. (2018). Private Donations for Public Transit: The Equity Implications of Detroit's Public–Private Streetcar. *Journal of Planning Education and Research*, *40*(3), 289–303. https://doi.org/10.1177/0739456x18761237

M-1 Rail. (2022). 2022-03-29 QLINE Station Map [Map]. https://qlinedetroit.com/assets/pdf/2022_qline_station_map.pdf

Mendez, J., & Brown, J. R. (2019b). The Relationship between Streetcars and Development Activity: An Examination of Portland and Seattle. *Transportation Research Record: Journal of the Transportation Research Board*, *2673*(2), 172–182. https://doi.org/10.1177/0361198119825647

McMillen, D. P., & McDonald, J. (2004). Reaction of House Prices to a New Rapid Transit Line: Chicago's Midway Line, 1983–1999. *Real Estate Economics*, *32*(3), 463–486. https://doi.org/10.1111/j.1080-8620.2004.00099.x

Mulley, C., & Du, H. (2012). Understanding spatial variations in the impact of accessibility on land value using geographically weighted regression. *Journal of Transport and Land Use*, *5*(2). https://doi.org/10.5198/jtlu.v5i2.225

Muth, R. F. (1969). Cities and housing. Chicago, IL: University of Chicago Press.

Nagl, Kurt. (2021, August 11). QLine to Restart in Detroit after COVID-19 Shutdown Last Year. *Crain's Detroit Business*. http://www.crainsdetroit.com/transportation/qline-restart-detroit-after-covid-19-shutdown-last-year.

Neavling, Steve (2019, May 1). *Two Years in, Detroit's QLine Falls Far Short of Expectations*. Detroit Metro Times. http://www.metrotimes.com/news/two-years-in-detroits-qline-falls-far-short-of-expectations-21552552

Nelson, A. C. (1992). Effects of Heavy-Rail Transit Stations on House Prices With Respect to Neighborhood Income. *Transportation Research Record*, *1359*, 127–132.

Nelson, A.C. (1999). Transit Stations and Commercial Property Values: A Case Study with Policy and Land-Use Implications. *Journal of Public Transportation*, *2*(3), 77–95. https://doi.org/10.5038/2375-0901.2.3.4

Nichols, D. & Walsh, T. (2017). *M-1 Rail Development and Construction Inclusion Report 2013–2017*. M-1 Rail. http://www.kresge.org/wp-content/uploads/2020/06/m-1rail-development-and-construction-inclusion-report.pdf.

Oosting, J. (2012, November 28). *Michigan Senate approves Regional Transit Authority for Metro Detroit.* MLive. https://www.mlive.com/politics/2012/11/michigan_senate_approves_regio.html

Osland, L. (2013). The importance of unobserved attributes in hedonic house price models. *International Journal of Housing Markets and Analysis*, *6*(1), 63–78. https://doi.org/10.1108/17538271311306020

Portland Bureau of Transportation (2019). *Portland Streetcar System Concept Plan: A Framework for Future Corridor Planning and Alternatives Analysis* [Report No. 321180]. City of Portland. https://www.portlandoregon.gov/transportation/article/321180

Rahal, S. (2021, September 8). DDOT to Drop, Shorten Some Bus Routes This Fall. *The Detroit News*. https://www.detroitnews.com/story/news/local/detroit-city/2021/09/08/ddot-drop-shorten-some-bus-routes-fall/5773294001/

Ramos-Santiago, L. E., Brown, J. R., & Nixon, H. (2016). Streetcar Resurgence in the United States: Transit Strategy, Growth Machine Tactic, or Some of Both? *Transportation Research Record: Journal of the Transportation Research Board*, *2540*(1), 30–38. https://doi.org/10.3141/2540-04

Rosen, S. (1974). Hedonic pricing and implicit markets: Product differentiation in pure competition. *Journal of Political Economy*, 82(1), 34–55.

Ryan, S. (1999). Property Values and Transportation Facilities: Finding the Transportation-Land Use Connection. *Journal of Planning Literature*, *13*(4), 412–427. https://doi.org/10.1177/08854129922092487

Shea B. (2015, January 4). 2014 Newsmakers of the Year: Matt Cullen. *Crain's Detroit Business.* https://www.crainsdetroit.com/awards/matt-cullen-0

Shea, B. (2016, September 11). M-1 Rail in Talks With Unnamed Major Donor. *Crain's Detroit Business*. https://www.crainsdetroit.com/article/20160911/NEWS/160919974/m-1-rail-in-talks-with-unnamed-major-donor

Shea, B. (2018, August 27). QLine: A Timeline. *Crain's Detroit Business*. http://www.crainsdetroit.com/article/20170507/news/170509857/qline-a-timeline.

Shi, X. (2010). Selection of bandwidth type and adjustment side in kernel density estimation over inhomogeneous backgrounds. *International Journal of Geographical Information Science*, *24*(5), 643–660. https://doi.org/10.1080/13658810902950625

Singhal, S., & Tyagi, Y. (2021). Analyzing the Influence of Metro Stations on Commercial Property Values in Delhi: A Hedonic Approach. *Real Estate Management and Valuation*, *29*(4), 10–22. https://doi.org/10.2478/remav-2021-0026

Snell, R. (2018). Investors Queue up for QLine: Real Estate Deals Show Economic Clout of Mass Transit Project. *Crain's Detroit Business*. http://www.crainsdetroit.com/article/20160417/NEWS/160419853/investors-queue-up-for-qline-real-estate-deals-show-economic-clout.

Song, Z., Cao, M., Han, T., & Hickman, R. (2019). Public transport accessibility and housing value uplift: Evidence from the Docklands light railway in London. *Case Studies on Transport Policy*, *7*(3), 607–616. https://doi.org/10.1016/j.cstp.2019.07.001

Suburban Mobility Authority for Regional Transportation (2020, February 6). *SMART FAST Ridership Continues to Increase*. SMART. http://www.smartbus.org/About/News/smart-fast-ridership-continues-to-increase.

Sugrue, T. J. (2014). *The Origins of the Urban Crisis: Race and Inequality in Postwar Detroit - Updated Edition (Princeton Classics)* (Revised ed.). Princeton University Press.

Transportation Riders United (2016). *Advocate: Regional Transit Funding*. Transportation Riders United. https://www.detroittransit.org/support-regional-transit-investment/

U.S. Census Bureau (2019). *Means of Transportation to Work by Selected Characteristics* [Data set]. American Community Survey. https://data.census.gov/cedsci/table?q=United%20States&t=Commuting&tid=ACSST5Y2019.S0802

U.S. Census Bureau (2020). *City and Town Population Totals: 2010-2020* [Data set]. https://www.census.gov/programs-surveys/popest/technical-documentation/research/evaluation-estimates/2020-evaluation-estimates/2010s-cities-and-towns-total.html

U.S. Department of Transportation (2020). *City of Detroit dba Detroit Department of Transportation: Annual Agency Profile, 2019* [Data set]. National Transit Database. http://www.transit.dot.gov/sites/fta.dot.gov/files/transit_agency_profile_doc/2019/50119.pdf.

U.S. Department of Transportation (2020). *Detroit Transportation Corporation: Annual Agency Profile, 2019* [Data set]. National Transit Database. http://www.transit.dot.gov/sites/fta.dot.gov/files/transit_agency_profile_doc/2019/50141.pdf.

U.S. Department of Transportation (2020). *M-1 Rail Dba QLINE Detroit: Annual Agency Profile, 2019* [Data set]. National Transit Database. http://www.transit.dot.gov/sites/fta.dot.gov/files/transit_agency_profile_doc/2019/50213.pdf.

U.S. Department of Transportation (2020). *Suburban Mobility Authority for Regional Transportation, 2019* [Data set]. National Transit Database. http://www.transit.dot.gov/sites/fta.dot.gov/files/transit_agency_profile_doc/2019/50031.pdf.

Vichiensan, V., Wasuntarasook, V., Hayashi, Y., Kii, M., & Prakayaphun, T. (2021). Urban Rail Transit in Bangkok: Chronological Development Review and Impact on Residential Property Value. *Sustainability*, *14*(1), 284. https://doi.org/10.3390/su14010284

Voith, R. (1991). Transportation, Sorting and House Values. *Real Estate Economics*, *19*(2), 117–137. https://doi.org/10.1111/1540-6229.00545

Wagner, G. A., Komarek, T., & Martin, J. (2017). Is the light rail “Tide” lifting property values? Evidence from Hampton Roads, VA. *Regional Science and Urban Economics*, *65*, 25–37. https://doi.org/10.1016/j.regsciurbeco.2017.03.008

Williams, C. (2021, February 15). QLine streetcars on track to resume service in late summer. *The Detroit News*. https://www.detroitnews.com/story/news/local/detroit-city/2021/02/15/qline-track-resume-service-late-summer/6753754002/

Witsil, F. & Lawrence, E. (2016, November 9). RTA millage rejected by metro Detroit voters. *Detroit Free Press*. https://www.freep.com/story/news/local/michigan/detroit/2016/11/09/rta-regional-transit-authority-millage/93535602/

Yan, S., Delmelle, E., & Duncan, M. (2012). The impact of a new light rail system on single-family property values in Charlotte, North Carolina. *Journal of Transport and Land Use*, *5*(2). https://doi.org/10.5198/jtlu.v5i2.261

Zhang, M., Meng, X., Wang, L., & Xu, T. (2014). Transit development shaping urbanization: Evidence from the housing market in Beijing. *Habitat International*, *44*, 545–554. https://doi.org/10.1016/j.habitatint.2014.10.012