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Public Transit and Property Values: Did the Metro Blue Line Affect Home Prices in Minneapolis?

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Abstract:

This study estimates the accessibility premium commanded by single family homes located near LRT stations using home sales data from Minneapolis covering 1990 to 2014. The region' first LRT, the "Blue Line", was announced in 1998 and opened in 2004. I find mixed evidence for an increase in home values following the introduction of LRT service to South Minneapolis using a repeat sales model. My central estimate suggests that no such premium exists when including all years of data. However, limiting my data to fewer years of operation, I am able to reproduce prior studies' positive premiums.

Key words: Economic Geography, Transportation, Light rail, Urban land markets, Minneapolis

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I. Introduction

Some of the main arguments for light rail transit (LRT) are that it provides alternatives to motor vehicles, lowers the cost of commuting, reduces congestion, and can reduce vehicle externalities. If individuals are able to capture these benefits by moving closer to a station, the introduction of a light rail line would result in an LRT premium on residential home values for areas close to stations.

This study uses property-level sales transaction data to test for the presence of such a premium for properties within a kilometer of stations on the METRO Blue Line in Minneapolis, Minnesota. Using a difference-in-difference estimation approach I find mixed evidence for such an LRT premium for homes in South Minneapolis: While my central estimate suggests that no such premium exists when including all years of data, I am able to reproduce prior studies' positive premiums when limiting my data to fewer years of operation. Furthermore, premiums are spatially limited to the stations at the southern end of the corridor.

The METRO Blue Line, opened in 2004, was the Twin Cities' first light rail project, connecting Downtown Minneapolis, South Minneapolis, Minneapolis-Saint Paul International Airport and the Mall of America (Map 1). First envisioned in 1985 as a mitigation strategy in the final Environmental Impact Statement (EIS) for the Hiawatha corridor highway, it became a reality when it received both federal and state funding in 1998. After four years of construction, the new light rail commenced service between Downtown Minneapolis and Fort Snelling in June 2004 and to the Minneapolis-Saint Paul International Airport and the Mall of America in December 2004. The project cost a total of $715.3 million dollars and surpassed its 2020 ridership forecast of 24,600 daily boardings as early as 2006 (Metro Transit, 2010).

In this paper, I study the magnitude and spatial distribution of increases in home values following the introduction of light rail service to the Hiawatha Corridor in South Minneapolis. Section II reviews the existing literature on the effects of introducing amenities to an area on home values and the existing studies on light rail in Minneapolis. Section III outlines the geographical and demographic characteristics of the study area, presenting theoretical predictions for what we expect to see following the introduction of light rail service. Section IV presents summary statistics, and section V outlines the methods employed in this study to estimate LRT premiums. Section VI presents empirical results and robustness tests, section VII concludes and lays out next steps of research.

II. Literature Review

A theoretical explanation for the linkage between rail service and property values commonly found in the literature is derived from William Alonso's location theory of residential bid-rent curves**:** The value of a location is a function of its accessibility, as individuals face a trade-off between expenditures on housing, commuting, and on other consumption. Therefore, the accessibility of a location represents a stream of benefits for which individuals bid. Following the introduction of new transport infrastructure improving accessibility, the value of the future stream of benefits such as reduced commute times and expenditures should be capitalized into home values, resulting in an observable premium in land prices (Alonso, 1964).

A common framework to analyze such premiums is hedonic price estimation, derived from Sherwin Rosen's theory of hedonic prices in which the price of a good is a function of its components (Rosen 1974). Hedonic prices can be expanded on using the repeat sales method, pioneered by Bailey et al. (1963) to create less erratic house price indices. While hedonic models set the price of a parcel of land as a function of its measurable characteristics, repeat sales models examine only properties that were sold at least twice during the study period. In doing so, all time-invariant observable and unobservable characteristics are differenced out, eliminating the risks of omitted variable bias at the expense of requiring much larger datasets to capture a sufficient sample size. Repeat sales models also eliminate potential bias from different homes selling in different periods, but introduce a potential source of bias, as houses that sold multiple times might differ from houses for which fewer transactions occurred (Case & Shiller, 1987), or if other changes other than the studied amenity were made to the houses (Malpezzi, 2002).

In meta-analyses of prior studies on the effect of rail access on property values, Debrezion (2007) and Mohammad (2013) show that there is a positive relationship between proximity to rail stations and property values, however this effect differs greatly between different types of service offered. Commuter rail systems generally command larger premiums than other types of rail, heavy rail sometimes leading to decreased property values in its surroundings due to environmental factors. While the overall relationship between rail proximity and property values may be positive, there is great variation across the findings of individual studies, some of which can be explained by context, variation in the kind of service offered and different demographic characteristics of station areas analyzed. Furthermore, Mohammad (2013) reveals that previous literature may suffer from slight publication bias toward statistically significant results.

Two studies separate the relationship between station areas and property values into multiple components: Bowes and Ihlanfeldt (2001) divide the relationship into both direct and indirect effects: Direct effects are the difference in property values between parcels close to stations from similar parcels elsewhere that are attributable to rail itself, such as location accessibility and noise. Indirect effects on the other hand are heterogeneity in property values attributable to such things as the local availability of retail or crime rates, which are themselves functions of the presence of rail. Using cross-sectional data from Atlanta's MARTA commuter rail, they suggest that direct effects generally outweigh both retail and crime effects. Furthermore, they find that station area premiums vary with income, distance from CBD and distance from station. For instance, they find that premiums for rail access are greater for lower-income neighborhoods, suggesting that this could be the case because the marginal effect of nuisance effects is smaller if the nuisance, in this instance crime, was present in a neighborhood prior to the introduction of rail service.

Expanding on Bowes and Ihlanfeldt (2001) with data covering condominium sales in San Diego, Duncan (2011) separates the premium for proximity to light rail stations from the premium for walkable neighborhoods, which often surround light rail stations. This study finds that much of the premium that would otherwise be explained by proximity to light rail stations could also be attributed to such factors as the presence of services and entertainment options in a neighborhood and various other measures of walkability such as road density and differences in elevation.

Lastly, Billings (2011) and (Knaap et al, 2001) demonstrate that locations close to light rail stations can command premiums even before a light rail enters service, as buyers of land bid for a future stream of benefits once they receive certain information about future amenities of any given location.

Overall, the literature suggest that for many rail systems, properties in close proximity to station areas command a premium relative to otherwise similar properties located elsewhere, but that these premiums vary greatly with the type of service offered, local demographics and land uses in station areas.

Two previous studies estimate the effect of the Blue Line on property values of nearby single family homes using a difference-in-difference approach. Both find statistically significant premiums: Kent and Parilla (2008) use a repeat sales model on Estimated Market Values data covering the years 1997 to 2006, and Goetz (2010) uses a hedonic price model on sales data from 1997 to 2007. Kent and Parilla find a premium of $15,693 in year 2006 dollars ($18,428 in year 2014 dollars), or about twelve percent for the average home located within half a mile of an LRT station relative to the rest of the city. Goetz attributes a premium of $5229 in year 2000 dollars ($7,188 in 2014 dollars) or about four percent for the average home located within half a mile of a station relative to the rest of South Minneapolis to the Blue Line, additionally noting that effects differ by which side of the Hiawatha corridor a property is located on. This is because Hiawatha Avenue may act as a barrier preventing homes to the east from sharing the benefits provided by the Blue Line LRT. Ko and Cao (2013) perform a similar analysis for retail and industrial properties, finding statistically significant premiums for proximity to light rail stations for commercial properties. Using a hedonic model on sales contained in the

Metropolitan Council's parcels data covering the years 2000 to 2008, they find a premium per meter closer to a light rail station of $6000 per meter at a distance of 400 meters and $4000 per meter at a distance of 800 meters for a typical commercial or industrial property, indicating a nonlinear spatial distribution of LRT benefits.

The findings of all three studies on property values stand somewhat in contrast with a more recent study by Hurst and West (2014), which shows that the Blue Line LRT did not statistically significantly change the rate of land use change within half a mile of the Hiawatha corridor relative to the rest of Minneapolis. They find this using a larger time span as well as different time period definitions, suggesting that prior findings may be influenced by how little of the operational time period their data cover.

A common issue shared between all studies on the Hiawatha light rail in Minneapolis is that their data only cover a very short period after the line's opening, all of which precedes the real estate bubble crash of the late 2000s: Ko and Cao's sales data end in 2008, capturing less than four years of light rail operations, all of which fall under the period of the housing bubble (Ko & Cao, 2013). Goetz et al. (2009) capture even less of the light rail's operations, ending in 2007. Kent and Parilla (2008) rely on estimated market values from 1997, 2000, 2003 and 2006, defining their "before" period as 2003 and their "after" as 2006 and using price developments between 1997 and 2000 as controls. Meanwhile, Goetz et al. (2010) divide the data into three periods; 1997- 2001 for the time before the light rail, 2002-2004 for the construction period and 2005-2007 as the operational period.

Because of the unique history of the Blue Line's corridor it is hard to pinpoint an exact date from which point on home buyers could have known with certainty that there would be light rail service along that route: Talk of light rail service started as early 1985 when a LRT was envisioned alongside Hiawatha Avenue in the environmental impact statement for Highway 55 in South Minneapolis. Although final funding was not approved and physical construction not begun until 2001, I choose 1998 as the time at which the light rail was "announced" for the purposes of this study. I deem this appropriate because local papers' references to a Hiawatha corridor light rail spiked in the first quarter of that year (Goetz, 2010). Furthermore, the line first received funding through both a federal grant and state funding at that point in time (Metro Transit, 2010). This would mean that any study of the Blue Line LRT would have to compare sales with a baseline prior to 1998 to receive an estimate unbiased by certain knowledge of the light rail's coming. As part of my robustness analysis, I test the influence of different baselines by including estimates for all possible start years between 1990 and 1997.

By using data covering the entire time between January 1990 and July 2014 I am able to study the effects of the light rail on property values in the Hiawatha Corridor using both ten full years of operation, including some years after the housing bubble and its crash, and a better baseline than prior studies. I will address the issue of prior knowledge by defining "before announcement", "planning and construction" and "after opening" periods; "Before" exclusively referring to a period in which it was undecided whether there would be a light rail project in the Hiawatha corridor, "planning and construction" between when it became certain there is to be rail service in the corridor and its commencement, and "after opening" starting when regular operations of the line began. In doing this, I can separately estimate the impacts of announcing a light rail line and opening a light rail line on property values. Lastly, like Goetz (2010), I will estimate the premium for proximity to light rail stations separately for properties east and west of the Hiawatha corridor.

III. Definition and Characteristics of Study Area

In this study, I define the treatment group as all single-family homes located within one kilometer (0.62 miles) of the Franklin Avenue, Lake Street, 38th Street, 46th Street, 50th Street and VA Center stations (Map 2). While the station itself is located outside of the city limits, I include the VA center station because there are homes within one kilometer of it for which it is the closest station. In my robustness section, I additionally consider alternative treatment groups of homes located within one mile and half mile radii, to test using all corridor sizes prevalent in the literature. I compare the price developments in this treatment group with those of a control group consisting of single family homes located in the rest of the South Minneapolis submarket, bounded by Interstates 35W and 94, State Highway 62 and the Mississippi River. For robustness, I additionally consider control groups consisting of all single family home sales in the city of Minneapolis and of single family homes located between one and two kilometers from LRT stations.

Looking at demographic indicators from ESRI's 2011 Demographic Estimates for South Minneapolis (Maps 3-12), we observe that the population of this part of the city is heterogeneous: To the northwest, communities' populations are younger (Map 10) and less white (Maps 3-8) than those in the rest of South Minneapolis, while those of southeastern areas are older (Map 12) and more white. Median income (Map 9) is considerably higher in the southern part of my study area than in the north.

Walkability

All neighborhoods adjacent to the Blue Line LRT are considered between "walkable" and "somewhat walkable" by pedestrian advocacy website Walkscore.com, which rates the walkability of areas by population density, street characteristics and availability of local amenities. Areas surrounding the northern stations of the study area are rated more walkable than those surrounding southern stations (Walk Score, 2015), somewhat contradicting my subjective impression.

A common attribute of all stations of the METRO Blue Line between Lake Street and 50th Street is that they are located to the West of Hiawatha Avenue. In this entire corridor, Hiawatha Avenue is a busy highway with four to six lanes, rendering it virtually impossible for pedestrians to cross at any point other than at traffic lights. In addition to this obstacle, a roughly two blocks or 100 meters wide industrial corridor separates Hiawatha Avenue from the residential areas to its east.

Based on indicators for demographics and walkability and using the theories provided by Bowes and Ihlanfeldt (2001) and Duncan (2011), we expect to see the greatest LRT premiums in the northeastern part of the study area in the Phillips community and the smallest at the southern end of the study area in the Nokomis community. Furthermore, we expect to see smaller light rail premiums for homes located to the east of the line than for those on the west due to the more complicated pedestrian access.

IV. Summary Statistics

Data Sources and Characteristics

The three main datasets used in this project contain sales data, parcels data, and Census data.

Parcel Identification Numbers

All datasets from the City of Minneapolis and from MetroGIS, the Twin Cities Metropolitan Council's spatial data kiosk, contain a common parcel identification number variable that is unique to each parcel of land. These identification numbers are assigned to parcels when they are created and are unique to one set of boundaries: If the parcel's outline changes it is assigned a new number, and its old number is not reused. Wherever possible, datasets are merged via this parcel identification number, all other datasets are merged via spatial location using ArcGIS' "Near Table" and "Intersect" functions.

Sales Data

Sales data come from the City of Minneapolis' Tax Assessment Office and record all market transactions for single family homes in Minneapolis from January 1983 to mid-July 2014. Variables included in this dataset are the parcel identification number, the address of the property sold, the date on which it was sold, and the nominal sales price, measured in dollars, which we deflate to year 2014 dollars. In this time, there were 129,969 unique sales transactions for 57,487 different parcels. Because demographic control variables were only available from the year 1990 onward, we drop all prior sales, leaving 98,680 sales.

Sales Trends

Looking at monthly mean sales prices (Figure 1) and sales volumes (Figure 2) at the housing market over time for both properties located within a kilometer of stations and properties located in the rest of Minneapolis, we identify multiple trends: First of all, the housing market is highly seasonal; both prices and sales volumes are greater in the summer months than in the winter. Secondly, much of the sales data fall into the period of the housing bubble and the following housing crisis, in which housing prices nearly doubled between the late 1990s and the mid-2000s, only to crash after the bubble burst around 2007-2008. Sales volumes remained fairly constant until this point, after which they drastically fell to less than half their previous level, only to recover very slowly starting in 2012. As of 2014, price levels are around 50% higher than in the 1990s while sales volumes remain around half the level of the 1990s. For sales prices, there are differences between homes within the light rail corridor and those in the rest of the city in both the average price level and the price trends: Homes within a mile of the light rail are cheaper than those located further away. Furthermore, the housing bubble crash appears to occur about a year earlier in a one mile radius of Hiawatha Avenue than in the rest of the city. Sales volumes observe similar time trends inside and outside the Hiawatha corridor. Comparing trends for homes within the corridor with those located in the rest of South Minneapolis (Figures 3 and 4), the differences become smaller. Comparing homes in the eastern half with those in the western half of the corridor (Figures 5 and 6) we see that submarkets on both sides of Hiawatha Avenue follow similar trends in prices and sales volumes, many more home sales occurring west of Hiawatha Avenue because more homes are located on that side.

Spatial Data

Parcels data come from MetroGIS and represent a snapshot in time of all parcels of land in Hennepin County in April 2014. For each parcel, this dataset contains, among other things, its parcel identification number, its address and spatial location, a description of how it is used, which school district it lies in, which year the structure on the parcel was constructed in as well as estimated market values for April 2014. At this time, Hennepin County was divided into 426,152 parcels of land, out of which 129,425 were in Minneapolis. This dataset is used to obtain the spatial locations of all parcels for further geoprocessing purposes.

Light rail line and station shapefiles also come from MetroGIS, are in GIS shapefile format and represent the spatial locations of the light rail tracks and of all stations. Similarly, MetroGIS supplied GIS polygon shapefiles for lakes, rivers and Minneapolis Neighborhoods. I generate distance and direction variables from the parcels data and light rail GIS shapefiles using ArcGIS' "Near Table" function. This function outputs the straight line distance in meters between each parcel and the closest light rail station as well as which station is closest to any given parcel. By using this same function with all parcels and a shapefile for LRT tracks rather than stations, I obtain the direction the line is from each parcel, allowing us to determine whether a parcel lies to the east or to the west of Hiawatha Avenue.

Further distances are generated to receive distances from each parcel to the closest body of water and to Minneapolis' Central Business District. For the closest body of water, I use shapefiles containing the outlines of lakes and the Mississippi river in

Minnesota. For the Central Business District, defined as Downtown West and Downtown East, I use a shapefile of all Minneapolis neighborhoods. To better represent the relationship between home values and proximity to these features, I additionally create the logarithms and squares of these distances.

Demographic control variables

A series of demographic control variables are drawn from the 1990 and 2000 US Censuses' SF3 files as well as from Environmental Systems Research Institute's proprietary "ESRI 2011/2016 Updated Demographic Data" dataset, which mimics the Census and contains estimates for the years 2011 as well as projections for the year 2016. From these, I draw the percentage of the population that is white, the percentage black, the percentage that is Asian or Pacific Islander, the percentage that is Hispanic, the percentage over the age of 65 and the percentage under the age of 20.

The smallest spatial level of aggregation at which these demographic control variables are available from both the Census and from ESRI's demographic projections is the block group level, one block group containing a population of about 1000 people. Because block group boundaries changed between census years, I assign each parcel to its respective block group for each census year by intersecting boundary shapefiles for each census year with the Hennepin County parcel shapefile. For each variable, the resulting dataset only contains estimates for 1990, 2000, 2011 and projections 2016, all values for years in between are interpolated.

Data characteristics

Merged Dataset

Merging sales, distance, census data and year of construction datasets, and removing duplicates as well as observations with missing variables, I obtain a dataset with a total of 96,641 individual home sales for a total of 49,823 unique parcels, all of which occurred in the time between January 1990 and July 2014. I define homes located within one kilometer (0.62 miles) of Blue Line stations as my treatment group, referring to all other homes in the data as my comparison group.

For the purpose of this analysis, the definition of time periods plays a large role. I divide the dataset into three distinct periods: “Before” refers to sales that occurred between 1990 and January 1998, the date at which funding was approved for the light rail project, the earliest date at which it was certain that the project would be realized. “After” refers to all sales after June 26th, 2004, the day the light rail commenced regular passenger service, and “During” to all sales that occurred in between these periods. I use these time period definitions for my baseline estimates, but conduct substantial robustness tests using alternate “before” and “after” definitions.

The resulting sample sizes are 35,588 sales in the period before light rail announcement starting in 1990, 32,370 during construction and 28,683 from the beginning of operations until July 2014. Out of sales, 10,961 or 11.34 percent occurred within a kilometer of a light rail station and 85,680 or 88.66 percent in the rest of Minneapolis, 26,464 or 27.38 percent of which occurred in the rest of South Minneapolis. Out of the sales within a kilometer of a light rail station, 7,425 or 7.68 percent of the total number of sales occurred to the west of the tracks and 3,536 or 3.66 percent of the total number of sales occurred east of the tracks (Table 1). Four sales occurred within a kilometer to the east of a station but outside of South Minneapolis, none of which are repeat sales.

Looking at the number of unique parcels sold, we see that the 10,961 sales that occurred within a kilometer of LRT stations were distributed across 5766 unique parcels. For the comparison group, 85,680 sales happened for 44,057 unique parcels of land, 13,693 of which are located in the rest of South Minneapolis. On average, each parcel for which there was a sale was sold almost twice, the ratio of parcels to sales is similar in all groups.

The stations with the most sales within a kilometer are 38th Street and 46th Street, the fewest sales occurred close to the Franklin Avenue and VA Center stations (Table 3). This pattern can be explained by the variation in the number of residential parcels located close to each station, fewer homes being located within a one kilometer radius of the southernmost stations.

Conditional Means for all sales

Some trends emerge from at the conditional means for home transaction prices by location and time period (Table 1): Homes in both the eastern and western parts of the corridor sell for around two thirds to three quarters the price of homes in the rest of Minneapolis, and for slightly less than homes in the rest of South Minneapolis. Measured in 2014 dollars, transaction prices in the 2004-2014 period average around twice the value of those between 1990 and 1997.

On both sides of Hiawatha Avenue, sales prices within a kilometer of stations grow relative to those in the rest of both the city and of South Minneapolis. Over the same time period, sales prices in South Minneapolis grew relative to the rest of the city, providing a justification for using this smaller, more similar comparison group in our analysis and thereby reducing bias from concurrent housing market trends left uncontrolled for by my control variables. Sales prices of homes located to the east of the line appreciate more in value between time periods than those in the western part of the corridor: Within a one kilometer radius round LRT stations, homes to the east of the line appreciated by 112.66 percentage points and homes to the west by 104.08 percentage points compared to 1990-1997, as opposed to an appreciation by 93.29 percentage points in the rest of the city or 97.96 percentage points in the rest of South Minneapolis (Table 1). This is opposite to what theory predicts based upon differences in quality of pedestrian access to the light rail station.

Repeat Sales Sample sizes

Restricting the data to only those homes that sold at least twice and merging in all datasets, I obtain a dataset with a total of 74,695 sales observations for a total of 27,877 unique parcels, of which 8,339 sales and 3,144 parcels are located within a kilometer of a light rail station. The comparison group consists of 66,356 sales over 24,733 parcels for the rest of Minneapolis or 20,391 sales over 7,620 parcels restricting the comparison to the rest of South Minneapolis (Table 2). The relative sizes of group and period means are very similar to those for the data presented in Table 1, suggesting that homes sold multiple times do not differ fundamentally from those sold only once. Furthermore, the average number of sales per parcel is almost the same for all groups within each period, and homes located within one kilometer of a station do to sell more often than homes located further away. The distribution between stations is the same as for all sales data (Table 4).

V. Model Specification and Estimation Strategy

Specification of the Dependent Variable

Following the methodology used by Natalie Camplair in her study of the effect of wind turbines on property values (Camplair, 2013), I employ a hedonic sales model on repeat sales data. I define the property value of property *i* in census block group *j* at the time *t* as a function of the structural characteristics of property *i* such as its size, age and features, the demographic characteristics of census block group *j* at the time *t*, and time characteristics of the time *t*, which I capture by using dummy variables. Rather than control for time-invariant property and location characteristics with structural data, I difference them out in running all regressions as fixed effects models, effectively including a dummy variable for each property *i*. Because my dependent variable is the logarithm of home sale prices in 2014 dollars, we can interpret all results as percent changes in home values.

Model specification

Control for city-wide trends using difference in difference estimation

I distinguish between three types of price shocks: global, local and corridor-specific. Global shocks are changes in property values that are common to both treatment and control groups. These are mostly responses to overall economic conditions, an example being a change in mortgage terms. Local shocks occur at smaller scales, reflecting changes in local economic conditions and demographics and can be controlled for by including a vector of demographic control variables. Lastly, corridor-specific changes are unique to the Hiawatha corridor and include the introduction of the Blue Line LRT. Global shocks can be controlled for using a difference-in-difference approach: By subtracting the change in prices over time for the entire sample from the concurrent change in prices for homes in the corridor, I control for all global shocks to the market for single-family homes.

Simple hedonic model

Starting with a hedonic model, I define the price *P* of home i in neighborhood *j* at time *t* as a function of a vector of home characteristics H, a vector of neighborhood characteristics *V*, a measure for whether home *i* is located close to a station or not, the time *t* and the interaction between the proximity and the time *t*. Such a model would be specified as shown in equation (1), The coefficient on the interaction term can be interpreted as the percent change in home values attributable to the introduction of the light rail line:

$$\ln P_{i,j,t} = \alpha_0 + \beta_1 H_i + \beta_2 V_{j,t} + \beta_2 LRT_i + \beta_3 Time_t + \beta_4 LRT_i * Time_t + \varepsilon_{i,j,t} \quad (1)$$

LRT can be either a binary measure for station proximity or a continuous measure of distance, allowing us to estimate both the effect on an average home located within walking distance and the spatial distribution of LRT premiums within neighborhoods respectively.

Repeat hedonic model

A possible source of differences in home sales prices between time periods not controlled for by a hedonic model would be a change in which houses are being sold, resulting in inherently different sample populations of home sales between periods. I address this using a repeat sales model: Rather than comparing all home sales occurring in a given period with a baseline, we only look at homes that were sold once or more in at least two periods. In doing so, we ensure that the sales are for the same set of homes both before and after light rail construction. So long as the availability of light rail is the only attribute of a home that has changed, this method also does away with the need for home characteristics as these are differenced out when looking only at the change in prices within a home from period to period. In doing this, I greatly reduce the risk of omitted variable bias, at the risk of introducing bias from fundamental differences in characteristics between the homes that sold at least twice and those that were only sold once. Because a repeat sales model looks at change rather than at a snapshot in time, I replace neighborhood characteristics with their change between the two points in time at which sales occurred. Such a model would be constructed as follows:

$$(\ln P_{i,j,t} - \ln P_{i,j,t-1}) = \alpha_0 + \beta_1 LRT_i * Time_t + \beta_2 (V_{j,t} - V_{j,t-1}) + \varepsilon_{i,j,t} - \varepsilon_{i,j,t-1} \tag{2}$$

Difference between neighborhoods east and west of Hiawatha Corridor

To estimate the difference in light rail premiums between the two sides, I include the interaction term between a home being located to the east of the line and its distance from the nearest station. The following equation allows the estimation of premiums commanded by properties close to stations of the METRO Blue Line relative to the comparison group as a function of how close to and on which side of a station they are located:

$$(\ln P_{i,j,t} - \ln P_{i,j,t-1}) = \alpha_0 + \beta_1 LRT_i * Time_t + \beta_2 Eastside_i * LRT_i * Time_t + \beta_4(V_{j,t} - V_{j,t-1}) + \varepsilon_{i,j,t} - \varepsilon_{i,j,t-1} \quad (3)$$

Difference between stations

To gain a more nuanced understanding of how light rail premiums are distributed across space, I estimate premiums separately for different stations. For this, I add a variable representing which station is the closest to a property *i* to the interaction term between proximity and time period as well as to the interaction term between proximity, period and side. Equation (4) allows us to estimate the premium home buyers are willing to pay to enjoy access to a station of the METRO Blue Line as a function of how close to and on which side of their respective station they live:

$$(\ln P_{i,j,t} - \ln P_{i,j,t-1}) = \alpha_0 + \beta_1 LRT_i * Station_i * Time_t + \beta_2 Eastside_i * Station_i * LRT_i * Time_t + \beta_4(V_{j,t} - V_{j,t-1}) + \varepsilon_{i,j,t} - \varepsilon_{i,j,t-1} \quad (4)$$

Specifications for Empirical estimation

Building off the model built in the prior section, this section outlines specifications I use for estimation, numbers corresponding with specification numbers in tables. The simplest specification I run is as follows:

$$\ln P_{ijt} = \alpha + \beta_1 * Year_t + \beta_2 * Month_t + \beta_3 * Construction_t + \beta_4 * Service_t + \beta_5 * Construction_t * LRT_i + \beta_6 * Service_t * LRT_i + \varepsilon_{itj} \quad (1)$$

This specification can be expanded by incorporating information for which side of Hiawatha Avenue a given parcel lies on. To do this, I replace the LRT_i dummy with two dummy variables, representing whether property *i* lies east or west of the tracks:

$$\ln P_{ijt} = \alpha + \beta_1 * Year_t + \beta_2 * Month_t + \beta_3 * Construction_t + \beta_4 * Service_t + \beta_5 * Construction_t * LRTEast_i + \beta_6 * Service_t * LRTEast_i + \beta_7 * Construction_t * LRTWest_i + \beta_8 * Service_t * LRTWest_i + \varepsilon_{itj} \quad (2)$$

I include time dummy variables for each month to account for seasonality and for each year to control for changes in the overall price level. The proximity variable LRT_i is either a dummy indicator for whether a property lies within a kilometer of a station, or a vector of distance, the logarithm of distance, and distance squared between a property and its nearest LRT station. The contribution from the light rail is in the parameters β_4 for 1998-2004 and β_5 for later years, the coefficients on the interaction term between the measurement of proximity and a dummy for whether the light rail was under unannounced, under construction or in regular service at the time *t*.

To account for changes of neighborhood characteristics over time other than the introduction of the Blue Line LRT, I expand on specifications (1) and (2) by including a vector D_{jt} of demographic control variables for each census block group *j* at the time *t* for each property *i*. Specification (3) does this for a simple one kilometer buffer, Specification (4) separately by side of Hiawatha Avenue.

$$\ln P_{ijt} = \alpha + \beta_1 * Year_t + \beta_2 * Month_t + \beta_3 * Construction_t + \beta_4 * Service_t + \beta_5 * Construction_t * LRT_i + \beta_6 * Service_t * LRT_i + \beta_7 * D_{jt} + \varepsilon_{itj} \quad (3)$$

$$\ln P_{ijt} = \alpha + \beta_1 * Year_t + \beta_2 * Month_t + \beta_3 * Construction_t + \beta_4 * Service_t + \beta_5 * Construction_t * LRTEast_i + \beta_6 * Service_t * LRTEast_i + \beta_7 * Construction_t * LRTWest_i + \beta_8 * Service_t * LRTWest_i + \beta_9 * D_{jt} + \varepsilon_{itj} \quad (4)$$

Mapping out the residuals from this specification revealed that while location characteristics such as the distance a parcel lies from the central business district or from the nearest body of water do not change over time, preferences with regards to such characteristics do appear to have changed over time. To control for these trends, I expand on specifications (3) and (4) by adding an interaction term between time periods and a vector L_i of the distances, logarithms of distances and squared distances between property i and both downtown Minneapolis and the nearest body of water, a body of water being either the Mississippi river or the nearest lake. This leads us to my preferred specifications, specification (5) estimating the size of the LRT premium for homes within a one kilometer radius of stations:

$$\ln P_{ijt} = \alpha + \beta_1 * Year_t + \beta_2 * Month_t + \beta_3 * Construction_t + \beta_4 * Service_t + \beta_5 * Construction_t * LRT_i + \beta_6 * Service_t * LRT_i + \beta_7 * D_{jt} + \beta_{10} * L_i * Service_t + \beta_{11} * L_i * Construction_t + \varepsilon_{itj} \quad (5)$$

Specification (6) performs the same analysis separately for homes on each side of the tracks:

$$\ln P_{ijt} = \alpha + \beta_1 * Year_t + \beta_2 * Month_t + \beta_3 * Construction_t + \beta_4 * Service_t + \beta_5 * Construction_t * LRTEast_i + \beta_6 * Service_t * LRTEast_i + \beta_7 * Construction_t * LRTWest_i + \beta_8 * Service_t * LRTWest_i + \beta_9 * D_{jt} + \beta_{10} * L_i * Service_t + \beta_{11} * L_i * Construction_t + \varepsilon_{itj} \quad (6)$$

All findings discussed in the remainder of this paper are results from specifications (5) and (6) or variations thereof.

VI. Empirical Results and Robustness

In all specifications, I control for logged median household income, the share of the population that is white, the share that is black, the share that is Asian or Pacific Islander, the share that is Native American, the share that is Hispanic or Latino, the share that identifies as another race, the share that is under the age of 20, and the share that is over the age of 65. To address potential spatial correlation of the error term from these control variables being reported at an aggregated scale (Moulton 1990), I report clustered standard errors, clustered by 2010 census block group boundaries.

For the preferred specification (5), we find that the value for homes within a kilometer of light rail stations increases by 1.42 percent relative to those outside a one kilometer radius in the period after June 2004 relative to 1990-1997, and by 1.29 percent in the period between 1998 and June 2004 relative to 1990-1997 (see Table 5). Neither of these findings, however, is statistically significant.

Splitting the treatment group into homes east and west of Hiawatha Avenue, we find effects that are counter to what theory predicts: Relative to the rest of South Minneapolis, homes within a kilometer of a station that lie to the west of the Hiawatha corridor appreciate by 0.90 percent after the introduction of light rail service. For homes within a kilometer of a station to the east of Hiawatha Avenue we find a larger effect, their values appreciating by 2.65 percent for the same time period. Again, neither coefficient is statistically significant. For the period between the announcement and the opening of the line, the corresponding values are a statistically insignificant 0.69 percent for the West and 2.70 percent for the East, statistically significant at the five percent level (see Table 6). Mapping residuals, we do see some clustering of residuals, however it does not appear to be spatially correlated with distance from LRT stations (Map 13).

Replacing the corridor membership dummy variable with a vector of distance measures containing the distance, the square of the distance, and the logarithm of the distance from the nearest LRT station located in our study area, we receive no statistically significant individual coefficients for any period in specification (5). With specification (6), we receive statistically significant coefficients for the interaction terms between distance, east side and both construction and service periods (Table 7). However, the confidence intervals for all linear combinations of distance variables contain zero (Table 8).

VII. Robustness

Results with different comparison groups

To test whether findings are influenced by the choice of comparison group, I re-run specifications (5) and (6) using sales from the entire rest of Minneapolis rather than just those in South Minneapolis.

This time, for specification (5) we find that the values for homes within a kilometer of light rail stations increase by 4.29 percent relative to those outside a one kilometer radius in the period after June 2004 relative to 1990-1997, and by 2.15 percent in the period between 1998 and June 2004 relative to 1990-1997 (see Table 9). The coefficient for the service period is statistically significant at the one percent level, whereas the coefficient for the construction period is statistically significant at the five percent level.

Splitting the treatment group into homes east and west of Hiawatha Avenue, we find the same trend as with the prior comparison group: Relative to the rest of the city, homes west of the Hiawatha corridor within a kilometer of a station appreciate by 3.47 percent after the introduction of light rail service, statistically significant at the five percent level. For homes to the east of Hiawatha Avenue within a kilometer of a station we find a larger coefficient 6.01 percent for the same time period, significant at the one percent level. For the period between the announcement and the opening of the line, the corresponding values are 1.68 percent for the West and 3.12 percent, statistically insignificant and significant at the five percent level respectively (Table 10).

Mapping the residuals from running specification (5) with the entire city as a control group, we see that the largest residuals, both positive and negative, are strongly clustered, and that they are clustered outside of South Minneapolis (Map 14). Furthermore, the conditional means presented in tables 1 and 2 show that South Minneapolis sale prices developed differently from those in the rest of Minneapolis[1]. For these reasons, I argue that restricting the dataset to homes located in the area south of Interstate 94 and east of Interstate 35W produces more reliable results as it removes distortion resulting from the inclusion of the home sales the most dissimilar from those in the treatment group.

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[1] Running an alternate version of specification (5) in which the treatment defined as a parcel being in South Minneapolis versus a comparison of all of Minneapolis reveals that all homes in South Minneapolis appreciated relative to the rest of Minneapolis over the period covered by the data.

Reducing the comparison group to homes located at a distance of between one and two kilometers from the nearest LRT station, I find similar results to the results for the rest of South Minneapolis as the comparison group. None of the coefficients for the interaction between period and corridor membership are statistically significant (Tables 9 and 10).

Influence of Corridor Size

To see whether my findings are influenced by my somewhat arbitrary choice of one kilometer as the size of the "light rail corridor", I re-run my preferred specifications for two further station area radiuses that are common in the literature, those being half a mile and a full mile. As is shown in Tables 11 and 12, the magnitude and statistical significance of the LRT Premium vary between different definitions of Light Rail Corridor, but only for the construction period. For the Service period, all results are close to zero and not statistically significant regardless of size.

Data start and end years

To see whether the choice of start and end years of my data influences the sign and size of the LRT premium, I re-run the preferred specifications trimming my data to start in each of the possible start years between 1990 and 1997 combined with each possible end year between 2004 and 2014.

In Table 13, we see the coefficient for the interaction term between the one kilometer dummy and the service period. The main finding of this study as well as figures corresponding to the combinations of start and end years for the data used by Kent and Parilla (2008) and by Goetz (2010) are bolded. We see that the estimates for the size of the LRT premium for the service period vary considerably depending on the years the data start and end in. I obtain positive and statistically significant coefficients for year combinations corresponding to the data available to prior studies, however, all estimates with larger sample sizes for the after period are positive but small and statistically insignificant or marginally significant. For specification (6), we observe a similar pattern in Tables 14 and 15: While estimates vary somewhat in magnitude, all estimates are very small and generally statistically significant for the west side. Estimates for homes to the east of Hiawatha Avenue are smaller than those for homes to the west for the time coverages of prior studies, this relationship disappears employing larger amounts of data covering the LRT service period.

Lastly, I test how assuming different announcement dates in our analysis changes our results, re-running specification (5) for eight different cutoff dates between the "before" and "during" periods, for the three data coverage periods of this study, Kent and Parilla (2008), and Goetz (2015). I find that the choice of announcement date does influence results, however, using data covering the entire time from 1990 to 2014, all announcement dates but January 1999 yield statistically insignificant coefficients for the service period (Table 16).

Concluding robustness checks, I find my results to be fairly robustly small and statistically insignificant for all theoretically sound regressions run on data covering the entire span of time available. While findings may be positive and statistically significant using all of Minneapolis as a comparison group rather than restricting the data to South Minneapolis, this is less good a fit, causing bias from including irrelevant observations. Similarly, it is possible to obtain positive and statistically significant estimates by modifying the definition of the construction period, however this goes against our knowledge that the line as effectively “announced” in the year 1998 and not at a later point in time.

Spatial Distribution of LRT Premiums

Breaking down the Hiawatha light rail corridor’s surroundings into five 250-meter rings surrounding stations, I gather estimates for where within South Minneapolis the appreciation of home values occurred. Looking at the change in home sales prices for both sides of the corridor together, the effects of the Light Rail on home values appear to be strongest close to the LRT rail, decreasing with distance. As is evident from the coefficients presented in Table 17, most of the gains in home values occurred East of Hiawatha Avenue between a distance of 0 and 500 meters from stations. This may be in part due to concurrent developments that occurred in the same area on a similar timeframe: Firstly, industrial activity in the industrial tracts located directly to the east of Hiawatha Avenue. Secondly, Minnehaha Avenue, a street that underwent other significant development, runs parallel to the LRT 300 meters to the East, and even closer toward the southern end of the study area. These other changes to the area call into question the ability to attribute the gains in home values in this subsection of the study area to the introduction of LRT service. Given this caveat, my findings for homes to the west of the LRT corridor may be better representations of the changes in home values caused by the introduction of LRT service.

Breaking down the treatment group into which station each property is closest to, we again observe significant heterogeneity (Table 18). Stations to the southern end of the corridor fairly consistently exhibit positive, statistically significant premiums, while stations toward the north end of my study area do not. These premiums however are driven largely by a tiny sample of homes located to the east side, only the 46^{th} Street and 50^{th} Street stations have statistically significant positive results for homes located to the west, their magnitudes being 2.62 and 2.89 percentage points respectively. The coefficients for the northernmost station of the study area, Franklin Avenue, are the largest, at -15.2 percentage points for homes located to the east and 12.5 percentage points for homes located to the west, both statistically significant, this again possibly being the result of a small sample sizes (Tables 3 and 4) and potential concurrent trends left uncontrolled for.

VII. Conclusion

My analysis allows the conclusion that the introduction of the Metro Blue Line did not have clear, consistent, permanent, statistically significant effects on home values in its corridor: Results are mostly very small or statistically insignificant, and are spatially heterogeneous. Where they are positive, there are often concurrent trends that make it difficult to attribute increases in home values to the Blue Line LRT. This gives us reason to believe that the value of the average home within a one kilometer radius of a station did not change relative to the rest of South Minneapolis, counter to the findings of Kent and Parilla (2008) or Goetz (2010). These findings do not mean that the Blue Line LRT had no effect on property values in the entire city: As is suggested by Billings (2011), LRT premiums might be larger for condominiums and multi-family housing, which I do not include in this study.

Regarding the spatial distribution of these price appreciations, this analysis suggests some appreciation may have happened among homes to the east of Hiawatha Avenue, counter to the theoretical prediction suggesting that homes to the west of the line would appreciate more due to better pedestrian access. This however is possibly the result of concurrent developments to the east of Hiawatha Avenue such as the decline of industrial activity and the redevelopment of Minnehaha Avenue, both of which would lead home values to increase. Given this, the estimate for homes west of Hiawatha Avenue may be closer to the change in home values attributable to the introduction of the Metro Blue Line to the Hiawatha Corridor – or lack thereof. Most importantly however, both the signs and magnitudes of the LRT premium estimates differ with regards to the data being cut off at different years and with regards to when we define the Blue Line as being "announced": I am able to obtain similar estimates to previous studies when limiting my data to the same end years, and obtain larger estimates for homes located west of Hiawatha Avenue imposing time-restrictions on my data. This raises the important question whether the findings of similar studies are similarly influenced by which years of data were available, and whether LRT premiums may have been a temporary phenomenon in Minneapoli.

Further research could be undertaken by expanding upon this analysis with the inclusion of structural characteristics or building permits to control for changes to homes. With data on structural characteristics, it would be possible to use propensity score matching to compare price developments for homes within the Hiawatha corridor with a comparison group that is similar on more grounds than mere geographical proximity. Building permits data could also be used to see whether the introduction of light rail service led to an increase in remodeling activity in the corridor. This could be estimated using the number and monetary value of building permit applications for homes in close proximity of light rail stations.

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Appendix

Table 1: Summary Statistics for all sales data by group and period

	Treatment group		Comparison group	
	1km East	1km West	S Minneapolis	All Minneapolis
Conditional Means				
Before (01/1990-12/1997)				
Mean Price (2014$)	$106,548.29	$107,081.61	$132,072.49	$156,450.56
Standard Deviation	$33,230.00	$35,402.59	$54,551.59	$126,758.73
n (sales)	1329	2601	9911	31658
n (parcels)	1100	2134	7983	25276
During (01/1998-06/2004)				
Mean Price (2014$)	$186,642.40	$178,192.61	$213,568.63	$237,063.55
Standard Deviation	$59,121.49	$63,363.65	$86,609.48	$180,945.66
n (sales)	1151	2594	8691	28625
n (parcels)	905	2011	6866	22443
After (07/2004-07/2014)				
Mean Price (2014$)	$226,116.36	$218,532.04	$260,521.57	$302,407.17
Standard Deviation	$64,137.37	$61,439.03	$97,487.42	$235,900.99
n (sales)	1056	2230	7862	25397
n (parcels)	877	1852	6465	20663
All (01/1990-07/2014)				
Mean Price (2014$)	$168,497.01	$165,397.62	$196,996.52	$226,646.72
Standard Deviation	$73,367.73	$71,213.04	$96,273.63	$192,167.54
n (sales)	3536	7425	26464	85680
n (parcels)	1896	3870	13693	44057
Appreciation				
After/Before	112.22%	104.08%	97.26%	93.29%
over S MPLS	115.39%	107.02%	-	-
over all MPLS	120.29%	111.56%	104.25%	-
During/Before	75.17%	66.41%	61.71%	51.53%
over S MPLS	121.82%	107.62%	-	-
over all MPLS	145.89%	128.88%	119.76%	-

Table 2: Summary Statistics for repeat sales data by group and period

	Treatment group		Comparison group	
	1km East	1km West	S Minneapolis	All Minneapolis
Conditional Means				
Before (01/1990-12/1997)				
Mean Price (2014$)	$106,912.30	$105,744.33	$130,845.47	$156,779.10
Standard Deviation	$34,822.72	$32,216.16	$52,376.74	$128,805.44
n (sales)	903	1897	7199	23349
n (parcels)	675	1430	5271	16967
During (01/1998-06/2004)				
Mean Price (2014$)	$187,550.03	$178,858.50	$213,988.16	$238,983.72
Standard Deviation	$59,278.86	$62,295.62	$84,037.68	$182,232.27
n (sales)	945	2104	7085	23316
n (parcels)	699	1521	5260	17134
After (07/2004-07/2014)				
Mean Price (2014$)	$228,086.36	$221,572.84	$263,929.24	$308,800.41
Standard Deviation	$61,742.91	$60,695.60	$96,757.45	$241,137.43
n (sales)	800	1690	6107	19691
n (parcels)	624	1312	4710	14957
All (01/1990-07/2014)				
Mean Price (2014$)	$172,298.22	$167,171.57	$199,591.90	$230,775.94
Standard Deviation	$72,796.20	$71,141.97	$95,947.93	$196,259.00
n (sales)	2648	5691	20391	66356
n (parcels)	1008	2136	7620	24733
Appreciation				
After/Before	113.34%	109.54%	101.71%	96.97%
over S MPLS	111.43%	107.69%	-	-
over all MPLS	116.89%	112.96%	104.89%	-
During/Before	75.42%	69.14%	63.54%	52.43%
over S MPLS	118.70%	108.81%	-	-
over all MPLS	143.85%	131.87%	121.19%	-

Table 3: Number of sales in corridor by closest station and period, all sales

Station	01/1990-12/1997	01/1998-06/2004	07/2004-07/2014	**Total**
38thSt	1,346	1,223	1,061	3,630
46thSt	1,046	927	865	2,838
50thSt	534	492	474	1,500
Franklin	195	250	186	631
Lake	452	473	359	1,284
VA	357	380	341	1,078
Total	**3,930**	**3,745**	**3,286**	**10,961**

Table 4: Number of sales in corridor by closest station and period, repeat sales only

Name	01/1990-12/1997	01/1998-06/2004	07/2004-07/2014	Total
38thSt	956	994	820	2,770
46thSt	723	763	651	2,137
50thSt	400	408	360	1,168
Franklin	142	203	142	487
Lake	315	369	269	953
VA	264	312	248	824
Total	**2,800**	**3,049**	**2,490**	**8,339**

Table 5: Coefficients on Log Deflated Sales Prices, 1km Buffer versus South Minneapolis, relative to 1990-1997

Specification:	(1)	(3)	(5)
After * 1km	0.0120	0.0182	0.0142
	(0.0169)	(0.0134)	(0.0121)
During * 1km	0.0119	0.0156	0.0129
	(0.0122)	(0.00988)	(0.00913)
After	0.607***	0.536***	-0.0300
	(0.0213)	(0.0257)	(1.577)
During	0.580***	0.511***	-2.263*
	(0.0227)	(0.0270)	(1.235)
Percent Black		-0.429***	-0.484***
		(0.114)	(0.123)
Percent American Indian		-0.683***	-0.386*
		(0.236)	(0.221)
Percent Asian or Pacific Islander		-0.0230	0.0100
		(0.330)	(0.306)
Percent Other Race		0.593*	0.00256
		(0.351)	(0.353)
Percent Hispanic		0.487***	0.156
		(0.121)	(0.114)
Percent Under 20		-0.214	0.00623
		(0.187)	(0.187)
Percent Over 65		0.304*	0.202
		(0.163)	(0.123)
Log Median Income		0.0311	0.0339
		(0.0359)	(0.0326)
Constant	11.61***	11.33***	11.26***
	(0.0104)	(0.407)	(0.373)
Sale Year and Month	X	X	X
Distance from Water			X
Distance from CBD			X
Number of sales	28,730	28,730	28,730
R-squared	0.751	0.756	0.759
Number of blockgroups	125	125	125
Number of parcels	10,764	10,764	10,764

*Standard errors clustered by 2011 blockgroups in parentheses, *** p<0.01, ** p<0.05, * p<0.1*

Table 6: Coefficients on Log Deflated Sales Prices, 1km by side versus South Minneapolis, relative to 1990-1997

Specification:	(2)	(4)	(6)
After * 1km West	0.00302	0.00388	0.00904
	(0.0198)	(0.0156)	(0.0139)
After * 1km East	0.0308*	0.0512***	0.0265
	(0.0175)	(0.0155)	(0.0170)
During * 1km West	0.00124	0.00352	0.00686
	(0.0133)	(0.0115)	(0.0105)
During * 1km East	0.0347**	0.0427***	0.0270**
	(0.0149)	(0.0123)	(0.0136)
After	0.607***	0.536***	-0.0633
	(0.0213)	(0.0258)	(1.596)
During	0.581***	0.511***	-2.287*
	(0.0226)	(0.0271)	(1.263)
Percent Black		-0.443***	-0.492***
		(0.114)	(0.125)
Percent American Indian		-0.712***	-0.399*
		(0.234)	(0.221)
Percent Asian or Pac. Islander		0.00138	0.0213
		(0.327)	(0.304)
Percent Other Race		0.551	0.00497
		(0.353)	(0.352)
Percent Hispanic		0.494***	0.159
		(0.118)	(0.113)
Percent Under 20		-0.183	0.0163
		(0.185)	(0.186)
Percent Over 65		0.261	0.189
		(0.174)	(0.130)
Log Median Income		0.0340	0.0342
		(0.0351)	(0.0323)
Constant	11.61***	11.30***	11.26***
	(0.0103)	(0.398)	(0.370)
Sale Year and Month	X	X	X
Distances from Water and CBD			X
Number of sales	28,730	28,730	28,730
R-squared	0.751	0.756	0.759
Number of Blockgroups	125	125	125
Number of parcels	10,764	10,764	10,764

*Standard errors clustered by 2011 blockgroups in parentheses, *** p<0.01, ** p<0.05, * p<0.1*

Table 7: Coefficients on Log Deflated Sales Prices by Distance versus South Minneapolis, relative to 1990-1997

Specification:	(5)	(6)
After * distance	6.75e-05	5.12e-05
	(6.60e-05)	(6.99e-05)
After * log distance	-0.0514	-0.0365
	(0.0567)	(0.0538)
After * distance^2	-8.58e-09	-4.67e-09
	(7.72e-09)	(9.56e-09)
After * east * distance	-	-9.68e-05**
		(4.55e-05)
After * east * log distance	-	0.0141**
		(0.00627)
After * east * distance^2	-	1.13e-08
		(8.34e-09)
During * distance	4.69e-05	6.25e-05
	(4.61e-05)	(5.07e-05)
During * log distance	-0.0308	-0.0329
	(0.0347)	(0.0330)
During * distance^2	-8.33e-09	-1.03e-08
	(5.85e-09)	(7.34e-09)
During * east * distance	-	-0.000100**
		(4.01e-05)
During * east * log distance	-	0.0136**
		(0.00543)
During * east * distance^2	-	1.48e-08*
		(7.58e-09)
After	0.131	-1.319
	(1.566)	(1.717)
During	-2.227*	-2.935**
	(1.226)	(1.405)
Constant	11.19***	11.14***
	(0.379)	(0.375)
Sale Year and Month	X	X
Demographic Control Variables	X	X
Distances from Water and CBD	X	X
Number of sales	28,730	28,730
R-squared	0.759	0.760
Number of blockgroups	125	125

Number of parcels	10,764	10,764

*Standard errors clustered by 2011 blockgroups in parentheses, *** p<0.01, ** p<0.05, * p<0.1*

Table 8: Linear Combinations of Distance, Log Distance and Distance Squared on Log Deflated Sales Prices

After	Estimate	Standard Error	t-Score	Confidence Interval	
(5)					
Distance	-0.0514	0.0566	-0.91	-0.1634	0.0606
(6)					
Distance West	-0.0364	0.0537	-0.68	-0.1427	0.0699
Distance East	-0.0224	0.0542	-0.41	-0.1297	0.0849

During	Estimate	Standard Error	t-Score	Confidence Interval	
(5)					
Distance	-0.0307	0.0346	-0.89	-0.0993	0.0379
(6)					
Distance West	-0.0329	0.0329	-1.00	-0.0981	0.0324
Distance East	-0.0193	0.0317	-0.61	-0.0820	0.0434

Table 9: Coefficients on Log Deflated Sales Prices for Specification (5) by comparison Group, relative to 1990-1997

Comparison:	All Minneapolis	South Minneapolis	1000-1999 Meters
After * 1km	0.0429***	0.0142	0.0128
	(0.0125)	(0.0121)	(0.0137)
During * 1km	0.0215**	0.0129	-0.00117
	(0.0105)	(0.00913)	(0.00976)
After	-0.789	-0.0300	Omitted
	(0.749)	(1.577)	
During	-1.804***	-2.263*	-1.569
	(0.637)	(1.235)	(0.947)
Percent Black	-0.686***	-0.484***	-0.286*
	(0.0799)	(0.123)	(0.152)
Percent American Indian	-0.907***	-0.386*	-0.606**
	(0.209)	(0.221)	(0.249)
Percent Asian or Pacific Islander	-0.601***	0.0100	-0.126
	(0.159)	(0.306)	(0.371)
Percent Other Race	-0.166	0.00256	0.140
	(0.332)	(0.353)	(0.403)
Percent Hispanic	-0.0415	0.156	0.0426
	(0.0987)	(0.114)	(0.111)
Percent Under 20	0.915***	0.00623	-0.238
	(0.147)	(0.187)	(0.224)
Percent Over 65	0.423***	0.202	0.0286
	(0.108)	(0.123)	(0.115)
Log Median Income	0.0729***	0.0339	0.0207
	(0.0257)	(0.0326)	(0.0368)
Constant	10.73***	11.26***	11.40***
	(0.290)	(0.373)	(0.413)
Sale Year and Month	X	X	X
Distance from Water			X
Distance from CBD			X
Number of sales	74,695	28,730	17,098
R-squared	0.726	0.759	0.764
Number of blockgroups	351	125	100
Number of parcels	27,877	10,764	6,492

*Standard errors clustered by 2011 blockgroups in parentheses, *** p<0.01, ** p<0.05, * p<0.1*

Table 10: Coefficients on Log Deflated Sales Prices for Specification (6) by comparison Group, relative to 1990-1997

Comparison:	All Minneapolis	South Minneapolis	1000-1999 Meters
After * 1km West	0.0347**	0.00904	0.00866
	(0.0146)	(0.0139)	(0.0142)
After * 1km East	0.0601***	0.0265	0.0258
	(0.0172)	(0.0170)	(0.0213)
During * 1km West	0.0168	0.00686	-0.00623
	(0.0132)	(0.0105)	(0.0102)
During * 1km East	0.0312**	0.0270**	0.0142
	(0.0130)	(0.0136)	(0.0157)
After	-0.807	-0.0633	Omitted
	(0.752)	(1.596)	
During	-1.813***	-2.287*	-1.560
	(0.639)	(1.263)	(0.951)
Percent Black	-0.688***	-0.492***	-0.292*
	(0.0799)	(0.125)	(0.154)
Percent American Indian	-0.918***	-0.399*	-0.613**
	(0.208)	(0.221)	(0.249)
Percent Asian or Pac. Islander	-0.598***	0.0213	-0.125
	(0.159)	(0.304)	(0.369)
Percent Other Race	-0.169	0.00497	0.138
	(0.331)	(0.352)	(0.405)
Percent Hispanic	-0.0368	0.159	0.0477
	(0.0977)	(0.113)	(0.110)
Percent Under 20	0.919***	0.0163	-0.225
	(0.147)	(0.186)	(0.225)
Percent Over 65	0.416***	0.189	0.0112
	(0.109)	(0.130)	(0.120)
Log Median Income	0.0734***	0.0342	0.0215
	(0.0257)	(0.0323)	(0.0368)
Constant	10.72***	11.26***	11.39***
	(0.290)	(0.370)	(0.413)
Sale Year and Month	X	X	X
Distances from Water and CBD	X	X	X
Number of sales	74,695	28,730	17,098
R-squared	0.726	0.759	0.764
Number of blockgroups	351	125	100
Number of parcels	27,877	10,764	6,492

*Standard errors clustered by 2011 blockgroups in parentheses, *** p<0.01, ** p<0.05, * p<0.1*

Table 11: Coefficients on Log Deflated Sales Prices for Specification (5) by corridor size, relative to 1990-1997, South Minneapolis only

Corridor:	One Mile	One Kilometer	Half Mile
After * Corridor	-0.00473	0.0142	0.0111
	(0.0119)	(0.0121)	(0.0137)
During * Corridor	0.00741	0.0129	0.0176*
	(0.00903)	(0.00913)	(0.00991)
After	0.141	-0.0300	-0.0193
	(1.578)	(1.576)	(1.583)
During	-2.172*	-2.263*	-2.273*
	(1.235)	(1.234)	(1.234)
Percent Black	-0.442***	-0.484***	-0.477***
	(0.122)	(0.123)	(0.125)
Percent American Indian	-0.365	-0.386*	-0.407*
	(0.222)	(0.220)	(0.222)
Percent Asian or Pacific Islander	0.0566	0.0100	0.0284
	(0.307)	(0.306)	(0.305)
Percent Other Race	0.0285	0.00256	-0.00520
	(0.354)	(0.353)	(0.352)
Percent Hispanic	0.177	0.156	0.155
	(0.116)	(0.114)	(0.114)
Percent Under 20	-0.0649	0.00623	-0.0208
	(0.182)	(0.187)	(0.183)
Percent Over 65	0.203*	0.202	0.203*
	(0.123)	(0.123)	(0.121)
Log Median Income	0.0368	0.0339	0.0335
	(0.0326)	(0.0326)	(0.0328)
Constant	11.24***	11.26***	11.27***
	(0.374)	(0.372)	(0.374)
Sale Year and Month	X	X	X
Distance from Water	X	X	X
Distance from CBD	X	X	X
Number of sales	28,730	28,730	28,730
R-squared	0.759	0.759	0.759
Number of blockgroups	125	125	125
Number of parcels	10,764	10,764	10,764

*Standard errors clustered by 2011 blockgroups in parentheses, *** p<0.01, ** p<0.05, * p<0.1*

Table 12: Coefficients on Log Deflated Sales Prices for Specification (6) by corridor size, relative to 1990-1997, South Minneapolis only

Corridor:	One Mile	One Kilometer	Half Mile
After * Corridor West	-0.00834	0.00904	0.00695
	(0.0125)	(0.0139)	(0.0163)
After * Corridor East	0.00315	0.0265	0.0209
	(0.0167)	(0.0170)	(0.0182)
During * Corridor West	0.00515	0.00686	0.0145
	(0.00932)	(0.0105)	(0.0120)
During * Corridor East	0.0122	0.0270**	0.0249*
	(0.0130)	(0.0136)	(0.0139)
After	0.201	-0.0633	-0.0606
	(1.589)	(1.596)	(1.585)
During	-2.139*	-2.287*	-2.295*
	(1.247)	(1.263)	(1.243)
Percent Black	-0.445***	-0.492***	-0.481***
	(0.123)	(0.125)	(0.126)
Percent American Indian	-0.369*	-0.399*	-0.412*
	(0.223)	(0.221)	(0.222)
Percent Asian or Pac. Islander	0.0627	0.0213	0.0332
	(0.306)	(0.304)	(0.304)
Percent Other Race	0.0311	0.00497	-0.00721
	(0.354)	(0.352)	(0.351)
Percent Hispanic	0.192*	0.159	0.156
	(0.114)	(0.113)	(0.113)
Percent Under 20	-0.0633	0.0163	-0.0148
	(0.181)	(0.186)	(0.182)
Percent Over 65	0.193	0.189	0.201
	(0.126)	(0.130)	(0.122)
Log Median Income	0.0377	0.0342	0.0342
	(0.0324)	(0.0323)	(0.0327)
Constant	11.23***	11.26***	11.26***
	(0.371)	(0.370)	(0.372)
Sale Year and Month	X	X	X
Distances from Water and CBD	X	X	X
Distance from CBD	X	X	X
Number of sales	28,730	28,730	28,730
R-squared	0.759	0.759	0.759
Number of Blockgroups	125	125	125
Number of parcels	10,764	10,764	10,764

*Standard errors clustered by 2011 blockgroups in parentheses, *** p<0.01, ** p<0.05, * p<0.1*

Table 13: Coefficients for the Service Period in Specification, Announcement in 01/98 (5)

	1990	1991	1992	1993	1994	1995	1996	1997
2004	0.0290	0.0388	0.0481*	0.0526*	0.0417	0.0369	0.0416	0.0477
2005	0.0363**	0.0400**	0.0472**	0.0474**	0.0402*	0.0312	0.0407*	0.0407
2006	0.0335**	0.0353**	0.0426***	0.0461***	0.0385**	0.0293	0.0381*	**0.0446****
2007	0.0307**	0.0329**	0.0373***	0.0406***	0.0325**	0.0258	0.0329*	**0.0375***
2008	0.0276**	0.0295**	0.0333**	0.0370**	0.0304*	0.0234	0.0321*	0.0346*
2009	0.0248**	0.0259**	0.0295**	0.0324**	0.0258*	0.0206	0.0282	0.0266
2010	0.0216*	0.0236**	0.0267**	0.0289**	0.0231	0.0192	0.0258	0.0226
2011	0.0181	0.0202*	0.0234*	0.0255*	0.0216	0.0199	0.0272	0.0212
2012	0.0145	0.0164	0.0196	0.0221*	0.0175	0.0156	0.0234	0.0156
2013	0.0153	0.0179	0.0211*	0.0232*	0.0198	0.0205	0.0264	0.0175
2014	**0.0142**	0.0166	0.0194	0.0221	0.0191	0.0199	0.0263	0.0164

*Standard errors clustered by 2011 blockgroups in parentheses, *** p<0.01, ** p<0.05, * p<0.1*

Table 14: Estimates for homes East of Hiawatha Ave in the Service Period (6), Announcement 01/98

	1990	1991	1992	1993	1994	1995	1996	1997
2004	0.0447	0.0565	0.0671*	0.0790**	0.0602	0.0556	0.0540	0.0422
2005	0.0473*	0.0535*	0.0645**	0.0667***	0.0514*	0.0361	0.0467	0.0433
2006	0.0337	0.0383*	0.0494**	0.0574**	0.0429	0.0255	0.0367	**0.0240**
2007	0.0314	0.0353*	0.0439**	0.0512***	0.0342	0.0207	0.0273	**0.0184**
2008	0.0311*	0.0341*	0.0416**	0.0490***	0.0333	0.0197	0.0289	0.0109
2009	0.0296*	0.0313*	0.0370**	0.0419**	0.0263	0.0160	0.0261	0.00782
2010	0.0219	0.0257	0.0312**	0.0352**	0.0214	0.00986	0.0205	0.00113
2011	0.0178	0.0205	0.0261*	0.0306*	0.0199	0.00768	0.0195	-0.00107
2012	0.0221	0.0245	0.0298*	0.0350**	0.0220	0.00687	0.0194	-0.00811
2013	0.0248	0.0272	0.0322**	0.0378**	0.0266	0.0154	0.0285	-0.00514
2014	**0.0265**	0.0286*	0.0333**	0.0400**	0.0291	0.0158	0.0302	-0.00301

*Standard errors clustered by 2011 blockgroups in parentheses, *** p<0.01, ** p<0.05, * p<0.1*

Table 15: Estimates for homes West of Hiawatha Ave in the Service Period (6), Announcement in 01/98

	1990	1991	1992	1993	1994	1995	1996	1997
2004	0.0230	0.0319	0.0405	0.0419	0.0347	0.0299	0.0359	0.0476
2005	0.0321	0.0346*	0.0403*	0.0397*	0.0358	0.0289	0.0373	0.0379
2006	0.0335*	0.0340**	0.0399**	0.0416**	0.0366*	0.0303	0.0378	**0.0530****
2007	0.0304*	0.0318**	0.0345**	0.0362**	0.0315	0.0275	0.0346	**0.0466***
2008	0.0263*	0.0275*	0.0299*	0.0320*	0.0291	0.0246	0.0330	0.0464**
2009	0.0229	0.0236*	0.0263*	0.0284*	0.0254	0.0223	0.0288	0.0359
2010	0.0214	0.0226	0.0247	0.0262	0.0235	0.0227	0.0276	0.0328
2011	0.0182	0.0199	0.0222	0.0231	0.0220	0.0245	0.0299	0.0315
2012	0.0113	0.0130	0.0152	0.0166	0.0156	0.0190	0.0249	0.0279
2013	0.0112	0.0139	0.0164	0.0170	0.0170	0.0224	0.0253	0.0289
2014	**0.00904**	0.0115	0.0137	0.0147	0.0149	0.0216	0.0245	0.0263

*Standard errors clustered by 2011 blockgroups in parentheses, *** p<0.01, ** p<0.05, * p<0.1*

Table 16: Coefficients for Service Period in (5) by date of announcement

Data Coverage:	**1990-2014**	**1997-2006**	**1997-2007**
Announcement	(Pilgram)	(Kent & Parilla)	(Goetz)
Jan 98	0.0142	0.0446**	0.0375*
Jan 99	0.0201*	0.0482**	0.0436**
Jan 00	0.0177	0.0339	0.0320*
Jan 01	0.0101	0.0239	0.0223
Jan 02	0.00834	0.0243	0.0216
Jan 03	0.00580	0.0188	0.0161
Jan 04	0.00477	0.0177	0.0143
At opening	0.00374	0.0180	0.0140

*Standard errors clustered by 2011 blockgroups in parentheses, *** p<0.01, ** p<0.05, * p<0.1*

Table 17: Variation in LRT Premium by Distance from Station

	(5) Entire Corridor	(6) East Only	(6) West Only
After introduction of Service			
0-249 Meters	0.0358	0.136***	0.00926
	(0.0588)	(0.0456)	(0.0672)
250-499 Meters	0.00339	0.0786***	-0.0179
	(0.0235)	(0.0278)	(0.0222)
500-749 Meters	0.00618	0.00726	0.00654
	(0.0162)	(0.0218)	(0.0191)
750-999 Meters	0.0193	0.0252	0.0173
	(0.0138)	(0.0276)	(0.0134)
1000-1250 Meters	-0.00858	0.0203	-0.0266
	(0.0142)	(0.0182)	(0.0170)
During Construction			
0-249 Meters	0.0499	0.111*	0.0378
	(0.0631)	(0.0605)	(0.0714)
250-499 Meters	0.0109	0.0797**	-0.00882
	(0.0186)	(0.0363)	(0.0163)
500-749 Meters	0.0160	0.0130	0.0177
	(0.0139)	(0.0183)	(0.0176)
750-999 Meters	0.0107	0.0271	0.00266
	(0.0120)	(0.0218)	(0.0132)
1000-1250 Meters	0.00678	0.0311	-0.00870
	(0.0144)	(0.0246)	(0.0158)

*Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1*

Table 18: Coefficients by Period by Station (5) and Side (6)

	After			**During**		
Station	Both	East	West	Both	East	West
Franklin	0.0153	-0.152**	0.125*	0.0415	-0.0743	0.120**
	(0.0665)	(0.0681)	(0.0695)	(0.0498)	(0.0500)	(0.0468)
Lake	-0.00137	-0.0134	0.0548	-0.0550	0.0256	-0.0763*
	(0.0507)	(0.0580)	(0.0842)	(0.0378)	(0.0833)	(0.0404)
38th Street	-0.0180	0.00634	-0.0315	-0.00573	0.0156	-0.0184
	(0.0197)	(0.0208)	(0.0253)	(0.0145)	(0.0203)	(0.0165)
46th Street	0.0421***	0.0588***	0.0262**	0.0304***	0.0456***	0.0156
	(0.0129)	(0.0148)	(0.0122)	(0.0106)	(0.0110)	(0.0108)
50th Street	0.0310***	0.0570***	0.0289**	0.0326**	0.0538***	0.0303*
	(0.0114)	(0.0166)	(0.0116)	(0.0160)	(0.0144)	(0.0165)
VA Center	0.0306	0.221***	0.0282	0.0515**	0.183***	0.0491**
	(0.0342)	(0.0174)	(0.0312)	(0.0234)	(0.0122)	(0.0227)

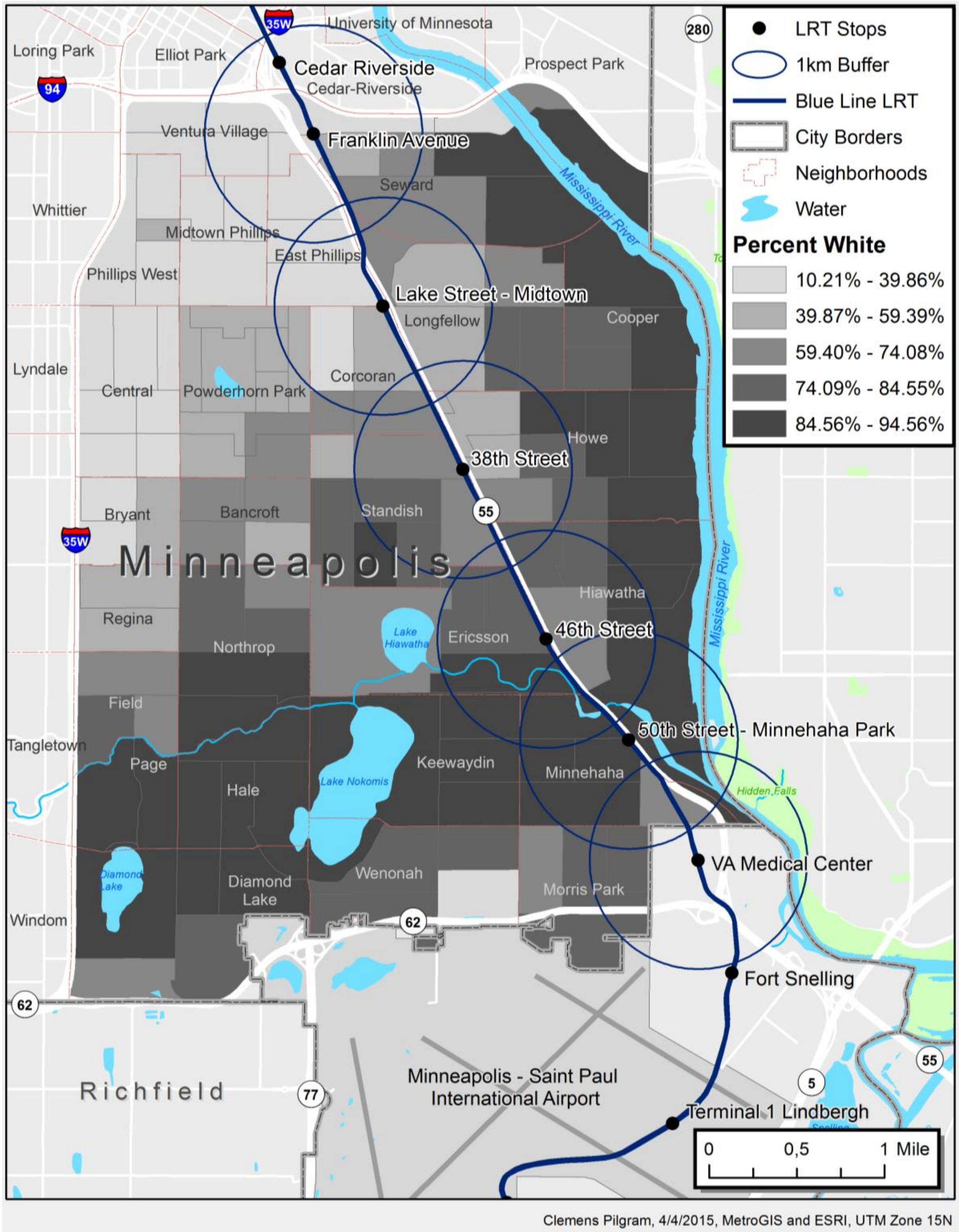
*Standard errors clustered by 2011 blockgroups in parentheses, *** p<0.01, ** p<0.05, * p<0.1*

Maps

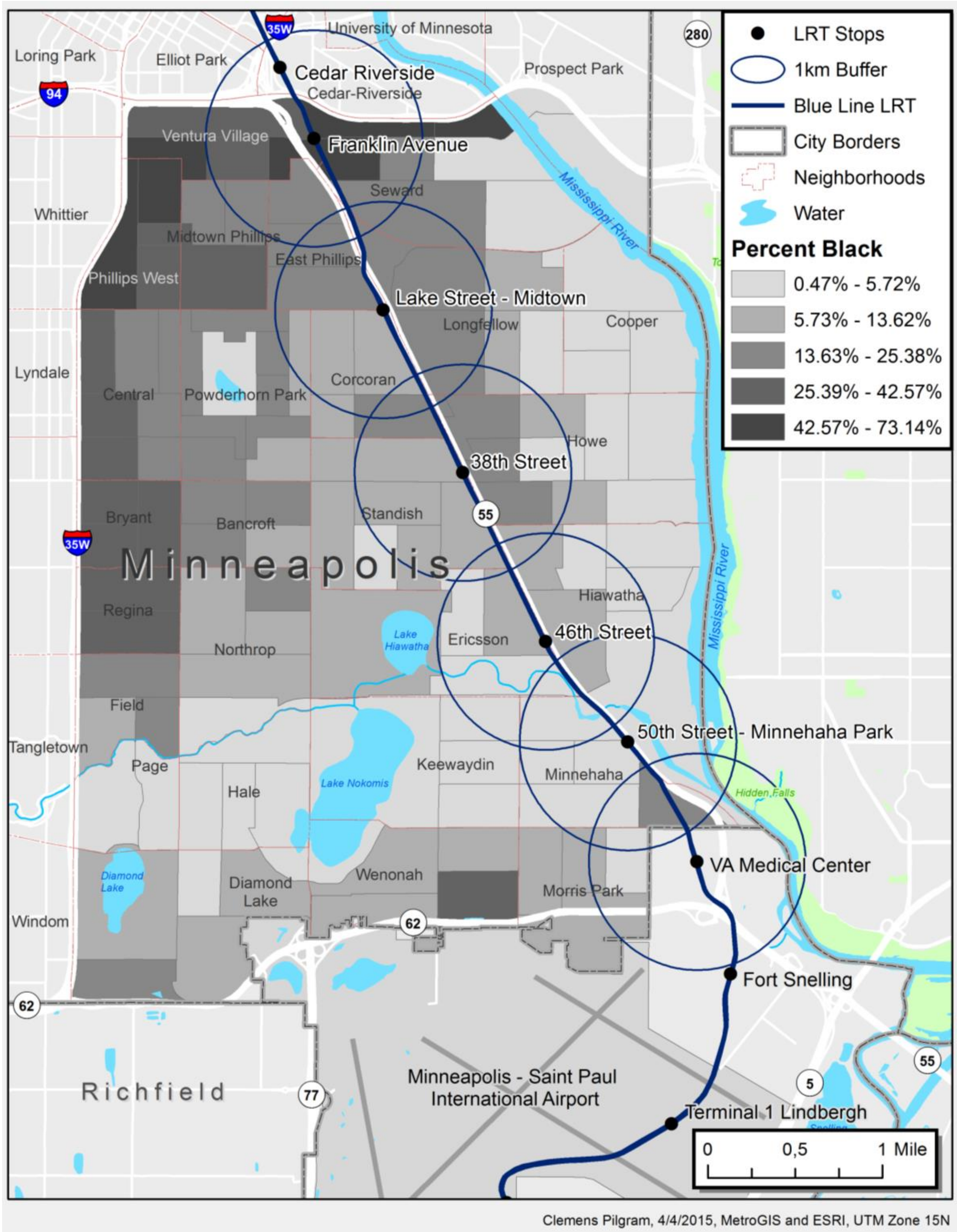
Map 1: Map of Hiawatha LRT Route

Map 2: Map of Hiawatha LRT Route in Study Area

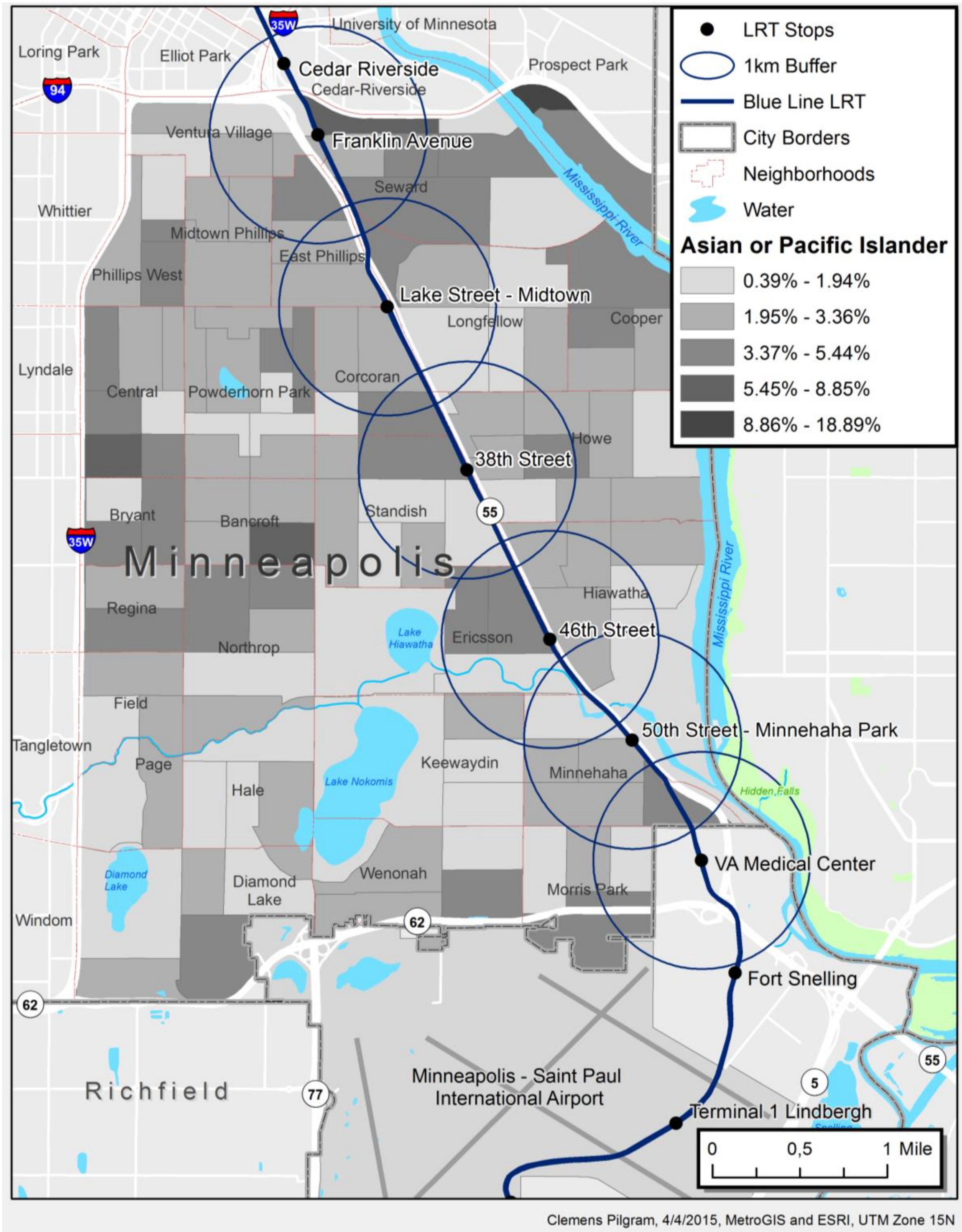
Map 3: White Population by Census Blockgroup in 2011



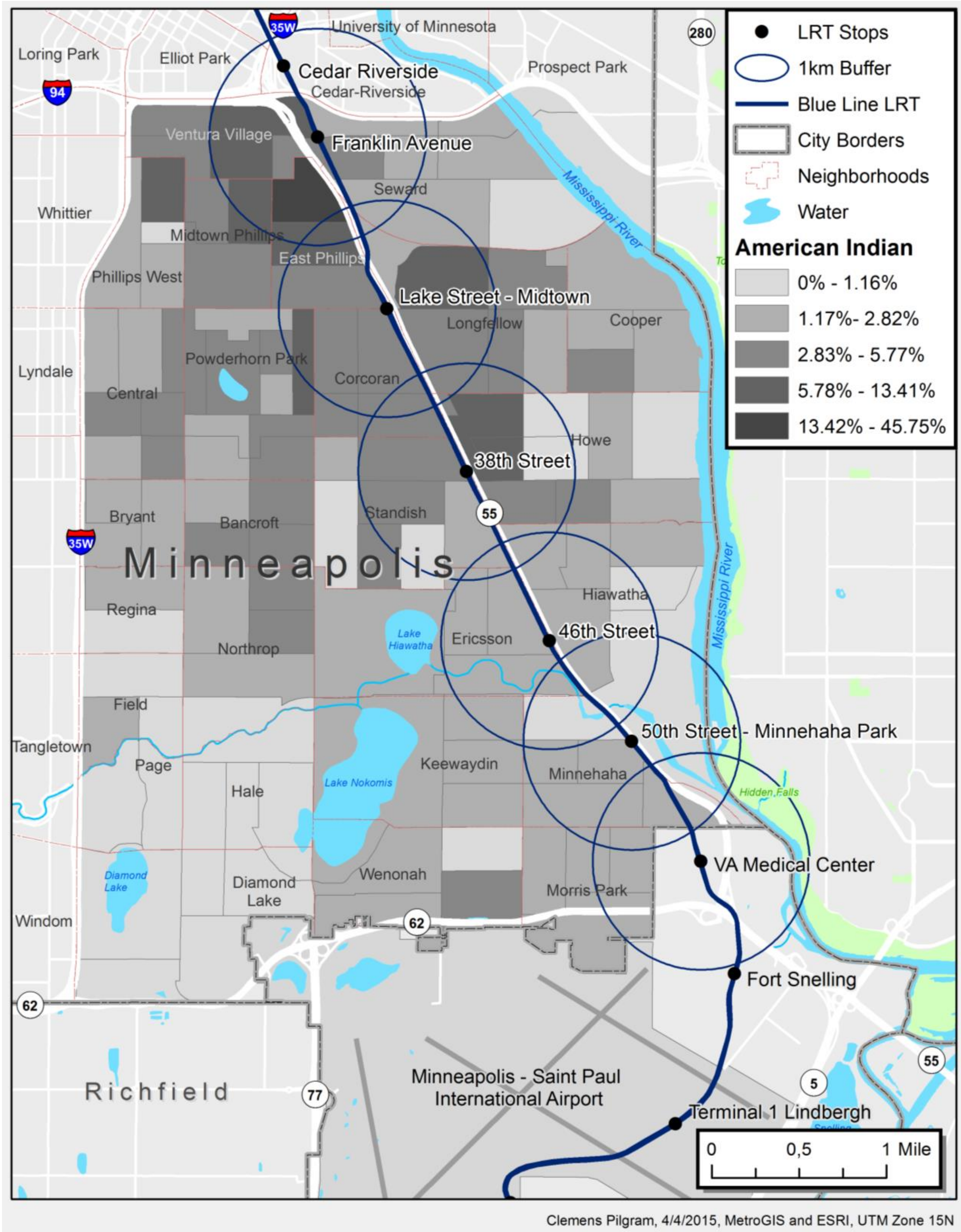
Map 4: Black Population by Census Blockgroup in 2011



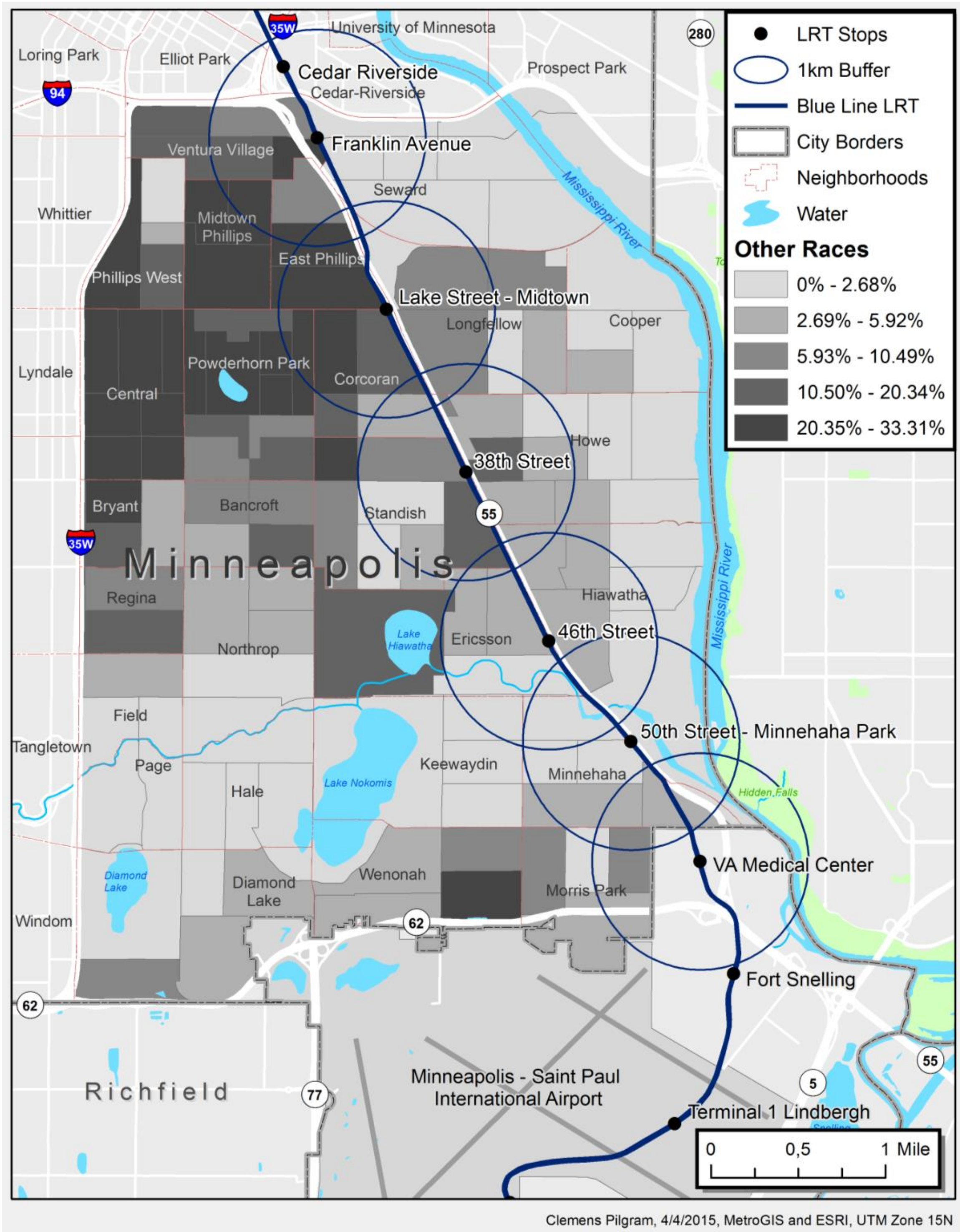
Map 5: Asian or Pacific Islander Population by Census Blockgroup in 2011



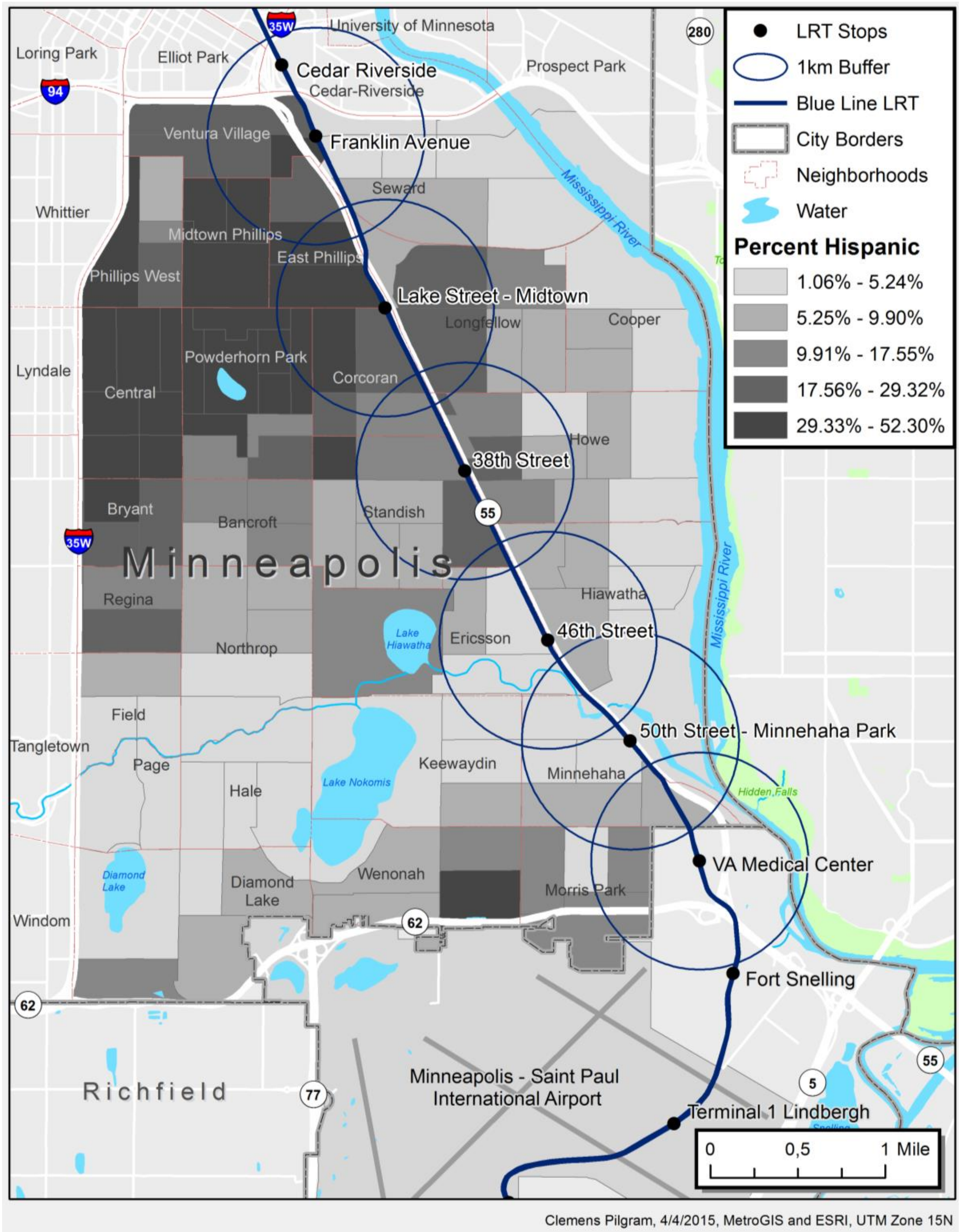
Map 6: American Indian Population by Census Blockgroup in 2011



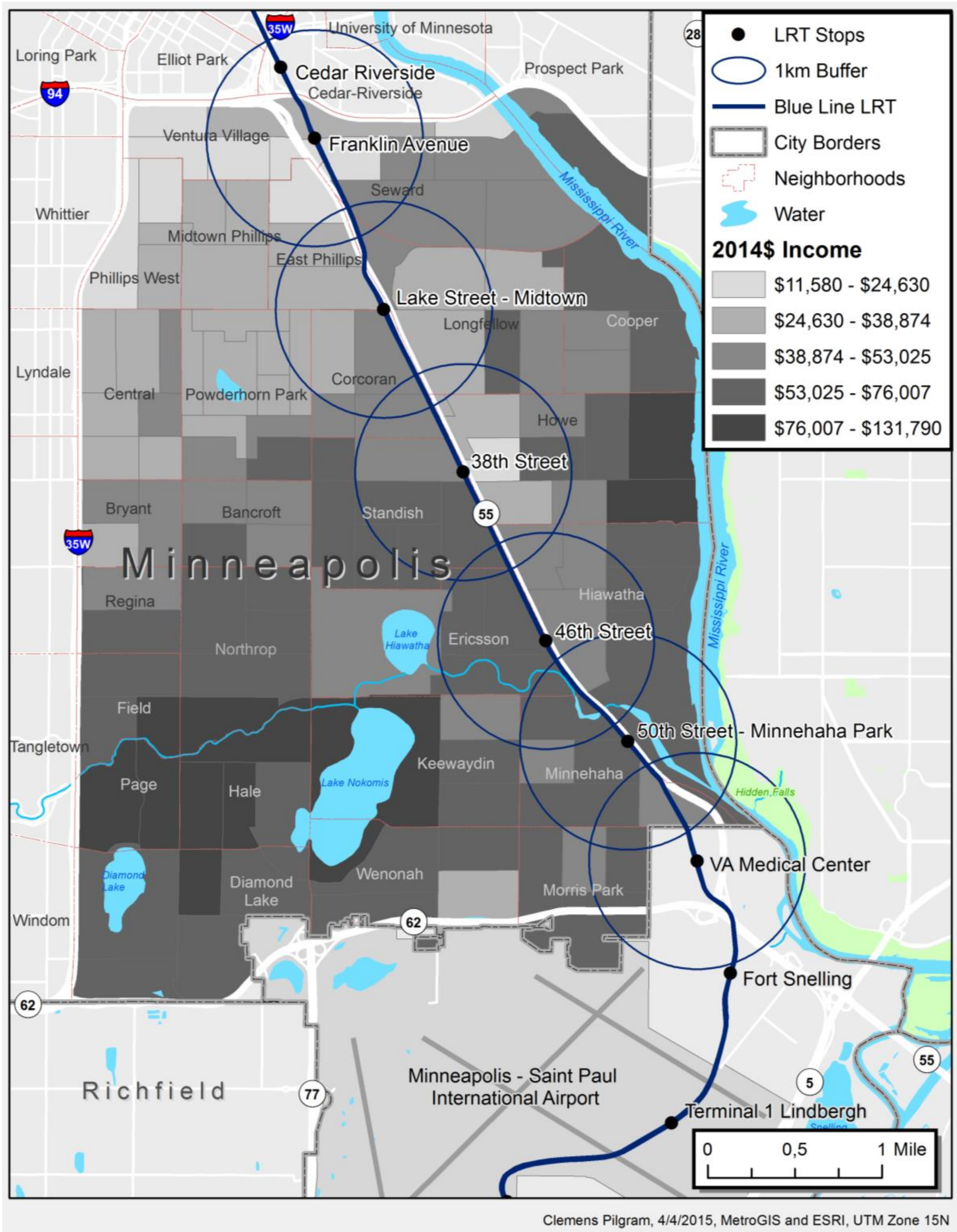
Map 7: "Other Race" Population by Census Blockgroup in 2011



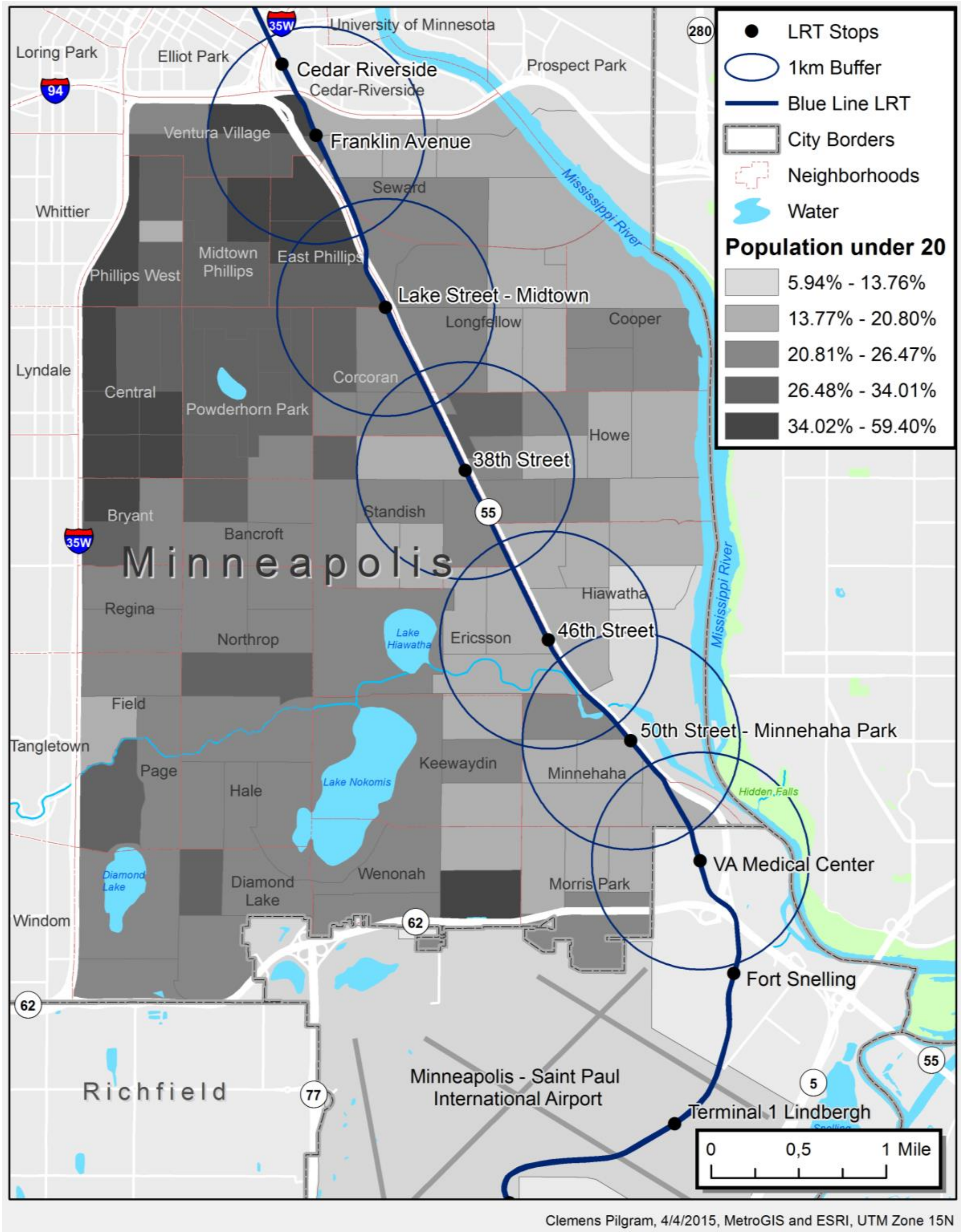
Map 8: Hispanic or Latino Population by Census Blockgroup in 2011



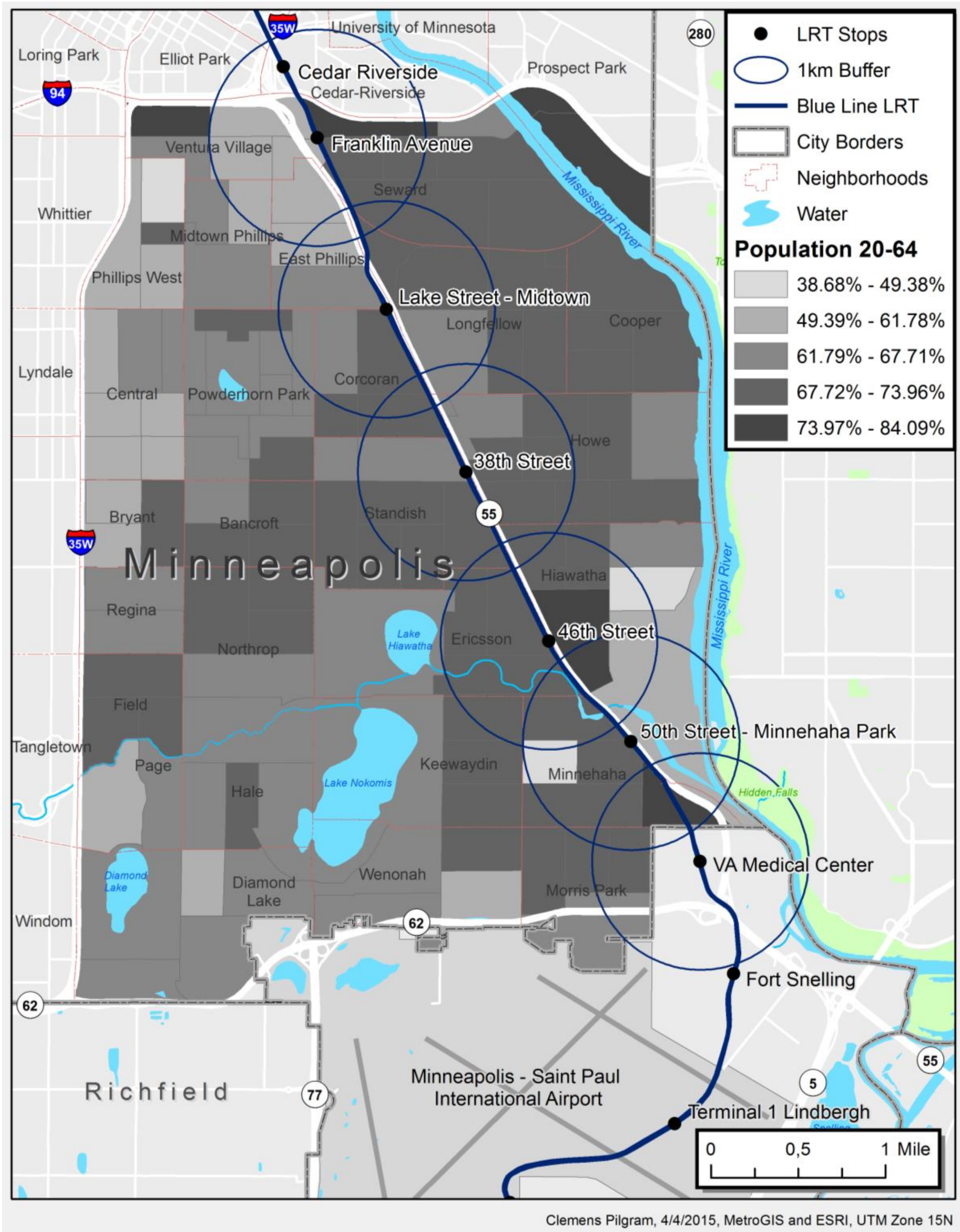
Map 9: 2011 Median Household Income in 2014 Dollars by Census Blockgroup



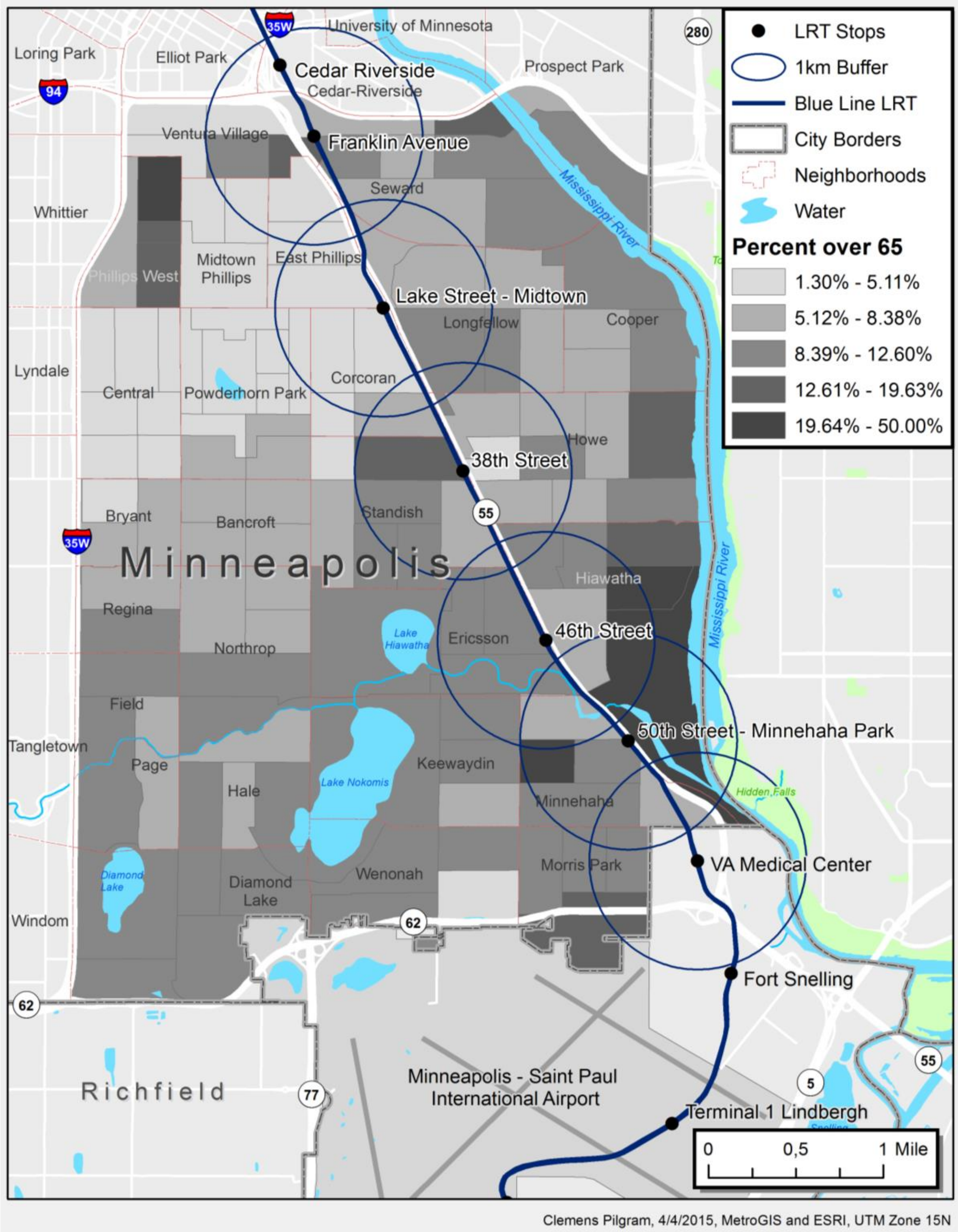
Map 10: Population under the age of 20 by Census Blockgroup in 2011



Map 11: Population aged 20 to 64 by Census Blockgroup in 2011

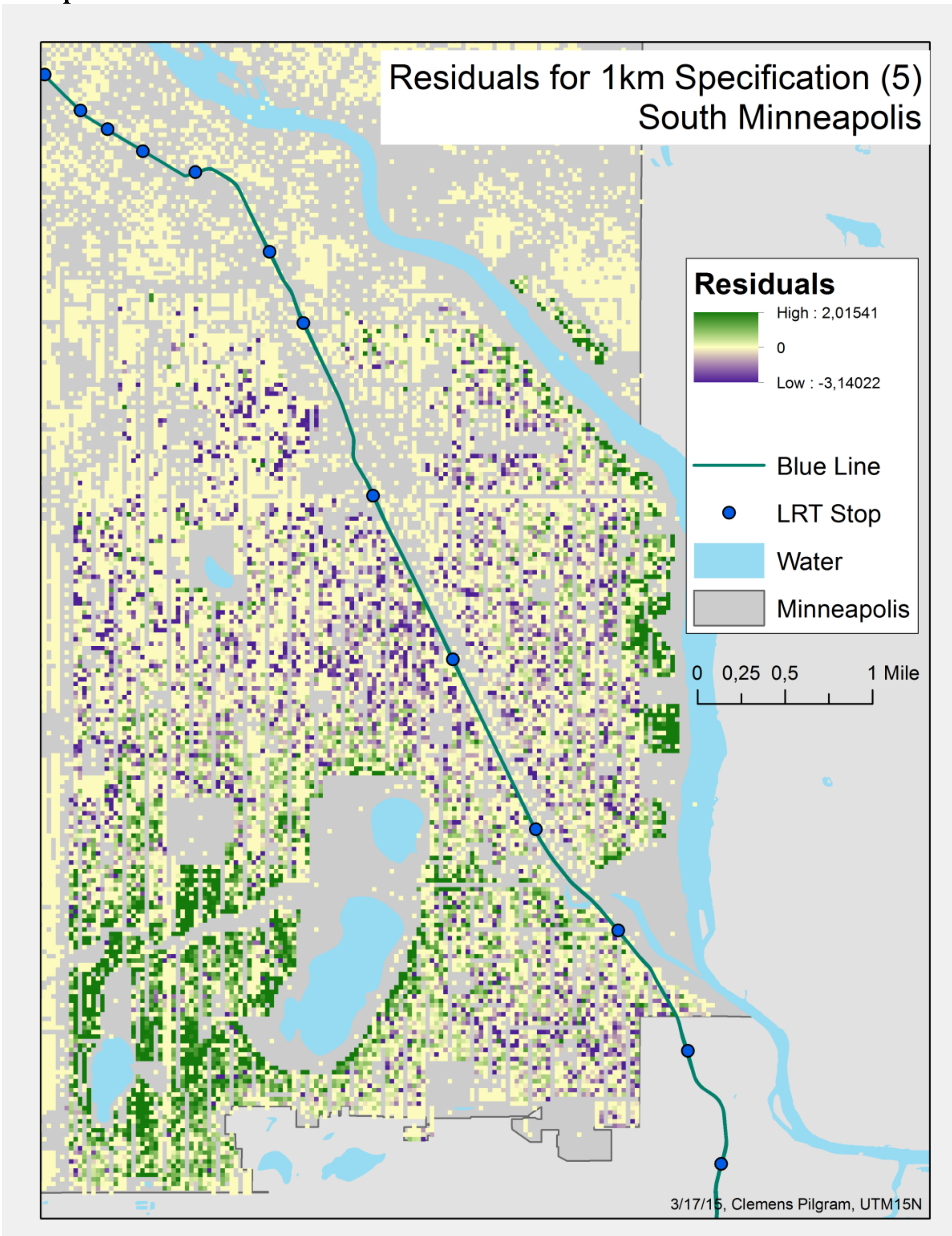


Map 12: Population 65 and over by Census Blockgroup in 2011



Clemens Pilgram, 4/4/2015, MetroGIS and ESRI, UTM Zone 15N

Map 13: Residuals for Specification (5) with South Minneapolis as Comparison Group



Map 14: Residuals from Specification (5) for all of Minneapolis as Comparison Group

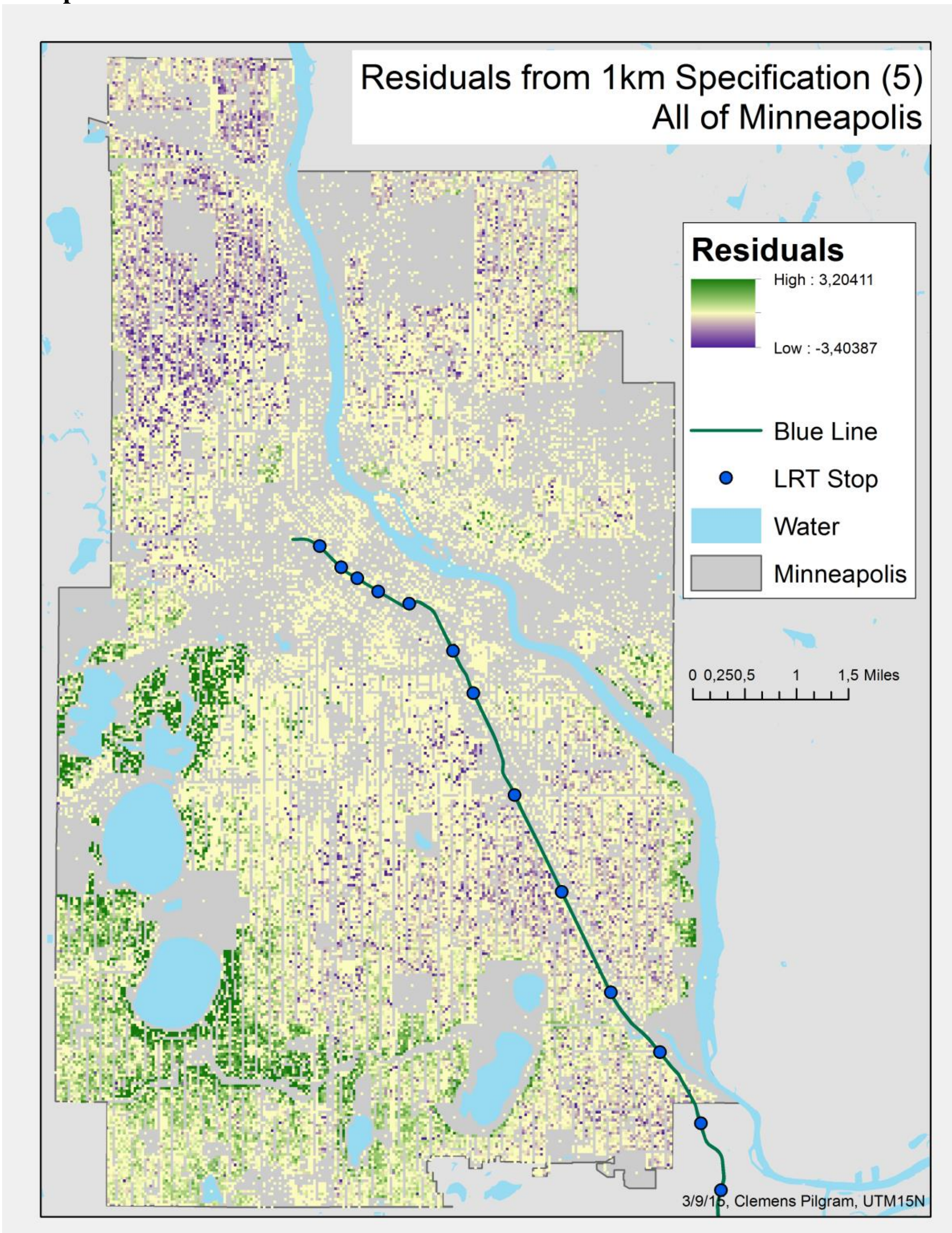


Figure 1: Average monthly Sale prices, 1983-2014, 1km vs. Rest of Minneapolis

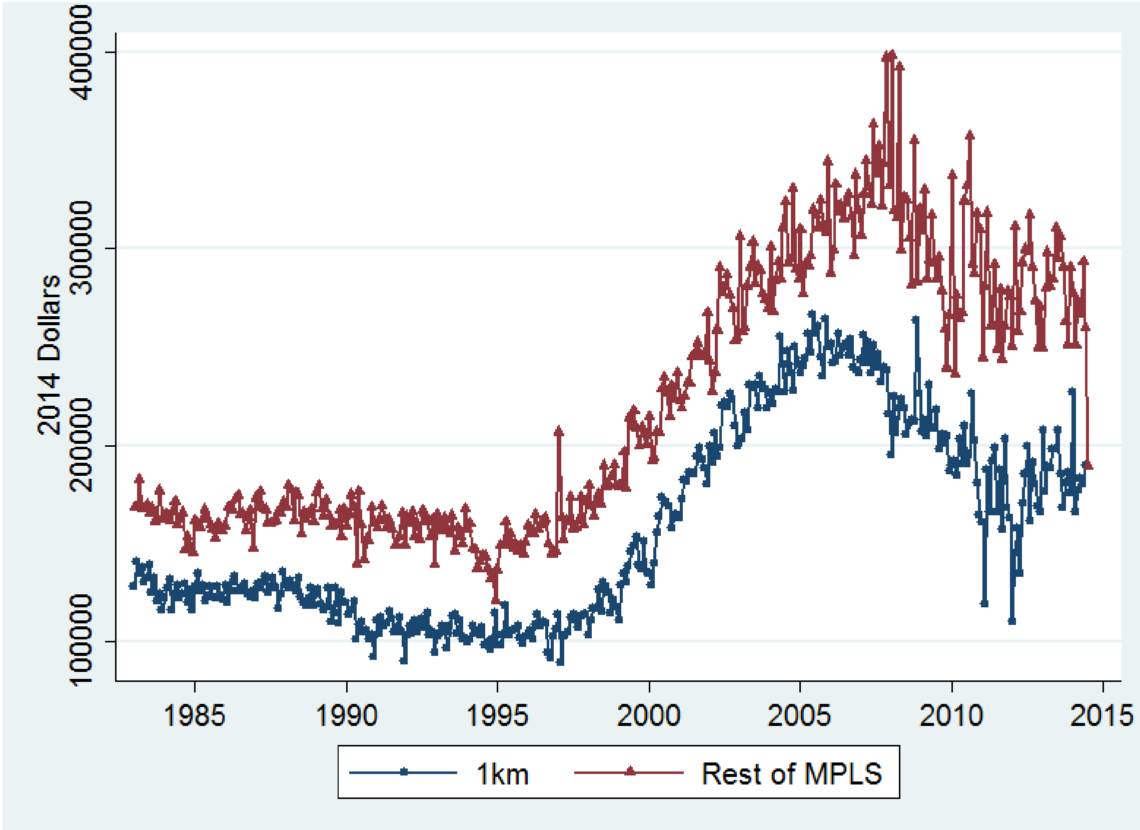


Figure 2: Monthly Sales volumes, 1983-2014, 1km vs. Rest of Minneapolis

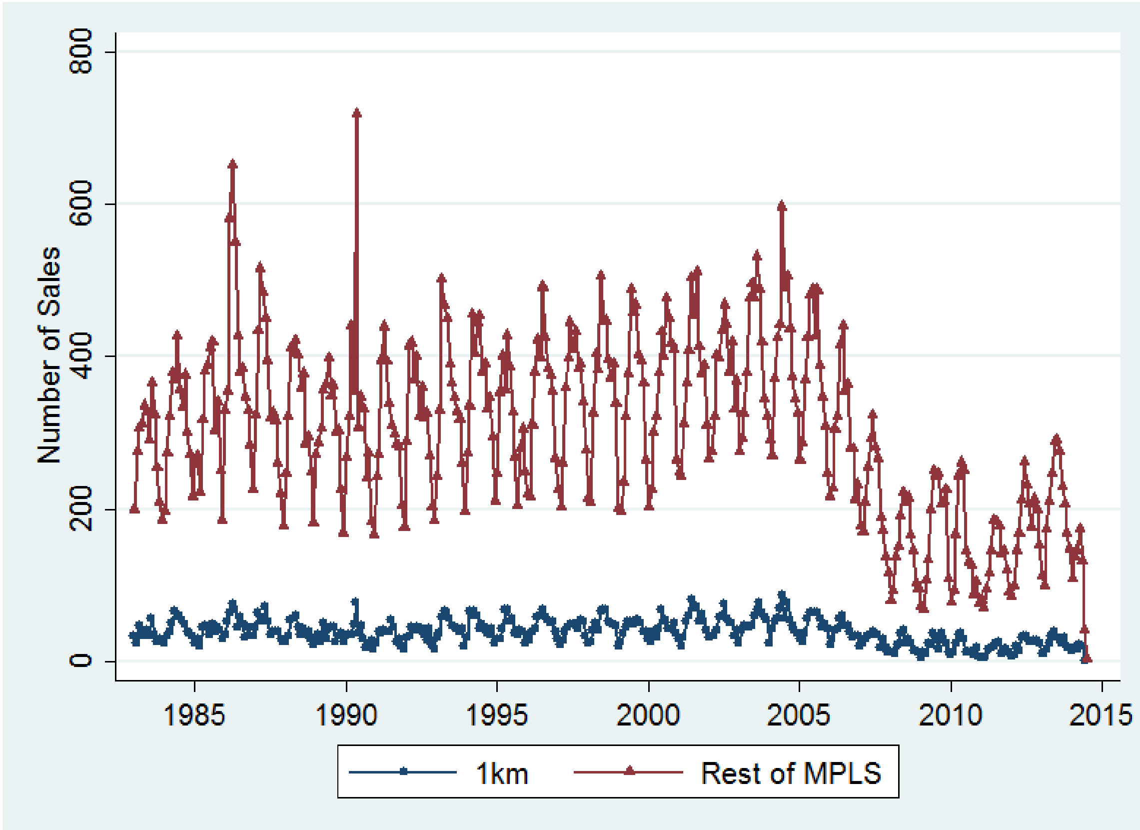


Figure 3: Average monthly Sale prices, 1983-2014, 1km vs. Rest of South Minneapolis

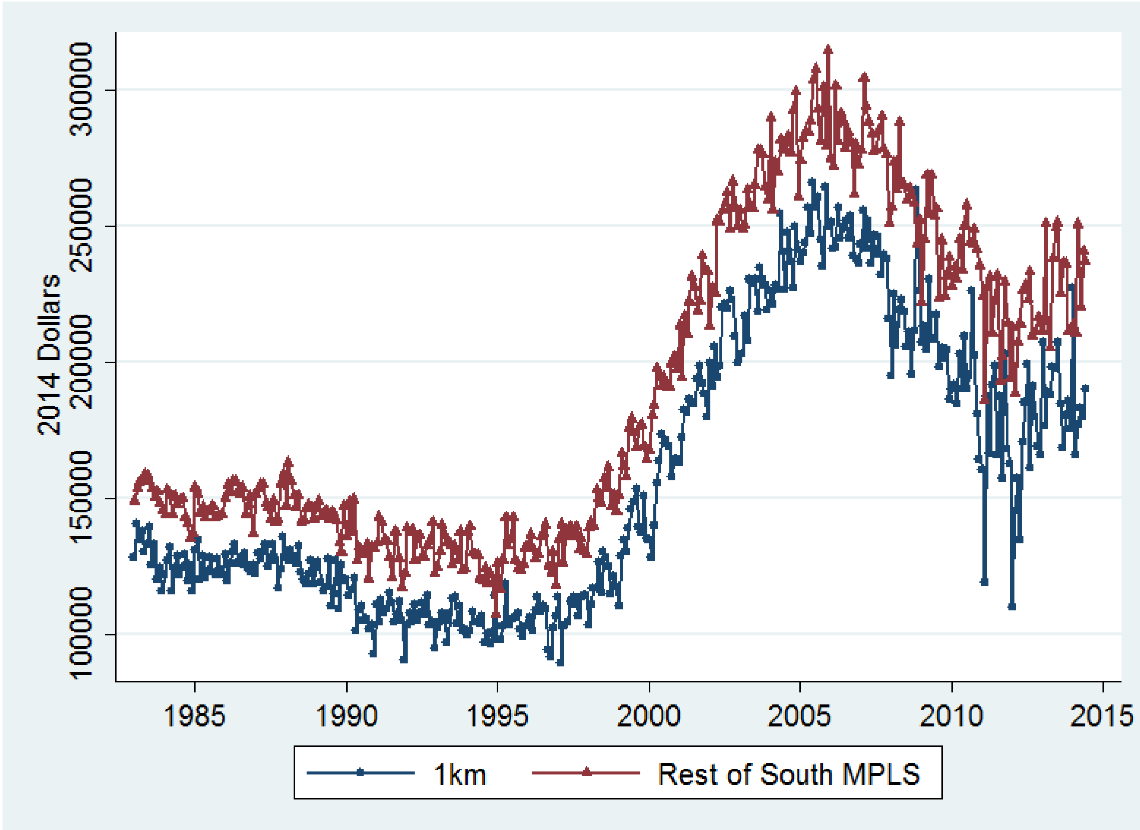


Figure 4: Average monthly Sales volumes, 1983-2014, 1km vs. Rest of South Minneapolis

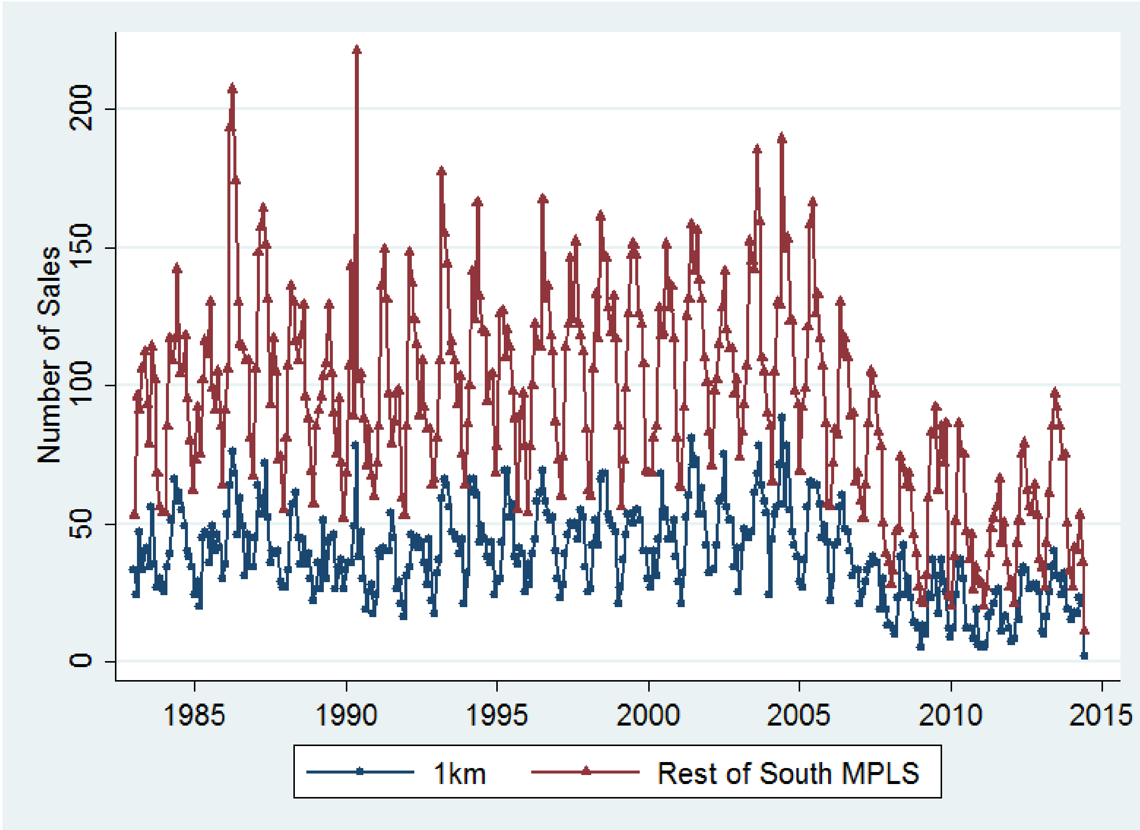


Figure 5: Average monthly Sale prices, 1983-2014, 1km East vs. 1km West

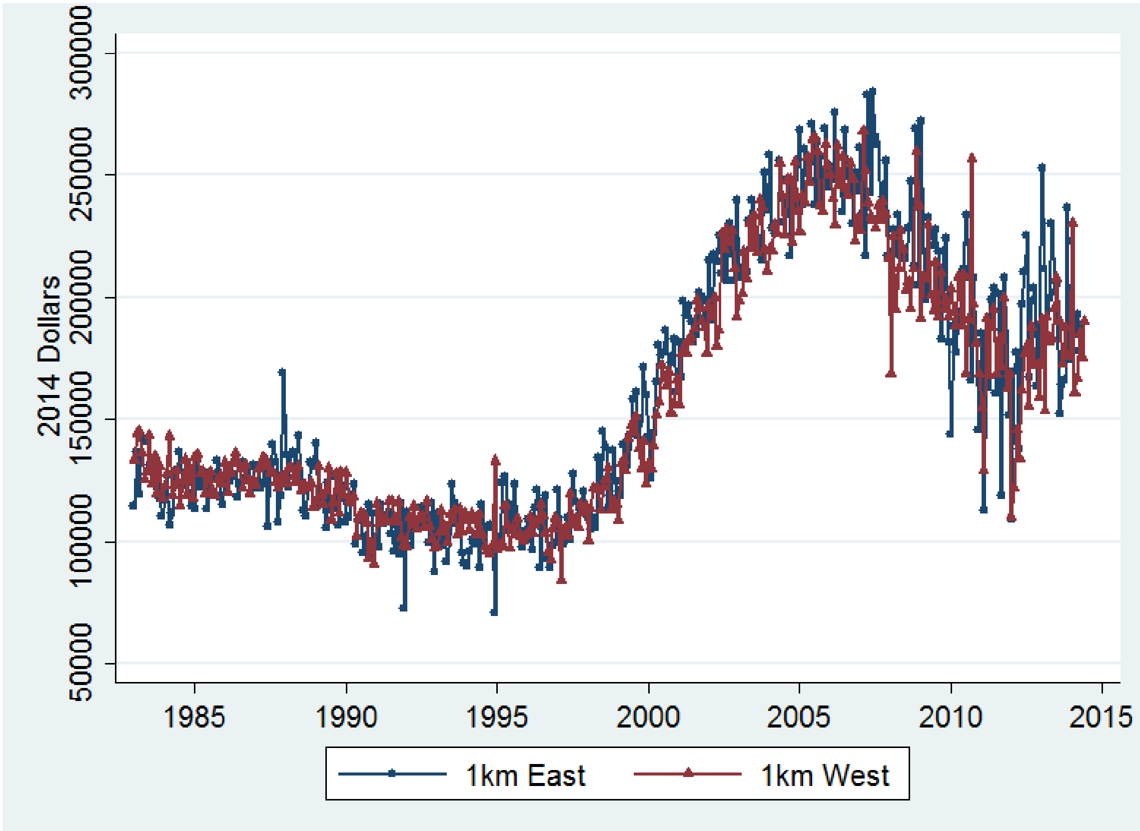


Figure 6: Average monthly Sales volumes, 1983-2014, 1km East vs. 1km West